

## Sammendrag

Hvert år rømmer oppdrettslaks fra kommersielle oppdrettsmerder i Norge. En betydelig og underestimert andel av disse er smolt som nylig har blitt overført til sjøvann og som klarer å svømme ut gjennom maskeåpningene i noten. Når disse lever fritt i havet, representerer de en potensiell genetisk og økologisk trussel overfor ville laksestammer. Tidligere er det gjennomført flere forsøk for å bestemme minimum smoltstørrelse for forskjellige nøter med ulik maskevidde. Disse forsøkene har omfattet fritt svømmende fisk, død fisk og modellering. Anbefalingene om hva den minste fiskestørrelsen er som ikke kan rømme gjennom en spesifikk maskestørrelse, har variert mellom forsøkene. Videre er det stor spredning i vekt, lengde og kondisjon i en kommersiell gruppe av laksesmolt som gjør det utfordrende å anbefale den best egnede noten for å unngå rømming.

## Summary

Every year farmed Atlantic salmon escape from commercial net pens in Norway. A significant and underestimated proportion are smolts that have been recently transferred to seawater and manage to swim through the mesh openings of the net. Once into the wild, these fish pose a potential genetical and ecological threat to wild salmon populations. Previously, several experiments have been done to determine the minimum smolt size for different size netting that included free swimming fish, dead fish and modelling. However, the results and recommendations what the smallest fish size is that cannot escape through a specific mesh size of netting have varied between experiments. Furthermore, there is a large spread in weight, length and condition in a commercial batch of Atlantic salmon smolts that makes it challenging to recommend the best suited netting in order to avoid escapees.

## Innledning

I Norge foregår laksens vekstfase i saltvann mest typisk i åpne merder i fjordene, der hver merd består av en innfestet not. De åpne nøtene sikrer god vanngjennomstrømning, men representerer også den eneste barrieren for fisken mot utsiden. Storskala lakseoppdrett i Norge medfører at mange fisk rømmer ut i naturen. Det er rapportert at det har rømt gjennomsnittlig over 287.000 laks årlig gjennom de siste 20 år, bare i Norge (Fiskeridirektoratet, 2016, 2022). Det sanne antallet rømt laks er antatt å være enda høyere (Fiske et al., 2006; Skilbrei et al., 2015) på grunn av uoppdagede og/eller urapporterte rømmingshendelser (Lund, 1998; Baarøy et al., 2004) og det er foreslått at kun hver fjerde eller femte rømte fisk blir rapportert som rømt (Sægrov and Urdal, 2006). Årsakene til rømminger fra merdene er ulike, slike som hull i nøtene, håndtering og behandlinger av fisken eller skader på merdstrukturen etter ekstreme miljøhendelser (Jensen et al., 2010). Uoppdagede rømmingshendelser kan forekomme når mindre eller tynnere fisk klarer å rømme gjennom maskeåpningene i merdnoten, enten som nylig utsatt smolt eller etter at noten er skiftet til en type med større maskeåpninger, da fisken har vokst. Når dette forekommer i liten skala, kan det skje at disse fiskene feilaktig registreres som døde eller som tellefeil under innhøsting. Overlevelsen er lav hos rømt oppdrettslaks, selv om overlevelsen hos smolt og postsmolt kan være høyere sammenlignet med voksen fisk (Skilbrei et al., 2015) og medføre en større genetisk trussel overfor ville populasjoner i sine seinere livsstadier (Skilbrei et al., 2010). Derfor må oppdretteren, ifølge Norsk Lov («Forskrift om drift av akvakulturanlegg, § 37. Plikt til å forebygge og begrense rømming, avsnitt 4: *"Maskeåpning i notpose skal være tilpasset fiskens størrelse, slik at fisken ikke kan slippe gjennom notposen. Nøter skal kontrolleres før de tas i bruk, og regelmessig under driften."*), sørge for at maskestørrelsen er mindre enn minimum smoltstørrelse, slik at ingen fisk kan rømme gjennom merdnoten. Konsekvensene av fiskerømming er ikke bare økonomiske tap for oppdretteren, men representerer i enda større grad en økologisk og genetisk påvirkning på ville laksebestander, noe som er grundig studert (Glover et al., 2013, Karlsson et al., 2016; Glover et al., 2017). Selv det motsatte har vært rapportert, altså at små villaks postsmolt har gått inn i merden fra utsiden (Fjellidal et al., 2021). Nøtene som brukes i lakseoppdrett er karakterisert ved ulike definisjoner, slik som halvmaske eller stolpelengde (distansen mellom to knuter i strukket not, målt fra senter av hver knute), maskelengde (halvmaske ganger to), omfar (antall halvmasker som passer inn i en alen på 627,5 mm) eller maskeåpning, som ofte brukes tilknyttet fiskerømming. Maskeåpning beskriver den indre avstand av maskelengden, målt fra den indre enden av hver knute i en strukket not. Når smolt, avhengig av deres størrelse, innledningsvis blir satt ut i merder i sjøen i Norge, er det vanlig å bruke nøter med maskeåpning på enten 30 eller 50 mm (Moe et al., 2009).

## Introduction

In Norway, the seawater grow-out phase of salmon farming typically takes place in open sea cages, called net pens, in the fjord systems. The open net ensures good water flow, but also represents the only single barrier to the outside. The large scale of salmon farming in Norway is accompanied by many fish that escape into the wild. On average, over 287.000 salmon annually, have been reported as escaped in the last 20 years in Norway alone (Fiskeridirektoratet, 2016, 2022). However, the true number of escaped salmon is believed to be even higher (Fiske et al., 2006; Skilbrei et al., 2015) due to undetected and/or unreported escape events (Lund, 1998; Baarøy et al., 2004) and it is suggested that only every fourth or fifth fish is reported as escaped (Sægrov and Urdal, 2006). Reasons for escapements from net pens are diverse, such as holes in the net, handling and treatments, or damages to the cage structure after extreme environmental events (Jensen et al., 2010). Undetected escape events can occur when smaller or thinner fish, manage to escape the netting in the sea cages through the mesh openings (maskeåpning) either as newly stocked smolts or after the netting is replaced with wider meshes once the fish grow in size. When this occurs on a small scale, those fish are likely accounted for as mortality or counting errors at harvest. Survival of escaped farmed Atlantic salmon is low, although survival in smolts and post-smolts may be higher compared to adult fish (Skilbrei et al., 2015) and pose a bigger genetic threat to wild populations in their later life stages (Skilbrei, 2010). Therefore, and by Norwegian Law, «Forskrift om drift av akvakulturanlegg, § 37. Plikt til å forebygge og begrense rømming, avsnitt 4: "Maskeåpning i notpose skal være tilpasset fiskens størrelse, slik at fisken ikke kan slippe gjennom notposen. Nøter skal kontrolleres før de tas i bruk, og regelmessig under driften."), the farmer must ensure that the mesh size falls below the minimum smolt size, that no fish can escape through the cage netting. The consequences of escaping fish are not only monetary losses for the farmer, but even more so represent an ecological and genetic impact on wild Atlantic salmon stocks which has been studied extensively (Glover et al., 2013, Karlsson et al., 2016; Glover et al., 2017). Even the opposite has been recorded, that small wild Atlantic salmon post-smolts have entered net pens in the sea (Fjelldal et al., 2021). The netting used in salmon aquaculture is defined in various terms, such as half mesh or bar length (stolpelengde) (distance between two knots of stretched netting, measured from the center of each knot), mesh length (maskelengde) (half mesh times two), "omfar" (number of half meshes that fit into an alen of 627,5mm) or mesh opening (maskeåpning), which is often used when in relation to escaping fish. Mesh opening (maskeåpning) describes the inner distance of the mesh length, measured from the inner end of each knot at a stretched net. When smolts are initially stocked in sea cages in Norway, depending on their size, nets with a mesh opening (maskeåpning) of either 30 or 50 mm are commonly used (Moe et al., 2009).

## Previous studies

In the past, studies with practical examinations, experimental setups and modeling have been used to determine the minimum Atlantic salmon smolt size for different sizes of netting (Hansen, 2005, 2006, 2007; Harboe and Skulstad, 2013; Sistiaga et al., 2020). However, the approaches and age/stage of the fish used in each publication was partly different, and the outcome and recommendation what fish size could or could not escape a specific mesh size were therefore different as well.

Hansen (2005) had approximately 100 Atlantic salmon parr in the weight range between 12 and 50g and 12 and 80g in a net of 1.5 x 1.5 x 1.5m with a half mesh (stolpelengde) of either 15.5 (omfar 40) or 20mm (omfar 32) in 5m tanks on land for one week. While all fish but three, that got stuck in the netting, were able to swim through the net with a half mesh (stolpelengde) of 20.0mm, only fish smaller than 12cm and 20g were able to get through the net with a half mesh (stolpelengde) of 15.5mm. In a subsequent experiment with the same set up but netting with half meshes (stolpelengde) of 16.5 (omfar 38), 17.5 (omfar 36) and 18.5mm (omfar 34), Hansen (2006) used Atlantic salmon parr between 6 and 165g. After one week the largest escaped fish was 22.8, 35.0 and 37.2 for netting with a half mesh (stolpelengde) of 16.5, 17.5 and 18.5mm, respectively.

In a practical examination, Hansen (2007) manually pressed dead smolts in the size range of 25 to 120g through different mesh sizes and found that a smolt of 100g could not be pressed through a mesh opening (maskeåpning) of 45mm, while fish in the range between 70 and 90g did go through, although fish in the top of that weight range had lost all their scales in the process. Similarly, it was not possible to press smolts of 55g through a net with 18mm mesh opening (maskeåpning), while fish between 40 and 50g did go through, however, these fish had lost all their scales. Only fish below 35g went through the mesh openings (maskeåpning) without significant damages. The author presented a table (Table 1) for different netting and the associated minimum smolt size.

Table 1. Revised recommendations for minimum smolt size in nets with half meshes (stolpelengde) between 15.5 and 20.0mm. Table adapted from Hansen (2007).

Bar length (mm)	15.5	16.5	17.5	18.5	20.0
Omfar	40	38	36	34	32
Min. smolt size (g)	25.0	29.0	55.0	65.0	100

In another study, Harboe and Skulstad (2013) used different nets with a half mesh (stolpelengde) of 15.5 (30.7 mesh opening (maskeåpning)); 18 (38.5); 19.5 (40.7); 22.5 (45.7); 25.5 (49.2) and 29 (54.4) mm in experimental tanks on land. The net was arranged in a cube shape with an open roof and a

square metal frame on the bottom that was positioned in the center of the tank. The fish were stocked either inside the net or outside the net within the tank itself. To allow a wide spread of fish sizes (7 to 642g), shapes, and conditions, the authors used autumn (0+) and spring (1+) smolts of commercial (AquaGen) and wild (Etne elva) origin. The experiments were carried out in triplicates of each mesh size with 120 or 135 fish per tank and a duration of either 5 or 24 days under continuous light. Fish were not only classified as escaped (1) or retained within the net (2), but to point out fish welfare issues, also if the fish was stuck in the net (3) and fish with damages or marks from the net (4). The authors found that there was no statistical difference in fish size for the four different categories in experiments where the fish were released into the net frame, into the tank or experiments with longer duration (24 vs. 5 days). Video footage and daily observations also pointed out that the main escape happens within the first two days after stocking and that larger fish did not seem to even try to escape the netting unlike smaller fish.

To demonstrate the spread of fish size from a commercial smolt production company, Harboe and Skulstad (2013) also measured 0+ autumn (n = 282 of 33000; 0.87%) and 1+ spring smolts (n = 822 of 90000; 0.91%) that were delivered to the Institute of Marine Research, Research Station Matredal. The weight of the measured autumn smolts had an average weight of  $67.1 \pm 8.6$ g. The data was normally distributed with a weight range from some fish in the 40 to 45g bracket to the largest fish in the 86 to 90g bracket. Spring smolts were on average larger in size,  $87.1 \pm 23.7$ g, and the weight data was skewed towards larger fish. The smallest fish were in the size bracket of 40 to 50g while the largest fish was between 171 to 180g.

Table 2. Largest fish that escaped or got stuck in the net, largest fish with net damage, and recommended minimum smolt size at given mesh openings (maskeåpning) with regards to the risk of escaping fish and fish welfare. Table taken and adapted from Harboe and Skulstad (2013).

Mesh opening (maskeåpning) (mm)	30.7	38.5	40.7	45.7	49.2	54.4
Half mesh (stolpelengde) (mm)	15.5	18.0	19.5	22.5	25.5	29.0
Largest escaped fish or stuck in the net (g)	21	45	70	103	156	200
Largest fish with damages from the net (g)	59	102	99	180	200	268
Recommended minimum smolt size (g)	26	56	87	129	195	250

In a recent study, Sistiaga et al. (2020) combined a practical approach with modelling to identify the smallest smolt size that should not be able to escape different mesh openings (maskeåpning). The study is based on the assumption that the netting in sea cages changes shape, due to being exposed to currents, sea surface waves or operational processes such as delousing or net cleaning. Those factors can have an impact on the general shape (Lader et al., 2008) and state, (either stiff, semi-

slack or slack), of the netting and hence alter, i.e. increase, the recommended minimum fish size that can fit through the mesh of a specific net, as it has been demonstrated in fisheries (Herrmann et al., 2016). According to the authors, this fact has not been taken into consideration by previous studies such as Harboe and Skulstad (2013). The study used FISHSELECT (Herrmann et al., 2009; 2012) which is described as “a framework of methods, tools and software developed to determine if a fish can penetrate a certain mesh or defined shape” (Sistiaga et al., 2020) and has its origin in the fishing industry for net size selection (Sistiaga et al., 2011). In summary, the length and weight of 127 fish (approximately 25 to 235 g) was measured, additional two cross sections (CS1 behind the operculum, CS2 before the start of the dorsal fin) of each individual with a morphometer before putting the data into FISHSELECT. Different shape models were developed based on each cross section and the best fitting models for each section were selected. By including the total length, the software established a virtual population of 5000 smolt between 0 and 40 cm.

To evaluate the maximum degree of tissue compression of a smolt can undergo when squeezing through a mesh opening (maskeåpning), Sistiaga et al. (2020) carried out a “fall-through experiment” (Tokaç et al., 2016). They tested whether or not each fish could, only by the force of gravity, pass through a wide selection (478) of different shapes that were cut into a solid 5 mm nylon-plate and represent stiff, open shapes between 20 and 245mm. The results were subsequently included into FISHSELECT where they serve the purpose to simulate the compressibility for each individual at CS1 and CS2, respectively. The data showed that the ventral compressibility, especially for CS2, was much higher, which was adjusted for in the model. Several individual models for each cross section and in combination were used, and with the FISHSELECT software the results of the different models were finally compared to the practical fall-through experiment. The outcome was a degree of agreement, that represents the percentage fraction where the model and the fall-through experiment came to the same result. Separately the “mesh openness” for a square mesh was modelled with the assumption that the horizontal mesh bars lose tension in, for example, situations with strong currents and that the square mesh can take a hexagonal shape and become semi-slack (Figure 1). The overall model calculated a smolt size that had a 99 % retention probability to stay within the net. The authors present data showing the necessary increase in recommended minimum smolt size when the netting is semi slack. The largest mesh openness is between 75 and 85% for 30 mm and 50mm square meshes.

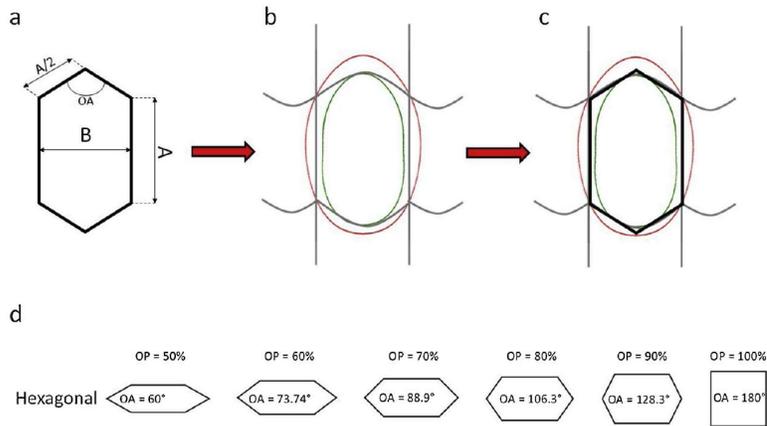


Figure 1. Approximation of a square mesh shape (maskeform) turning into a hexagonal shape (a-c) and different examples of hexagonal shape openness (åpenhet av maske) (%) depending on the opening angle (d). Figure taken from Sistiaga et al. (2020).

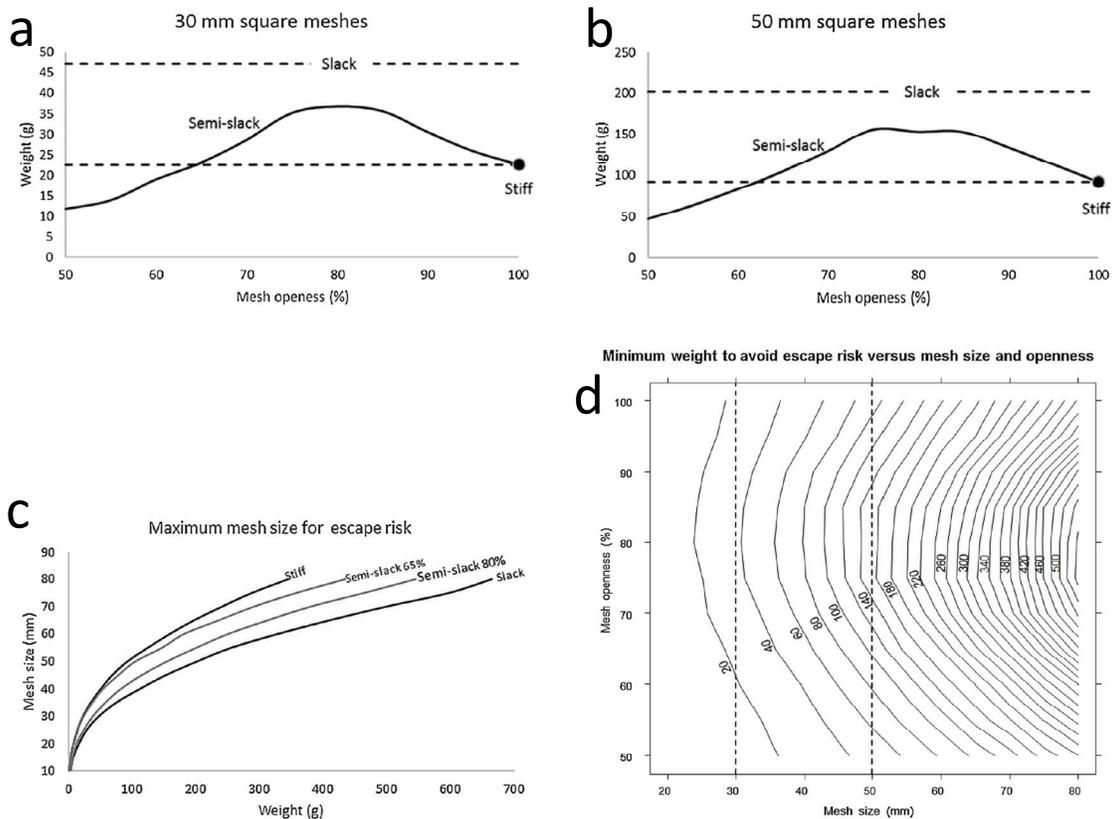


Figure 2. Correlation between fish weight, mesh openness and net shape with regards to the escape risk of salmon smolts for (a) 30 mm and (b) 50 mm square meshes and maximum mesh size for escape risk in a square mesh with regards to the mesh shape (c). Isolines showing minimum smolt size with escape risk <1 % for square meshes with regards to mesh size and mesh openness (åpenhet av maske). Figure taken from Sistiaga et al. (2020).

## Discussion

Due to recent escape events on a larger scale where Atlantic salmon smolts managed to pass through the sea cage netting shortly after seawater transfer and possible unknown and hence unreported escapees in that same situation, it is of major importance to identify the minimum smolt size that cannot escape through a specific netting. Moreover, smolts that barely manage to squeeze through the mesh opening are likely to suffer from significant scale loss, while others get completely stuck in the net and suffer marks, wounds or under commercial settings most likely suffer mortality. Both, Hansen (2005, 2007) and Harboe and Skulstad (2013) have noted that fish either got stuck in the netting or had marks/ wounds which poses a significant welfare problem, particularly when increasing the fish numbers of approximately three orders of magnitude such under commercial conditions.

In the past, different approaches have been chosen when determining the minimum smolt size that cannot escape through a specific netting. These have been described in more detail above, but briefly: Hansen (2005, 2006) and Harboe and Skulstad (2013) chose an experimental setting with free swimming fish, Hansen (2007) also manually pressed salmon through different mesh openings (maskeåpning) and Sistiaga et al. (2020) only used the force of gravity to determine whether a smolt can compress through a specific opening. It is possible that the maximal tissue compression by manual force used by Hansen (2007) may have been too much compared to what is in a smolt's capability or compressibility, while only the force of gravity in the fall through experiment by Sistiaga et al. (2020) may have been too little. This is supported by a revision and larger minimum smolt sizes compared to a previous version with free swimming fish (Hansen, 2007).

Sistiaga et al. (2020) put their main emphasis on the fact that larger smolt can escape through the mesh openings under slack and semi slack net shape conditions, compared to stiff ones. Frequently they note that previous studies on this topic, i.e. Harboe and Skulstad (2013) have not taken this fact into account and only used stiff net shapes. However, they write *"In a square mesh net panel hanging at sea, the load in the netting is on the vertical bars due to gravity, meaning that the horizontal bars are to a certain extent tensionless, and therefore deformable. This leads to a situation with semi-slack meshes where smolt could potentially deform the horizontal bars in the meshes in the process of squeezing itself through and finally escaping"*, and thereby give an actual description of the experimental setup of Harboe and Skulstad (2013). Already the title picture of the report shows that the netting is not completely stiff but offers a certain degree of mesh openness (åpenhet av maske), particularly by the horizontal bars that Sistiaga et al. (2020) describe in their publication.

The process of smoltification is undoubtedly one of the main physiological challenges in the life cycle of Atlantic salmon. In aquaculture, the fish are additionally challenged with the transport from the freshwater production site to the sea cages and subsequently the sudden change of environment and salinity increase. Therefore, it is not uncommon that a certain part of the population will lose weight, and hence condition, in the first few weeks after seawater transfer. One can think that there is an increased risk of smolts escaping through the mesh openings (maskeåpning) after that period of weight loss. This assumption seems false as Harboe and Skulstad (2013) did not note an increase of escapees in their long-term experiment (24 days) after fish had lost condition. Moreover, they observed that the main escape happens in the first few days after stocking and there was no difference in experimental length (5 vs. 24 days) with regards to which fish can escape. The authors support this claim as smolts may reduce weight and condition, but the girth of the skull will stay the same. Also, Sistiaga et al. (2020), who modelled the number of penetrations for two cross sections, based on a fall-through experiment, counted a higher number of penetrations for cross section 2 (at the start of the dorsal fin) than cross section 1 (behind the operculum) that is in line with higher compressibility at the second cross section.

In order to use a large variety of different fish shapes and sizes, Harboe and Skulstad (2013) used autumn and spring smolts of commercial origin and additionally smolts from a wild strain ( $n = 6168$ ), while Sistiaga had a sample size of  $n = 127$  consisting of smolts and post-smolts of the same strain which were used to establish a virtual population of 5000 individuals. With such a small sample size for the model it is possible underestimate for the smaller weight spectrum of a population or fish with a low condition factor. An attempt to verify this claim by comparing the mean condition factors of the fish in Sistiaga et al. (2020) to fish in the same weight class from the Matre Research Station failed, as the authors have measured total length instead of the commonly used fork length. Hansen (2005, 2006) on the other hand used Atlantic salmon parr in his experiments and notes that parr generally have a higher condition factor compared to underyearling and yearling smolts.

The difficulty when choosing netting for the minimum smolt size is the fact that the true minimum smolt size is likely unknown, even by the smolt producer. Harboe and Skulstad (2013) have measured smolts that were out for delivery to seawater and noted a wide spread of different sizes, although these fish constituted not even 1% of the population. It is highly possible that in the delivery (the remaining >99%) there were several other fish that were even smaller than the minimum smolt size that was measured by the authors. It should be the duty of the smolt producers to certainly know what the minimum smolt size of a delivery is. However, even when the smallest fish is identified, the variation of length, weight and accordingly the condition factor in a commercial production of smolts can still be very large. A selection of different salmon sizes from previous

studies carried out at the Matre Research Station (Appendix, Table 1 and 2) shows that there is a significant spread of fish length (fork length) within narrow weight classes and vice versa for a sample size of 6645 and 6728, respectively. For example, between 60 and 120g (12 weight classes, n = 2683), the difference between minimum and maximum in length ranged between 13.6% and 24.4% and between 31.9% and 51.4% for the condition factor. Similarly, in 14 length classes (17 - <24cm, n = 4542) the difference between minimum and maximum fish weight and condition ranged from 35.0 to 54.0% and 34.2% to 53.3%, respectively.

The large spread of different smolt sizes and shapes also becomes apparent when using different genotypes and smolt production regimes. Fjellidal et al. (2009) reared Atlantic salmon of wild (W), farmed (F) and hybrid (H) origin as either 0+ autumn/ off season or 1+ spring smolts. Before seawater transfer in January (0+) and May (1+), the fish were weighed and measured (Table 3). Overall, in freshwater, farmed fish grew faster than hybrids and wilds, and underyearling smolts faster than yearling smolts. However, in farmed salmon for example, there is a large size difference between the smallest and largest individual, making up 65% (35 vs. 102g) and 61% (44 vs. 112g) in underyearlings and yearlings, respectively, and 43% and 48% difference in condition factor.

Table 3. Means, minimums, and maximums of length (L), weight (W) and condition (K) for farmed (F), hybrid (H) and wild (W) autumn (0+) and spring (1+) smolts shortly before seawater transfer. Data from Fjellidal et al. (2009).

Group	n	L			W			K		
		mean	min	max	mean	min	max	mean	min	max
F0+	86	17.1	15.1	20.0	65	35	102	1.28	0.81	1.42
H0+	79	15.2	13.1	17.2	44	29	61	1.25	1.00	1.37
W0+	65	13.7	11.9	15.4	31	18	43	1.19	1.07	1.40
F1+	96	18.8	16.0	21.0	78	44	112	1.16	0.67	1.30
H1+	70	16.8	14.5	18.5	53	34	73	1.09	0.93	1.25
W1+	55	15.2	13.3	17.0	37	23	53	1.05	0.89	1.28

This enormous spread of different fish shapes either within certain weight (Appendix, Table 1) or length classes (Appendix, Table 2) and populations (Table 3) of relatively small sample sizes when in comparison to what is stocked in a single net pen, underpins the difficulty of finding the minimal smolt size that cannot escape from a given mesh size.

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## Appendix

Table 1. Minimum (min), maximum (max) and percent difference (diff) between the two for length (L) and condition (K) of different weight classes of salmon used at the Matre research station either in the late freshwater or the early seawater stage.

Vekt (g)	n (6645)	L-min	L-max	L-diff%	K-min	K-max	K-diff%
20 - <25	27	11.2	14	20.0	0.84	1.57	46.5
25 - <30	19	12.3	13.6	9.6	1.07	1.50	28.7
30 - <35	30	12.8	14.8	13.5	0.96	1.50	36.3
35 - <40	49	13.4	15.8	15.2	0.90	1.58	42.7
40 - <45	87	14.2	17.4	18.4	0.84	1.50	44.4
45 - <50	133	15	17.5	14.3	0.91	1.36	33.1
50 - <55	228	14.6	18.1	19.3	0.86	1.67	48.5
55 - <60	275	15.5	18.6	16.7	0.90	1.53	41.1
60 - <65	298	15.9	18.9	15.9	0.92	1.59	42.4
65 - <70	270	16.1	19.5	17.4	0.89	1.58	43.7
70 - <75	287	17.1	19.8	13.6	0.95	1.40	31.9
75 - <80	239	17	22.5	24.4	0.93	1.59	41.4
80 - <85	260	17.3	22	21.4	0.79	1.62	51.4
85 - <90	205	18.3	21.3	14.1	0.89	1.45	38.7
90 - <95	208	18.5	23.5	21.3	0.71	1.42	50.1
95 - <100	177	18.5	22.3	17.0	0.88	1.56	43.5
100 - <105	201	19.4	23.5	17.4	0.77	1.39	44.5
105 - <110	178	19.5	23.4	16.7	0.84	1.46	42.1
110 - <115	198	19.7	23.1	14.7	0.90	1.44	37.3
115 - <120	162	20.2	23.5	14.0	0.89	1.42	37.6
120 - <125	243	20.5	26.6	22.9	0.71	1.42	50.2
125 - <130	188	21	25	16.0	0.82	1.39	41.2
130 - <135	279	21.4	27.8	23.0	0.85	1.35	36.9
135 - <140	220	20.5	25.5	19.6	0.83	1.60	48.0
140 - <145	282	21.2	24.6	13.8	0.96	1.49	35.5
145 - <150	210	21.3	26	18.1	0.84	1.51	44.3
150 - <155	224	21.6	25	13.6	0.97	1.51	35.5
155 - <160	196	21.4	25.3	15.4	0.96	1.60	40.3
160 - <165	185	22.5	25.5	11.8	0.98	1.42	31.3
165 - <170	180	22.3	25.7	13.2	0.97	1.49	34.7
170 - <175	147	23	26	11.5	0.97	1.40	30.8
175 - <180	117	23	25.8	10.9	1.03	1.45	29.1
180 - <185	111	23.2	26.5	12.5	0.98	1.47	32.9
185 - <190	66	23.6	26.5	10.9	1.00	1.43	30.1
190 - <195	62	23.9	27	11.5	0.98	1.41	30.6
195 - <200	54	23.5	27	13.0	1.01	1.52	33.7
200 - <205	55	23.9	26.8	10.8	1.04	1.47	28.9
205 - <201	25	24.3	27.9	12.9	0.95	1.44	33.6
210 - <215	27	24	27	11.1	1.07	1.55	31.1
215 - <220	26	24.5	27.3	10.3	1.06	1.48	28.1
220 - <225	17	24.6	28.5	13.7	0.96	1.48	35.1
225 - <230	19	24.7	27.8	11.2	1.07	1.51	29.6
230 - <235	22	25	28.2	11.3	1.03	1.48	30.0
235 - <240	8	25	26.6	6.0	1.25	1.53	18.0
240 - <245	11	24.7	28.2	12.4	1.08	1.61	32.8
245 - <250	11	25.9	30.2	14.2	0.90	1.41	36.1
250 - <255	10	26.1	29	10.0	1.03	1.42	27.7
255 - <260	15	25	28	10.7	1.17	1.65	29.4
260 - <265	10	26.2	28.5	8.1	1.14	1.45	21.1
265 - <270	7	25.8	27.4	5.8	1.30	1.56	16.5
270 - <275	16	26.5	29	8.6	1.11	1.45	23.7
275 - <280	13	27.2	30.5	10.8	0.97	1.37	28.8
280 - <285	15	26.5	30	11.7	1.05	1.50	30.1

285 - <290	13	27.4	30	8.7	1.07	1.40	23.8
290 - <295	14	27.1	32	15.3	0.89	1.46	39.1
295 - <300	16	27.1	31.5	14.0	0.96	1.49	35.5

Table 2. Minimum (min), maximum (max) and percent difference (diff) between the two for weight (W) and condition (K) of different weight classes of salmon used at the Matre research station either in the late freshwater or the early seawater stage.

Length (cm)	n (6728)	V-min	V-max	V-diff%	K-min	K-max	K-diff%
10 - < 10.5	5	12	16	25.0	1.16	1.60	27.2
10.5 - < 11	6	14	18	22.2	1.18	1.39	15.4
11 - < 11.5	8	16	22	27.3	1.14	1.57	27.3
11.5 - < 12	14	18	24	25.0	1.07	1.50	28.7
12 - < 12.5	9	21	28	25.0	1.18	1.50	21.4
12.5 - < 13	16	19	30	36.7	0.93	1.43	35.0
13 - < 13.5	19	20	38	47.4	0.89	1.58	43.7
13.5 - < 14	7	27	34	20.6	1.07	1.38	22.3
14 - < 14.5	26	23	43	46.5	0.84	1.50	44.2
14.5 - < 15	25	31	52	40.4	0.96	1.67	42.8
15 - < 15.5	51	35	54	35.2	1.00	1.54	35.2
15.5 - < 16	93	35	64	45.3	0.90	1.59	43.2
16 - < 16.5	190	40	66	39.4	0.92	1.58	41.6
16.5 - < 17	219	41	67	38.8	0.90	1.42	37.1
17 - < 17.5	373	44	84	47.6	0.84	1.62	48.5
17.5 - < 18	315	49	82	40.2	0.91	1.45	36.9
18 - < 18.5	375	51	89	42.7	0.86	1.45	40.8
18.5 - < 19	299	58	99	41.4	0.90	1.56	42.4
19 - < 19.5	305	65	100	35.0	0.92	1.41	34.7
19.5 - < 20	245	66	112	41.1	0.89	1.46	38.9
20 - < 20.5	230	76	117	35.0	0.93	1.42	34.2
20.5 - < 21	180	82	138	40.6	0.95	1.60	40.6
21 - < 21.5	232	82	157	47.8	0.86	1.60	46.3
21.5 - < 22	238	96	152	36.8	0.91	1.51	39.4
22 - < 22.5	443	84	165	49.1	0.79	1.49	47.0
22.5 - < 23	347	100	168	40.5	0.88	1.46	39.7
23 - < 23.5	562	92	184	50.0	0.76	1.47	48.4
23.5 - < 24	398	92	200	54.0	0.71	1.52	53.3
24 - < 24.5	481	132	214	38.3	0.95	1.55	38.6
24.5 - < 25	275	131	242	45.9	0.89	1.61	44.5
25 - < 25.5	250	128	258	50.4	0.82	1.65	50.4
25.5 - < 26	139	138	268	48.5	0.83	1.56	46.7
26 - < 26.5	108	124	266	53.4	0.71	1.50	52.8
26.5 - < 27	55	183	280	34.6	0.98	1.50	34.6
27 - < 27.5	40	192	296	35.1	0.98	1.49	34.4
27.5 - < 28	33	207	323	35.9	0.95	1.49	35.9
28 - < 28.5	41	232	348	33.3	1.03	1.52	31.9
28.5 - < 29	32	222	367	39.5	0.96	1.54	37.6
29 - < 29.5	27	250	373	33.0	1.03	1.52	32.4
29.5 - < 30	17	286	397	28.0	1.10	1.50	26.5