WP 2 - Social enrichment and requirements for the tank rearing of Atlantic salmon

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Task 2.1
Optimization of group size for animal experimentation with group-living salmon

3 Rs

- Reduction: As few fish as possible
- Refinement: Optimal environment
- Is few fish optimal?
  - Welfare
  - Relevance (a 4th R)

In sea cage, 3-kg salmon

Group size increased every 2nd day by adding fish

Folkedal et al., unpublished

Welfare aspects of group size

- Salmon are territorial in small groups, but schooling in large groups
- Small groups should give more damages and higher stress levels, at least for subdominant fish
- Which group size/density is large enough?

Relevance aspects of group size

- In experiments where results should be comparable to commersial aquaculture fish should behave and perform as at commersial densities
- Fish at densities with low aggression may still deviate behaviourally from commersial densities, with results being irrelevant for aquaculture

Three experiments

- Different behaviour at different stages
- Therefore the experiment must be made with all stages

- Pre-smolts (50 g)

- Smolts (100 g)

- Post-smolts (1000 g)

Pre-smolts

Pre-smolts

From 3 m circular tanks to 1 m squared tanks
21 days duration

- Fish: Salmon pre-smolts, 48.8 ± 6.9 g
- Tanks: 1 × 1 m (350 L)
- Flow: 18 L/min
- Current direction : clockwise
- Duplicates

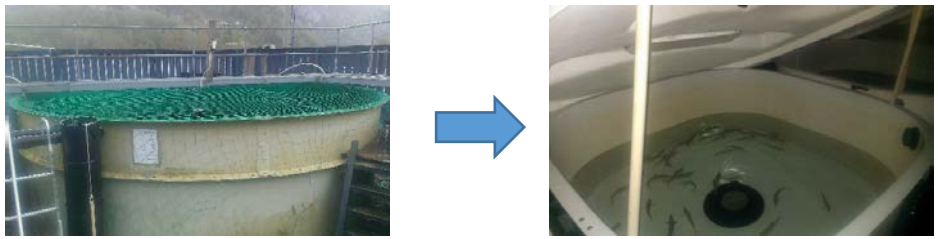
Group size	Stocking density (kg/m3)
10	1.4
15	2.1
23	3.2
34	4.8
51	7.2
76	10.8
114	16.3
171	24.4

Smolts

- Fish: Salmon smolts, 78.1 ± 22.1 g
- Tanks: 1.5 × 1.5 m (775 L)
- Flow: 30 L/min
- Current direction : clockwise
- Triplicates

Start at sea water transfer

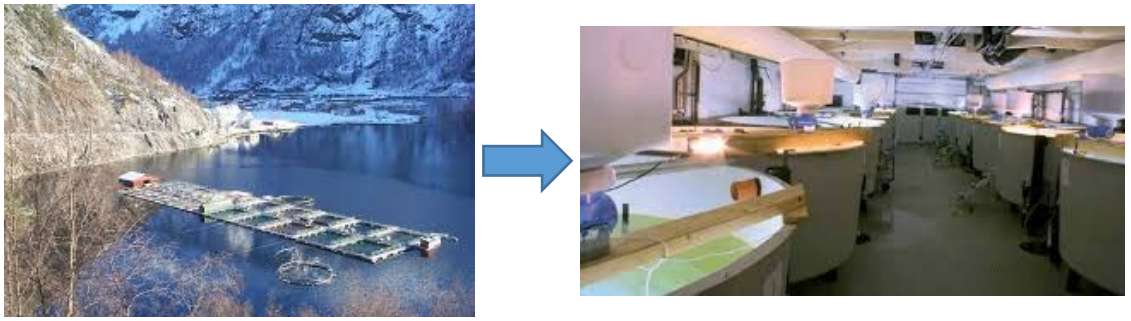
42 days duration



Group size	Stocking density (kg/m3)
12	1.4
25	2.6
50	4.9
100	11.2
200	21.1

Post-smolts

Transferred from 12×12 m cages to 3 m tanks
28 days duration



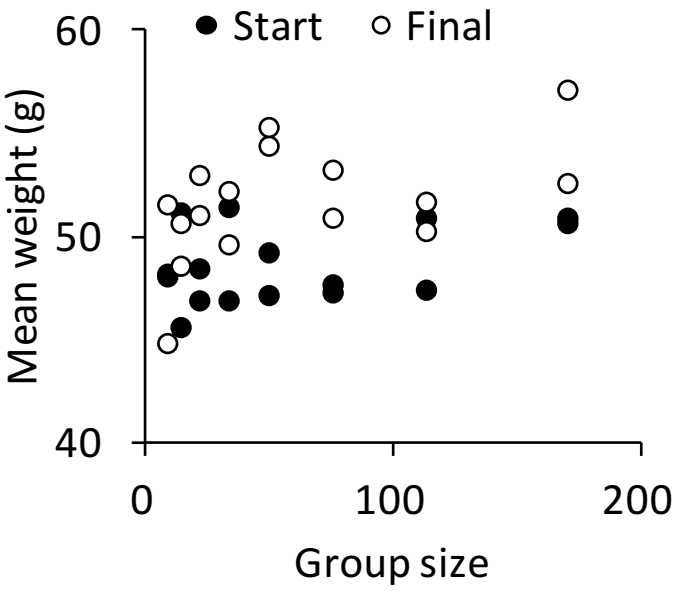
- Post-smolts, 941 ± 306 g
- Tanks: 3 m circular (5600 L)
- Flow: 200 L/min
- Current direction : clockwise
- Triplicates

Group size	Stocking density (kg/m3)
10	1.7
30	5.0
70	11.7
150	25.0

Weight

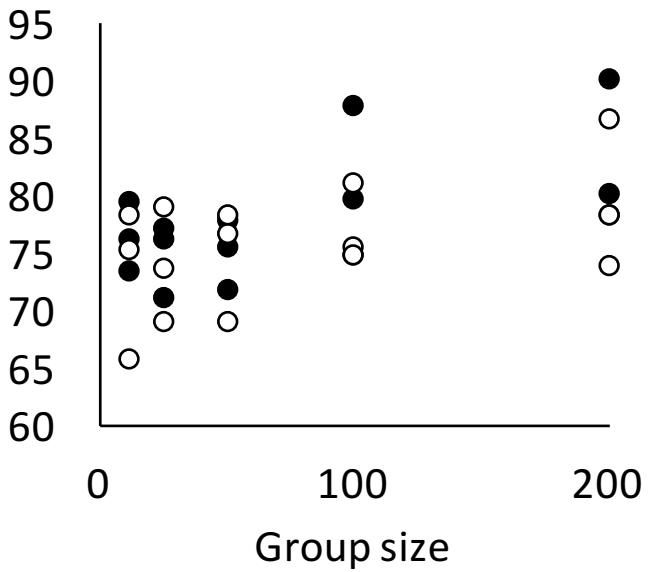
21 days

Pre-smolts



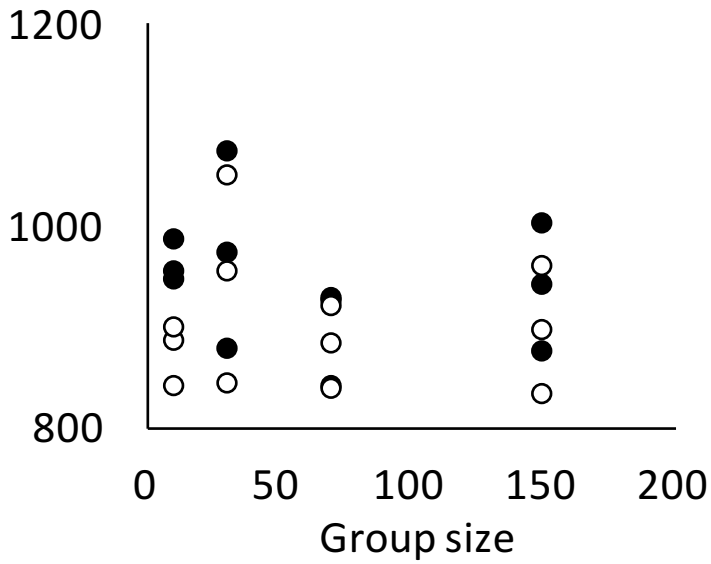
42 days

Smolts



28 days

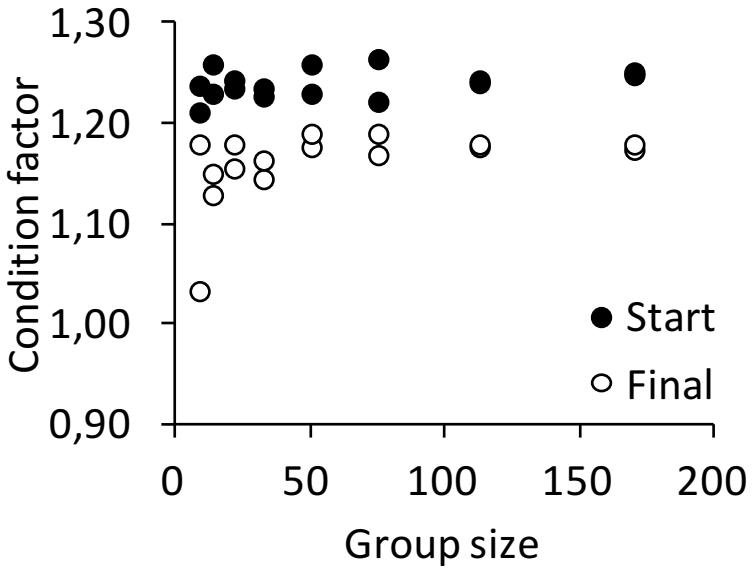
Post-smolts



Condition factor

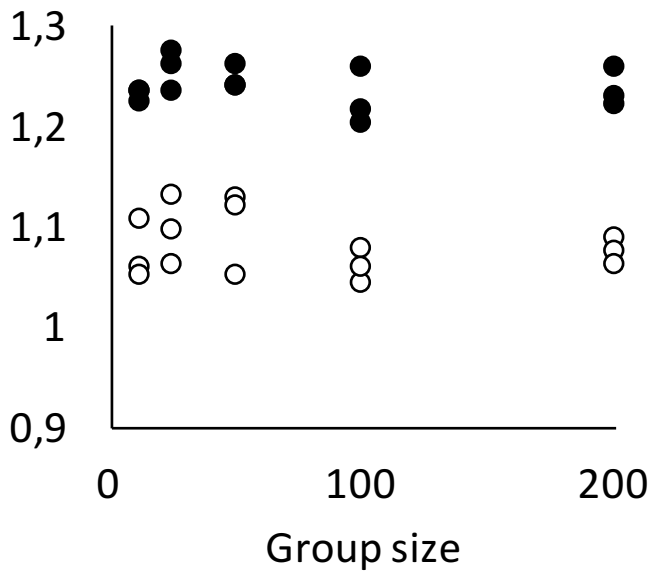
21 days

Pre-smolts



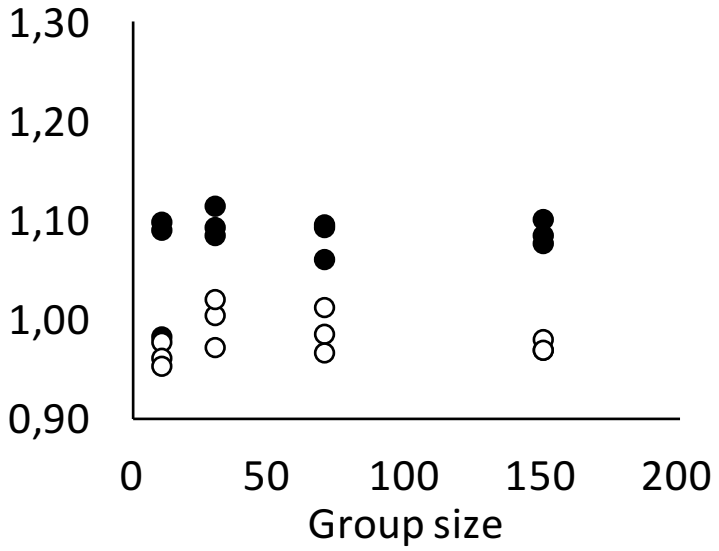
42 days

Smolts



28 days

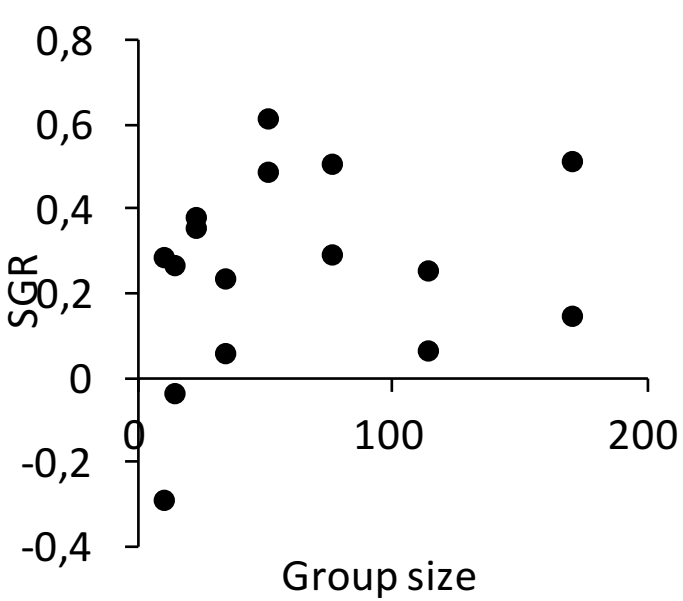
Post-smolts



Growth rate

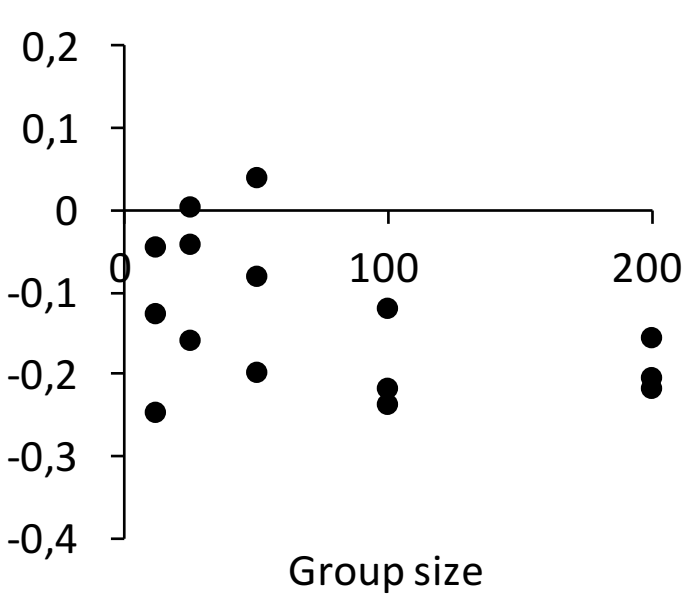
21 days

Pre-smolts



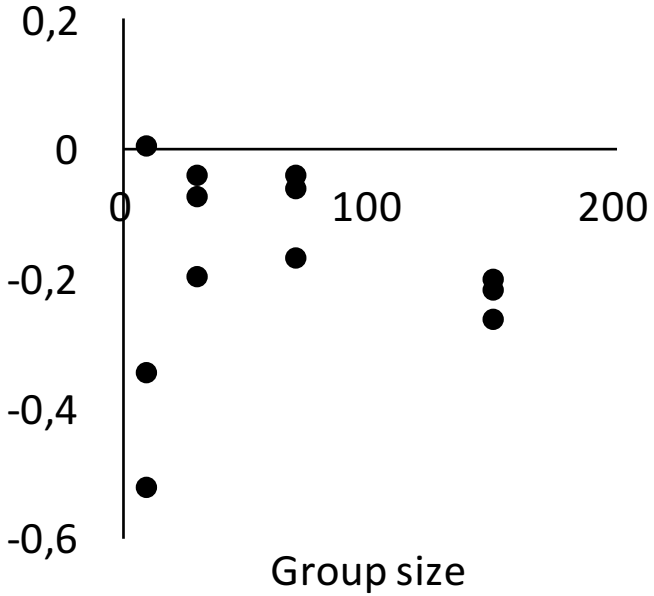
42 days

Smolts

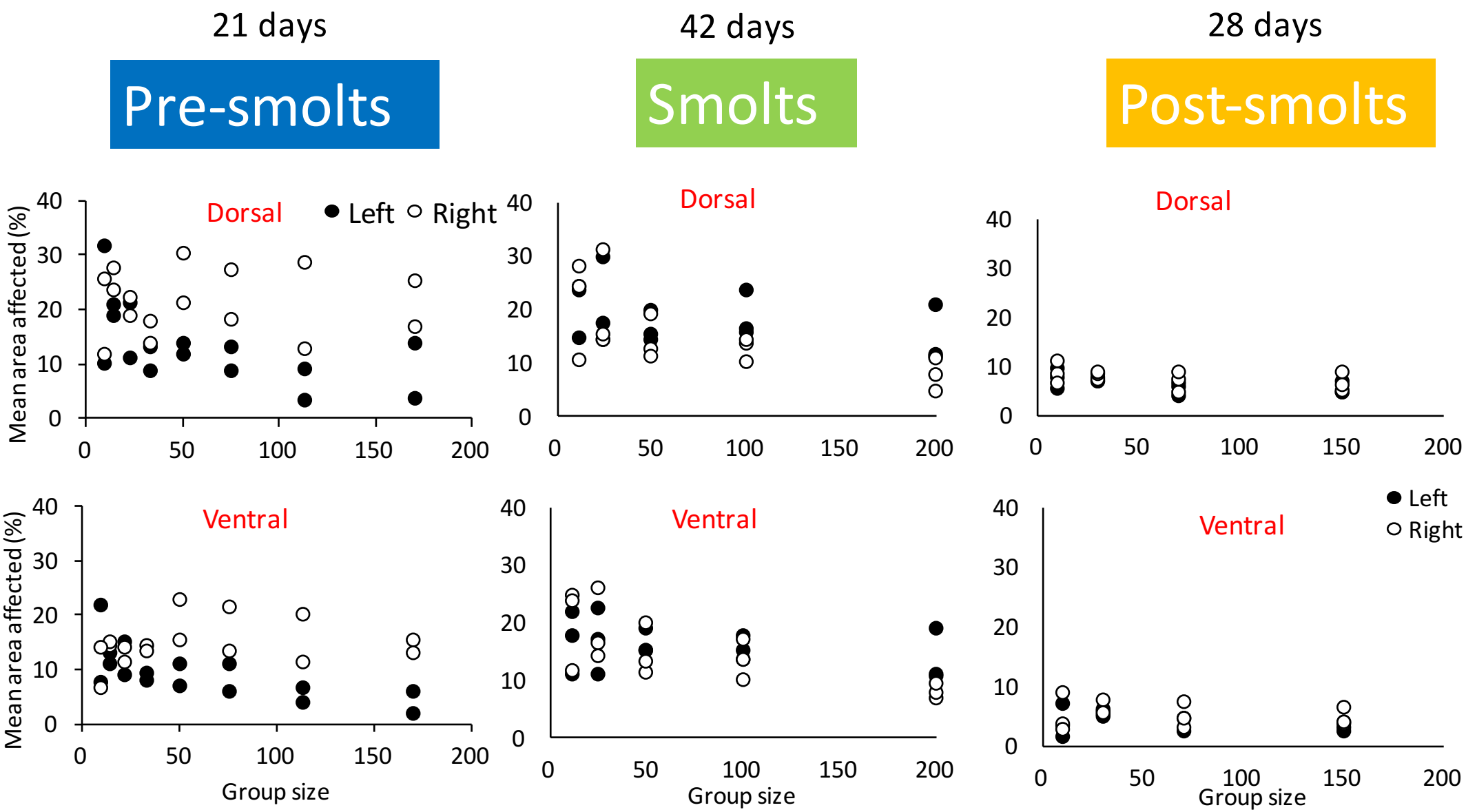


28 days

Post-smolts

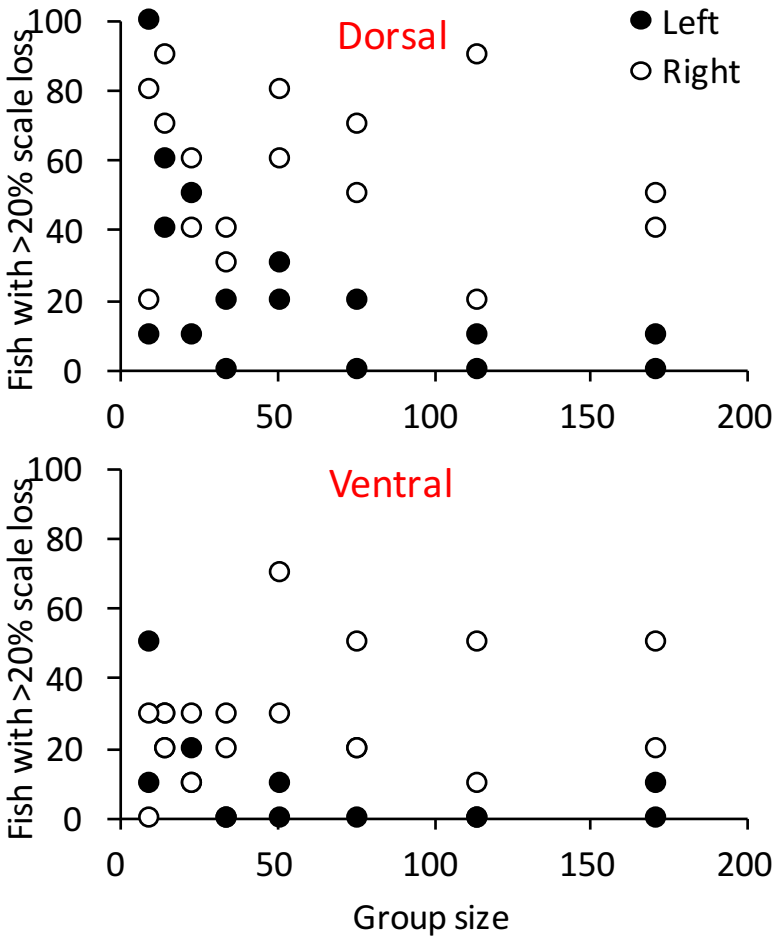



Scale loss


21 days
42 days
28 days
Pre-smolts
Smolts
Post-smolts
Dorsal
Left
Right
Ventral
Mean area affected (%)
Group size
0
10
20
30
40
50
100
150
200

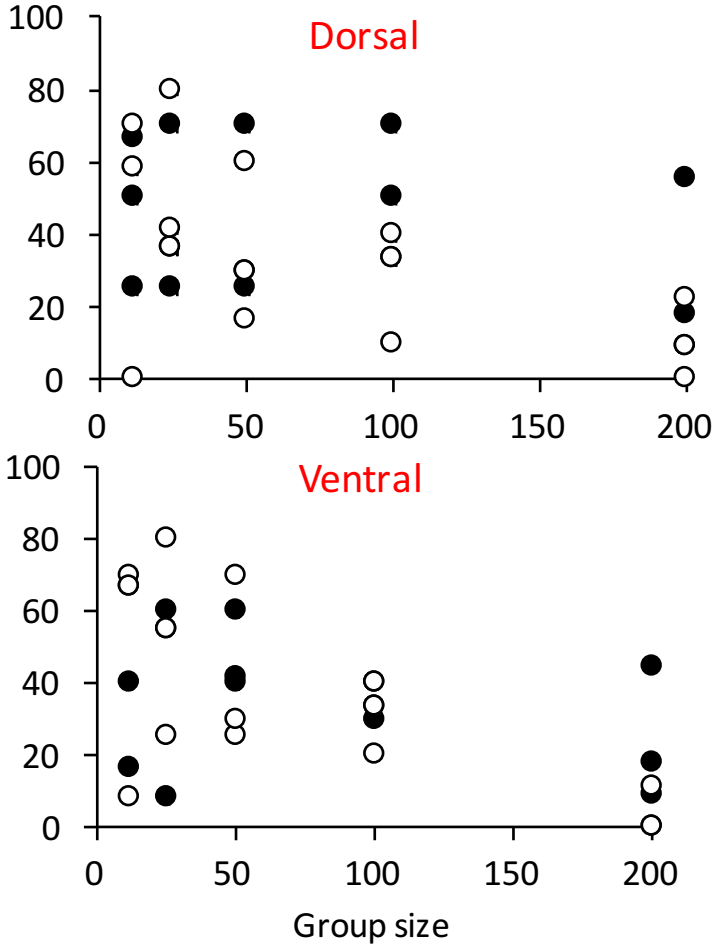
21 days

Pre-smolts



42 days

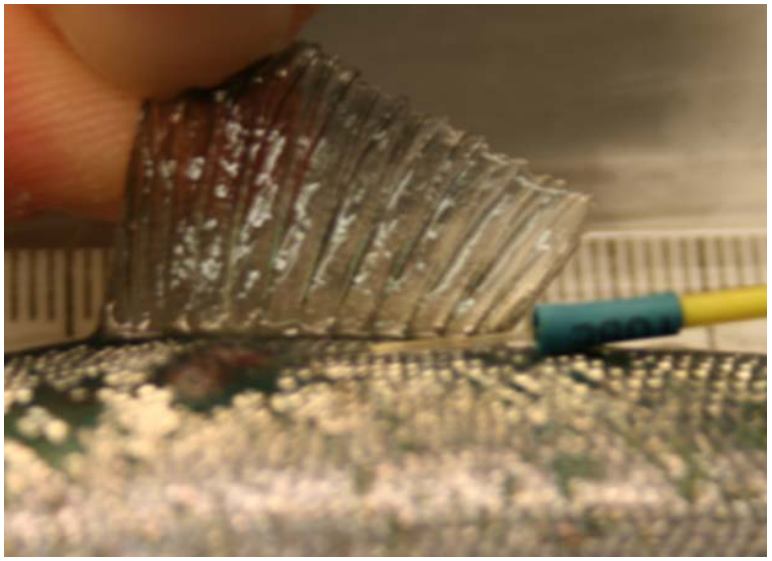
Smolts



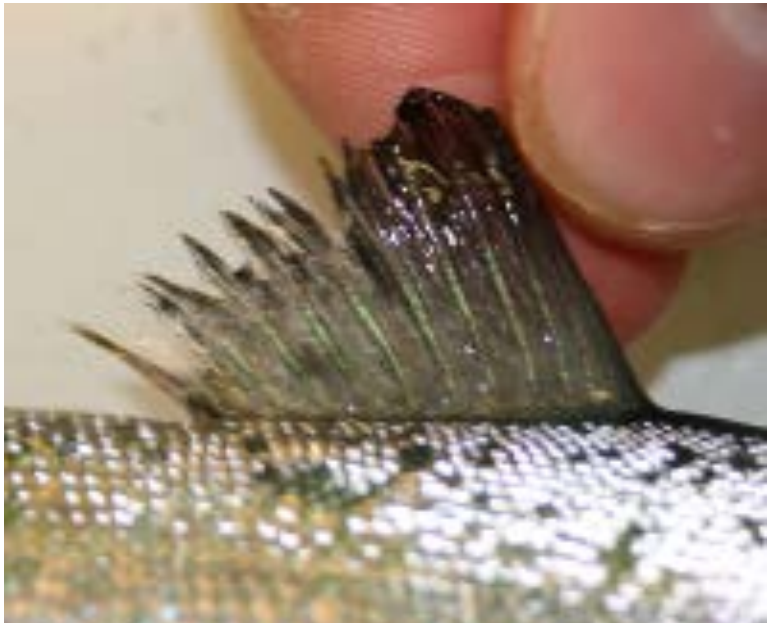
28 days

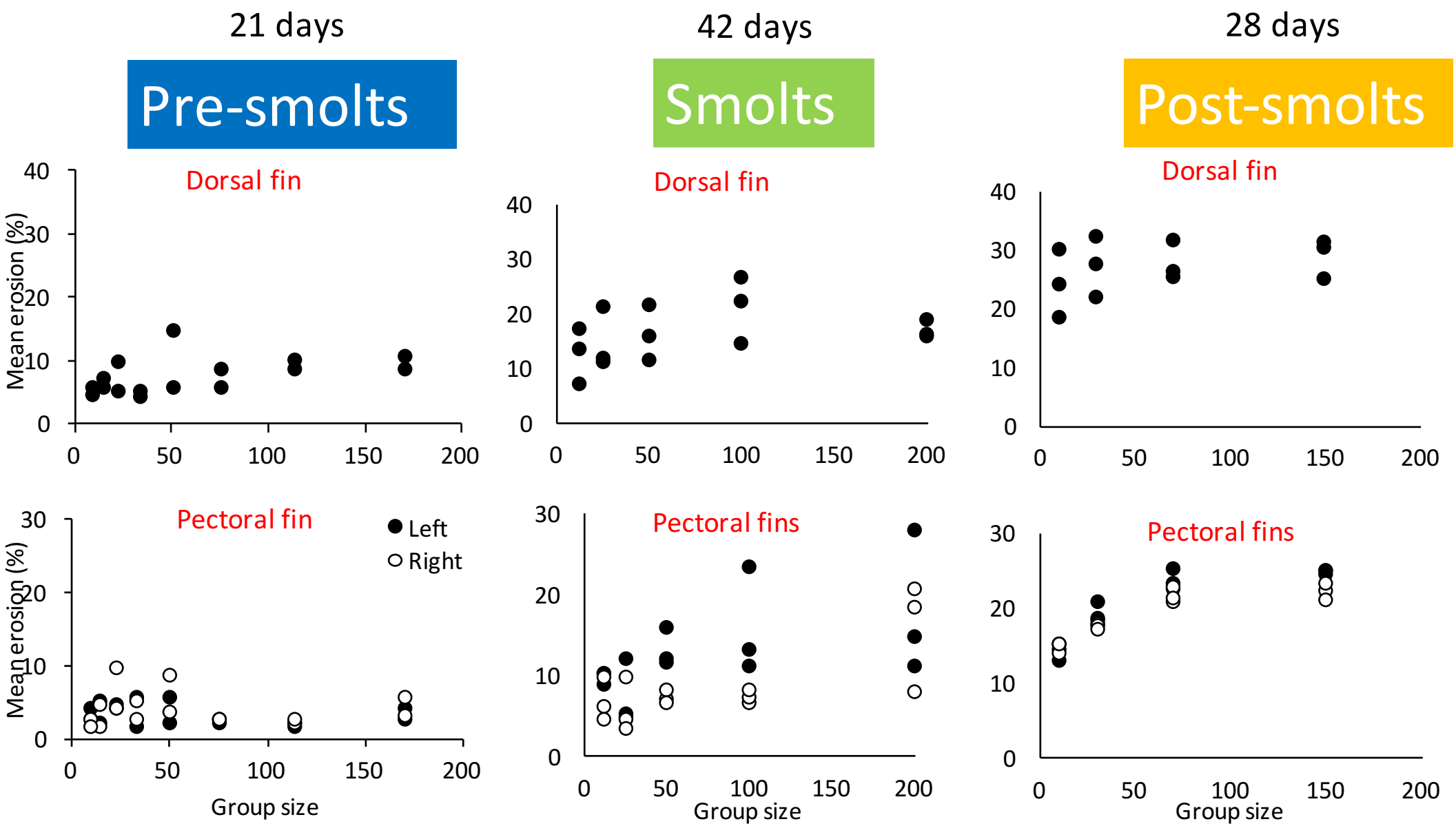
Post-smolts

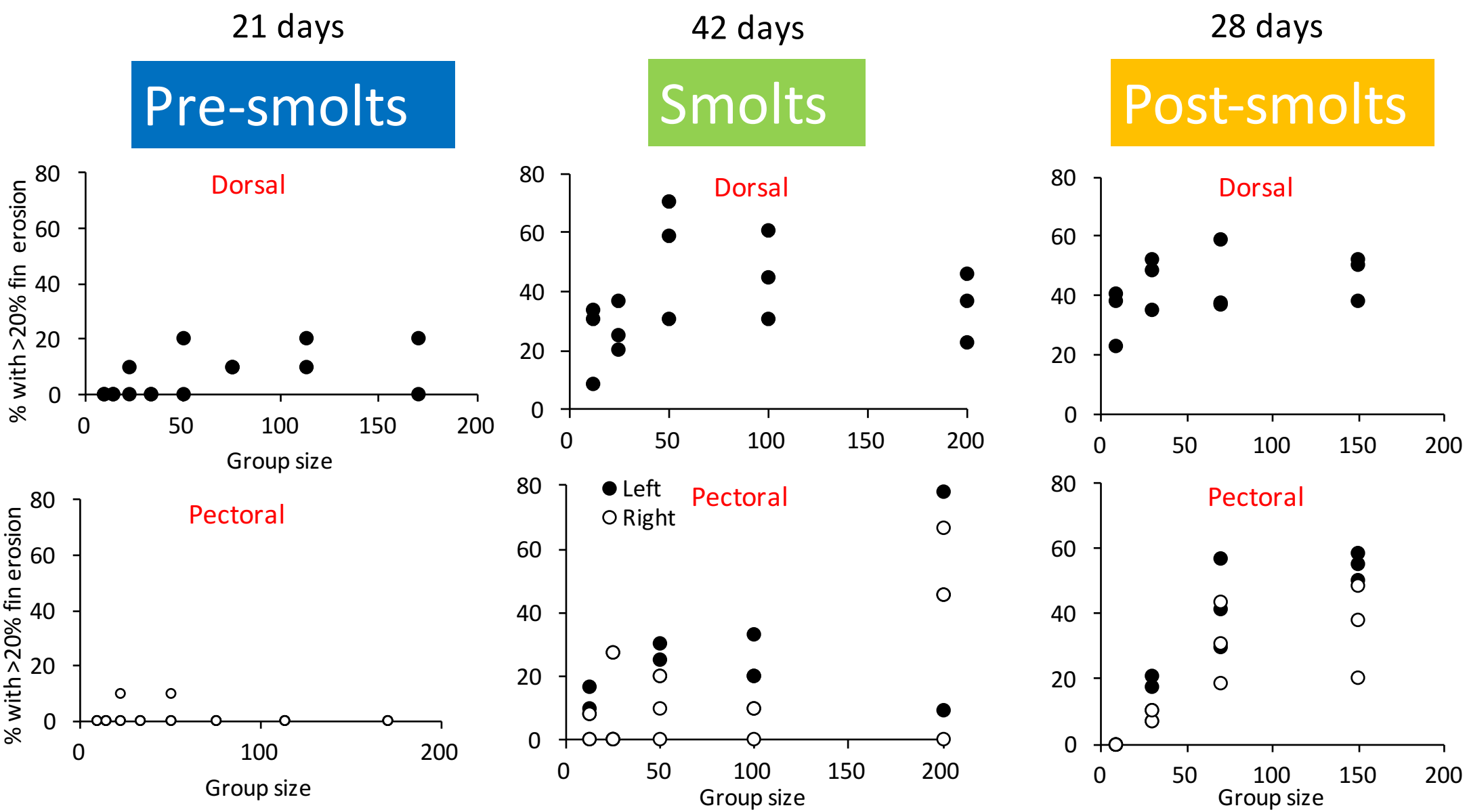
Very few fish with >20% scale loss



Fin erosion



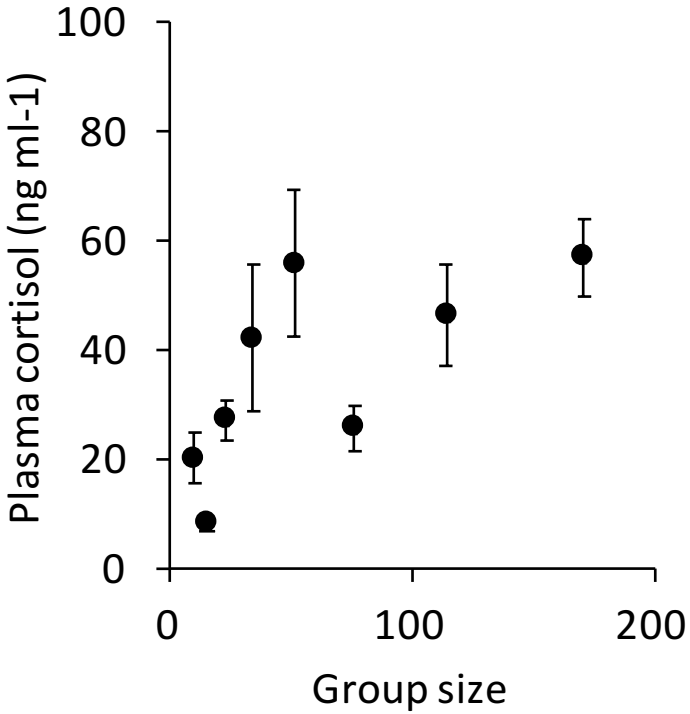

21 days
42 days
28 days
Pre-smolts
Smolts
Post-smolts
Dorsal fin
Dorsal fin
Dorsal fin
Mean erosion (%)
Pectoral fin
Left
Right
Pectoral fins
Pectoral fins
Mean erosion (%)
Group size
Group size
Group size


21 days
42 days
28 days
Pre-smolts
Smolts
Post-smolts
Dorsal
Dorsal
Dorsal
% with >20% fin erosion
Group size
Pectoral
Pectoral
Pectoral
Left
Right
% with >20% fin erosion
Group size
Group size
Group size
0
20
40
60
80
0
50
100
150
200

Baseline plasma cortisol

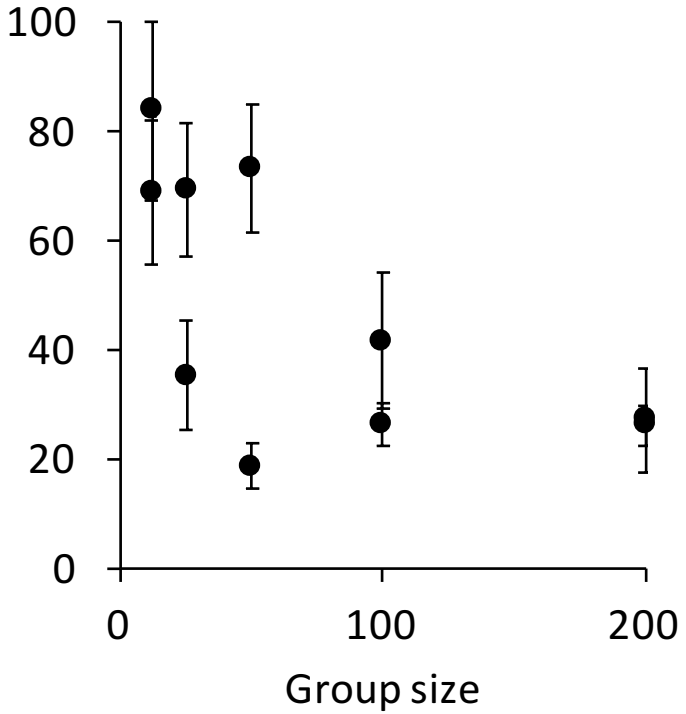
21 days

Pre-smolts



42 days

Smolts



28 days

Post-smolts

To be analyzed

Aggression

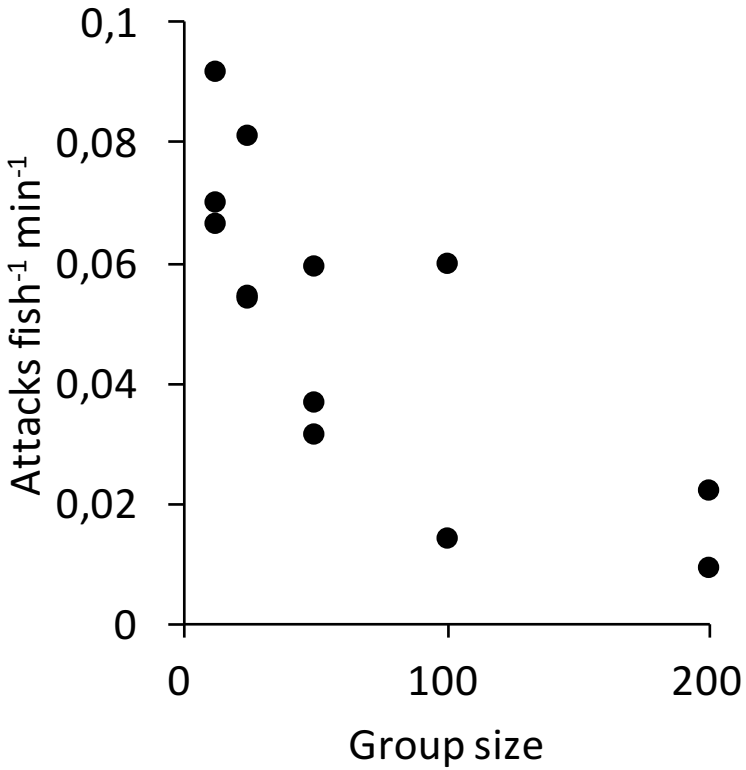
21 days

Pre-smolts

To be analyzed

42 days

Smolts



28 days

Post-smolts

To be analyzed

Summary Task 2.1.

- Scale loss decreased with group size
- Erosion of pectoral fins increase with group size (smolts and post-smolts)
- Baseline plasma cortisol increases with group size in pre-smolts, but decreases with group size in smolts
- Aggression level decreases with group size (in smolts)
- Generally less between-tank variation in the larger groups

Task 2.2
Effect of changing rearing unit volume on acclimation and behaviour of salmon pre-smolts.

- How long acclimation period is needed?
- Acclimation period before the experiment starts varies extensively between conductors, but the true acclimation status is seldom documented
- Too short acclimation periods may give false results, too long periods extend the total time of the experiment

Examples:

- Trout showed a cortisol acclimation time over one month (Pottinger & Pickering, 1992)
- Salmon post-smolt transferred to smaller tanks and group size showed a marked drop in daily food intake (>50%) followed by a steady increment towards normal levels over 6 weeks (Folkedal et al., unpublished)
- (and Task 2.1 suggests long acclimation periods)

- A rule of thumb amongst salmon farmers for the fish to thrive is to avoid transfer of fish to smaller group sizes or rearing units than their current ones
- The opposite is more or less standard in aquaculture research
  - Sufficient replicates and statistical power
- How does change in rearing unit size affect acclimation time?

Acclimation for 8 weeks

Planned to spring 2016

Original tank size (m)	Original volume (L)	New tank size (m)	New volume (L)	New group size
1	350	0.5	100	20
1	350	1	400	80
1	350	1.5	900	180

- Smaller tanks
- Similar tanks
- Larger tanks

Pre-smolts of ca 50 g

Stocking density 10 kg/m^3 in all tanks

Triplicates

Measures

- Appetite (feed collection 3 days/week)
- Water cortisol once per week
- Growth
- Welfare scores/fin erosion and scale loss
- Behaviour