Kolarctic ENPI CBC - Kolarctic salmon project (KO197) - Report I

Results from the coastal and fjord salmon fishery in 2011 in Nordland, Troms and Finnmark: timing of the salmon catches, wild and escaped salmon, sea- and freshwater ages, sex distributions and other biological parameters

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Kolarctic ENPI CBC | CROSS-BORDER COOPERATION

KOLARCTIC SALMON 2011 - 2013

Contents

Photo nr 60 – unknown photographer

All other photos Eero Niemelä

All figures: FGFRI – Finnish Game and Fisheries Research Institute

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Abstract

General migratory pattern with the ecology of salmon was studied in the last phase of the marine life for wild and escaped salmon in Northern Norway within Kolarctic salmon ENPI EU KO197 project. Huge coastal area in Northern Norway from Lofoten in Nordland County over Troms County to the easternmost Finnmark County in the border area between Norway and Russia was covered by 39 professional salmon fishermen fishing salmon from early May to early September. These fishermen collected information from each individual salmon in their catches and they took scale samples from salmon for genetic, age- and growth analysis and for wild salmon or escaped salmon detection. Scales from salmon are used for genetic analysing methods in determining river of origin for all wild salmon. Based on the timing of salmon belonging to 1SW (one sea-winter) 2SW, 3SW, 4SW, previous spawners and escaped salmon in the catches one can determine the time of the migration periods for salmon in outermost coastal areas as well as in fjords. In this study we covered the entire migration period of salmon from the beginning of May to the end of August-early September, which period has been historically the salmon fishing time. Professional fishermen served their help to obtain all the material collected from salmon with ordinary fishing methods like bag nets and bend nets. There are some hundreds of salmon rivers in this Kolarctic salmon project area (Nordland, Troms, Finnmark in Norway; tributaries for the River Tana and upper areas of the River Neiden in Finland; Kola, Archangelsk, Karelia, Komi in Russia) with their genetic different stocks. Therefore the sampling of salmon was decided to cover spatially and temporally from May to September to cover the migration periods of all the stocks. Especial attention was put to select fishermen on the areas where there catches are the highest.

Introduction

Atlantic salmon has a high socio-economic value in northern Barents Sea areas both through commercial and subsistent coastal fisheries and recreational fisheries in rivers. The fisheries in these areas represent a significant cultural heritage from indigenous people employing traditional knowledge and old harvesting methods. Presently, the salmon stocks in the Barents Sea area are highly important, as stocks elsewhere on both sides of the Atlantic have declined greatly in the last 50 years while the Barents Sea stocks still retain a high level of production.

Salmon have a complicated life cycle, spending their first years as juveniles in rivers, and then migrating out into the open sea to feed and grow large for one up to five years before returning to their home river to spawn. After spawning some salmon succeed to survive and migrate as kelts (post spawners) to sea for recondition and then after one to three years they are migrating along the coast back to their river of origin as previous spawners. Within the huge Kolarctic project area, from Nordland in Norway to Petchora in Russia, there are almost 250-300 genetically different salmon stocks out of which alone in the River Tana with its tributaries there is c. 35-40 stocks. During their return migration salmon are exploited in coastal and river fisheries. These rivers in northernmost Norway, Finland and Russia support the world's largest wild Atlantic salmon stocks and resources.

Sea water migration is the key element in the life history of the Atlantic salmon. Salmon from Kolarctic project area is known from earlier tagging results to migrate widely to its growing areas in Barents Sea, Faroese fishing areas in Northern Norwegian Sea and as far as South-East Greenland. After reaching maturity at sea they are returning to their natal river to reproduce. Because of their well-known characteristic to home to their natal river, salmon inhabiting different rivers are reproductively isolated from each other and, therefore, the populations are significantly different with regards to genetics, morphology and behaviour. Behaviour here means the time in early summer, summer, early autumn or even late autumn to migrate from their feeding grounds in high sea waters to coastal areas and finally to ascend into their river of origin. Returning salmon are exposed to diverse, intensive exploitation along their journey including coastal, fjord, estuarine and finally in-river fisheries.

The extensive salmon migrations, taking place mainly in June and July for summer run salmon and in August - October for autumn run salmon, between open sea and home rivers pose a major problem for fish managers regulating fisheries in different areas. While the river fisheries mainly exploit river-specific stocks, the coastal and fjord fisheries are exploiting a mixture of stocks from widely different areas, including fish from neighbouring countries. The coastal mixed-stock fishery can simultaneously exploit salmon from healthy and struggling stocks.

In the Kolarctic salmon project we are studying i. a. the time of migrations of some hundreds of salmon stocks along the Northern Norwegian coast and fjord as well as in some areas in the coast of North-West Russia White Sea area included. We are analysing for example the following things:

- the time when these genetically different stocks including all their sea-age groups of 1SW (one sea winter), 2SW, 3SW, 4SW and previous spawners are migrating through the Norwegian fishing areas in Nordland, Troms and Finnmark. This is the migratory pattern for the stocks and for all the different sea-age groups.

- how the fishery is exploiting these stocks in general and by which methods and where. This is the migratory model including exploitation rates and natural mortality estimates from the abundance estimate before they enter to the fishing areas (pre fishery abundance) and finally when they reach their river of origin and after the river exploitation making the spawning stocks.

- smolt ages, sex ratios, size of captured salmon, age distributions in different fishing methods are also studied in different areas

To succeed to produce the information mentioned above for developing and enhancing the management of the shared Atlantic salmon resource in the Barents region and enabling a future adaptive sustainable and knowledge-based harvesting regime, it was important to organize good and cost effective sampling in good cooperation with the professional salmon fishermen. The sampling was covering all the fisheries including both outermost coast and the fisheries in fjords. Spatial and temporal coverage was prerequisite for the successful study.

Material and methods

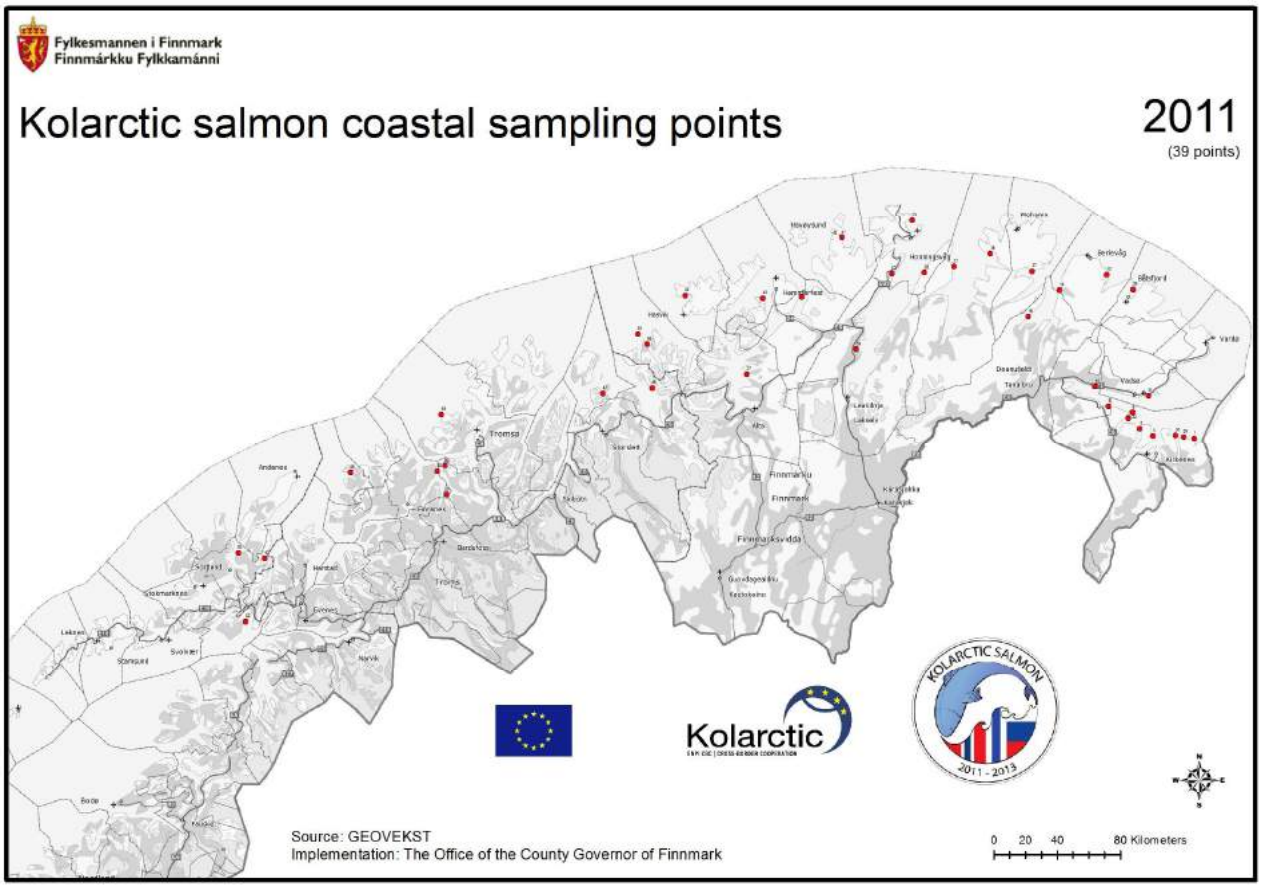


Figure 1. Sites (red points) in the salmon fishing at sea in Kolarctic area in Northern Norway in the year 2011. Sites are indicating the locations where sampling from the salmon catches took place from May to September. In Kolarctic area there were 39 salmon fishermen in 2011 who took samples from their catches; in Nordland 3, in Troms 7 and in Finnmark 29 fishermen, respectively.

In the Kolarctic salmon project we are studying the migratory pattern of salmon in the coastal and fjord areas of Northern Norway where the captured salmon have their origin from hundreds of rivers. Migratory pattern includes the work to clarify the timing of wild 1SW (one sea-winter salmon), 2SW, 3SW, 4SW salmon and previous spawned salmon in the catches as well as the timing of the escaped salmon in the catches. The aim was to have continuous sampling covering the entire period during that time when salmon is migrating along the coastal areas from early May to late September. To fulfil the goal of the Kolarctic salmon project and to have good documentation from the timing of different stocks in different areas and in different fisheries all the fishermen serving this project received special permission to catch salmon outside the official fishing season. Within this project in Nordland and in Troms counties fishermen had also possibility to use bend nets in addition or instead of using bag nets which are the only allowed fishing method today there. Especial attention was put to include fishermen from the outermost coastal areas, where the catch informs more precisely the timing of the migrations in general and especially for different stocks than the catches in fjords (Figure 1).

All the fishermen were advised to take careful measurements from all their salmon catches like lengths and weights and it was especially highlighted to take the scale samples from the recommended area of the fish.

Fishermen had to write information in the scale bags which were designed especially for this Kolarctic project. Scales were collected from the advised area of the fish to be sure on the correct ageing and growth measurements analysed and measured from the scales. Fishermen recognized also the origin (wild/escaped) of the salmon using external and internal features of salmon and in this work the manual with photos from wild and escaped salmon helped the recognition. The date of the capture, fishing method and sex of fish and numbers of salmon lice was also recorded into the scale bag. Fishermen sent the scale bags in envelopes in two weeks periods to County Governor in Finnmark or scales were collected when frequently visiting them.

The data written into the scale bags was transferred into data file and the first evaluation of the accuracy of the data took place by correcting the false or some lacking information. All scale bags had a new numbering corresponding to the number in the data file. At this phase also 5 scales were picked into a new numbered scale bag and they (only wild salmon) were sent for genetic analysis to the University of Turku. Scale impressions for age determination, growth measurements and for analysing the origin of salmon (wild/escaped) were done from all c. 8400 scales.

Photos 1-4. The skin of the fish must first wash out of extra mucus attracted from other fishes (photo 1. on the left above), scales are then taken with a clean knife just from the area between adipose fin and lateral line (photo 2. on the right above and photo 3. on the left below) and finally scales are transported into scale bag (photo 4. on the right below). The number of scales in each scale bag was 20-30.


Photo 5a and 5b. In May and in the summer and in the autumn fishermen had special permission to fish during periods when the salmon fishery was not generally allowed. Fishing and sampling was controlled in Finnmark by visiting 19 fishermen. In the photo 5 Harry Emil Severinsen, Honningsvåg is handing in scale bags for further processing.


Photos 6 and 7. Fishermen transported their salmon catches to their home or to their fishing cabin where they had facilities to take measurements and scale samples from salmon. Outdoors laboratory (photo 6. in the left) in Varangerfjord by John Georg Dikkanen, and another laboratory (photo 7 on the right) in Porsangerfjord, Repvåg by Josef Samuelsen. Josef Samuelsen is cleaning his salmon with water spray to avoid mucus contamination between fishes.

Almost all the scales in scale envelopes from all individual salmon had impressed figures in the plastic plates. After the scale impressions were available, ageing and discrimination between wild and escaped salmon took place. Work was done following the ICES scale reading working group's (2011) recommendations. Last work was the internal evaluation and correction of the basic scale data where we compared the ages of salmon to the informed lengths and weights.

Out of 39 fishermen who promised to have the sampling over the whole season 5 ceased the sampling after May or in June (Figure 3). The numbers of salmon caught in May to September was in total 8303 and separately in Nordland, Troms and Finnmark 275 (3%), 2411 (29%), and 5617 (68), respectively (Table I).

Photos 8-14. Kolarctic salmon scale processing

Photos 15-17. The best scale image from the plastic plate will first be selected (photo on the left), then it is stored as a digital image (photo in the middle). Two photos are taken from the same scale for each salmon, one photo from the juvenile period and one from the whole scale.

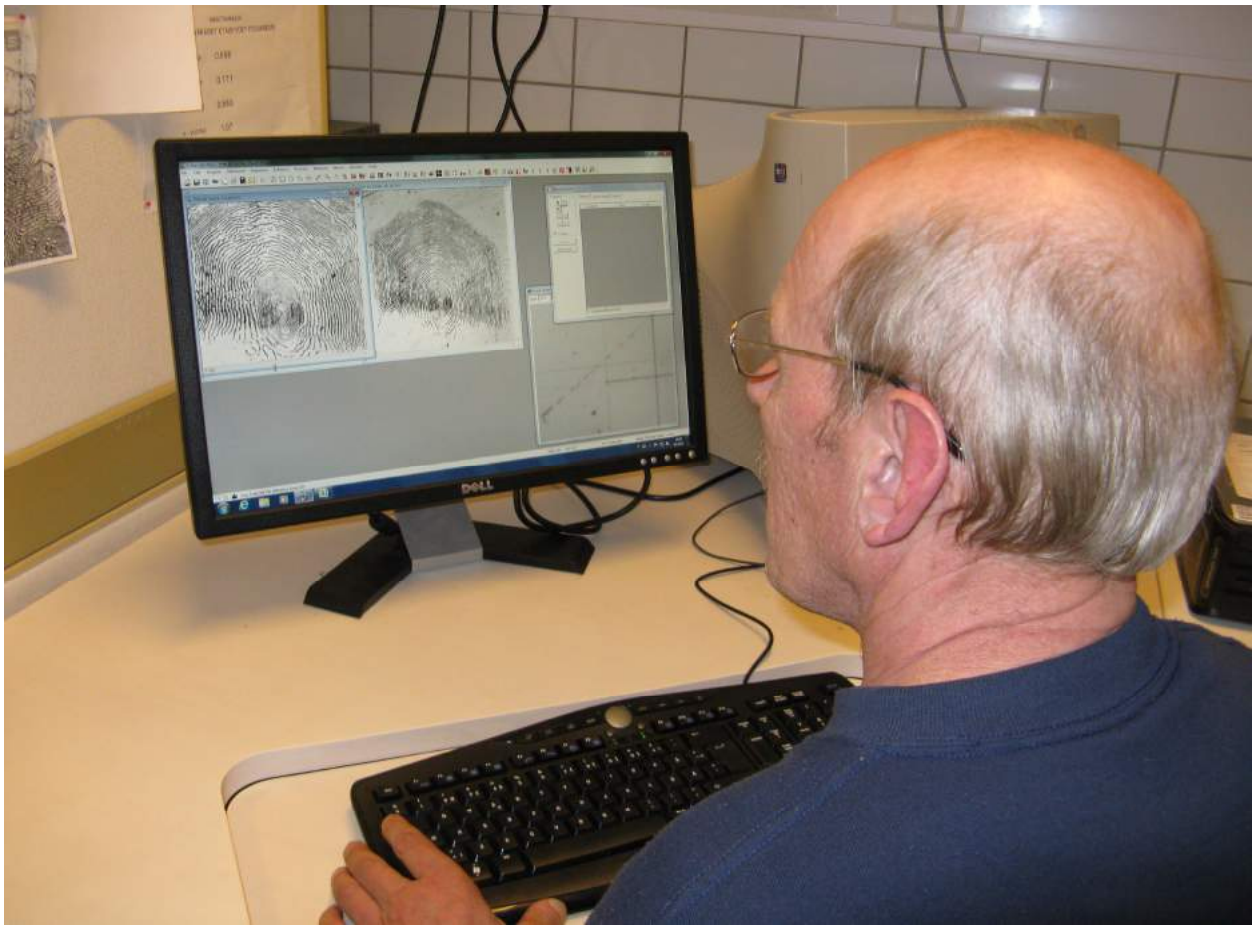
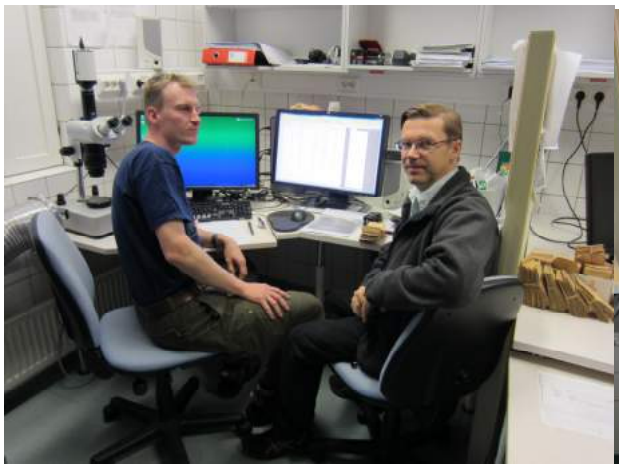
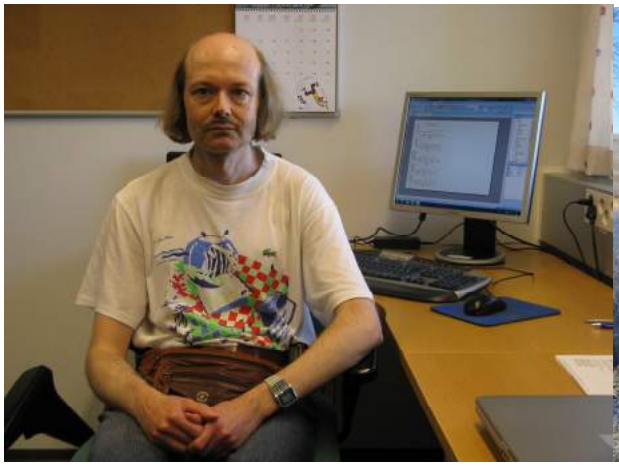


Photo 18. Scale analysis are done with the scale reading program, where distances from the scale centre (=focus) are measured to the end of each annual growth phase. After the genetic analysis of the fish also the numbers of growth rings are counted for a limited number of salmon in selected rivers. This scale analysis gives the most important data from the origin (wild or escaped salmon), sea-age distributions in the catches, smolt ages between rivers and sea ages, information if salmon is first time spawner or previous spawner and growth increments during the marine life. Scale analysis makes basis for stock identification for 1-4 sea winter salmon, modelling for migratory pattern and growth of salmon.






Photos 19-22. Jari Haantie (in the photo 19 on the left) and Jorma Kuusela (in the photo 19 on the right) carried the main responsibility from the last evaluation of the collected scale material. Jorma Kuusela is leading the work on the digital data analysis and storing the data from the scales. Pauli Aro (photo 20, on the right above) is controlling the scale data accuracy comparing lengths and weights to the age of salmon. Esa Hassinen (photo 21, below) is responsible for analysing the data from the adult salmon scales, environmental parameters, catch statistics and also participating in to write scientific articles. In the photo 22 the FGFRI Teno research station Kolarctic staff (from the left to right Jorma Kuusela, Jari Haantie, Satu Metsola, Eero Niemelä, Mari Lajunen, Pauli Aro, Sami Järvensivu).

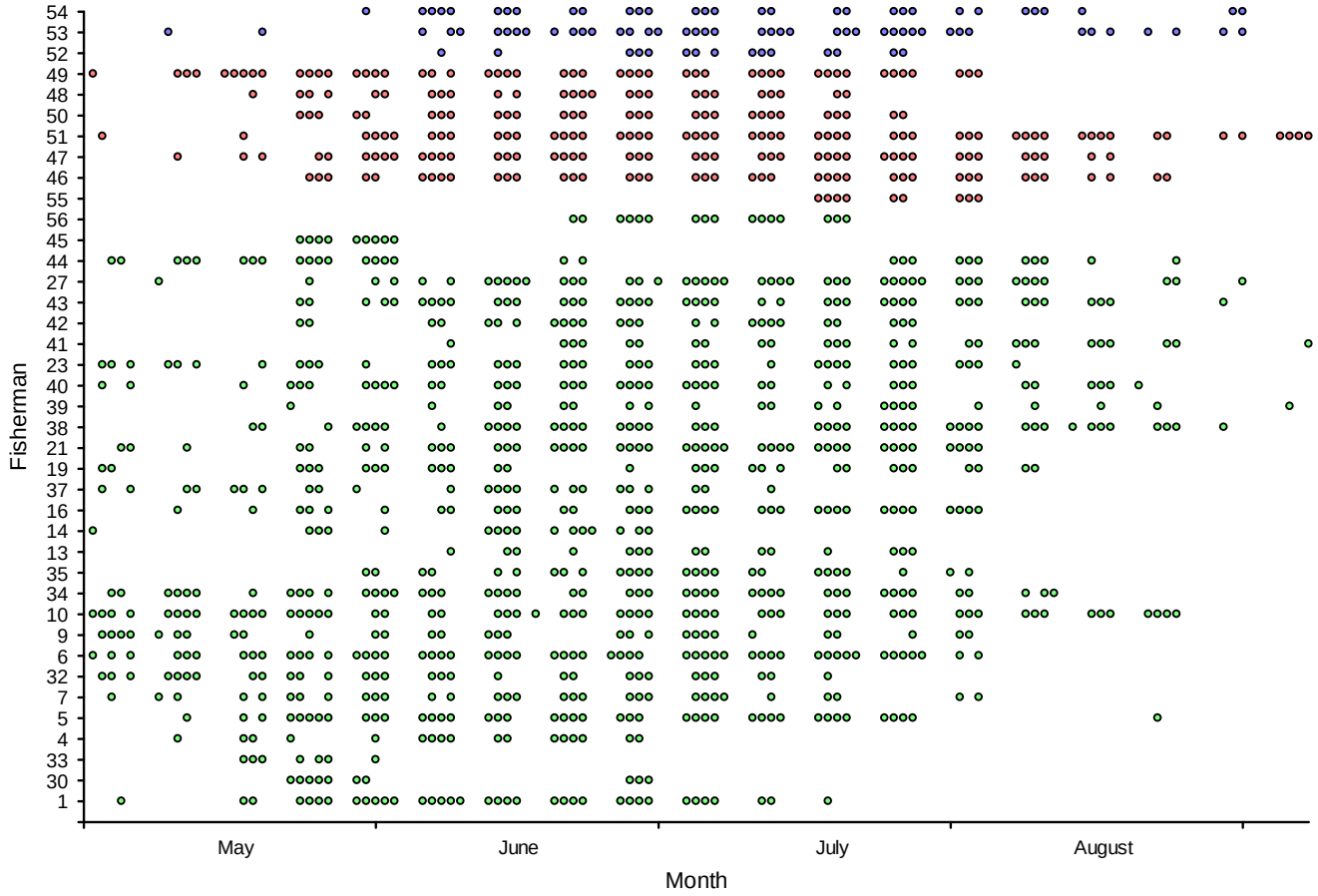


Figure 2. Dates when salmon catch occurred in the fishery between May and early September. The numbers of fishermen (y-axis) from the number 54 to the number 1 are from west (blue= Nordland), middle (red=Troms) to east (green=Finnmark) in 2011. Salmon fishing started with a special permission in the beginning of May instead of the ordinary start in the beginning of June in Finnmark or in the middle of July in Troms and Nordland.

Table I. Numbers of samples from the coastal and fjord salmon fishery in Kolarctic project in 2011 by county, by month and by salmon sea-age for 1SW (one-sea-winter), 2SW, 3SW, 4SW, previous spawner and escaped salmon. In parentheses the values are indicating the monthly percentage distributions for each sea ages. In the total column there are the numbers for each sea-age group of salmon and the percentages are indicating the proportion of each sea-age group in the total number of salmon caught in each county during the whole fishing time.

Sea-age	May	June	July	August	September	Total. total-%
Nordland						
1SW salmon		10. (33)	15. (50)	4. (17)		29. (11)
2SW salmon	2. (1)	76. (51)	61. (41)	10. (7)		149. (54)
3SW salmon	1. (8)	4. (33)	6. (59)			11. (4)
Previous spawning salmon	1. (25)	1. (25)	2. (50)			4. (1)
Kelt		2. (29)	5. (71)			7. (3)
Escaped salmon		14. (19)	44. (60)	15. (21)	2.()	75. (27)
Missing data from salmon				1		1. (<1)
Total salmon	**4. (1)**	**107. (39)**	**133. (48)**	**29. (11)**	**2.(1)**	**276**
Trout		*2*	*6*	*2*		*10*
Troms						
1SW salmon	1. (<1)	95. (13)	564. (76)	85. (11)	1. (<1)	746. (31)
2SW salmon	80. (11)	390. (53)	229. ()	31. (4)	5. (<1)	735. (31)
3SW salmon	29. (7)	226. (51)	161. (35)	33. (7)	2. (<1)	451. (19)
4SW salmon	2. (11)	11. (58)	6. (31)			19. (1)
Previous spawning salmon	9. (17)	29. (55)	14. (26)	1. (2)		53. (2)
Kelt	1. (3)	15. (48)	11. (35)	4.(14)		31. (1)
Escaped salmon	15. (4)	65. (18)	179. (49)	102. (28)	5. (1)	366. (15)
Missing data from ages		3. ()	7. ()			10. (<1)
Total salmon	**137. (6)**	**834. (35)**	**1171. (48)**	**256. (11)**	**13. (<1)**	**2411**
Trout		*7*	*1*	*1*		*9*
Finnmark						
1SW salmon		337. (17)	1444. (73)	191. (10)		1972. (35)
2SW salmon	423. (21)	912. (44)	608. (30)	103. (5)		2046. (37)
3SW salmon	200. (26)	293. (38)	243. (31)	40. (5)	1. (<1)	777. (14)
4SW salmon	2. (8)	17. (62)	7. (26)	2. (4)		28. (<1)
Previous spawning salmon	27. (27)	60. (60)	11. (11)	2. (2)		100. (2)
Kelt	5. (7)	40. (57)	24. (35)	1. (1)		70. (1)
Escaped salmon	61. (10)	136. (23)	267. (46)	118. (20)	3. (1)	585. (10)
Missing data from ages		18.	17.	4.		39. (<1)
Total salmon	**718. (13)**	**1813. (32)**	**2621. (47)**	**461. (8)**	**4. (<1)**	**5617**
Trout		*5*	*9*	*1*		*15*
Pacific salmon		*1*	*2*	*1*		*4*

Table II. Weights in kilos of samples from the coastal and fjord salmon fishery in Kolarctic project in 2011 by county, by month and by salmon sea-age for 1SW (one-sea-winter), 2SW, 3SW, 4SW, previous spawner and escaped salmon.

Sea-age	May	June	July	August	September	Total
Nordland						
1SW salmon		24	33	7		64
2SW salmon	6	262	234	35		537
3SW salmon	7	28	38			73
Previous spawning salmon						
Kelt		9	16			25
Escaped salmon		63	187	61	14	325
Missing data from salmon						
Total salmon	**13**	**386**	**508**	**103**	**14**	**1024**
Trout		*3*	*9*	*6*		*18*
Troms						
1SW salmon	2	212	1251	197	2	1664
2SW salmon	290	1680	1056	130	21	3177
3SW salmon	209	1819	1208	242	13	3491
4SW salmon	21	147	88			256
Previous spawning salmon	62	207	84	11		364
Kelt	3	85	61	17		166
Escaped salmon	66	345	859	566	22	1858
Missing data from ages		10	29			39
Total salmon	**653**	**4505**	**4636**	**1163**	**58**	**11668**
Trout		*19*	*1*	*2*		*22*
Finnmark						
1SW salmon		767	3291	414		4472
2SW salmon	1721	3903	2649	461		8734
3SW salmon	1546	2251	1923	293	6	6019
4SW salmon	34	229	107	19		389
Previous spawning salmon	142	367	106	18		633
Kelt	31	146	133	4		314
Escaped salmon	325	787	1394	603	10	3119
Missing data from ages		77	54	28		159
Total salmon	**3799**	**8527**	**9657**	**1840**	**16**	**23839**
Trout		*13*	*23*	*2*		*38*
Pacific salmon		*2*	*3*	*1*		*6*

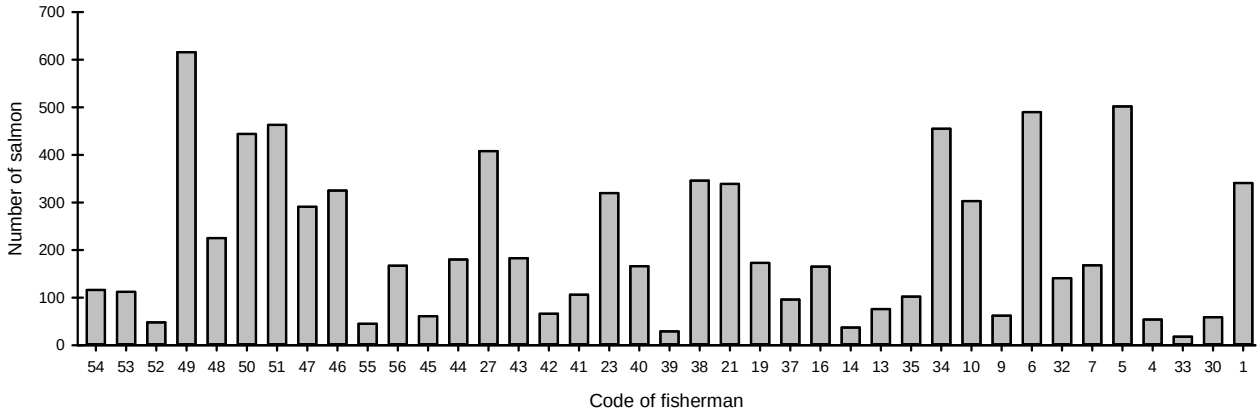


Figure 3. The numbers of Atlantic salmon scale samples for each fisherman from Nordland (from the left) to Finnmark (to the right).

Salmon catches can be seen as the total numbers of salmon (Figure 3) caught by each fishermen but to understand the huge diversity in the catches between areas and during the migration period it is best to analyse the material divided by sea-age groups (Figures 4 and 5).

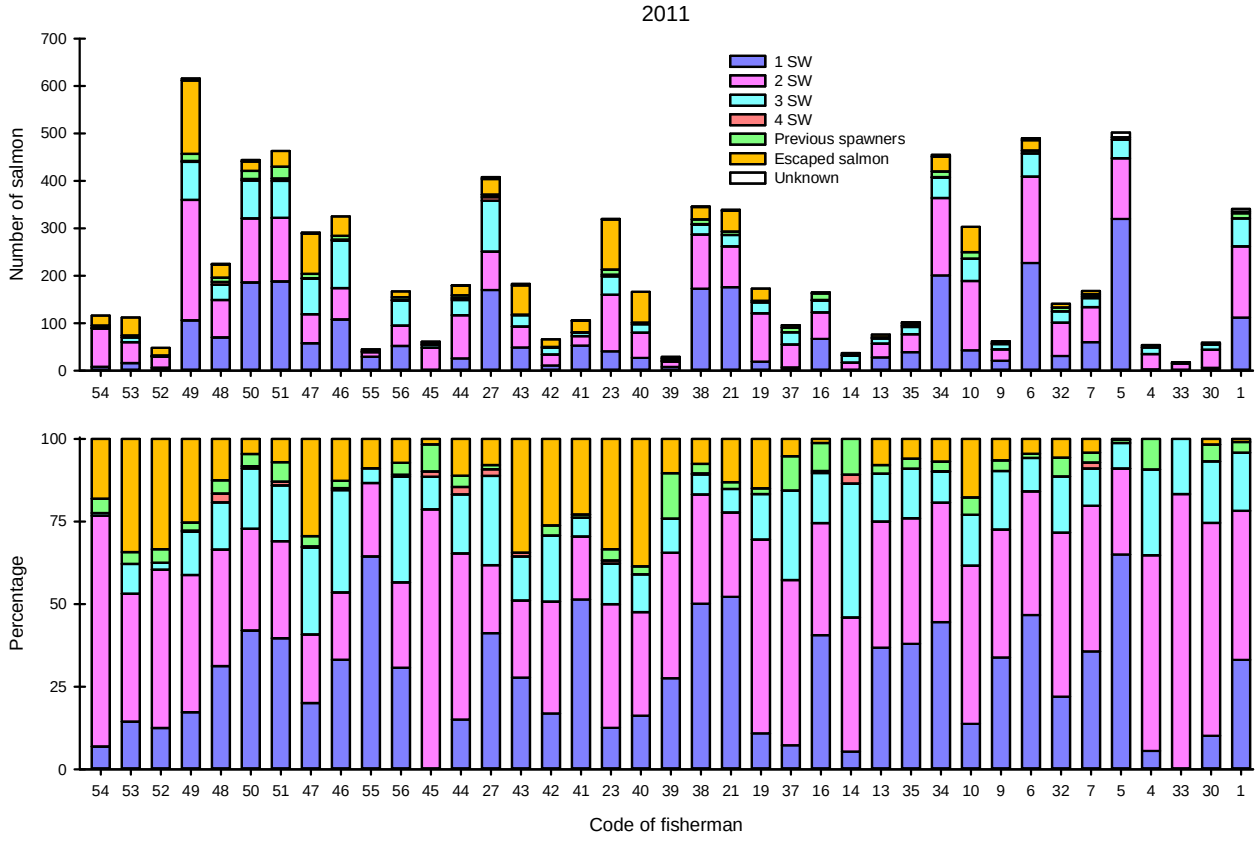


Figure 4. Numbers of salmon in the fishery and sea-age distributions and origin (wild/escaped) of salmon catches from the numbers of fish caught in Kolarctic area in Norway from May to September. The numbers of fishermen are from the Middle of Nordland (from the left) to Eastern Finnmark (to the right). See also the figure 1.

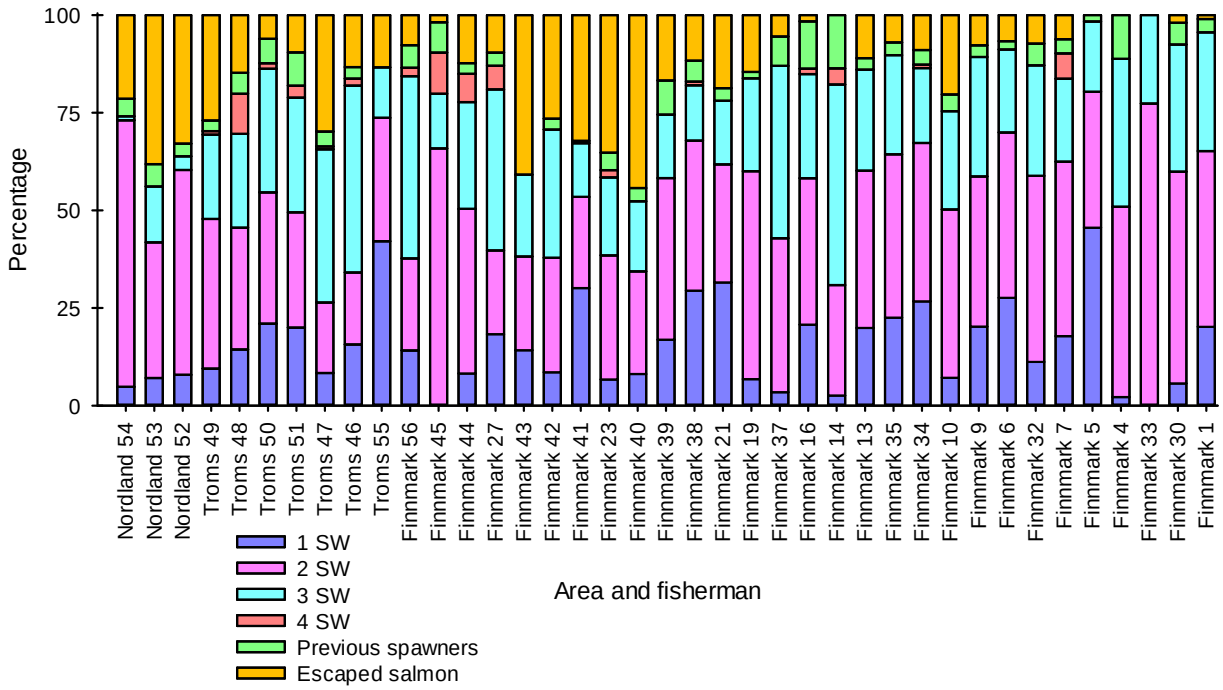


Figure 5. Sea-age distributions and origin (wild/escaped) of salmon catches from the weight of fish in Kolarctic area in Norway from May to September. The numbers of fishermen are from the Middle of Nordland (from the left) to Eastern Finnmark (to the right). See also the figure 1.

Most of the fishermen made good work taking careful samples from all their catches. Figures 4 and 5 are illustrating the sea-age distributions of salmon caught by each fisherman in term of numbers and in terms on weight. Some fishermen didn't have smallest salmon at all or only small amounts in their fishery because they ceased the fishery early in the season or they had large sized meshes in their bend nets which are selecting mainly large fishes of 2-3SW. Previous spawned salmon occurred in the catches in the entire Kolarctic area in the outermost coastal areas and in fjords. Figure 4 clearly indicates that the proportion of escaped salmon in the catches was decreasing steadily towards east in Northern Norway. In easternmost areas of Varangerfjord the occurrence of escaped salmon was low resulting partly from lower fishing activity late in the prolonged season compared to other areas.

Sea-age distributions in the salmon catches between fishermen are indicating differences in the mesh sizes in bend nets and in some areas fishery was targeting more or less only to multi-sea-winter salmon or mainly to small salmon. Figure 5 illustrates clearly the importance of large salmon (MSW salmon, multi-sea-winter salmon) for the fishery making large proportion of the catches measured in weight. These figures 4 and 5 are indicating the catch composition during the entire salmon migration period, not the catch composition during the legal fishing time in each county. Small 1SW salmon made for many fishermen large proportion in the catches in numbers but MSW salmon, however, made the highest values for them in the economic aspects. 3SW salmon made quite small proportions in numbers in general in 2011 but in weight it was remarkable. Also the catch of escaped salmon in weight highlights its very high proportion in the fishery.

Results and discussion

1. May and June are important periods for the migrations for large salmon and July for small salmon

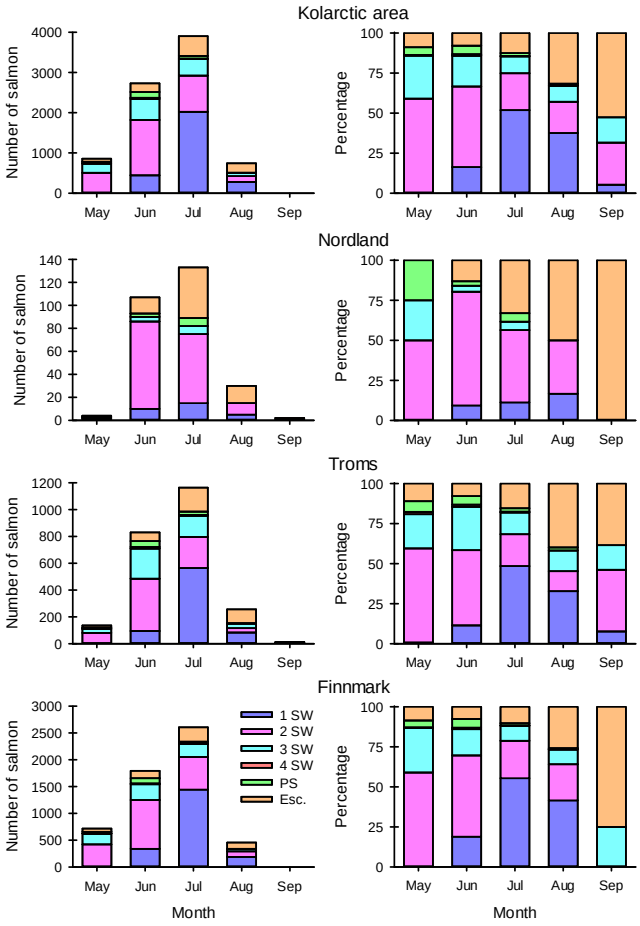


Figure 6. Numbers and percentages of salmon caught during their migration period in the Kolarctic research in three northern counties in Norway in the year 2011. Note differences in y-axis between counties and sea-ages.

Wild Atlantic salmon as well as escaped salmon is available to be caught at sea in the coast and fjord areas mainly from May to the end of September in Northern Norway (Nordland, Troms, Finnmark). Figure 6 gives on overview from the distributions of the catches in terms of numbers of salmon between the summer months in Kolarctic area. Figure 6 gives also an answer to one of the Kolarctic –project's activities indicating the general migratory pattern. 1SW salmon made only 11% in the total salmon catches in Nordland compared to 31% and 35% in Troms and Finnmark, respectively (Table I). Reason to the low abundance and therefore to the low percentage of 1SW salmon in Nordland catches can be that the sampling was not spatially and temporally representative in the coast areas and therefore not to be comparable with the data from other counties. In Troms and Finnmark, however, there were also some localities with low abundance and percentage of 1SW salmon (Figures 4 and 5). Two sea-winter salmon made in Troms and Finnmark 31% and 37%, respectively, from the total numbers of salmon but in Nordland its share was as high as 54% (Table I). The percentage of previous spawners was quite low, 3%, in all counties. Escaped

salmon made declining percentage with the increasing latitude in Kolarctic area being 27%, 15% and 10% from Nordland over to Finnmark.

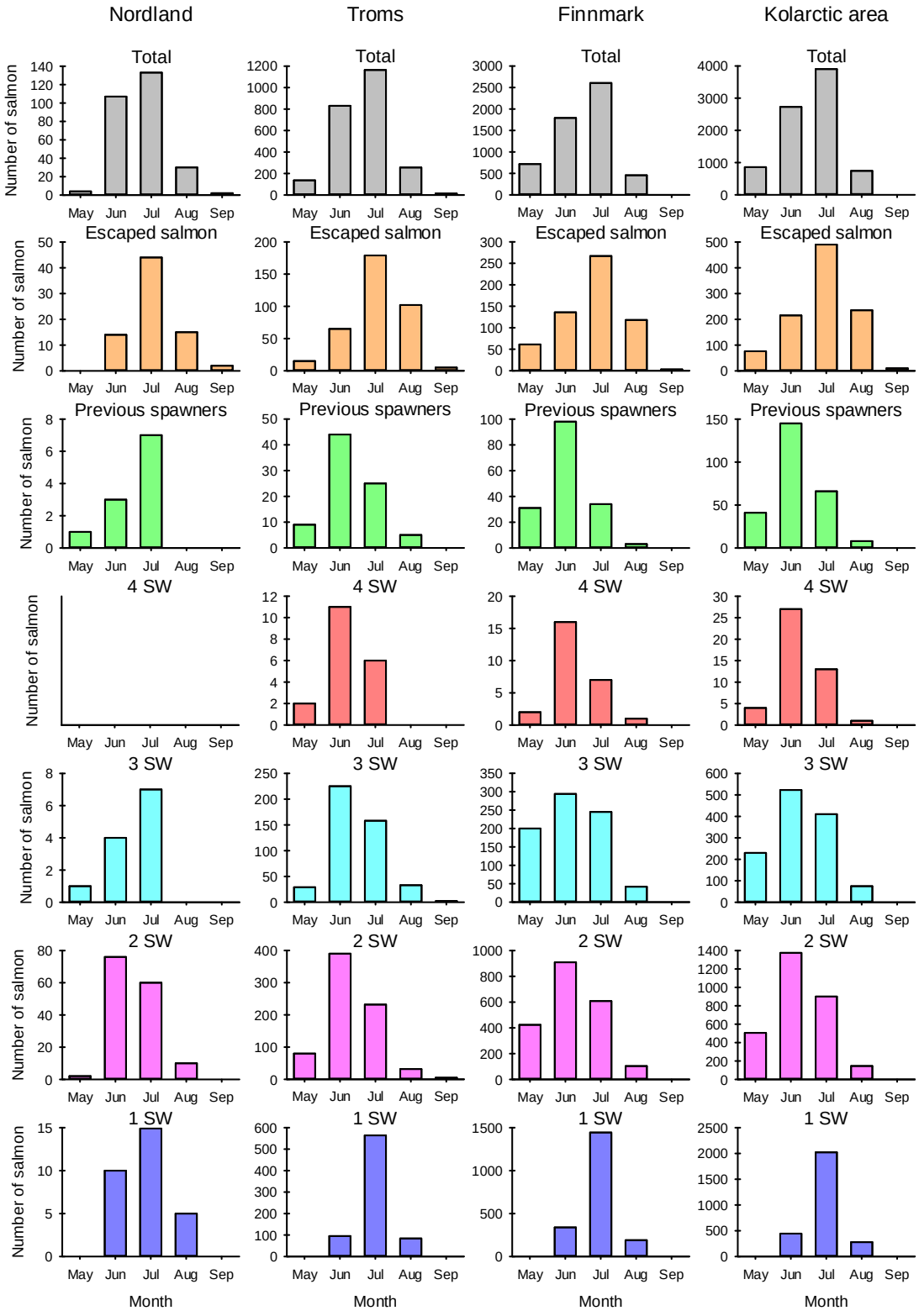


Figure 7. The numbers of salmon in the catches in each summer month in Kolarctic counties in the year 2011. Note differences in y-axis between counties and sea-ages.

The monthly timing of the salmon catches was more or less the same between Troms and Finnmark counties (Figure 7). That was true for wild salmon as well as for escaped salmon. Material from Nordland County was too small for 1SW, 3SW and previous spawners to make good conclusion from the catch distribution between the summer months. Close to 75% of 1SW salmon was taken in July in Troms and Finnmark but c. 65% of 2SW salmon was caught earlier, in May-June, and this 2SW catch had higher proportion in May in Finnmark than in Troms (Table I). From the large salmon, 3SW fish, catches almost 30% was taken in May in Finnmark compared to much lower proportion of 7% in Troms in May. The catch of previous spawners distributed also over the whole summer but the catch in June with 50-60% in Troms and Finnmark was remarkable compared to the catch in May with 10-20%. Catches of escaped salmon increased steadily from May to July and then their catch declined remarkably. The most important reason to the dramatic declining of escaped salmon catches in August is certainly the much lower interest of fishermen in this project to continue their fishing after the ordinary season when there is usually much lesser number of wild salmon available for fishery than earlier in the summer. Fishermen get also tired after fishing salmon actively over three months (May, June, July) and the fishing effort was much less in autumn than in the summer.

Photos 22-23. Ocean currents are transporting water plants especially in July which will be attached into the guiding nets of bend nets or bag nets (photo 22. on the left). Guiding nets must be cleaned many times during the summer. If the nets are not cleaned that might affect negatively to the catch ability of the fishing system. Figure 23. on the right indicates that salmon fisherman, here Harry Emil Severinsen with his assistant, must search sometimes his fishing gears independent from the weather conditions. Big waves and stormy weather are preventing the trips to the fishing sites for safety reasons.

Photo 24. Later in the season jellyfish can be harmful to the skin of fishermen causing allergic reaction if there are contacts between skin and this animal when removing it out form fishing gear. It can be possible that some new and harmful animals will start to occur in northern sea environment due to global sea water temperature increases. Here Ansten Mathisen is removing jellyfish out from his bend net.

2. Wide diversity in the age distributions of wild salmon in the coast fishery

Salmon caught in the coast and fjord areas in Northern Norway are representing salmon stocks living in the rivers in Norway from Nordland in west to the river Pechora in northwest Russia including stocks from the Finnish side of the River Tana. In Northern Nordland and maybe also in Troms area some salmon caught in the coast areas are heading to the rivers in more western areas in Mid- Norway or even to South- Norway, or even to South-West Sweden. Alone in the River Tana system it might be c. 35-40 salmon stocks which are clearly separated genetically from each other indicating huge natural genetic resource which is unique within the salmon rivers in the world.

Rivers in Kolarctic area are representing a large variety of running waters from glaciers with very oligotrophic and cold rivers to the rivers where summer temperatures are close to the levels of the highest tolerance for juvenile salmon to survive and where the bottom animal production is high giving resources for maximum growth for juveniles. These environmental factors including the genetics are determining the river specific growth patterns of juvenile salmon. Due to the different growth and different genetics

juvenile salmon are reaching in the Kolarctic area smolt age and smolt size after two to eight years and hence they will migrate to the sea during their third to ninth year of live. In the material collected in 2011 from the Kolarctic area there were 22 different smolt age and sea-age groups for first time spawners. In addition to that there were 33 smolt age and sea-age combinations for previous spawning salmon which is including alternate and consecutive previous spawners. This large diversity of 55 age groups indicates that the catches in 2011 originated from the spawnings of altogether nine years between the years 1998-2007. First time spawners represented in the catches recruitments from the spawnings in 2001-2007 and previous spawneres were recruited from the spawnings in 1998-2005 (Figure 8). Previous spawners with 33 age combinations add to the very high life-history variation of the Kolarctic Atlantic salmon stock complex. In addition to their role in life-history complexity, previous spawners contributed in 2011 to the commercial value of the coastal salmon catches in terms of numbers accounting for up to 4% of the catch. The wide variety of age groups informs that catches at sea like in the year 2011 are not originating only from some few spawning years and hence catches are "ecologically " guaranteed from the successful reproduction over many years and from the successful reconditioning of salmon from earlier spawnings. This great plasticity in the age groups offers possibilities and a safeguard for the genetic contribution of each year class over a number of years. Although marine environmental conditions may be the major forces regulating Atlantic salmon stocks and their fluctuations, successful management is of vital importance in enabling diversity in Atlantic salmon life histories and high abundance of various groups of repeat spawners including large, maiden high-fecundity females, and also improved catches.

In first time spawning salmon there were in Nordland, Troms and Finnmark 12, 20 and 20, respectively, smolt age and sea-age groups and within previous spawners there were 6, 25 and 30 age groups, respectively. The oldest salmon (age of 4.2S1S1S1+) was 12 years old having been first in fresh water 4 years and then spawning for the first time after feeding two full years at sea. Later this old fish had two more spawning and always reconditioning one year between spawning. Most remarkable age groups in previous spawning salmon were fishes which were returning to spawn for the second time after they have had their first spawning in the sea-age of 1SW, 2SW and 3SW followed by one full year's reconditioning period at sea. The numbers of these previous spawners in the catches for the sea-age groups of 1S1, 2S1 and 3S1 were 86, 35 and 19, respectively. Interestingly, salmon post spawners are descending after the spawning from the rivers in the Kolarctic salmon area to sea for reconditioning and some of those were caught in the coast and fjord fisheries also in the end of the summer. This indicates that a proportion of post-spawners are reconditioning very close to the coast instead of that they are migrating to those ocean feeding areas, which are the main growing areas for most of the salmon stocks.

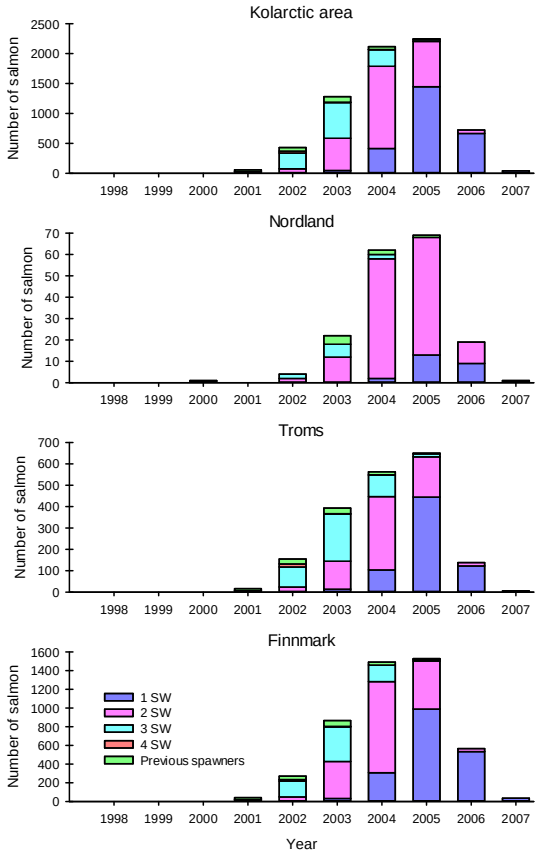


Figure 8. Figure illustrates those spawning years of salmon from which consecutive salmon catches recruited in Kolarctic project in the year 2011. Salmon catches in Kolarctic area originated from first time spawners recruiting from the spawnings in the years 2001-2007 and from previous spawners recruiting in the spawning 1998-2005.

3. Overall migratory pattern for wild and escaped salmon at sea in Northern Norway

As soon as fishermen started to fish in the beginning of May only few of them caught some salmon (Figure 9). It was expected, however, to have much better catches in early May in general at least in Finnmark based on the old historical information. Also based on the experiences of some of the oldest salmon fishermen it was expected to catch salmon belonging to the largest size group, larger than 7 kg fish. Unfortunately, weather conditions in most of the outermost coastal areas did not favor practical fishery and strong winds eliminated totally in some areas the use of bend nets.

In the Kolarctic area in the catch of female salmon, 2SW and 3SW fishes dominated the catches almost the whole "official" fishing season in June and July. 1SW fish entered to the coastal fishery during the week 24 and dominated in the male salmon catches from the week 25 to the week 34. Escaped salmon made almost throughout the entire official fishing season c. 10-15% from the weekly catches (female and male salmon catches combined) but their proportions started to increase clearly in the week 30 being 25% and that means each forth salmon in the catches to be escaped salmon, which is high amount. In August, when most of wild salmon has entered into their own rivers in Northern Norway the proportions of escaped salmon in the catches made extremely high proportion exceeding almost 50% in the week 33.

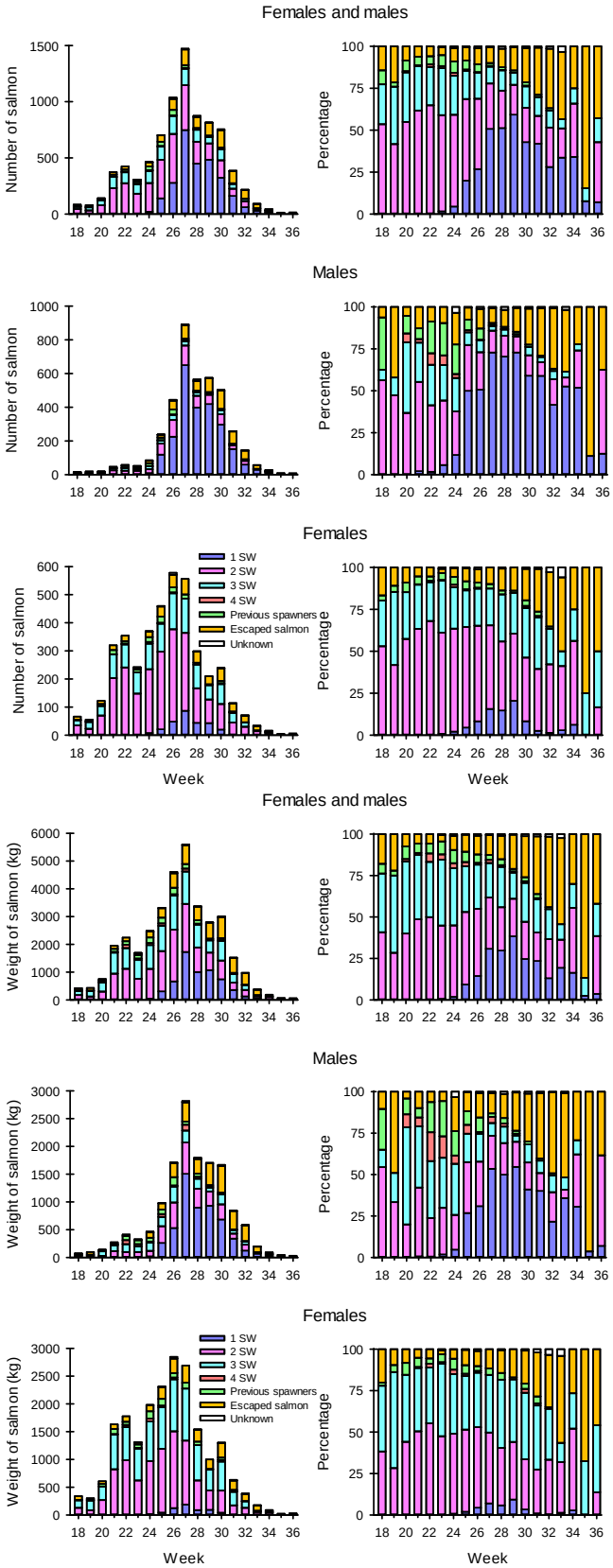


Figure 9. Weekly salmon catches in the Kolarctic area (Nordland, Troms, Finnmark) in terms of numbers (figure on the top) and weights (figure below).

Photo 25. In the year 2011 the majority of the catches in terms of numbers of salmon in Kolarctic area were made from 1SW and 2SW salmon in terms of numbers. In the photo there are three one sea winter and one two sea winter salmon.

Salmon catches expressed as weights (Figure 9) in each sea ages gives more informative picture on the economic value of medium and large sized salmon compared if expressing the data with numbers of salmon in each age groups. The catch in term of numbers is used especially when calculating the spatial and temporal exploitation of salmon between fishing methods, between the fisheries at sea and in the rivers etc. In Kolarctic area the catches were composed mainly of large salmon (2SW and older) to the end of the week 26, that is to the end of June. In whole July the mass of 1SW salmon made in average one quarter of the total catch. Interesting is that in the end of July escaped salmon made as much as 25% from the total catches and its proportion increased to 50% to the end of the week 33 (Figure 9). In female salmon catches 1SW salmon had only very minor importance reaching c. 10% in the week 29. Previous spawning salmon made quite stable proportion in the total catches throughout the whole official fishing season being <10%, but making even 20% in some weeks in male salmon catches.

In the Kolarctic project fishermen tried to start the fishery as early as possible in the beginning of May to collect data from salmon for the migratory pattern analysis of all the sea age groups and especially to analyze the rivers of origin for all salmon caught in the coast and fjord areas. From the figure 10 it can be observed clearly that in the whole Kolarctic area, combining the data from Nordland, Troms and Finnmark, female salmon with the sea-ages of 2, 3-4SW and previous spawners ascended earliest around the same time and they were caught evenly throughout the entire summer. In males also the age groups of 3-4SW and previous spawners ascended earliest into the fishery but 2SW salmon came clearly later. Although escaped salmon occurred in the catches throughout the entire summer time their cumulative catches took place later but, however, a little earlier than that for 1SW salmon. Figure 10 indicates the general migratory pattern for wild 1-4SW salmon, previous spawners and escaped salmon.

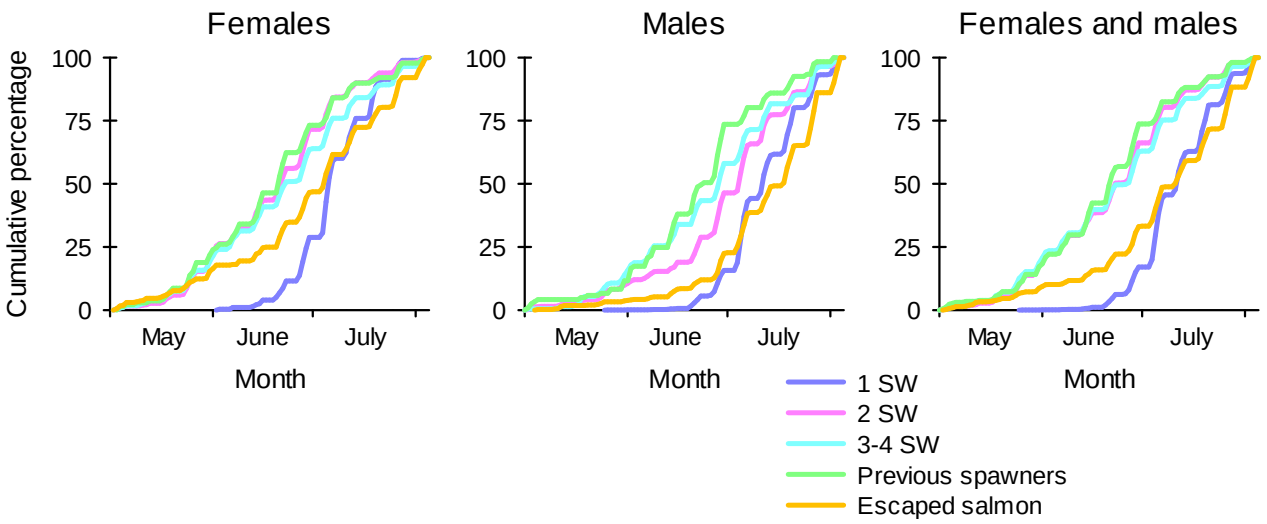


Figure 10. Cumulative percentages of the catches in terms of numbers for wild 1-4SW salmon, previous spawners and escaped salmon in Kolarctic area between May to August 4.

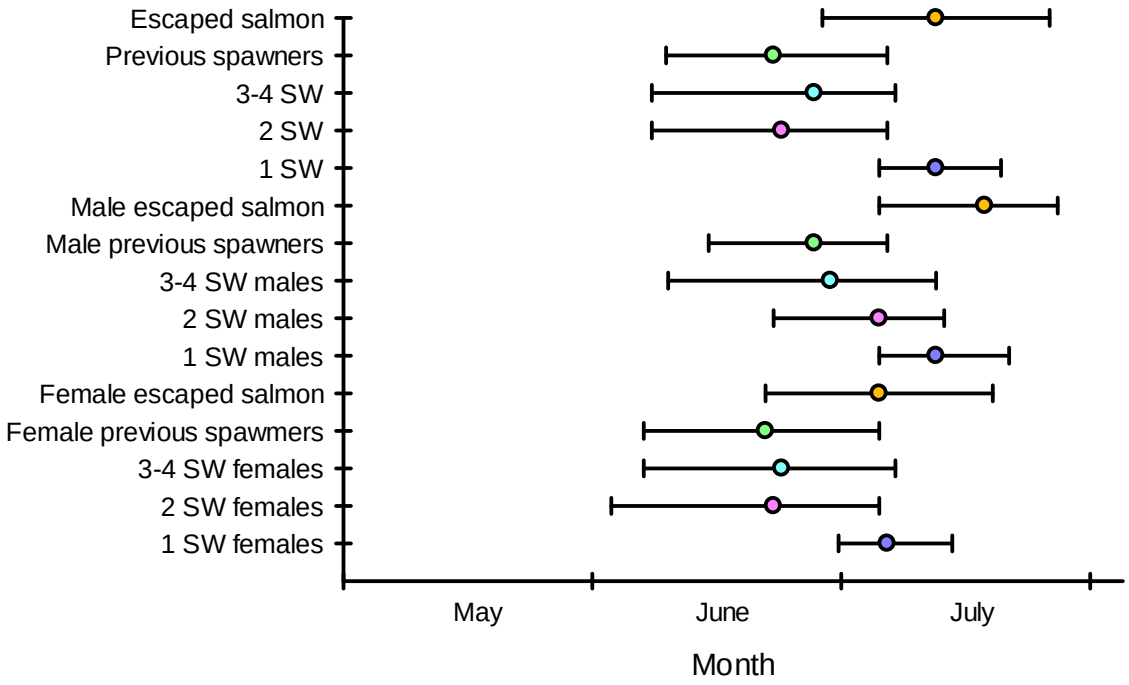


Figure 11. Median dates with 25% and 75% interquartile range of the catches in terms of numbers for wild 1-4SW salmon, previous spawners and escaped salmon in Kolarctic area between May to August 4. Median date is the date within the main migratory period when 50% from the catch has been accumulated and 25% interquartile date point is the date in the summer when 25% from the salmon were accumulated in the catches and respectively 75% corresponds the date when 75% from the salmon catches were accumulated.

Median date of capture with the interquartile range of 25% and 75% is one clear statistical parameter to indicate differences in the timing of migrations especially in such cases when the fishery is covering almost the entire migratory period stretching from early May to the begin of August. Figure 11 demonstrates clear differences in the median dates of the capture within the entire Kolarctic area in Norway between all sea-age groups for wild salmon and escaped salmon. In females the earliest median dates were for 2SW, 3-4SW salmon and previous spawners being around June 20th, and for 1SW salmon and escaped salmon around July 5. Here we must remember that migrations for escaped salmon are clearly continuing after August 4, which date is the end of the official fishing time in Finnmark and therefore this median date of capture is not comparable to the corresponding dates of wild salmon (See Figure 9). In male wild salmon the median dates of capture are more clearly different between the sea-age groups than it is for females (Figure 11). Previous spawners ascended first to the fishing areas followed by 3-4SW, 2SW, 1SW salmon and latest came escaped salmon.

Photos 26 a, b -27 a, b. Above. Reidar Larsen from Tanafjord, Smalfjord, was driving daily with the boat long distances to the middle of Smalfjord to his fishing site (photo 26 on the left). Reidar caught one salmon without adipose fin and after genetic assignment we know its river of origin (photo 26 on the right). Below. Steinar Magnussen fish in Jarfjord (left picture) and Arnt Ivar Ring fish in Altafjord (right picture)

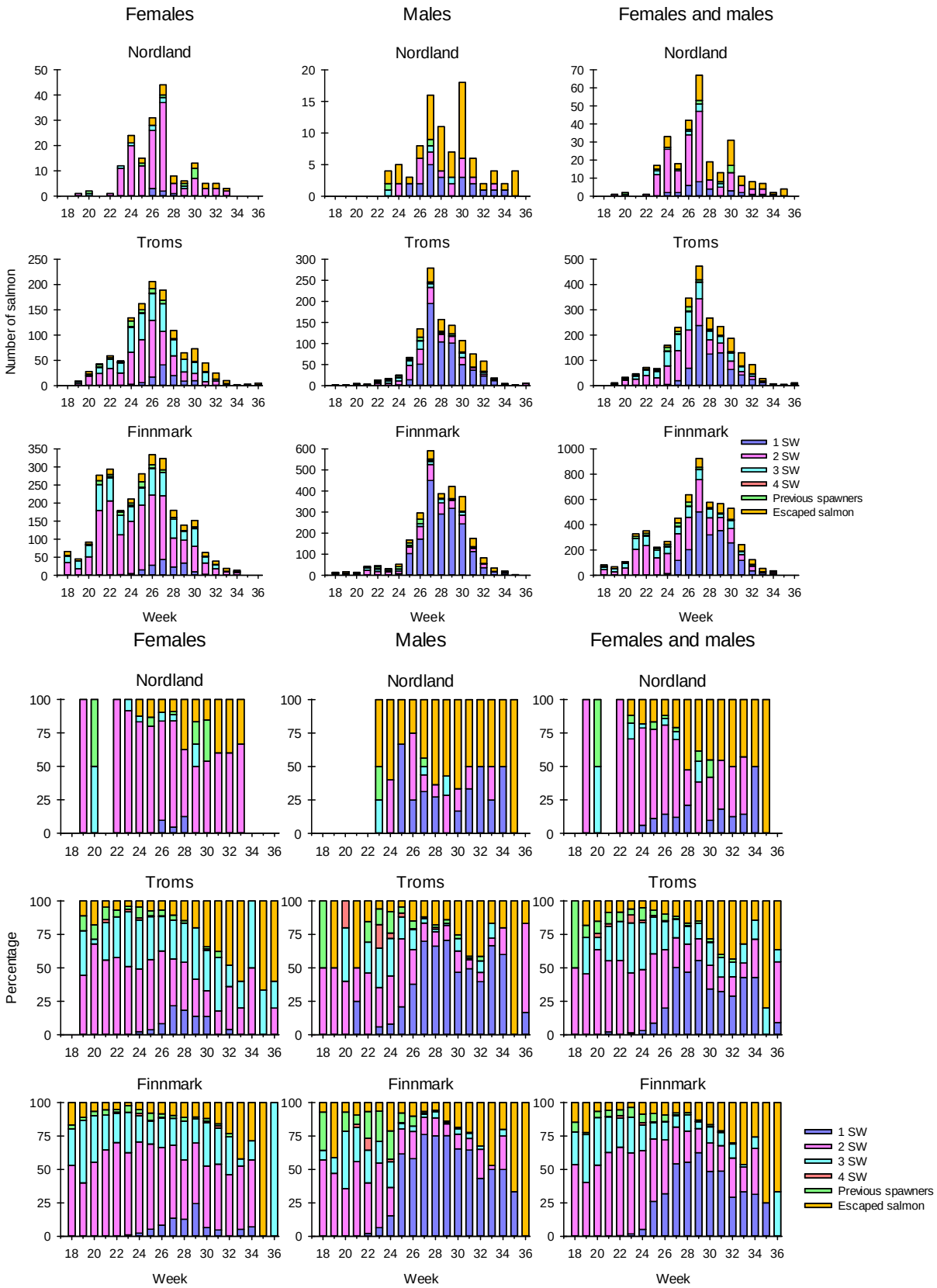


Figure 12. Weekly salmon catches in terms of numbers (figure on the top) and weekly sea-age distributions (figure below) in Finnmark, Troms and Nordland in the Kolarctic area fishing methods combined.

In general when talking about salmon catches the information is mainly the total weight caught at sea or in the rivers and seldom the numbers of salmon. In the Kolarctic area (Nordland, Troms, Finnmark) the sampling in 2011 included c. 30% of 1SW salmon in terms of numbers (Table I, Figure 6) but if we are considering the catch in terms of mass then 1SW salmon made only c. 15% from the total catches.

By comparing the information between the figures 12 (=numbers of salmon) and 13 (=weight of salmon) we can observe that 1SW salmon doesn't mean so much in the catches in terms of weight than in terms of numbers. The economic value of MSW salmon in the sea catches is clearer to observe in the figure 13 than in the figure 12. During the peak migration time of the smallest salmon in Finnmark 1SW salmon is making only c. 25-30% from the catches in terms of weight compared to c. 50% in terms of numbers of fish. These figures are highlighting the high value of MSW salmon through May to the end of July not only from the point of economy for sea salmon fisherman but also from the point of the ecology of salmon. Large salmon, larger than 3 kg and older than 1SW fish, is usually female salmon belonging to higher prize category and from ecological point of view producing more juveniles than 1SW females.

Photo 28. Happy fisherman with 2SW wild salmon near North Cape, Northern Norway.

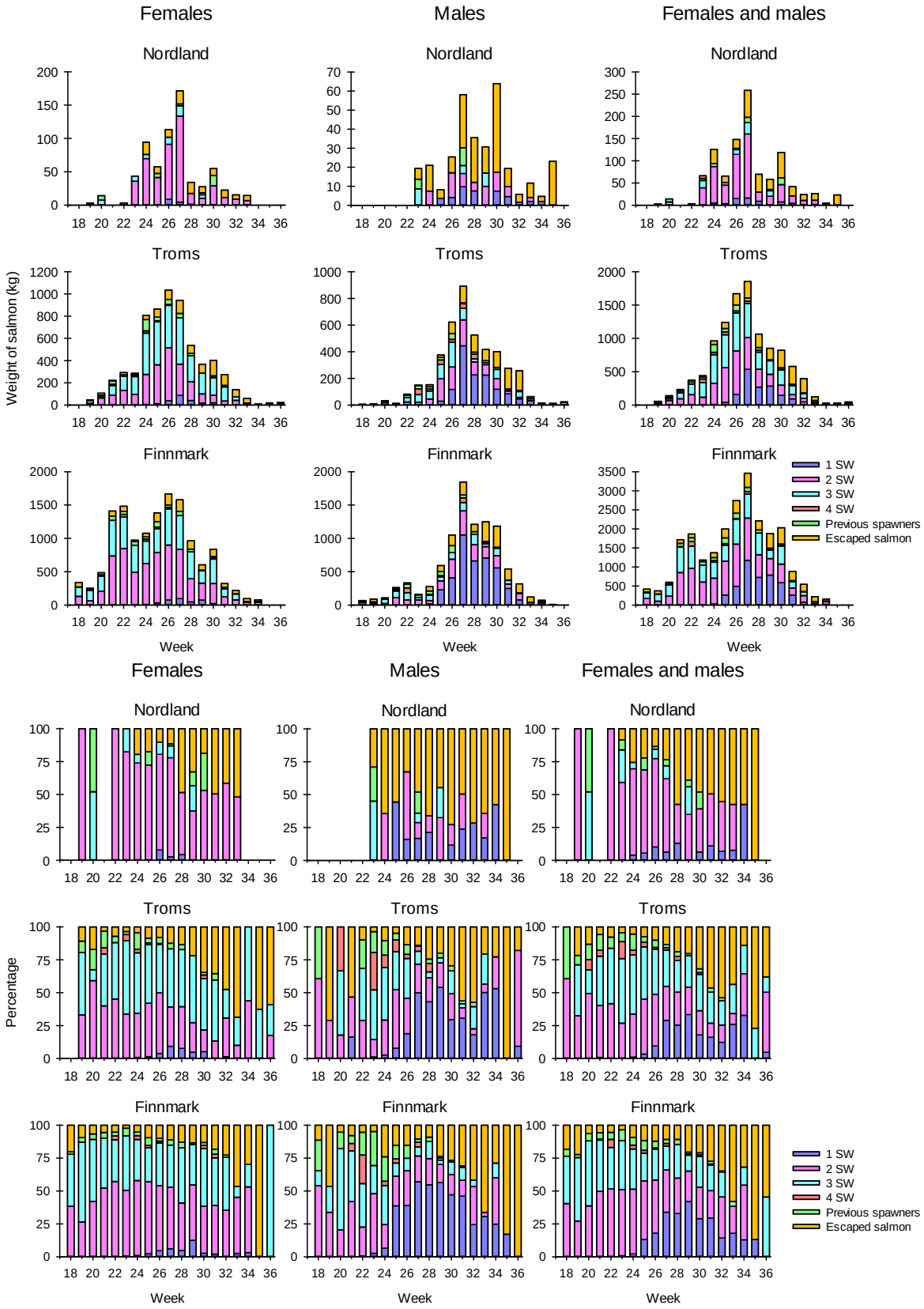


Figure 13. Weekly salmon catches in three counties in Kolarctic area in terms of weight (figure on the top) and weekly sea-age distributions from weight of salmon (figure below) in Finnmark, Troms and Nordland fishing methods combined.

Photos 29a and 29b. The round weight (not slaughtered) of each salmon is important biological parameter for example when analysing long-term changes, spatial and temporal variation and differences in the growth between the Kolarctic salmon stocks

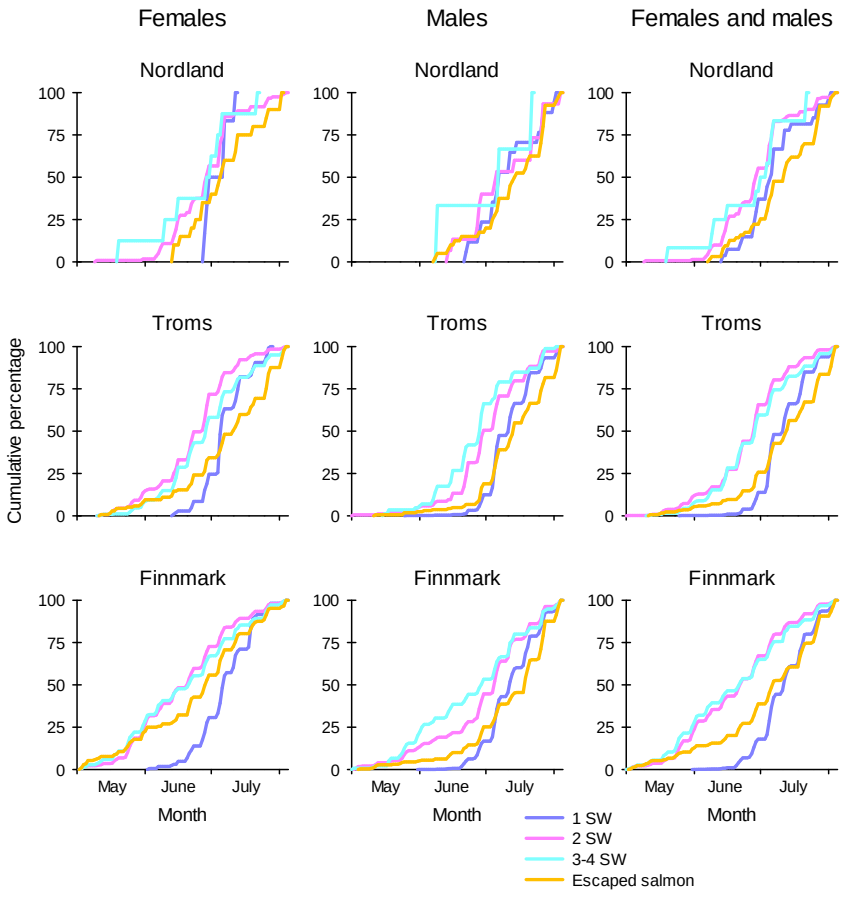


Figure 14. Cumulative percentages of the catches in terms of numbers for wild 1-4SW salmon and for escaped salmon in Nordland, Troms and Finnmark between May to August 4.

Cumulative percentages of the catches in Finnmark and Troms were close to each other for females and males in 1-4SW salmon and escaped salmon (Figure 14). That confirms the similar migratory behaviour of wild salmon for all the sea-age groups and for escaped salmon within a larger geographical area in Northern Norway. Material from Nordland in the year 2011 indicates same kind of timing in the migrations of salmon.

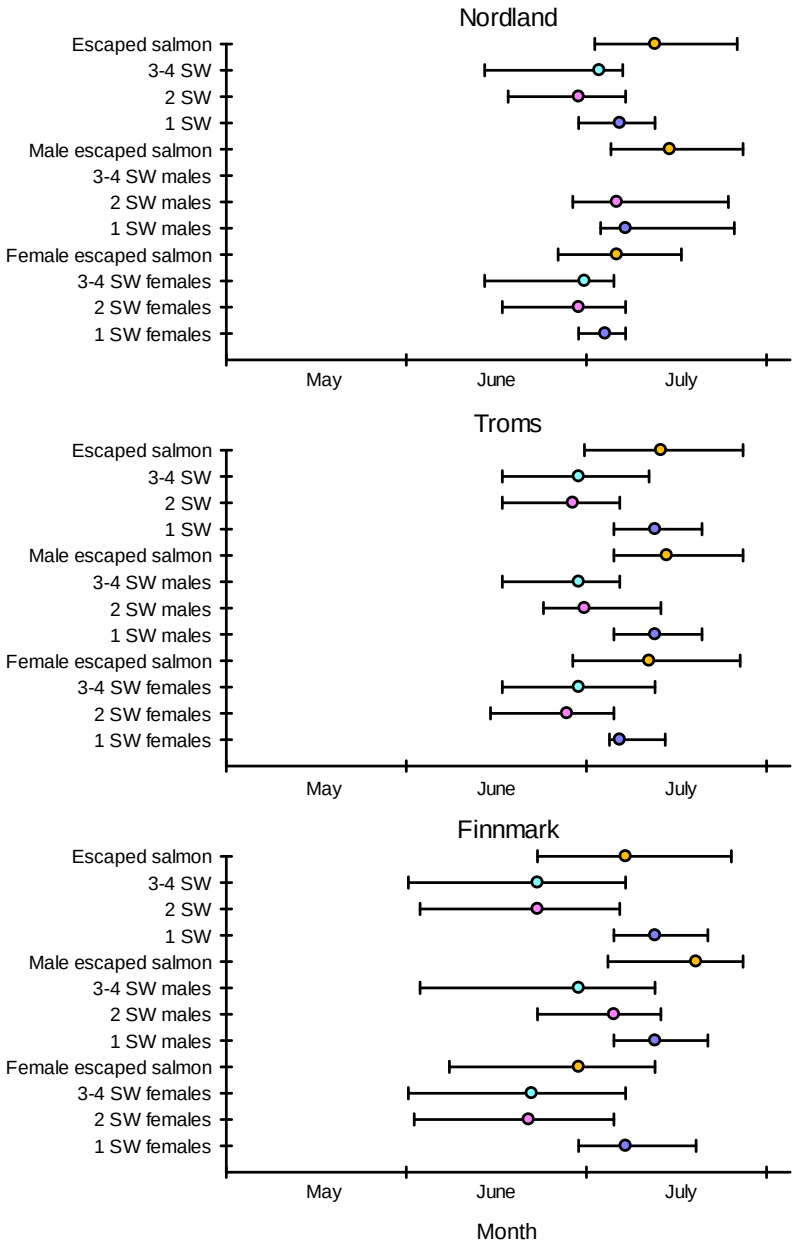


Figure 15. Median dates with 25% and 75% interquartile range of the catches in terms of numbers for wild 1-4SW salmon and for escaped salmon in Nordland, Troms and Finnmark between May to August 4.

Median dates with 25% and 75% interquartile range of the salmon catches can be used as one tool for management purposes to regulate, if necessary, the fishery before and after the peak migration. The figure 15 with median dates of the catches confirms the fact on the different migration periods observed from the

cumulative catches illustrated in the figure 14. Especially median dates in Finnmark and Troms have high similarity among all the sea-ages of wild salmon and escaped salmon.

Finnmark can be divided into three distinct areas, West-, Middle- and East-Finnmark, where the timing of migrations of salmon is differing between areas. The differences can be observed from the differences in the timing of the peak migrations for 1SW, 2SW and 3-4SW as well as for escaped salmon (Figures 16 and 17). The proportion of 1SW fish is in general low in female salmon catches being lowest in West-Finnmark and highest in East-Finnmark. In male salmon catches the proportion of 1SW fish is very high in the middle of the summer in all Finnmark areas.

The same difference between the median dates of catches for 1SW, 2SW, 3-4SW and escaped salmon which was found between the three northern counties can be found also between the three areas in Finnmark (Figure 18). Median dates of catches for female salmon are earlier compared to the dates of males in the sea-age groups of 1SW and 2SW wild salmon and escaped salmon but not for 3-4SW salmon. Escaped female salmon had almost the same median dates of catches in all the three areas.

Photos 30 a, b and 31-32. Usually bend net fisherman is fishing alone because the use of that method is easier than the use of bag net. Ansten Mathisen must drive first with bigger boat to his fishing site where he is using small boat. Small boat is more practical to handle the fishing gear-if it is good weather.

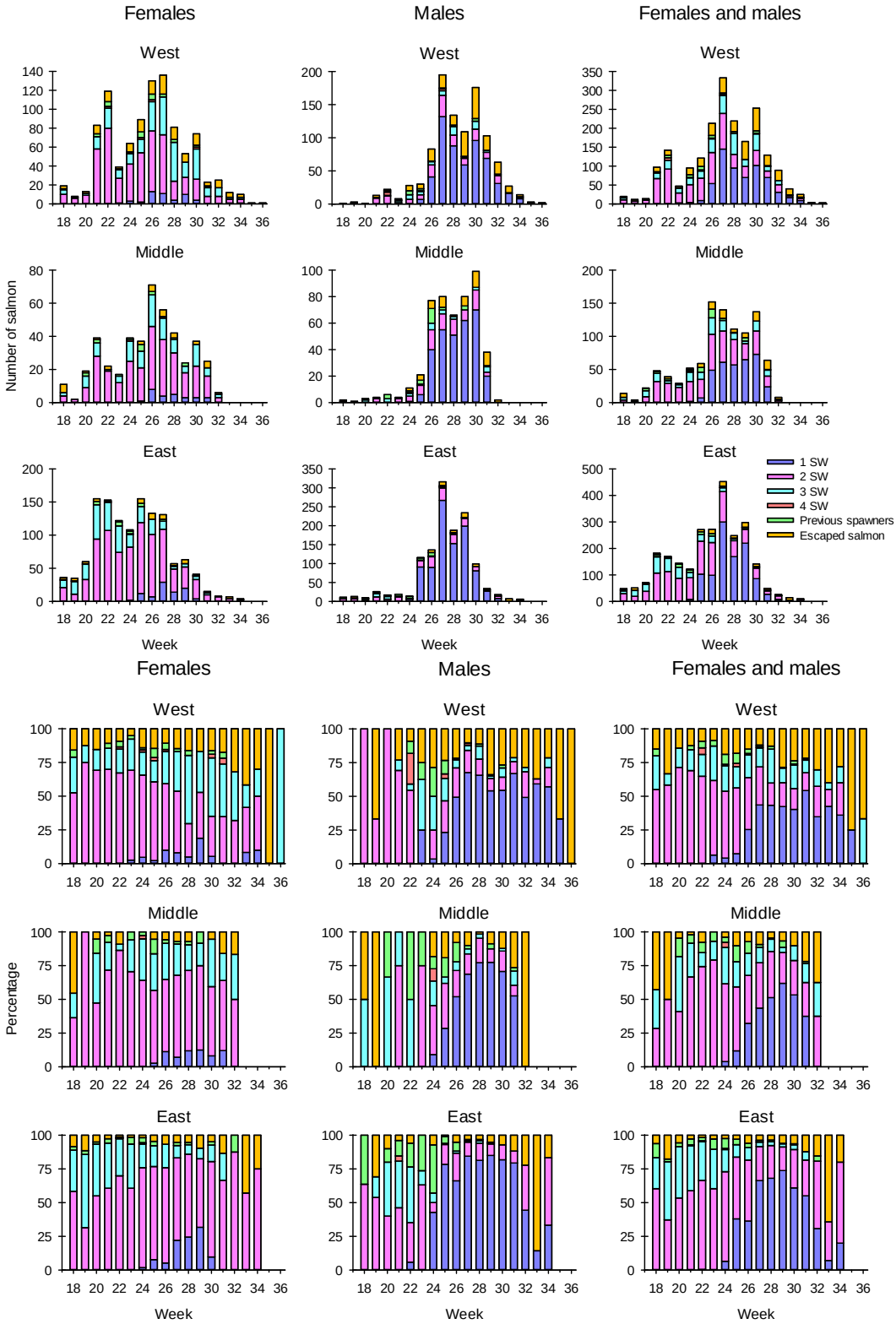


Figure 16. Weekly salmon catches in West-Finnmark (from Loppa to Porsanger), in Middle-Finnmark (from Lebesby to Berlevåg) and in East-Finnmark (from Båtsfjord to Sør-Varanger) in terms of numbers (figure on the top) and weekly sea-age distributions from numbers of salmon (figure below).

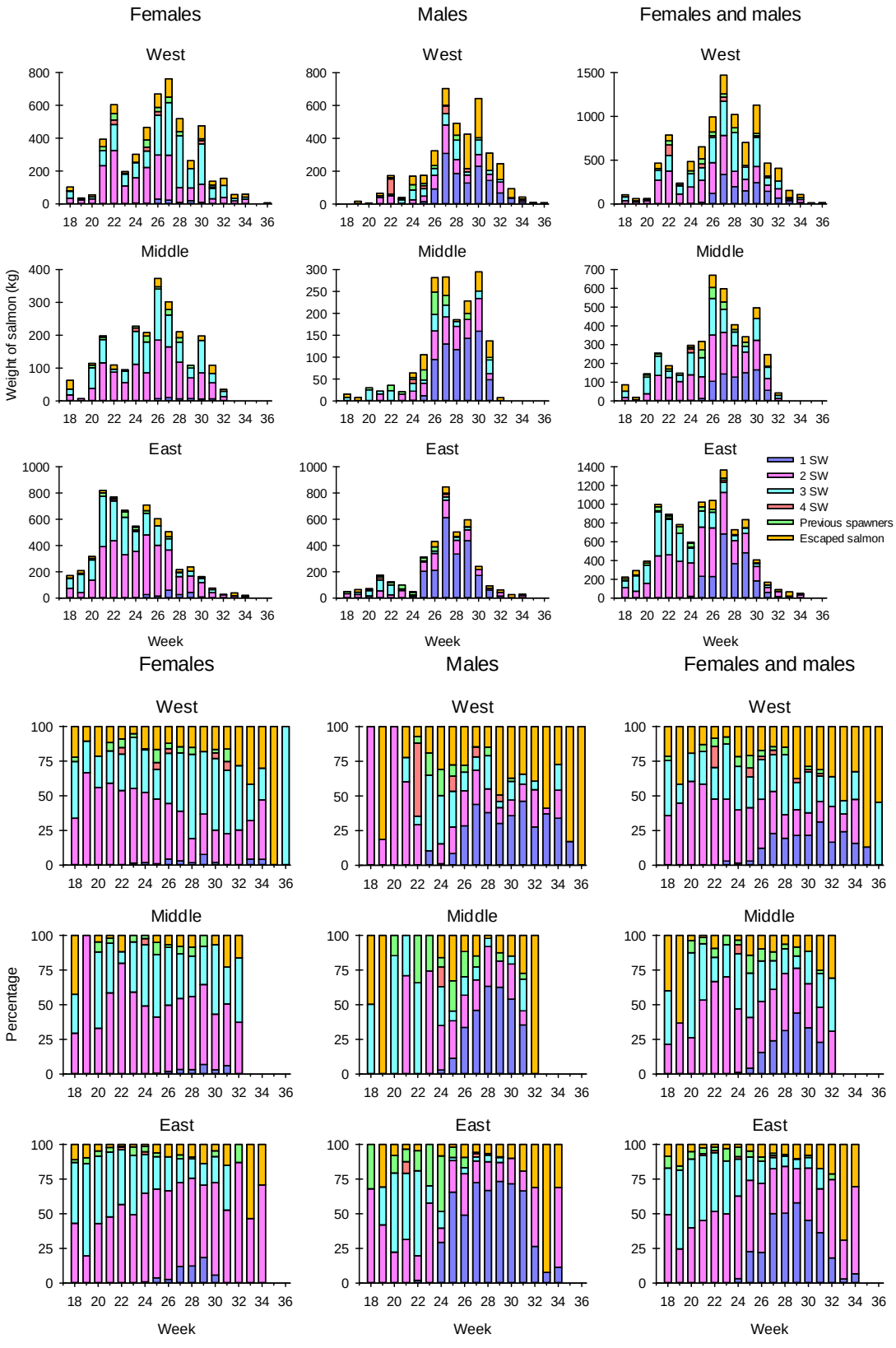


Figure 17. Weekly salmon catches in West-Finnmark (from Loppa to Porsanger), in Middle-Finnmark (from Lebesby to Berlevåg) and in East-Finnmark (from Båtsfjord to Sør-Varanger) in terms of weight (figure on the top) and weekly sea-age distributions from weight of salmon (figure below).

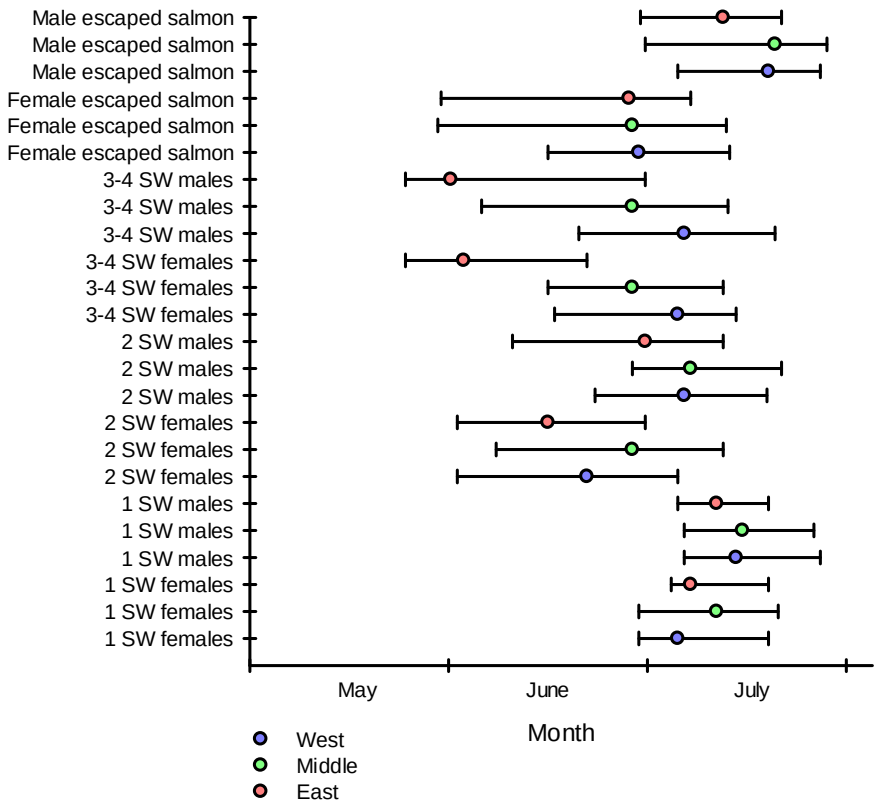


Figure 18. Median dates with 25% and 75% interquartile range of the catches in terms of numbers for wild female and male 1-4SW salmon and escaped salmon in West, Middle and East Finnmark between May and to August 4.

4. Catches in bag net and bend net fishery were composed out of six groups of salmon

In the Kolarctic area in North Norway salmon catches included six groups of salmon; 1SW, 2SW, 3SW, previous spawners and escaped salmon. The occurrence of 4SW salmon was very low. The following conclusions can be drawn from the material collected by salmon fishermen in 2011 during the whole summer period from May to early September (Figure 19):

-proportions of 1SW salmon in the catches increased with the increasing latitude; that was true for females and males separately

-proportions of escaped salmon decreased with the increasing latitude; that was true for females and males separately

-each fourth salmon in Nordland was escaped fish, in Troms each fifth salmon and in Finnmark each tenth salmon was escaped fish

-highest proportion of 2SW salmon was caught in Nordland and that was especially for female salmon

-the proportion of 3SW salmon was highest in Troms and very low in Nordland

-in bag net fishery the proportion of 1SW salmon was much higher than in bend net fishery and that was true especially in Finnmark and Troms

-bend net fishery selected in female salmon mainly MSW fish in Finnmark and Troms but bag net fishery targeted also to 1SW females with c. 20-25%

-in bend nets the mesh sizes are larger than in bag nets and therefore smaller salmon, like 1SW females, are escaping from bend nets (swimming through the meshes)

-in bag nets with the minimum mesh sizes, with 58 mm from knot to knot, most of salmon of 1-5SW fish will be caught except the smallest ones with the weight of 0.6-1.5 kg can swim through the net

Photos 33 a and b. Bag net on top and below a bend net, both in Varanger fjord.

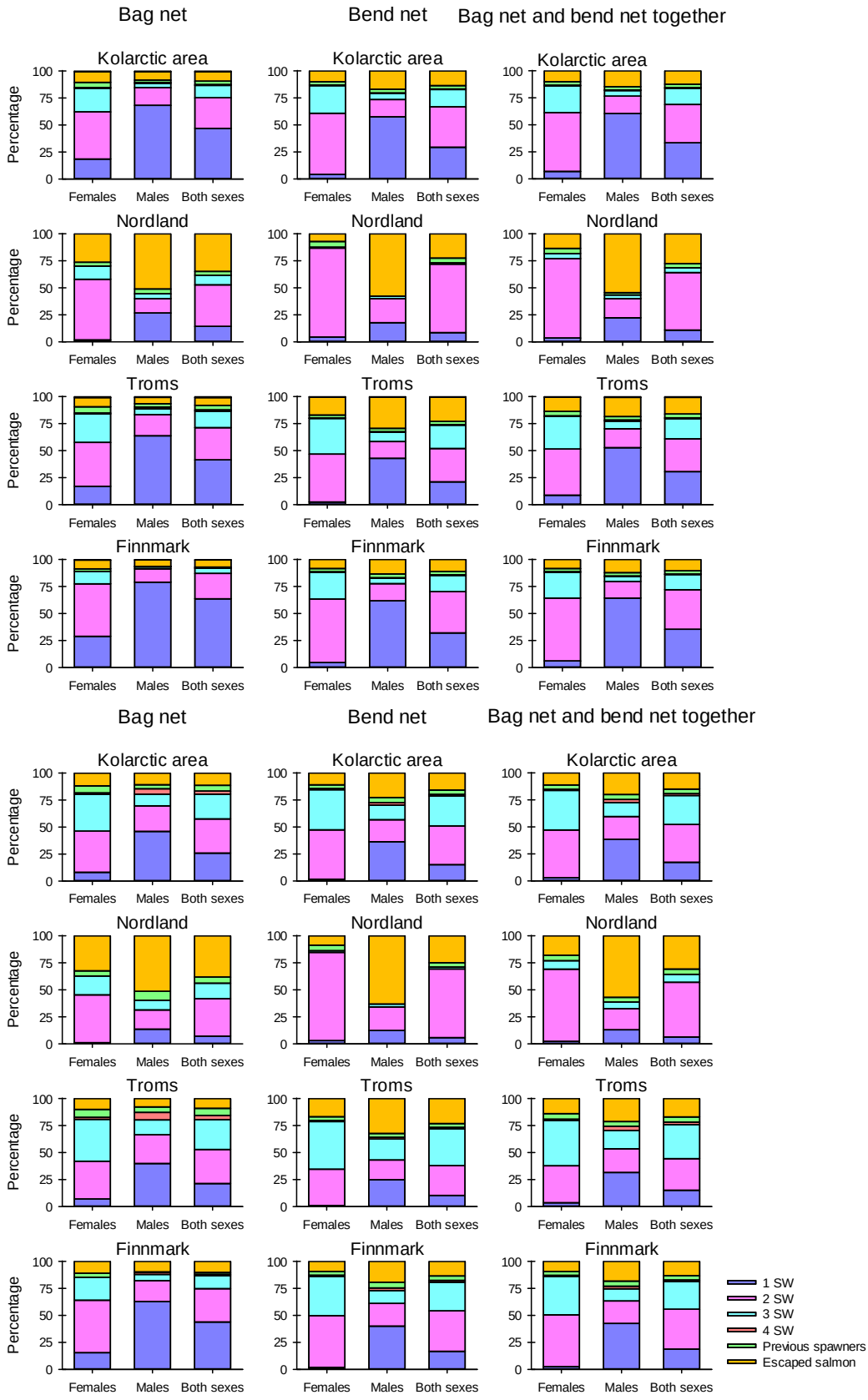


Figure 19. Sea-age distributions of salmon catches from the numbers (figure on the top) and weights (figure below) of salmon for Nordland, Troms and Finnmark in bend nets and bag nets in May-September.

Figure 20 illustrates the timing of salmon catches caught with bend net and bag net in Kolarctic area. Fishermen started the fishery with bend nets for practical reasons because the use of bag nets early in the May is not so successful. The use of bag nets is also more difficult and needs more manpower than bend net fishery. Most probably the catch early in May consists from large fish and therefore fishermen used bend nets where it is possible to use larger and more effective mesh sizes during the early migration period of large fish and then later in the season fishermen are using smaller mesh sizes to catch smaller salmon. Bag net fishery is targeting more to 1SW fish, and there especially to females, than the bend net fishery in the middle of the summer. Figure 20 and there especially the bend net catches are illustrating clearly timing of wild and escaped salmon in the Northernmost Norway at the time when wild salmon is actively moving towards its home rivers.

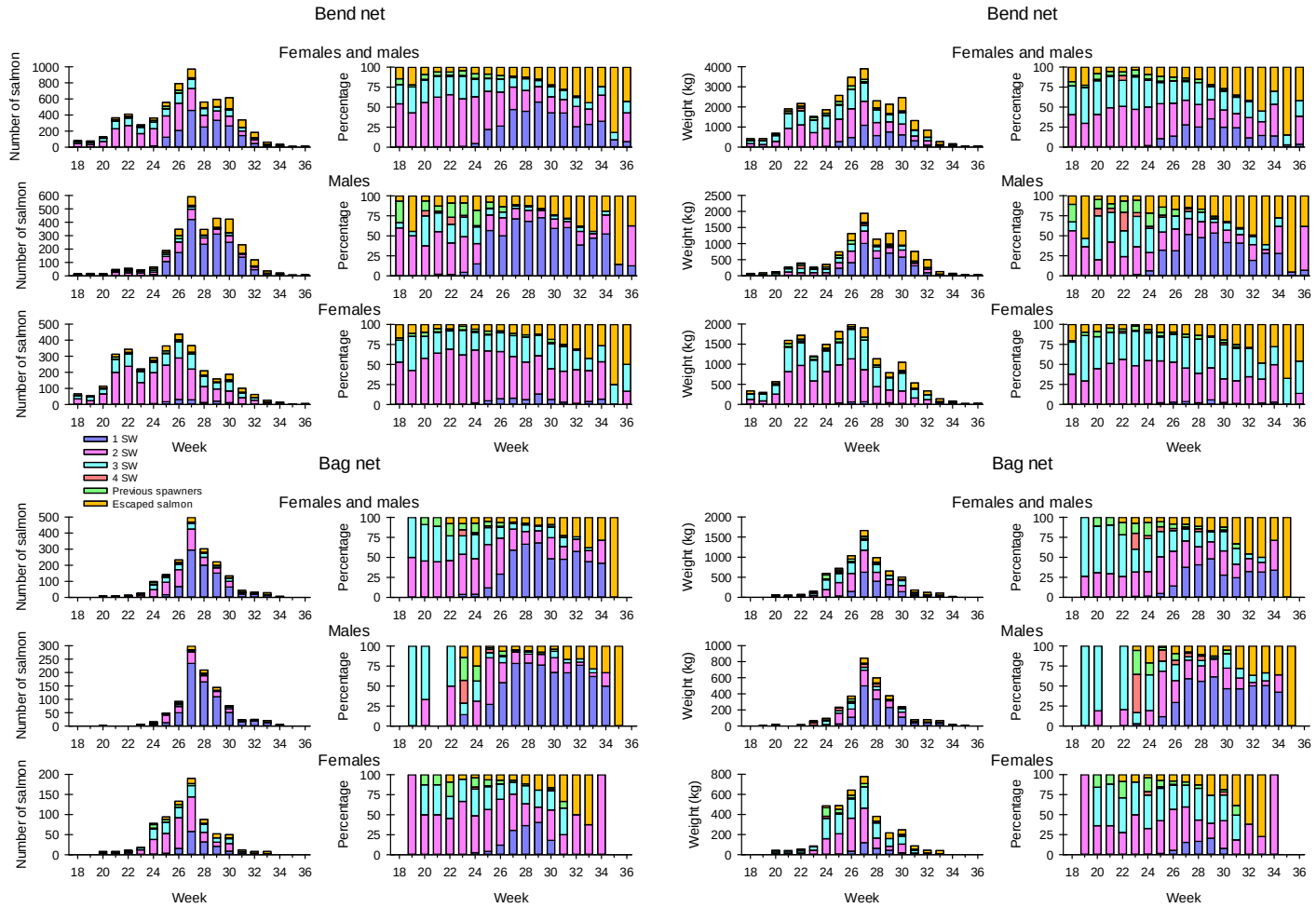


Figure 20. Weekly salmon catches in terms of numbers (figure on the left) and weights (figure on the right) in the Kolarctic area (Nordland, Troms, Finnmark) in bend nets and bag nets in May-September.

Salmon catches had one clear peak at the same week, 27, all the counties combined (Figure 20) and in females the peak was in Troms and Finnmark one week earlier than in males (Figures 12, 13). In MSW female salmon especially in Finnmark but slightly also in Troms there was some higher activity in the migrations in the end of May (weeks 21 and 22) followed by weakening migration lasting 2 weeks (Figure 12). Reasons for lower catches after the first peak can partly be combined to unfavourable weather conditions early in the season. In all Kolarctic areas escaped salmon are making contributions to the weekly catches and with especial high proportions in male salmon catches in Nordland (Figure 12). In Kolarctic area

MSW salmon is making the majority of female and male salmon catches until the beginning of the week 25 in Finnmark and week 26 in Troms. From the week 27 onwards 1SW salmon is making c. 50% from the catches in Finnmark during 5 weeks (to the end of ordinary fishing time) and during 3 weeks in Troms. After the ordinary fishing time from August 4th onwards there is still some but minor migration of wild 1SW, 2SW and 3SW salmon and especially escaped salmon and in all areas the proportions of escaped salmon are high.

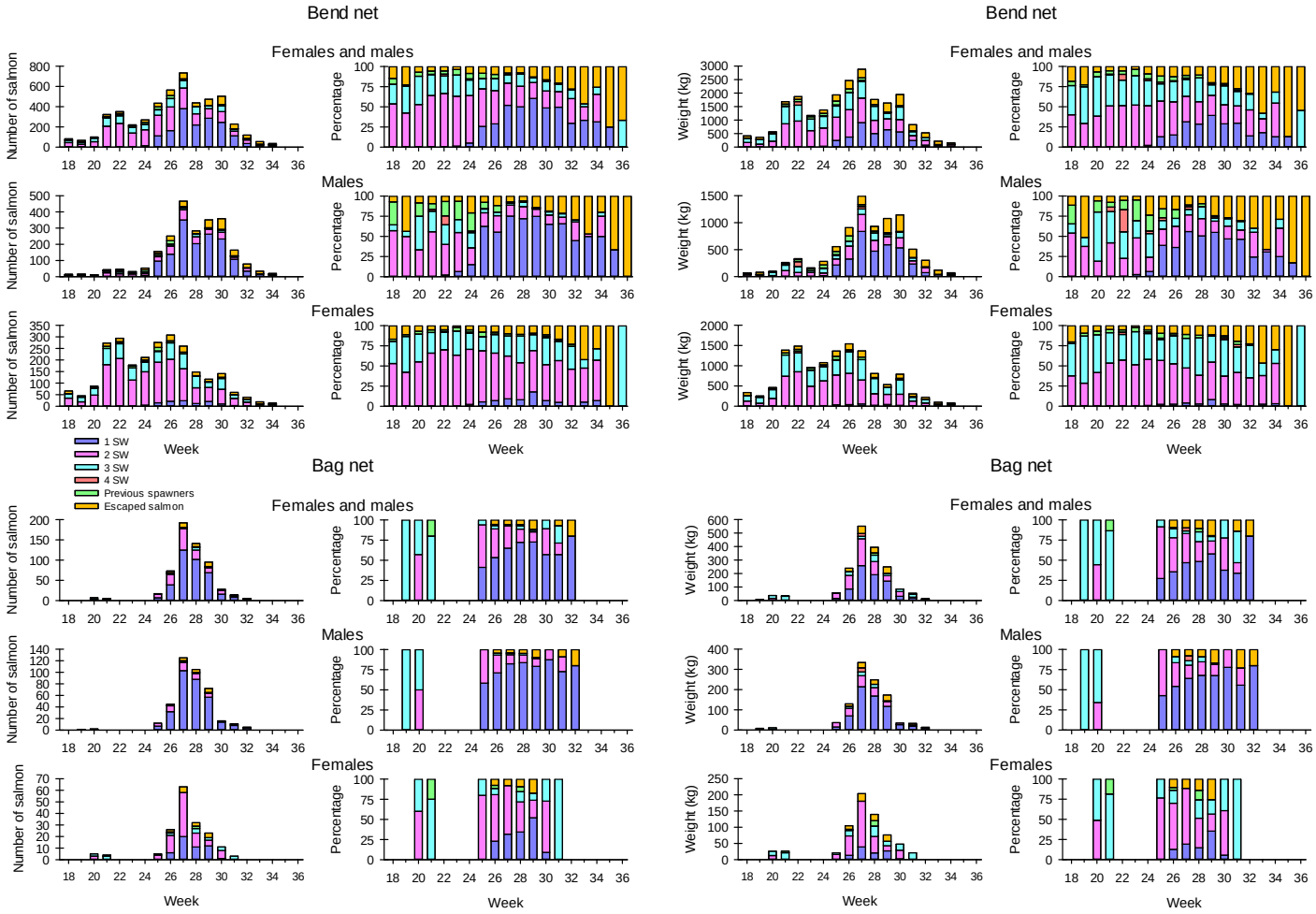


Figure 21. Weekly salmon catches in terms of numbers (on the left) and in weight (on the right) in Finnmark county in bend nets and bag nets in May-September.

Figure 21 illustrates the weekly catches and sea-age distributions in Finnmark for bend nets and bag nets. Especially bend net catches are indicating migration patterns during the entire summer period. There might be some but minor migration also before May especially in female MSW salmon. Salmon catch caught only with bag nets in Finnmark doesn't explain the migratory patterns of wild 1-4SW salmon, previous spawners or escaped salmon due to the limited period when fishermen are using it nowadays.

5. Many sea-ages in each of the three size groups of salmon

In the Norwegian official catch statistics salmon smaller than 3 kg has been understood to be a fish with the sea-age of 1 sea winter. So is the case in general manner. Salmon of the age of 2SW has been combined to belong to the size group of 3-7 kg salmon and salmon of 3SW to the size group of larger than 7 kg fish. The growth of salmon at sea, however, has varied annually a lot and also declined in the latest years and therefore some 2SW fish are belonging to the smallest size group as well as some previous spawners and escaped salmon (Figure 22). Most of salmon belonging to the size group smaller than 3 kg which were caught before the week 25 in Troms and Finnmark were actually 2SW fish. From the week 25 onwards in Finnmark and week 26 onwards in Troms most of salmon belonging to the size category smaller than 3 kg were really 1SW fish coinciding with the time period of 1SW fish migrations between c. June 15. and August 4. The size category 3-7 kg fish includes salmon of 1SW, 2SW, 3SW, previous spawners and escaped salmon with varying proportions throughout the summer and the weekly age distributions are almost the same in Troms and Finnmark. Throughout the entire summer the maximum percentage of 2SW salmon within the weekly catches of 3-7 kg salmon was c. 75% and the rest 25% was covered with 3SW, previous spawners, and escaped salmon, and in the end of the official fishing season also with 1SW salmon. During the 3-4 last weeks of the official fishing time before August 4th c. 30% from the salmon catches in the size category of 3-7 kg fish were escaped salmon in Finnmark (Figure 22). In Troms County in the size category of 3-7 kg the proportion of 2SW salmon declined steadily from the very beginning of July of 70% towards August 4th to smaller than 20%. In Troms county in the end of July and begin of August the proportion of escaped salmon was as high as 70% from the fishes in the size category 3-7 kg salmon. In West Finnmark the proportion of escaped salmon was in the size group of 3-7 kg salmon even 50% in the middle of July and stayed c. 40% to the end of official fishing season (Figure 23).

Figures 22 and 23 are indicating that it is necessary to cover the entire official fishing time in scale sampling if and when estimating the weekly and seasonal numbers of wild 1-4SW salmon, previous spawners and escaped salmon from the official catch statistics, where catches have been reported separately for the size groups of <3 kg, 3-7 kg and >7 kg salmon. If assuming that all the fish in the official catch statistics which are belonging into the size group smaller than 3 kg are 1SW salmon, or all fish in the size group of 3-7 kg are 2SW salmon, that is resulting to wrong conclusions when estimating f. ex. the status of salmon stocks especially for 2SW and 3SW salmon.

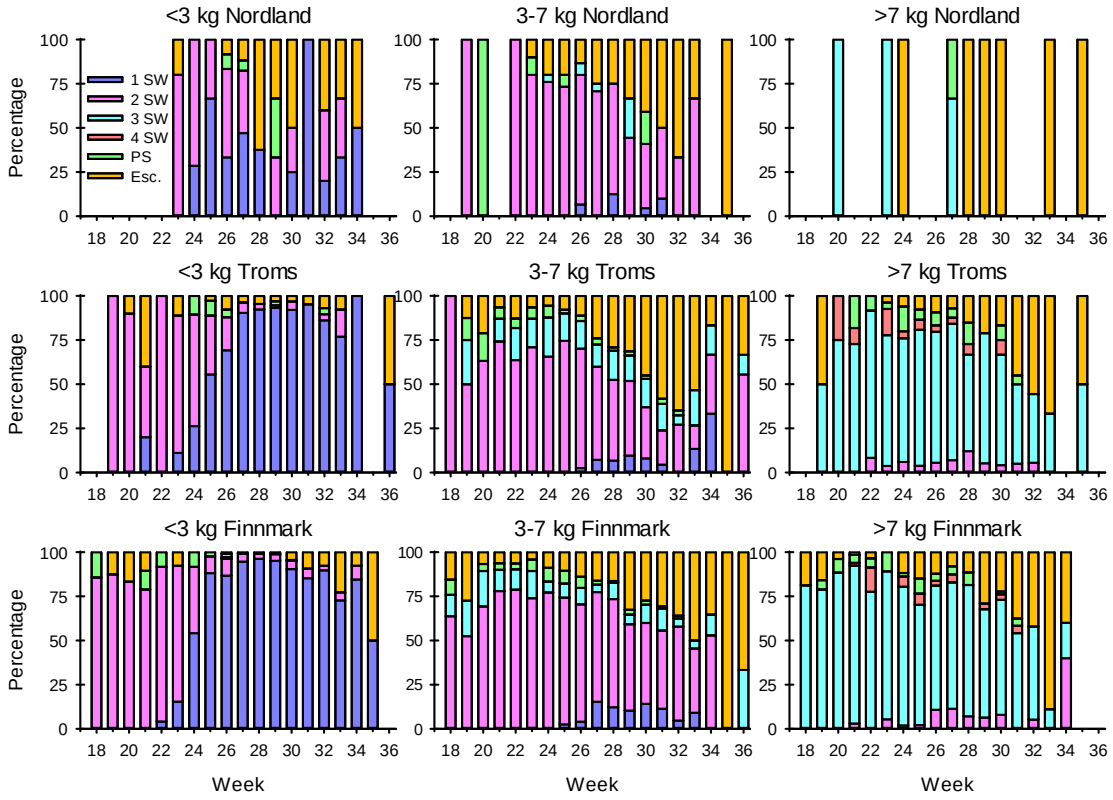


Figure 22. Sea age distributions in three size groups of salmon in terms of numbers in Kolarctic area

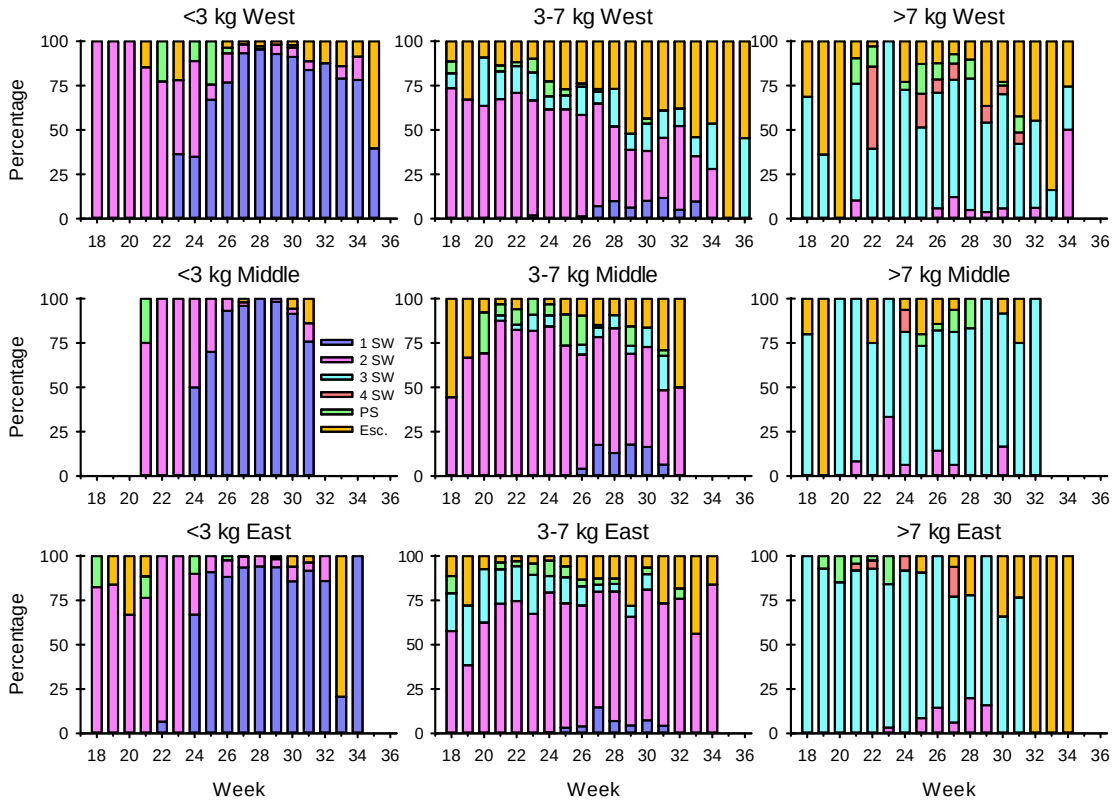
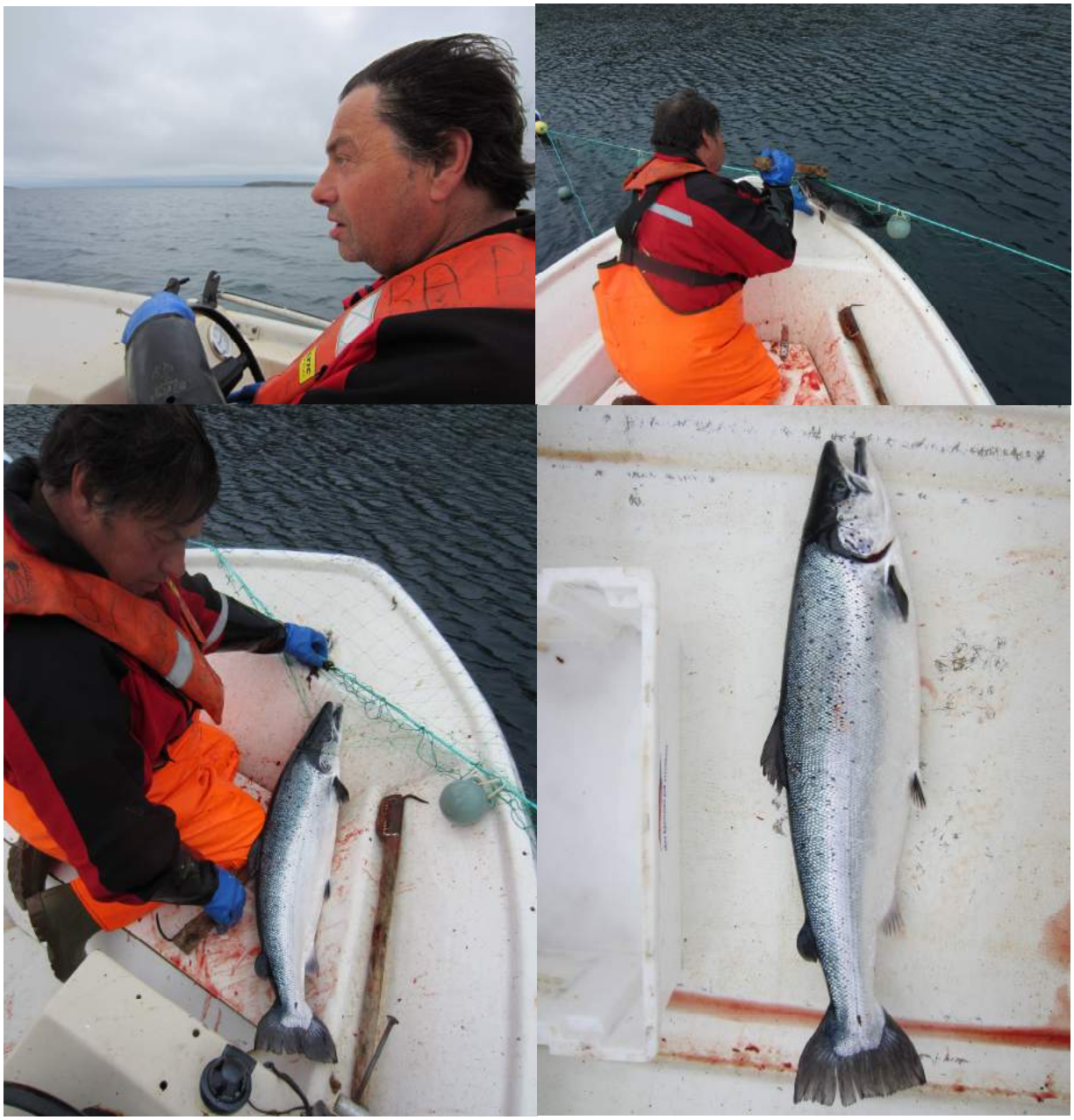


Figure 23. Sea age distributions in three size groups of salmon in terms of numbers in Finnmark

The proportions of sea-age groups among salmon below three kilos are about the same in West-, Middle- and East-Finnmark throughout the entire migratory period between May to the end of August (Figure 23). In the size group of 3-7 kg salmon there are higher proportions of escaped salmon in West-Finnmark than in Middle- and East-Finnmark throughout the entire summer. Remarkable information from the research fishery in the year 2011 was that in West-Finnmark almost 50% from salmon belonging into the size group of 3-7 kg was escaped salmon from the middle of July onwards.



Photos 34-37. Josef Samuelsen, Porsangerfjord, Repvåg, on the way to his bend net. All the fishermen have to wear lifebelts for security reasons. He caught nice looking, median size, male salmon, but unfortunately it was escaped salmon. Samuel is driving every morning and evening to his fishing site, which is c. 3 km from his home. Some fishermen have to drive even 20-40 minutes to their fishing sites.

6. Sex distributions of wild and escaped salmon

Knowledge on the sex ratio, proportion of females especially, in wild 1-4 SW salmon, previous spawner and in escaped salmon catches is one of the most important ecological factors related closely to the juvenile production. It is used closely or should be used as an argument in the much better and successful management of salmon fishery when reducing spatially and or temporally exploitation towards the weakened stocks at sea and in the rivers.

The material from salmon collected in Kolarctic project concerning sex ratios covers the entire migratory period of salmon in the coastal areas and hence it indicates reliably the mean values for each age groups presented here. In Nordland County the proportion of females exceeded that of males in the total wild salmon catches and main reason to that was low number of samples indicating that sampling was not representative in that area (Table I). In Troms and Finnmark females and males in the total wild salmon catches represented equal proportions between the counties. In the entire Kolarctic area males were major sex in 1SW salmon (89%) but females represented with 78% in 2SW and with 83% in 3SW salmon and males exceeded females in 4SW salmon with the proportion of 54% (Figure 24). These sex ratios are indicating the mean values from the entire salmon migratory period between May and September and during the ordinary, much shorter fishing season values are not the same and might differ between Nordland, Troms and Finnmark due to different official fishing seasons. In 1SW salmon the proportion of females declined with the increasing latitude; in Nordland, Troms and Finnmark 1SW females represented with 23%, 15% and 8%, respectively, but the female proportions increased towards north in escaped salmon being 32%, 44% and 40%, respectively. The higher proportion of females in 1SW salmon in Nordland and Troms compared to Finnmark might be caused from the fishing method used. In Nordland and Troms the only method allowed in salmon net fishery at sea is bag net which is usually equipped with small 58 mm mesh sized net. Therefore bag net is selecting smaller 1SW salmon where the proportions of females are exceeding the proportions of males. In Finnmark, however, the usual fishing method is bend net with larger mesh sizes than which is used in bag nets and these bend nets are therefore selecting larger 1SW salmon where the proportion of males is exceeding that of females. Interesting, the proportion of males increased in previous spawners towards north indicating maybe better survival for especially 1SW males in post-spawners in Finnmark. In Finnmark the proportions of females in 2SW and 3SW salmon were 78% and 83% and in Troms county 72% and 82%, respectively.

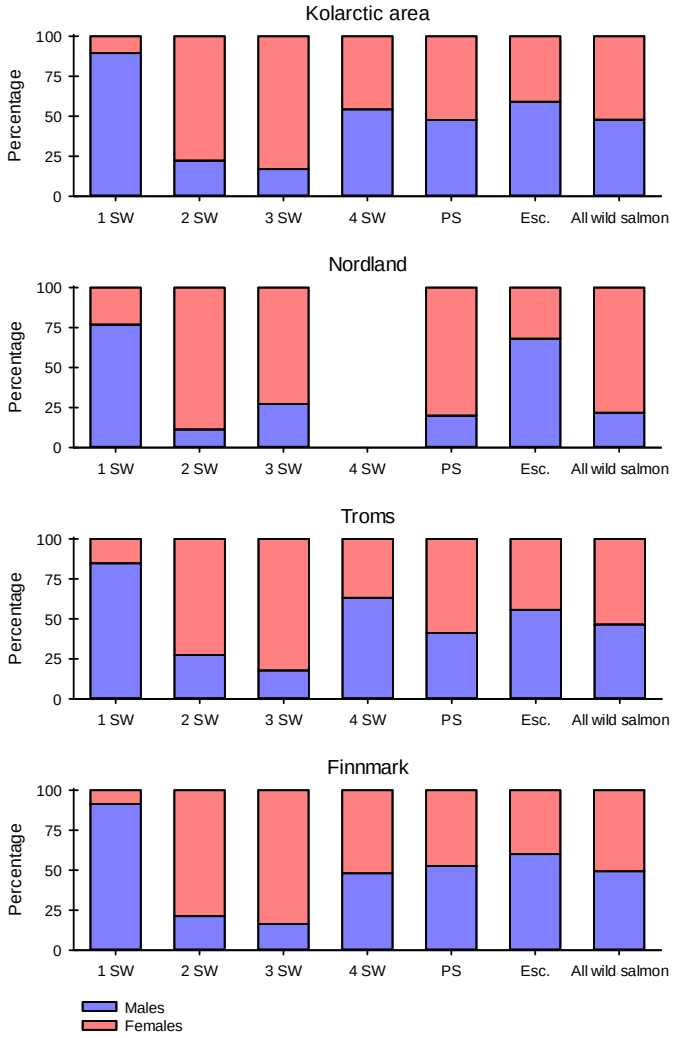


Figure 24. Sex distributions for wild 1SW, 2SW, 3SW, 4SW and previous spawning salmon, for escaped salmon and only for all wild salmon all sea- ages combined in three areas in Northern Norway and in the whole Kolarctic area between May and September.

Photos 38-39. Female salmon on the left has gonad in spawning condition for the year 2011 (eggs are filling most of the body cavity) indicating that she was on the way to her home river. Female salmon on the right has gonads in a low development stage indicating that she was not going to spawn during this summer.

Maybe this female salmon (photo 39) was on the way to ascend her home river this year and stay there over the winter and have spawning next year.

Sex distributions changed throughout the entire migratory period in all wild salmon age groups and also in escaped salmon towards the majority of males in the end of summer (Figure 25). Females had clear majority especially in 3SW salmon but they had high proportion also in 2SW fish early in the summer. This indicates that female salmon generally ascended to the coastal areas clearly before the ascending of males. Males were almost exclusively in 1SW salmon migrating in the coastal areas later in the season. Interesting, females also in escaped salmon, were the major sex during the whole May month like in wild 3SW salmon. In all the wild salmon catches sea-ages combined females dominated clearly until the June 15. with c. 80% from the numbers of salmon followed by the steady declining in the proportion later on in June and early July. During the second week of July and thereafter the proportion of females in the entire wild salmon catches stayed c. 25% to the end of September.

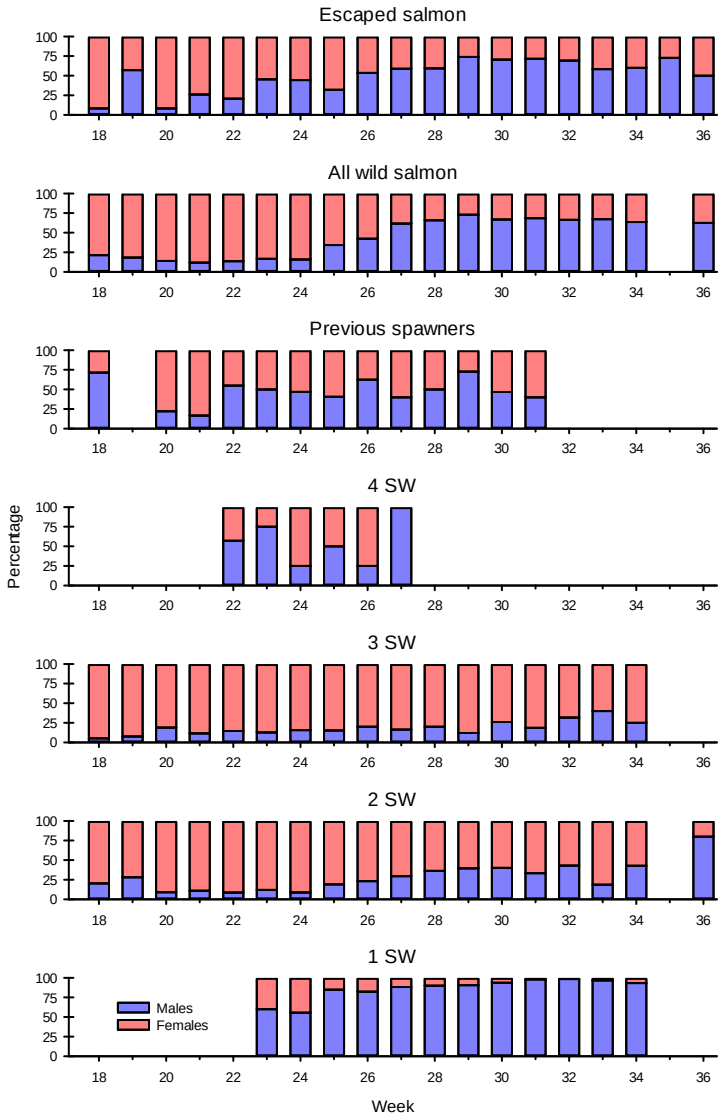


Figure 25. Weekly sex distributions for wild and escaped salmon in Kolarctic area.

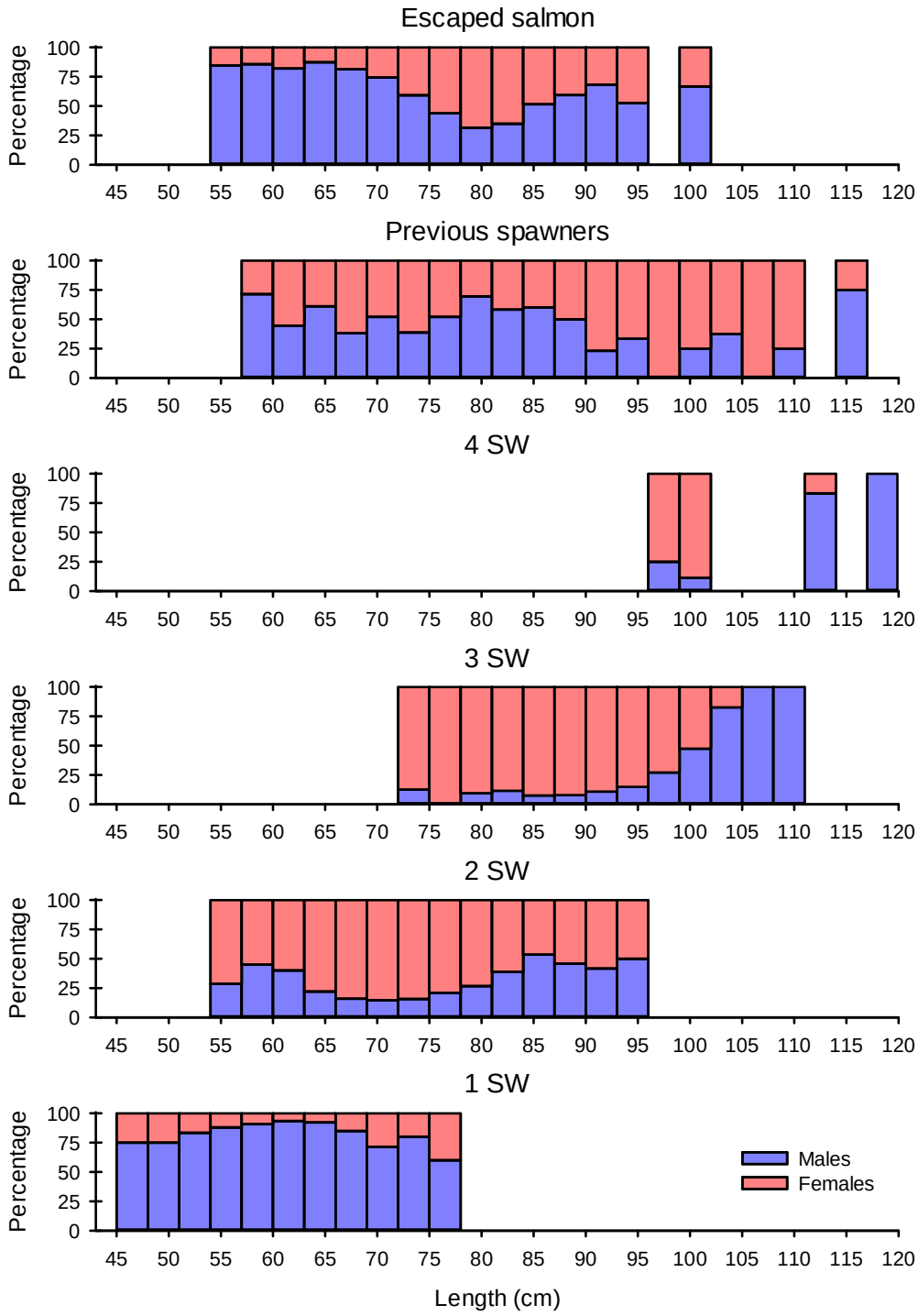


Figure 26. Sex distributions for 1-4SW salmon, previous spawners and escaped salmon according to the lengths in 3 cm intervals.

Sex ratios are changing in each of the sea-age groups of salmon along the length of fish and that is most pronounced for 3SW salmon where the largest fishes were only males but females exceeded males clearly in smaller 3SW salmon (Figure 26). Within the smallest 1SW salmon (below 55 cm) the proportion of females was 25% but decreased to 5% in 1SW salmon with the length between 55 cm and 65cm. Also in 2SW salmon the proportion of females declined with the increasing length of fish.

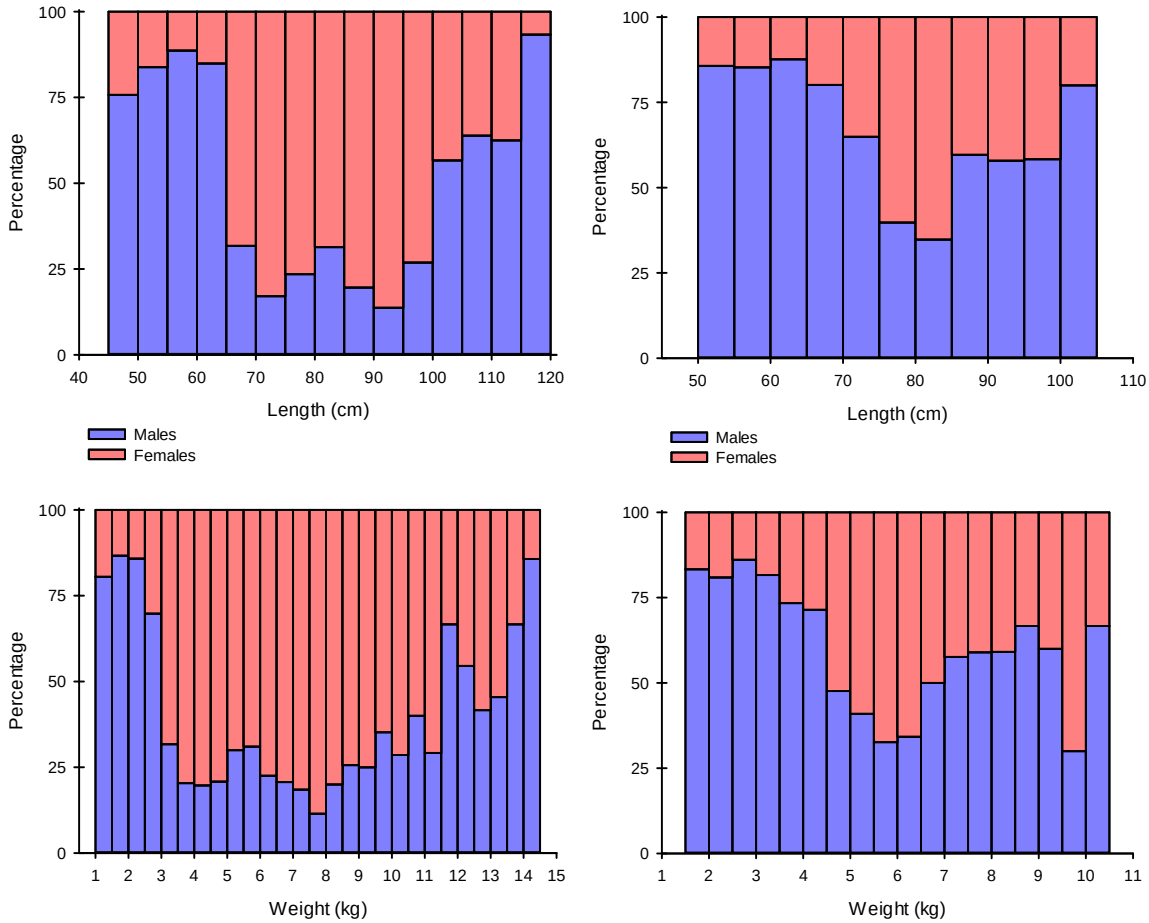


Figure 27. Sex ratios for wild salmon (first time spawners and previous spawners) (figure on the left) and for escaped salmon (figure on the right) against length and weight.

The proportions of females are varying a lot against the length and weight of wild salmon (Figure 27). In general, the occurrence of females was low (c. 20%) in salmon smaller than 3 kilos corresponding the length smaller than 65 cm. Then females exceeded with 70%-80% the proportions of males in fish between the weights from 3 kilos almost up to 11.5 kilos. The proportions of females declined clearly after salmon reached the size of 12 kg and length of more than 100 cm.

Sex ratios in escaped salmon are different in most of the size groups compared to wild salmon although there are not so big differences in the proportions of females between all wild and all escaped salmon catches in Kolarctic area (see the Figure 24). The highest proportion of females was in the size group of 5.5-6.5 kg escaped fish being close to 65%.

Photos 40-41. To use the oldest type of coastal fishing method, bag net, is energy demanding. Here Finn-Hjalmar Seipæjærvi is catching salmon in Bygøynæs in Varangerfjord area and he caught a small lumpfish, as a by catch.

Photos 42-43. Salmon fishermen can have quite often in July also Pacific salmon in their fishing gears like also sometimes there can be a surprise with some hundred kilos or even 1-2 tons of saithe/ pollock in bag net. In the left photo there are three smaller Pacific salmon and one wild Atlantic salmon caught in Varangerfjord. In the right photo there are two Pacific salmon, one Atlantic salmon, one cod and one saithe. In many cases fishermen do not recognize Pacific salmon from Atlantic salmon and therefore they are included into the catch reports to Atlantic salmon.

7. Length and weight of salmon

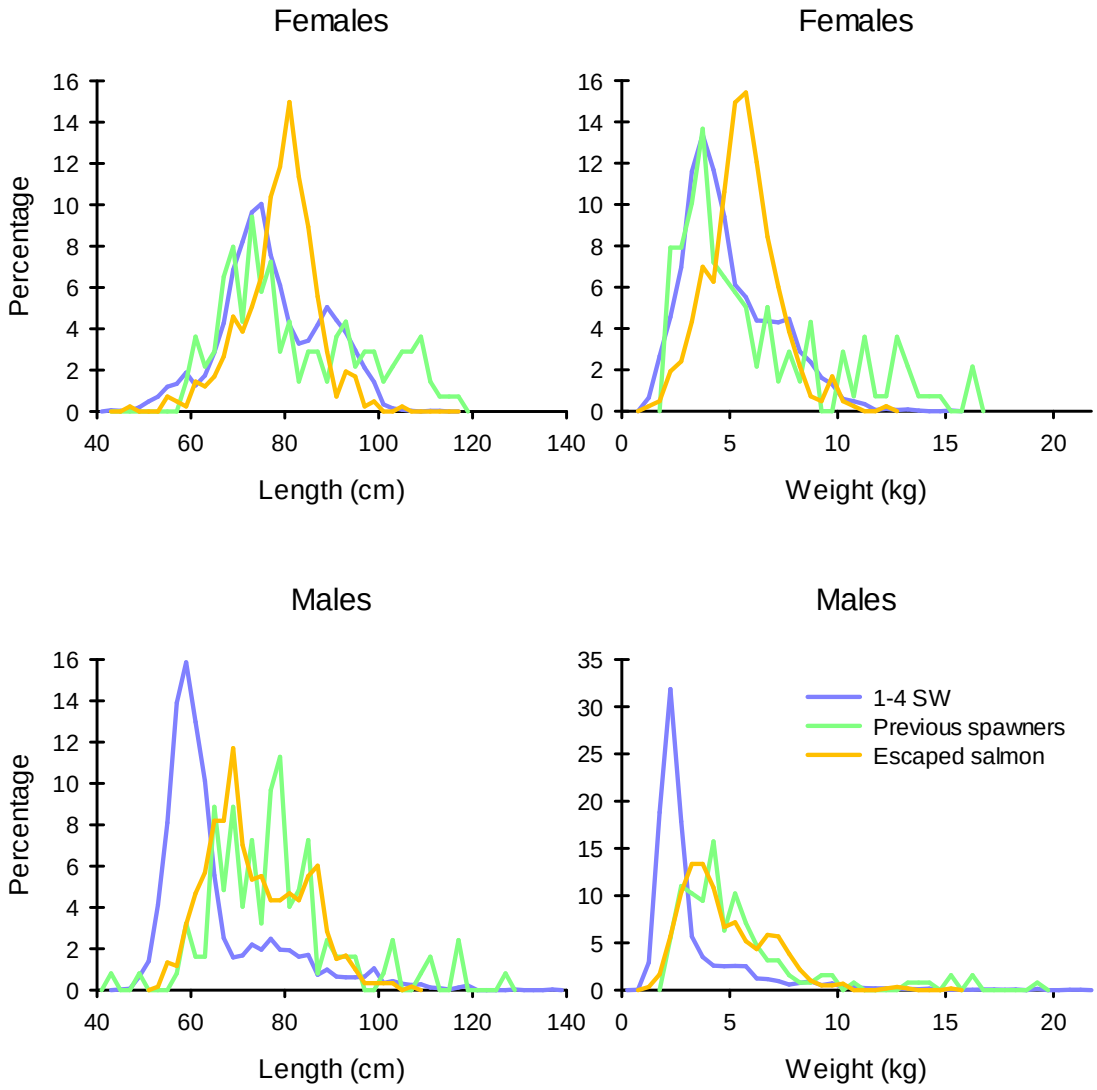


Figure 28. Length and weight distributions for wild 1-4SW salmon, previous spawners and escaped salmon in the Kolarctic area at sea.

Length and weight distributions are differing between females and males in wild salmon (Figure 28). Reasons for that are the differences in the sea-age distributions between sexes. Small sized 1SW salmon in male salmon catches are more numerous that in females where 2SW and 3SW salmon are making the majority. In the length distribution of wild female salmon three size groups can quite clearly be identified but in male salmon only one clear size group can be separated. In length and weight distributions of female escaped salmon there is only one peak but in the distributions of males there are two peaks. Length and weight distributions of previous spawners are almost the same compared to wild salmon in females but these distributions are differing clearly in male salmon.

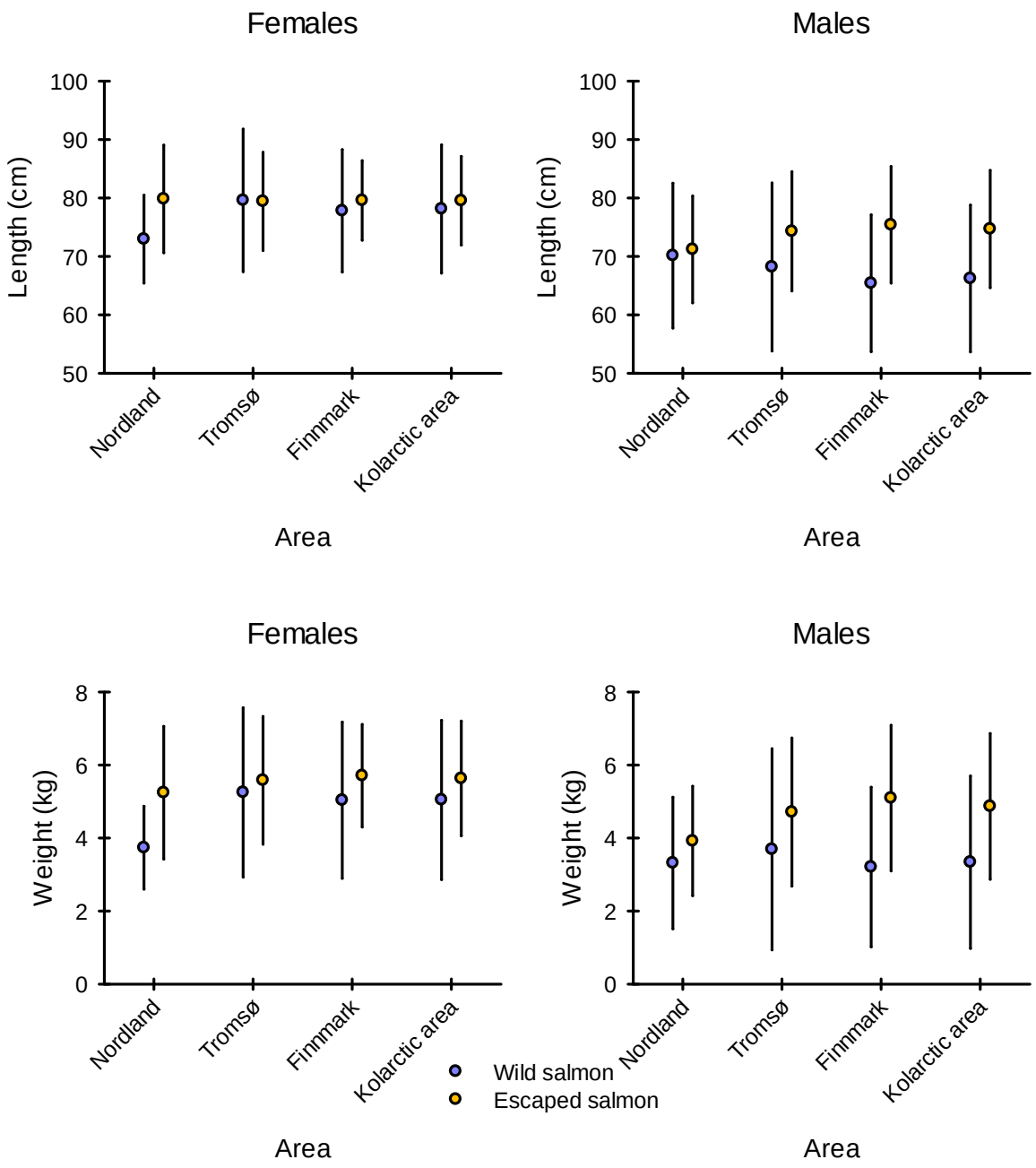


Figure 29. Mean lengths and weights of wild and escaped salmon in Kolarctic area.

In Troms and Finnmark the mean lengths of escaped male salmon were clearly larger than for wild salmon material from the entire summer combining. Material from Nordland was too small to make conclusions from the differences between lengths and weights for wild and escaped salmon. The mean weights especially for escaped males were much larger than those for wild males (Figure 29).

Photo 44. Sometimes the length of guiding net is up to 150 or even 200 meters. The length depends on the water depth, bottom structure and local/ traditional knowledge at the fishing site. All the fishing sites are registered and numbered. Sites have been used over tens of years or sites for bag nets have even more than 100 years in use in the same places. It could be possible that salmon shoals following the shore lines and meeting the long nets from shore to the active catching net in the outer end of the system are then swimming slower and more careful. Still early 1980's but especially between 1950-1970's there has been more fishing systems in the coastal areas of Kolarctic area compared to the numbers today and that might have affected temporally to the migrations.

Photos 45 a, b and c. In some sites the effective fishery needs only a sort guiding net. Fisherman is measuring the fish and taking the scale sample.

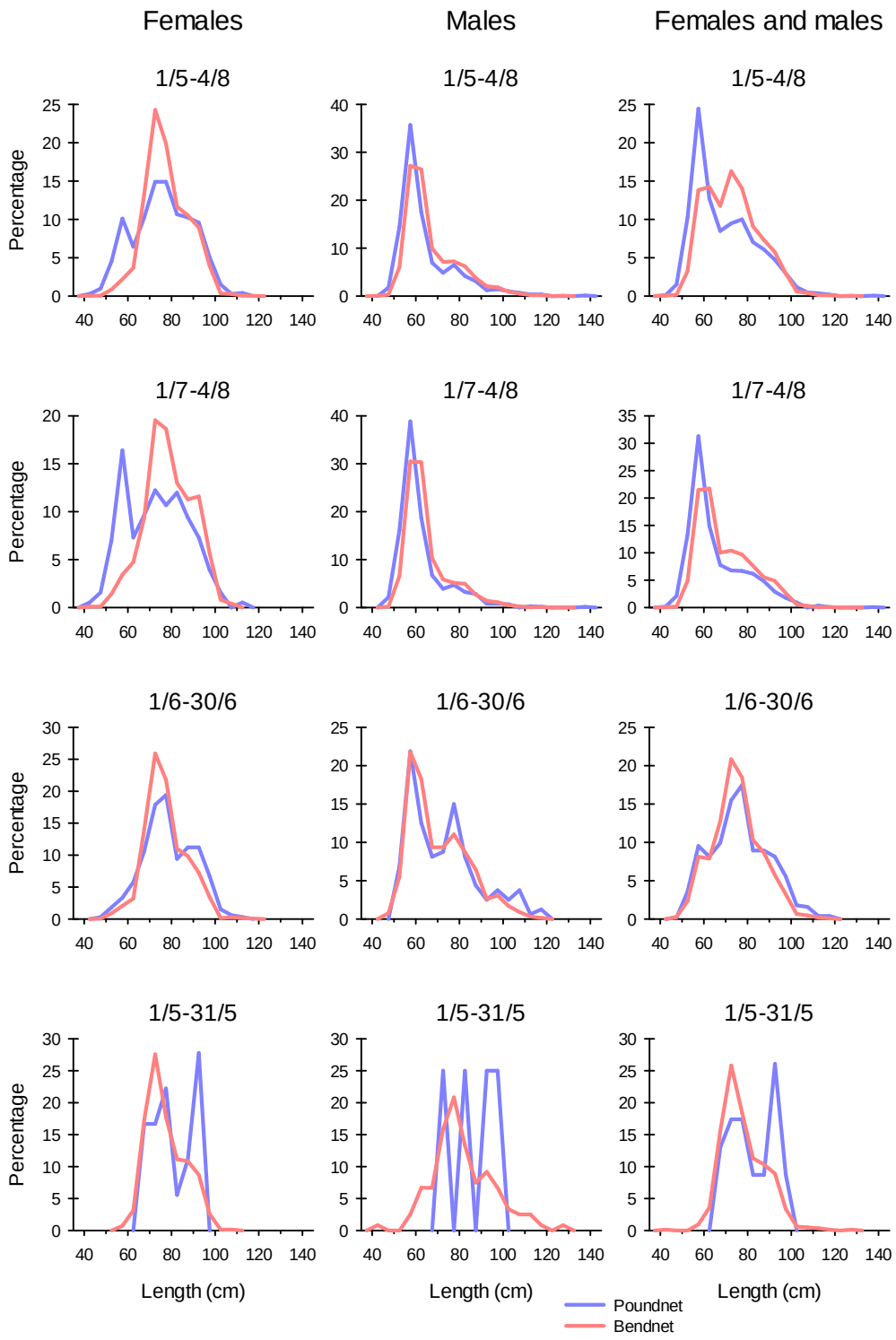


Figure 30. Length distributions of salmon in bend net and bag net catches in Kolarctic area, wild and escaped salmon combined.

Length distributions of salmon caught with bend nets and bag nets are indicating that in June there are not clear differences in the length distributions for females and males. In July, however, when smaller sized 1SW salmon is migrating in large amounts along the coasts bend nets are targeting more to larger salmon like towards 2SW and 3SW females than the bag net fishery (Figure 30). Bag net fishery in July with smaller

mesh sizes in nets is catching also small sized 1SW female salmon. From the total catch caught between May and beginning of August in Kolarctic area bend net fishery is targeting more towards larger salmon than the bag net fishery.

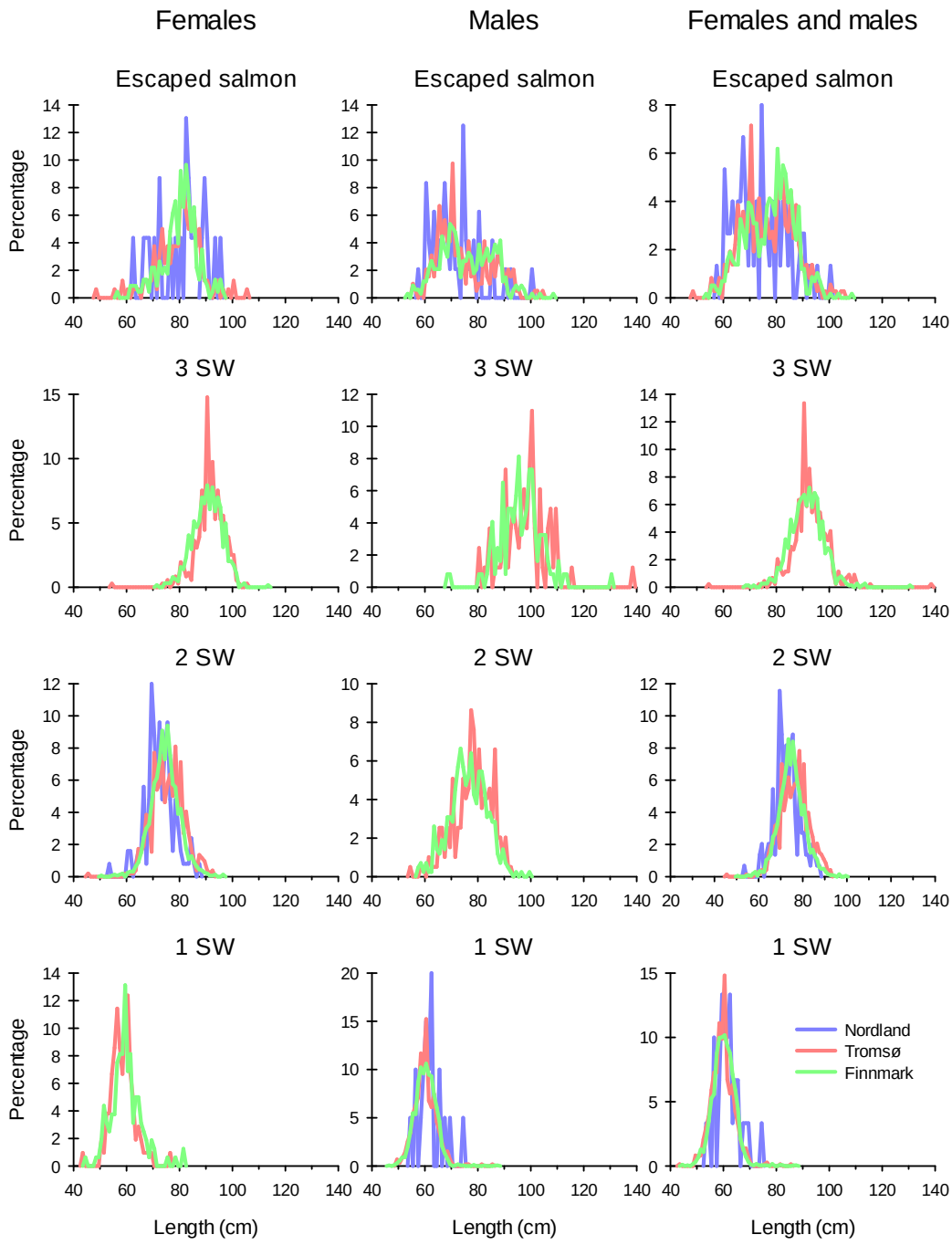


Figure 31. Length distributions of wild 1-3SW salmon and escaped salmon in Nordland, Troms and Finnmark.

In all the three counties in Northern Norway the length distributions of salmon were close to each other for the sea-age groups 1SW, 2SW and 3SW and also for escaped salmon (Figure 32). Length distributions of escaped salmon are indicating wide range and they are overlapping all the wild 1SW, 2SW and 3SW salmon length distributions.

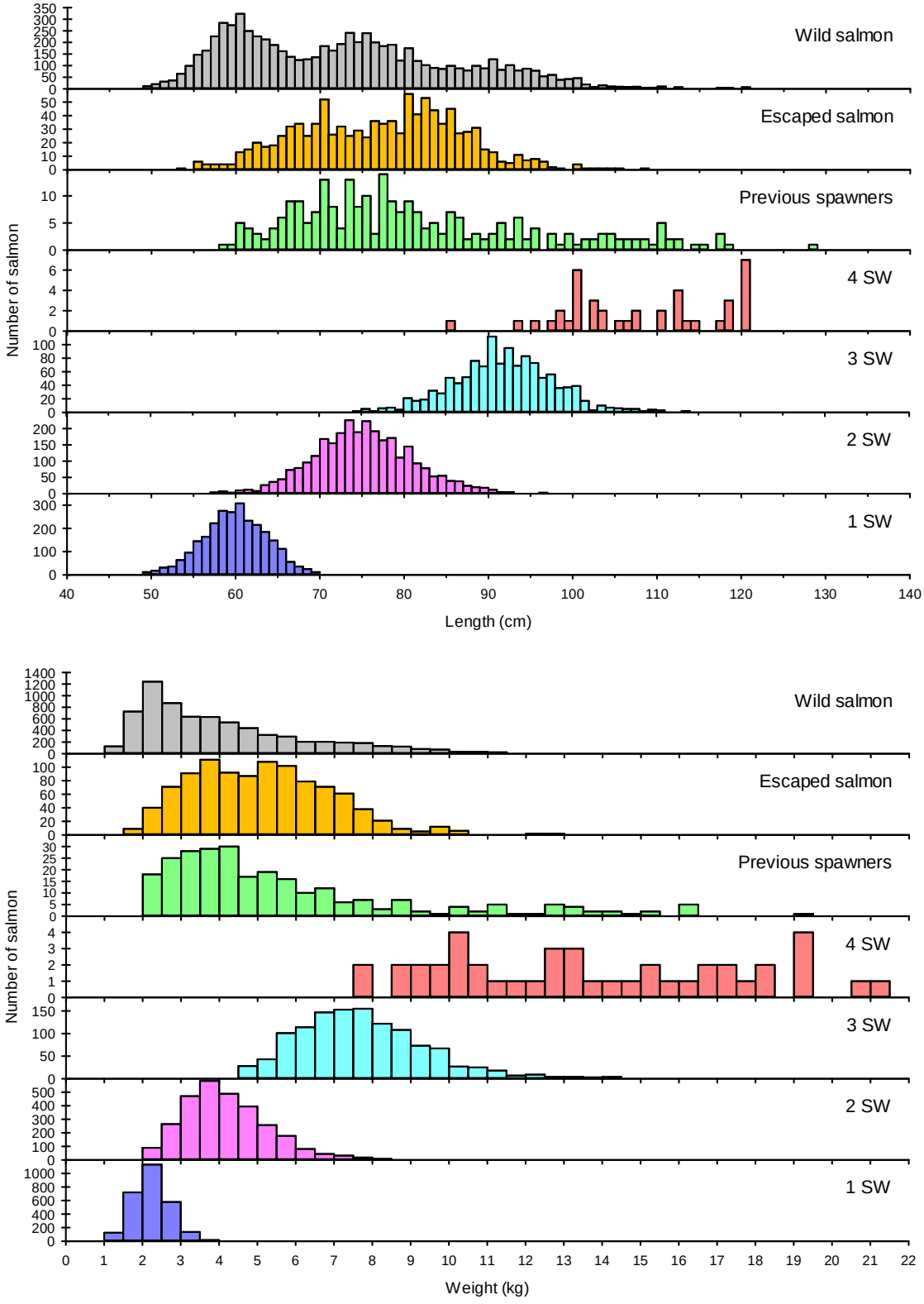


Figure 32. Length and weight distributions for wild and escaped salmon caught in May-September in the Kolarctic area.

Length distribution combining all the lengths of wild 1SW-4SW salmon is giving a crude view from the ages available in the fishery (Figure 32). There is, however, extensive overlapping in the lengths and weights between the ages of 1SW and 2SW, 2SW and 3SW, 3SW and 4SW salmon that makes it impossible to use length and weight groups to identify ages of salmon. Length and weight distributions of previous spawners and escaped salmon combined into the wild salmon distributions are increasing the difficulty of separating sea-ages in the salmon catches.

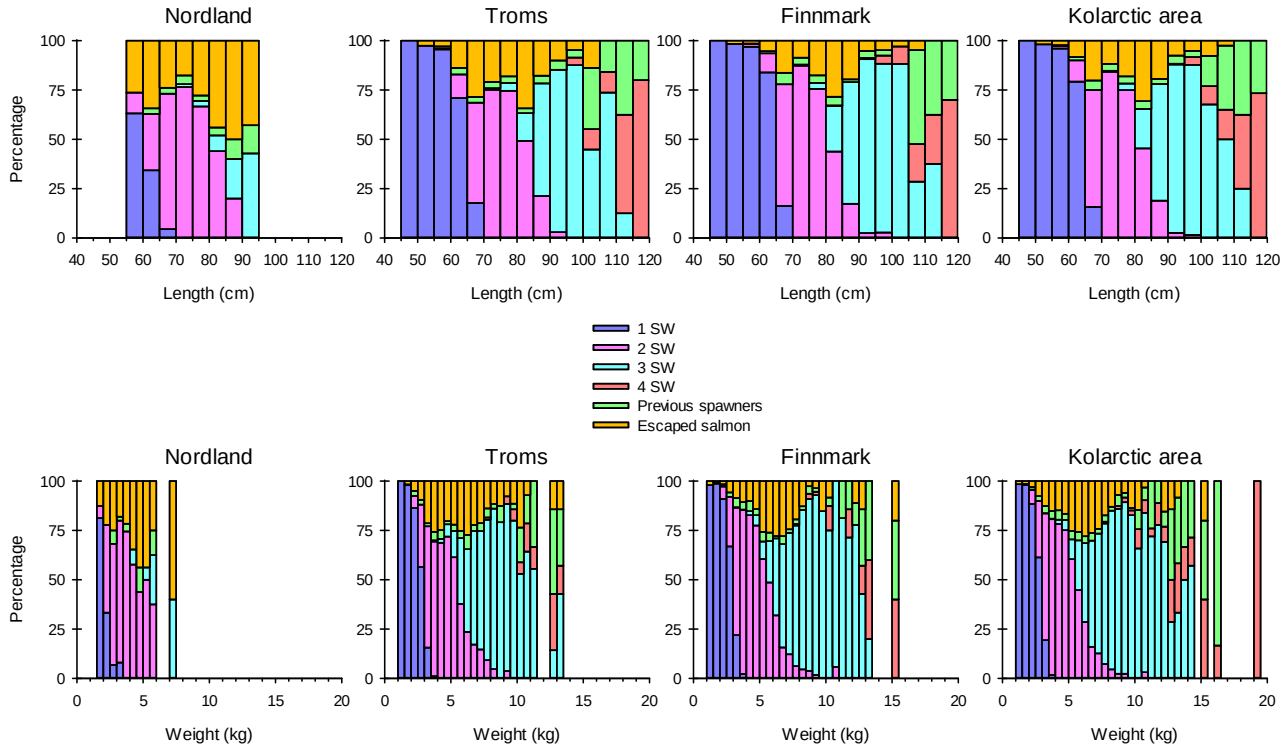


Figure 33. The proportions of wild 1SW, 2SW, 3SW, 4SW salmon, previous spawners and escaped salmon in each length and weight categories in three counties and in the entire Kolarctic area in the salmon catches caught between May and September.

There are up to four groups of salmon in the transition to larger salmon in the length and weight categories (Figure 33). The proportions of escaped salmon are covering almost all the size categories with quite high prevalence in all the counties. Escaped salmon represents with its high proportions its important occurrence within the medium sized salmon catches.

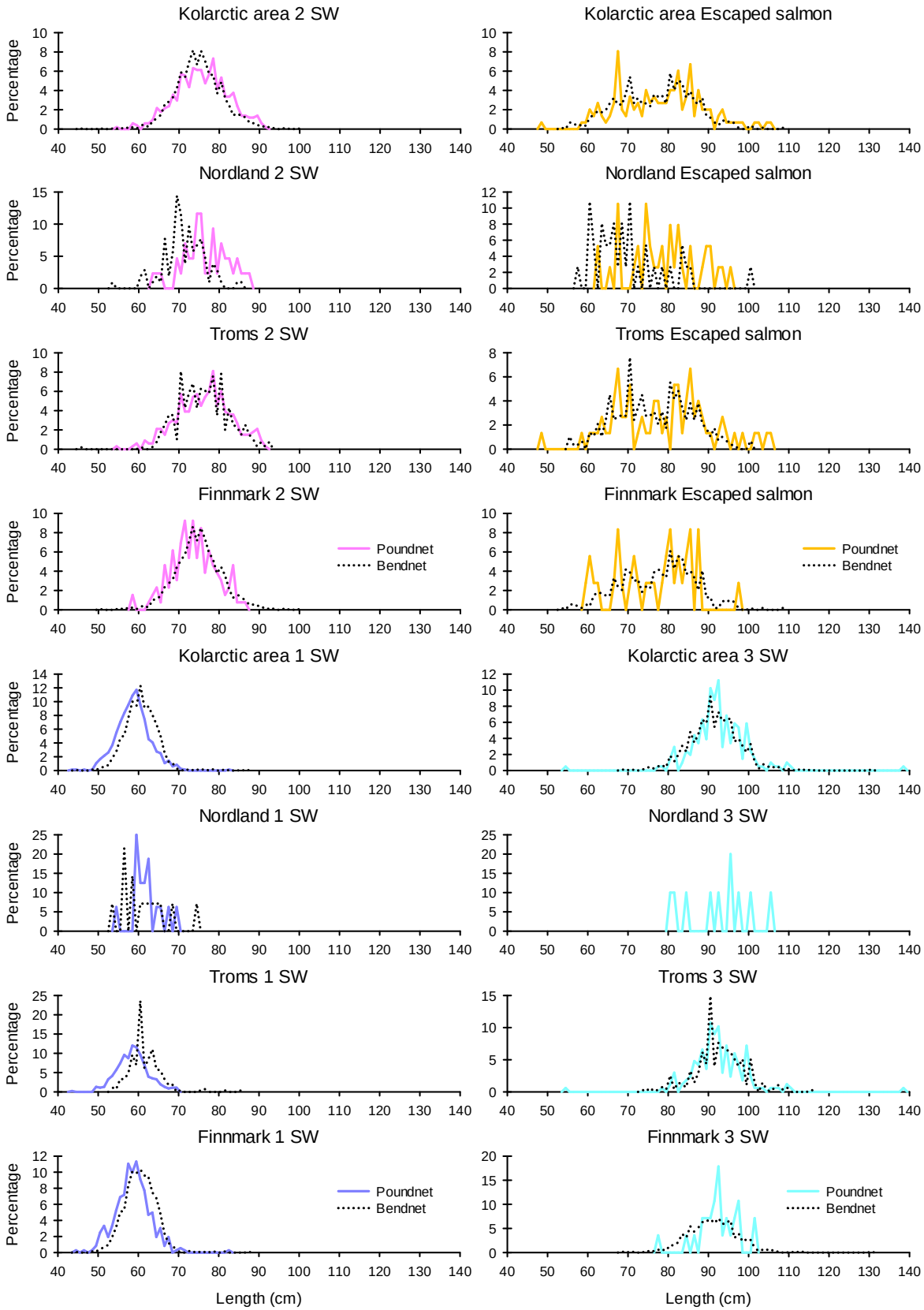


Figure 34. Size distributions of 1SW, 2SW, 3SW wild salmon and escaped salmon caught with bag nets and bend nets in Nordland, Troms and Finnmark and counties combined between May and September.

Two salmon fishing methods, bag nets and bend net, have different ways to catch fish. The ordinary and original method is bag net. It is catching salmon usually alive, at least those fishes which are larger than 1SW old. In bag nets fishes will be gathered into special chamber. The smallest 1SW fishes can escape through the mesh sizes but the largest 1SW fish will remain in the gillnet and usually die after short period.

Bend net is catching salmon with the meshes when salmon is trying to escape. Salmon is attaching into the gillnet. Fishermen are also using variable mesh sizes in the bend net during the season. Early in the season when 3SW and 4SW salmon is migrating along the coastal areas fishermen are using larger mesh sized nets to capture more effectively large salmon. Later in the season when 2SW and 1SW salmon have their migrations fishermen start to catch salmon with smaller mesh sized nets in bend net fishery. Usually the mesh sizes are from 62 mm to 68 mm between knot to knot and especially 1SW salmon can escape these nets.

The length distributions of 1SW salmon caught with bag nets and bend nets are indicating in Troms and Finnmark that bend nets are catching the largest 1SW salmon (Figure 34). Size distributions of 2SW salmon in Finnmark are indicating that bend nets are catching a little larger salmon than bag nets. In the catch of 3SW salmon and escaped salmon no clear differences can be observed in the size distributions between the two methods.

Photos 46 a, b and 47 a, b. Big waves at sea make it difficult to check the fishing gear.

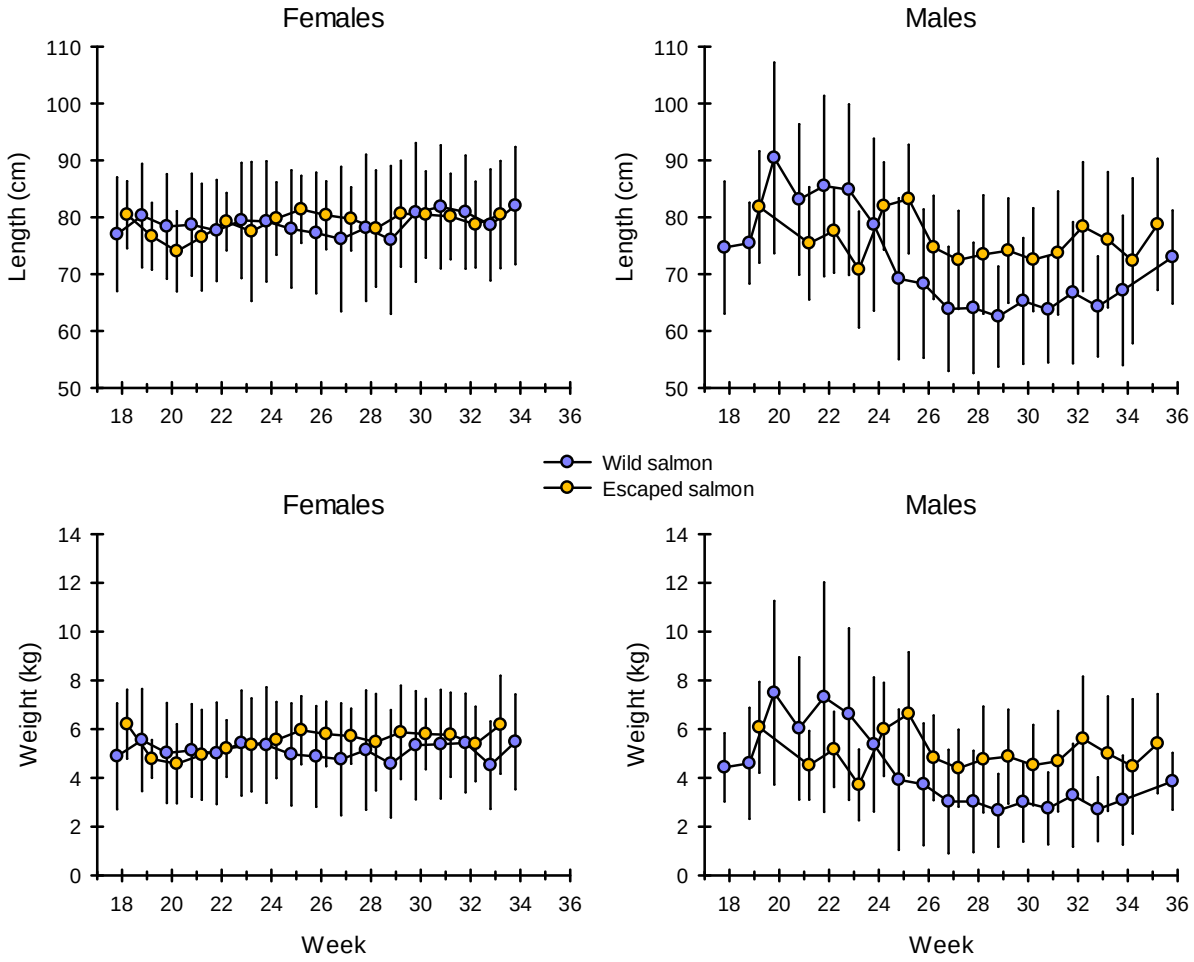


Figure 35. Weekly mean lengths and weights of wild and escaped salmon in the Kolarctic area. In wild salmon the sea- ages of 1-4SW and previous spawned salmon are combined.

The mean weekly lengths and weights of wild and escaped female salmon caught in Kolarctic area were almost unchanged throughout the period from May to September. Reason to that is the very small change in the weekly sea-age distributions during the entire migration period which could affect to the weekly mean sizes in female salmon catches (Figure 13). Especially the low abundance and thereafter the low proportion of female 1SW salmon only in the middle of the summer in the catches did not affect substantially to the mean sizes of females.

In male salmon, however, the mean weekly sizes of wild salmon declined from the week number 20 to the week number 26 and thereafter mean sizes stayed quite stable to the week 34. This declining of the mean sizes of wild salmon is caused by the high abundance and proportion of 1SW males in the catches over 8 weeks (Figure 13). In male escaped salmon the mean weekly sizes varied early in the season due to their low abundance in the catches compared to the abundance of female escapes.

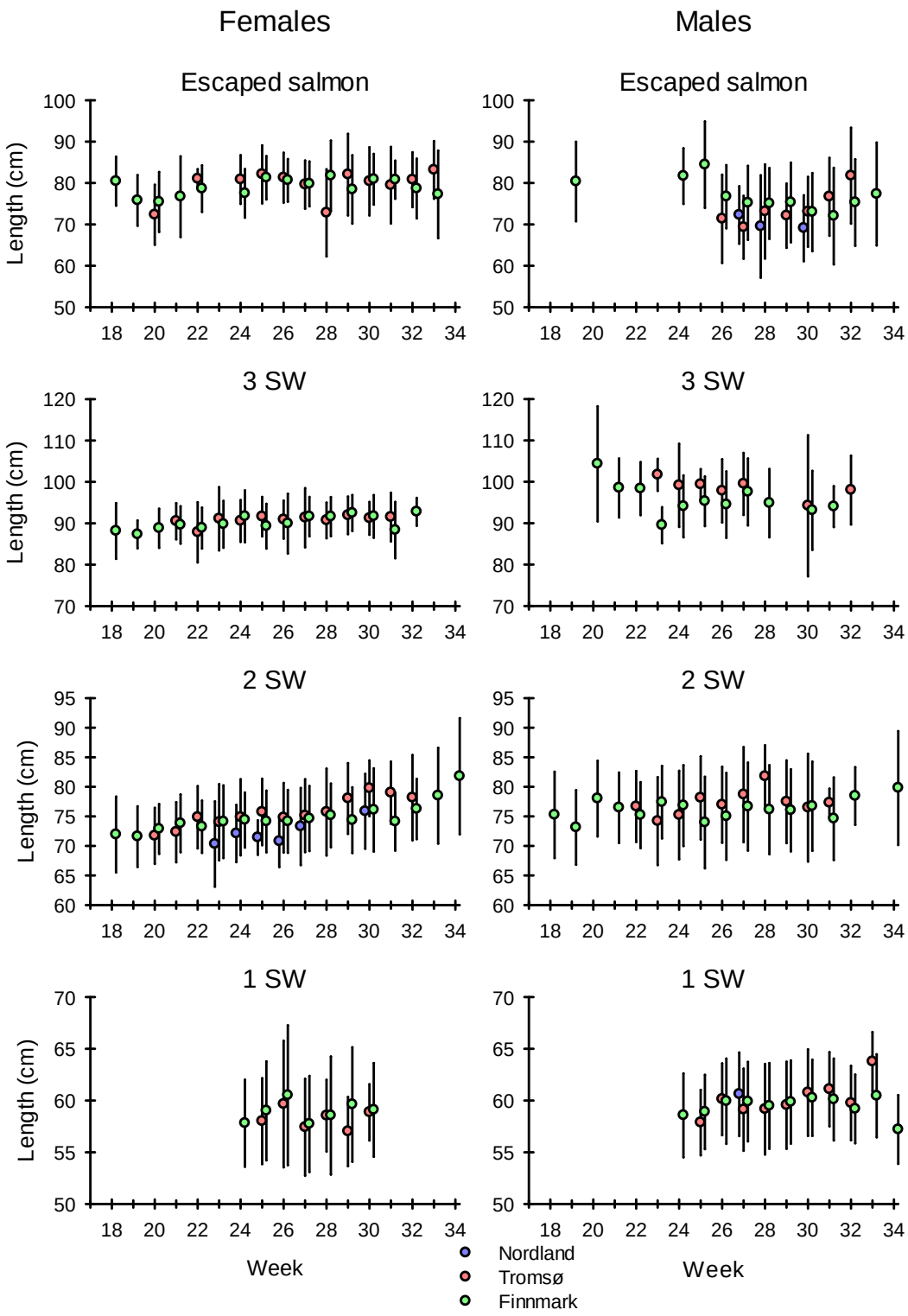


Figure 36. Weekly mean lengths of wild and escaped salmon in Nordland, Troms and Finnmark counties.

Salmon catches in the coastal areas in Nordland, Troms and Finnmark are consisting approximately from 200 salmon stocks. It is believed that each of these stocks is migrating within a quite narrow time frame along the coastal line and therefore the mean weekly sizes of salmon do not differ much in each sea-age groups. The most obvious observation was the clear increase in the weekly mean sizes of 2SW females in all

the counties (Figure 36 and 37). There was also slight increase in the mean weekly length of female 3SW fish. The larger weekly mean lengths of 2SW females in the end of the migration might be explained that those fishes were so called late running salmon and they have had some additional growth during the summer. The increase of the size towards autumn can increase the catch ability in bend net fishery especially in 1SW salmon.

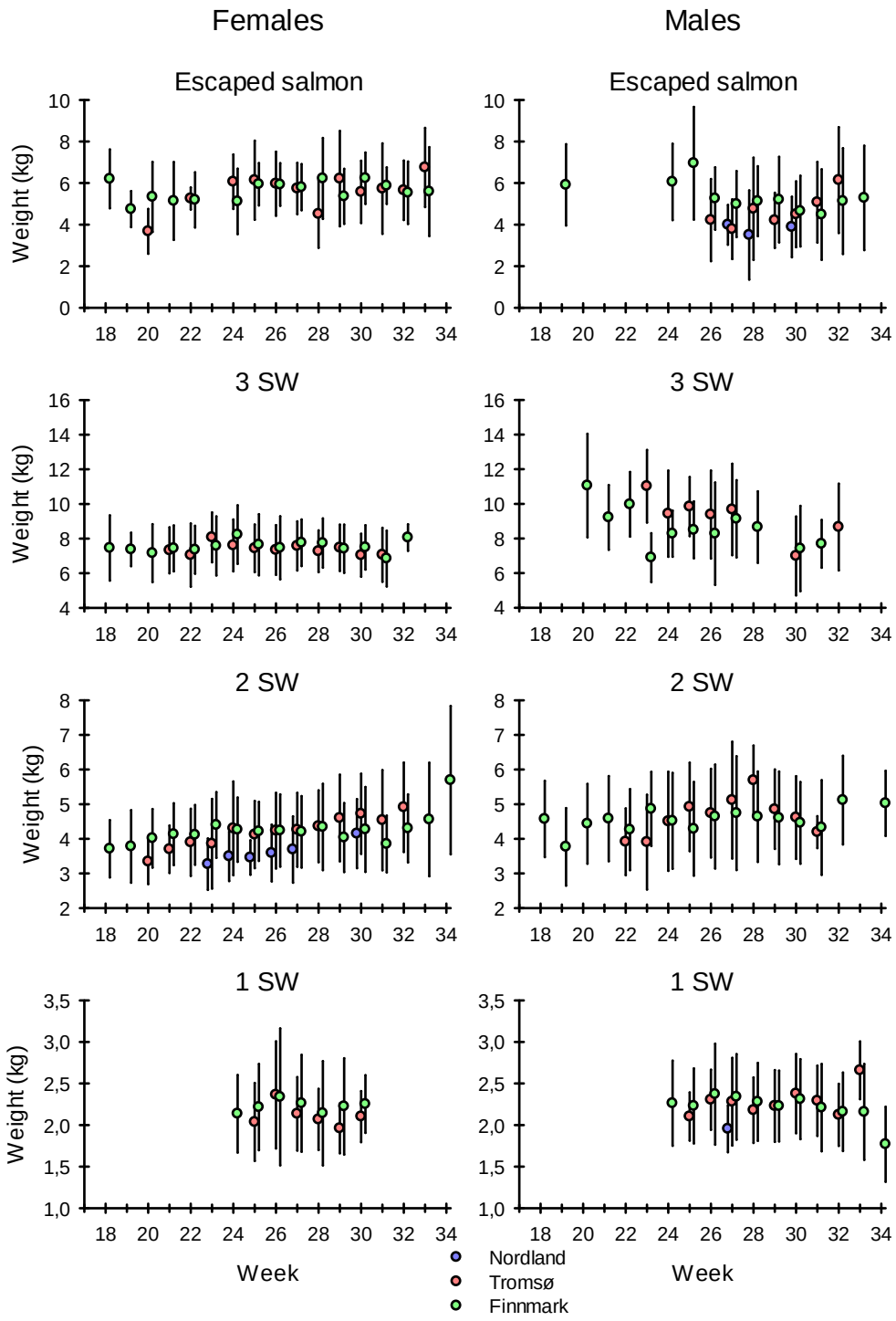


Figure 37. Weekly mean weights of wild and escaped salmon in Nordland, Troms and Finnmark counties.

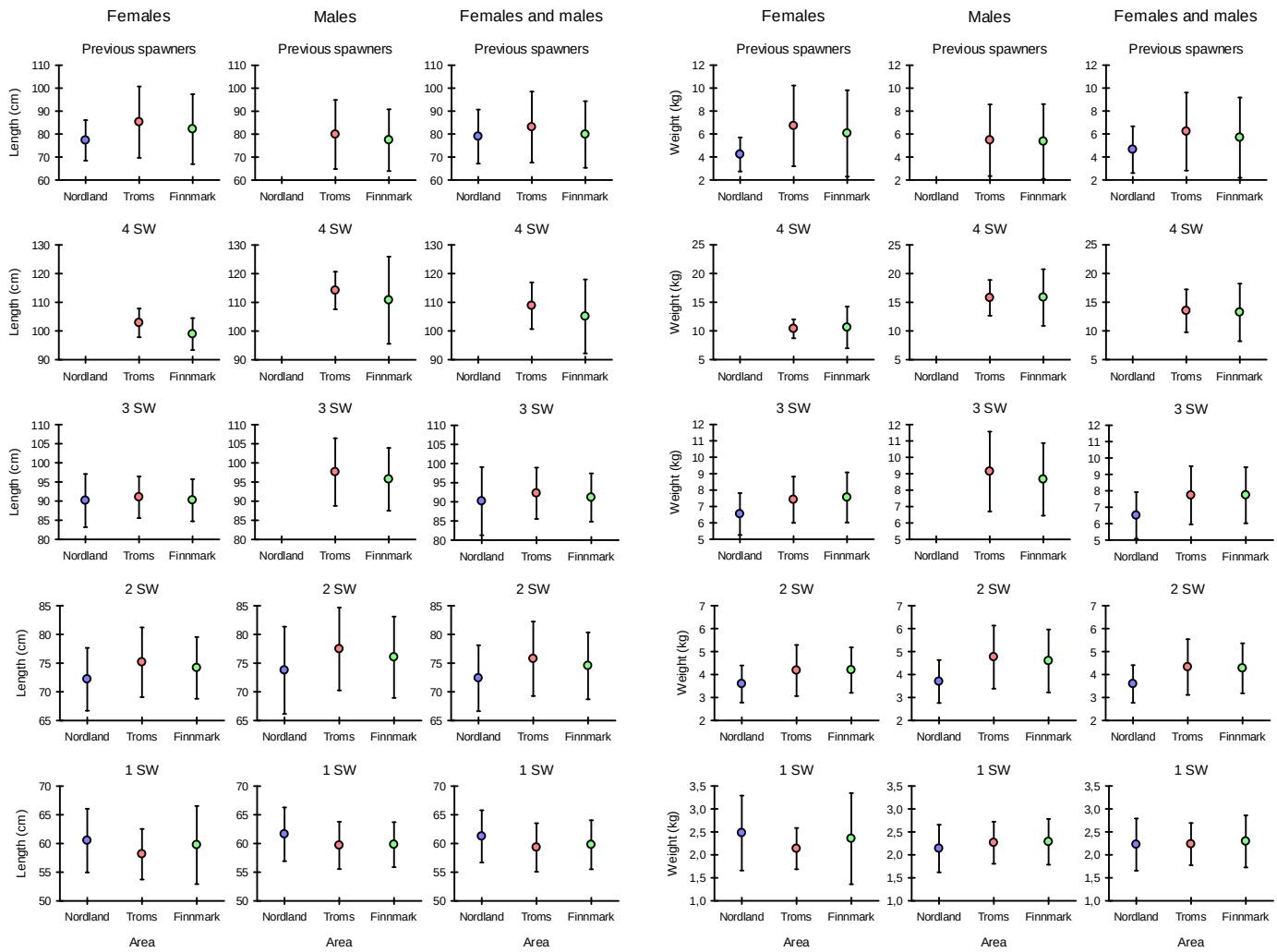


Figure 38. Mean lengths and weights of wild salmon in Kolarctic area from May to August 4.

Mean weights and lengths of wild salmon were almost the same in Troms and Finnmark for females and for males (Figure 38). Material from Nordland was too small to make comparisons.

Photos 48 a and b. Fishermen taking exact weights of salmon.

Photos 49 a and b. Most of the fishing gears used in Finnmark are bend nets (photo below) and only low percentage from the gears are bag nets (photo above). Bag net can catch fish alive because the gear has a chamber (one or two chambers), mesh size in the net is usually 58 mm from knot to knot and therefore many of the salmon stay alive in the gear. Bend net is catching salmon with the nets and fisherman can select the mesh sizes during the season and change the mesh size if smaller or larger fish are predominantly migrating.

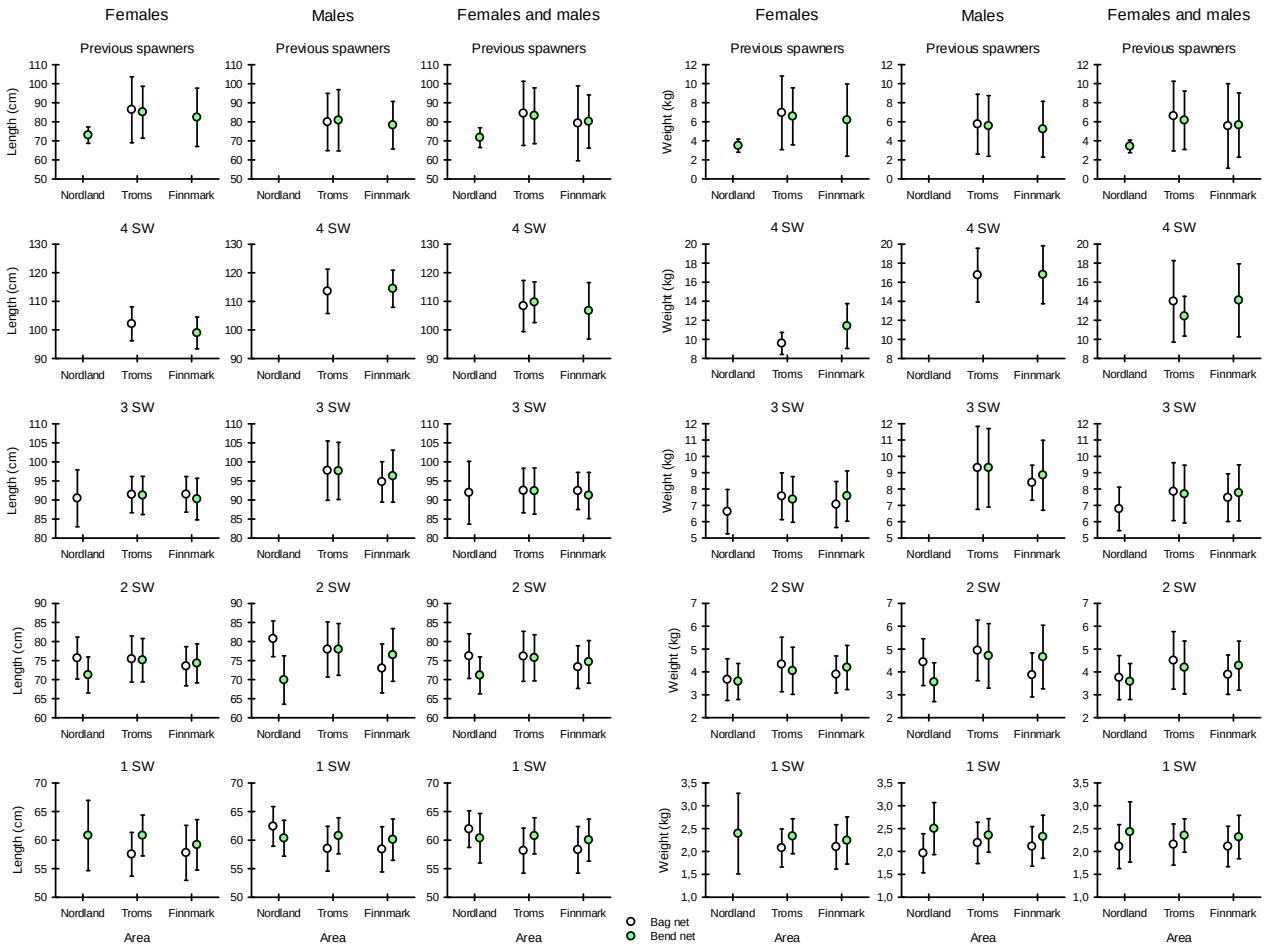


Figure 39. Mean lengths and weights of wild salmon in bag net fishing and bend net fishing in Northern Norway between May to August 4.

Photo 50. Salmon fisherman Eilif Hansen, Bygøynes, Varangerfjord, is controlling his bag net. At his fishing site the sea currents are strong.

Bend nets selected clearly larger 1SW salmon in Troms and Finnmark than bag nets in terms of length and weight of fishes (Figure 39). In 2SW salmon catches in Finnmark the mean sizes of fishes were larger also in bend net fishery than in bag net fishery. One reason to the size differences in 1SW and 2SW salmon between the fishing methods can be differences in the time when these methods were used. If bend nets were used more effectively in the end of the season than bag nets then it is obvious that they are explaining the larger sizes of 1SW and 2SW salmon. In the end of the fishing season 1SW salmon and 2SW salmon are larger than early in the summer (Figures 36 and 37) due to the additional growth during the summer.

8. Escaped salmon in the salmon fishery in Northern Norway

Photos 51-52. Cage culture of Atlantic salmon is wide spread industry in Kolarctic area having most probably negative impacts for wild salmon with regards to changes in genetics, increased diseases and parasites causing additional mortality and also with the fishery.

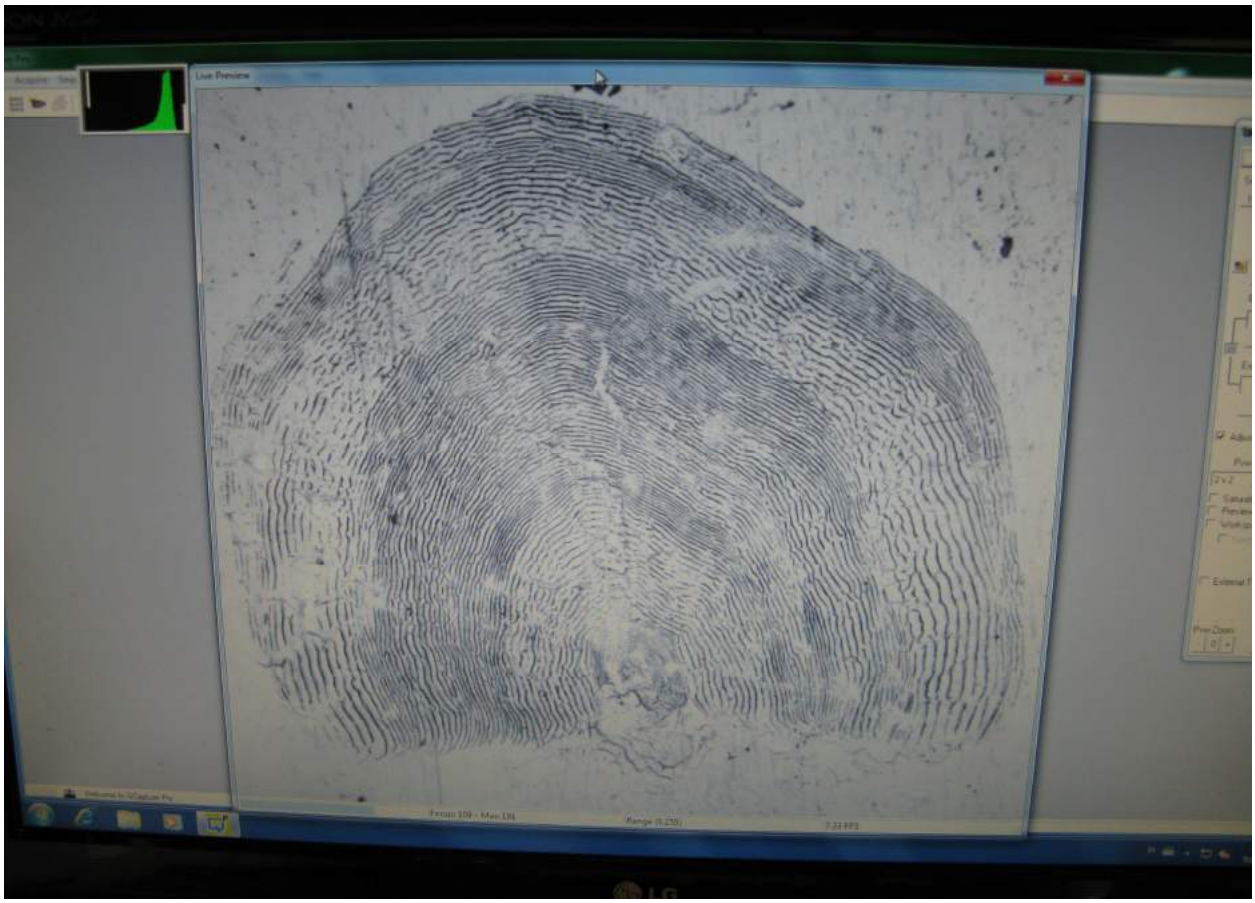


Photo 53. Atlantic salmon scale images are informing the origin of salmon (wild or escaped salmon), smolt ages, sea-ages, possible previous spawning and growth of salmon during its life history. In most of multi-sea-winter salmon (2SW and older salmon) the growth during the second year at sea has not been normal compared to scales from previous years. This might indicate changes in the amount of food available for salmon for normal growth or changes in sea water temperatures.

Photos 54-55. Fisherman taking salmon from bend net in Varangerfjord (on the left) and soon after return to fishing cabin he is measuring salmon and taking scale samples (on the right).

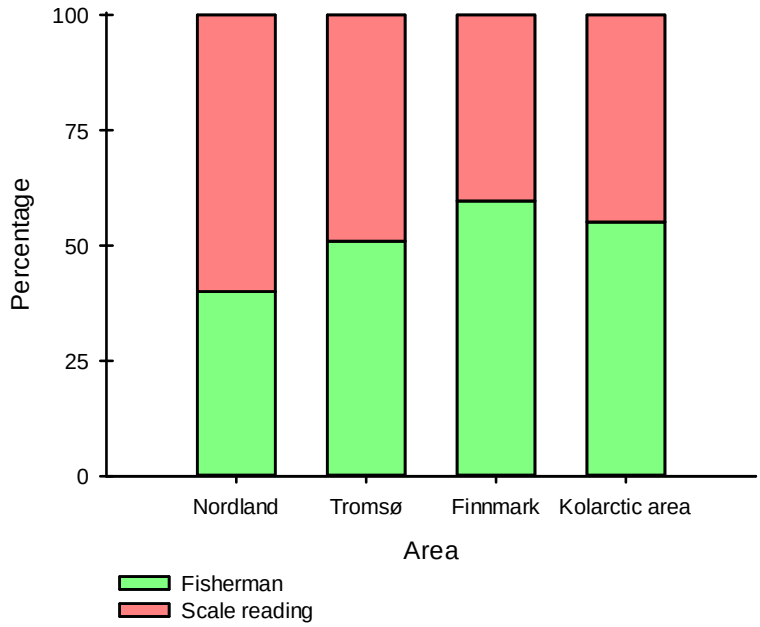


Figure 40. Recognition percentages of escaped salmon identified by fisherman out of all escaped salmon and confirmed by scale reading. Green colour indicates the proportions of escaped salmon identified by fishermen out of all escaped salmon. Red colour indicates the proportions of escaped salmon identified by scale reading. Fishermen in Finnmark could identify salmon more precisely to be escaped than fishermen in Troms and Nordland.

Photo 56-57. Ansten Mathisen, Havøysund, recognized immediately his salmon to be escaped fish based to the external features

Escaped salmon occurred in the catches in all the counties (Figure 6), in all the months (Figure 7), in all the weeks (Figure 9) and in all the fishermen's catches (Figures 4). Most of the fishermen who were collecting material from salmon for Kolarctic project in Finnmark were instructed to recognize escaped salmon from their wild counterparts in the salmon catches. In Nordland and Troms escaped salmon has occurred in the catches over many years due to the extensive salmon cage production and escaped salmon from the cages. Escaped salmon has occurred in the catches in Kolarctic area since the second half of 1980s'. Therefore it

was expected that fishermen should be aware to make recognition between wild and escaped salmon. There have also been a lot of official brochures with informative photos in Norway to inform all salmon fishermen how the escaped salmon looks like. In general salmon fishermen recognized only half from the real abundance of escaped salmon which were later identified by scale analysis to be escaped salmon (Figure 40). Only very few wild salmon were identified wrongly by the professional fishermen to be escaped salmon. In careful scale reading it was found c. 50% more escaped salmon, which fishermen identified to be wild salmon. There were some clear differences between the counties to make correct identification on the escaped salmon. In Nordland fishermen recognized c. 40%, in Troms c. 50% and in Finnmark ca. 60% from all the escaped salmon to be escaped.

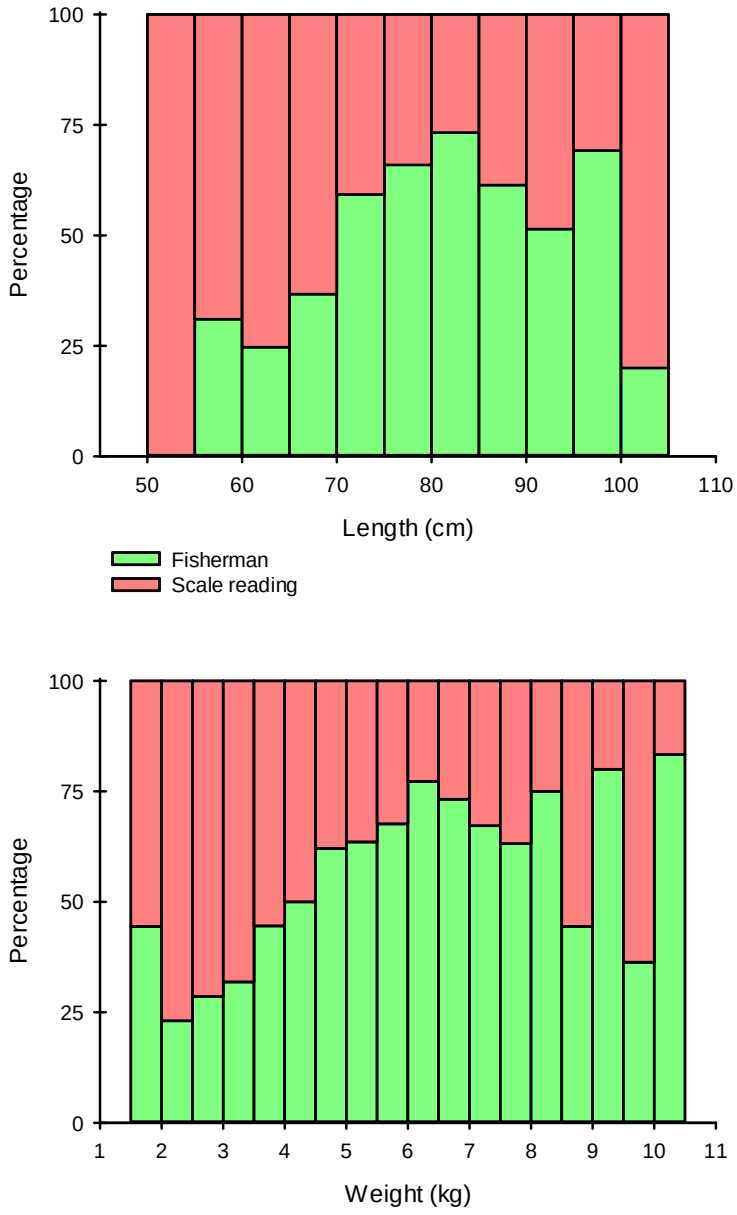


Figure 41. Recognition of salmon to be escaped salmon by fisherman and by scale reading in each size groups of salmon. Fishermen recognized more precise salmon to be escaped salmon with the increased size of fish.

Photos 58-59. Wild salmon on the left and escaped salmon on the right. Fishermen were advised to make careful work when identifying the origin of salmon to be wild or escaped salmon. Based to long-term experimental observing some fishermen told that there is one very clear difference between wild and escaped salmon. For instance in escaped salmon there is an extra tissue between the intestine and the wall of body cavity. This extra tissue is binding the intestine especially in the back side of the cavity. This phenomenon is caused by the vaccination and might disappear when escaped salmon is getting larger.

Juvenile salmon which is used for cage culture at sea is growing its first 8-10 months in freshwater tanks. Juveniles are growing in large schools and their growth in length and weight is fast compared to the growth in natural conditions. Due to the high population density and unnatural living conditions in tanks juvenile salmon have some erosion in the edges of pectoral and dorsal fins and also the tail can be rounded already in smolt phase. After releasing smolts into the net pens at sea they start the fast seawater growth which takes 1-2 years before they will be slaughtered. The longer time the salmon is in the net pens the larger and clearer are the damages especially in the fins and the clearer is the shortening of the gill cover compared to those of wild salmon. Therefore it was understandable that fishermen couldn't recognize the smallest escaped fish to be escaped because these fishes had not yet been so long time in cages (Figure 41). From the figure 41 it can easily see that the recognition is getting better with the increase in the length and weight of escaped salmon. Fishermen had best practice to identify escaped salmon with the weight of 6-7 kilo and with the length of 75-85 cm salmon. That might indicate that those fishes had stayed in the net pens rather long time before escaping and during that period they had experienced clear erosions in fins and gill covers. If salmon is escaping rather soon after the transfer into the salt water, from some months to not more than one year, it is not so easy for a fisherman to recognize it to be escaped salmon. Fishermen succeeded to recognize 65-75% from escaped salmon to be real escaped salmon when the weight of escaped salmon was 4.5-8.5 kg.

Photo 60. Large escaped salmon caught in the River Vestre Jacobselva by Terje Holm (in the photo), Finnmark, in August 15.in the year 2011. Weight was 16.5 kg for this male salmon (photo: unknown).

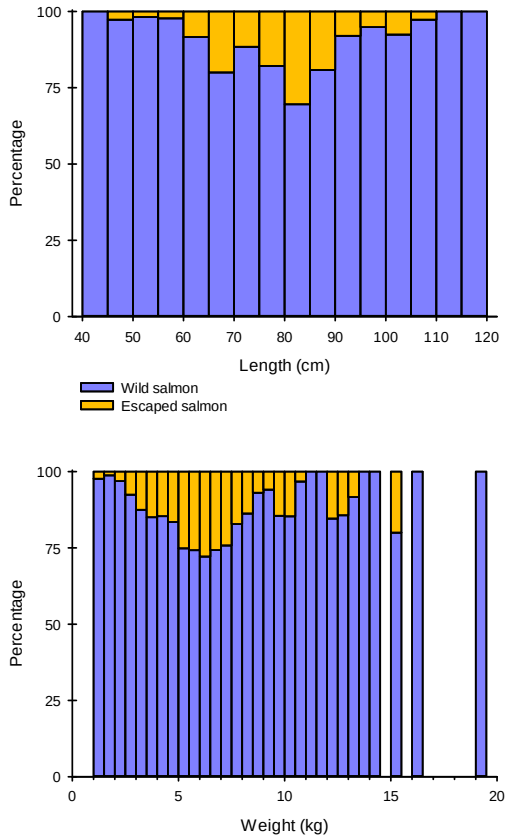
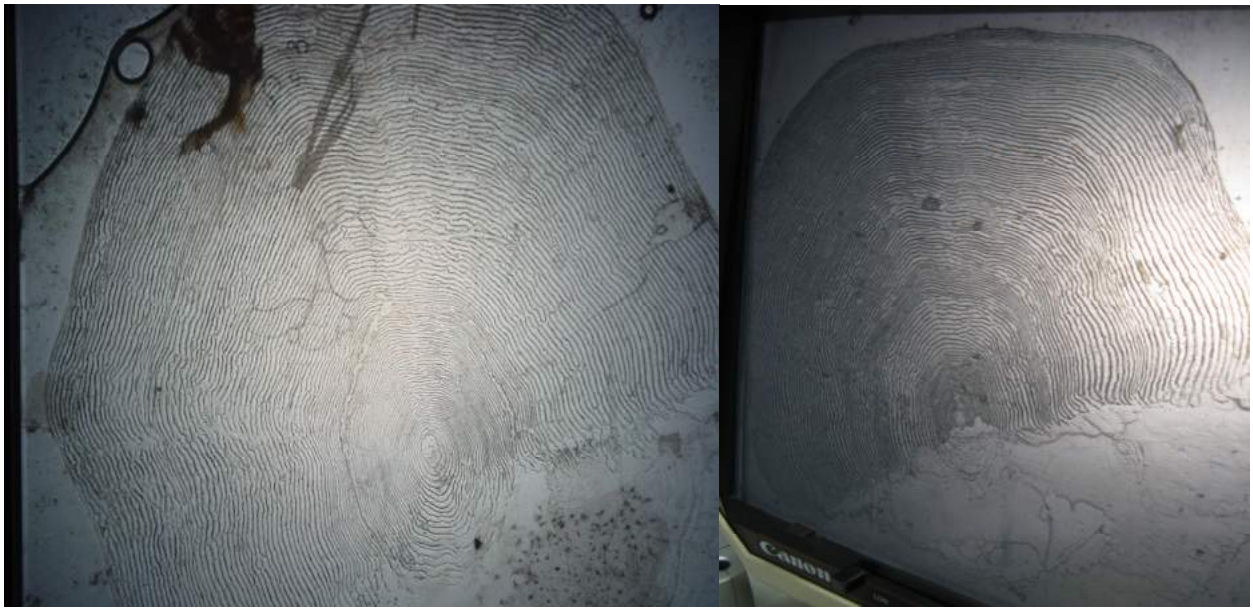


Figure 42. Proportions of escaped salmon and wild salmon (first time spawners and previous spawners) in different length and weight groups in Kolarctic area at sea. Note that the proportion of escaped salmon is very low in one sea winter salmon length and weight groups but highest in 2 SW age groups.

Escaped salmon occurred almost in all the same weight and length groups where wild salmon is occurring (Figure 32). Its proportions were 25% in the weight groups of 5-7.5 kg salmon in the Kolarctic area which weight corresponds to the length of 75-90 cm fish (Figure 42). The high proportion of escaped salmon mainly in the above mentioned size groups can have two explanations. If the escaping from net pens takes place in their very early ocean life phase then these escaped salmon might migrate straight away to oceanic feeding grounds avoiding to be caught like small sized wild salmon in the coastal areas and therefore their proportions are small in small size group salmon. If cage culture salmon is escaping in its later life phase its natural mortality might not be as high as with salmon escaping in younger phase and therefore their proportion is higher in larger fish. Another thing and maybe the most important thing is that there are not so many wild 2SW and 3SW salmon in the weight groups of 5-7.5 kg fish and therefore the proportion of escaped salmon is there large (see the figure 32).



Photos 61-62. Scale from escaped salmon on the left and from wild 3SW salmon on the right. Based to scale analysis one can say very precise is the fish wild or escaped using the growth information in the fish scale in freshwater and at sea.

Photos 63-64. Wild male salmon on the left and escaped male salmon on the right. In escaped salmon there are many black spots in the gill covers compared to only 2-4 spots in wild salmon. High number of spots can be found also in previous spawning salmon and therefore it is important for fisherman to look also other morphological characters. Fishermen do not separate escaped salmon from wild salmon in the catches

during the normal fishing season and therefore in the daily catch reports the numbers of wild salmon are higher than they should be at least in some areas.

9. Salmon lice; occurrence in wild and escaped salmon

Salmon lice (*Lepeophtheirus salmonis*) is a common parasite on salmon. It is a crustacean belonging to the large group of *Crustacea* and it occurs at sea in northern hemisphere. This parasite is living only on the salmon and therefore it is called to be ectoparasite. Salmon can be attracted by the larvae of this parasite already in very early phase of the sea life as smolt or post smolt. Parasite is attached mainly into such a places of the fish body, where they are "sheltered" against the water current. Parasite is feeding mucus and sucking blood from fish. If the number of parasite is high that can affect negatively to the survival, growth etc. of the host. Parasite can also carry bacterial or virus diseases that can be transported to wild salmon stocks from salmon cage culture.

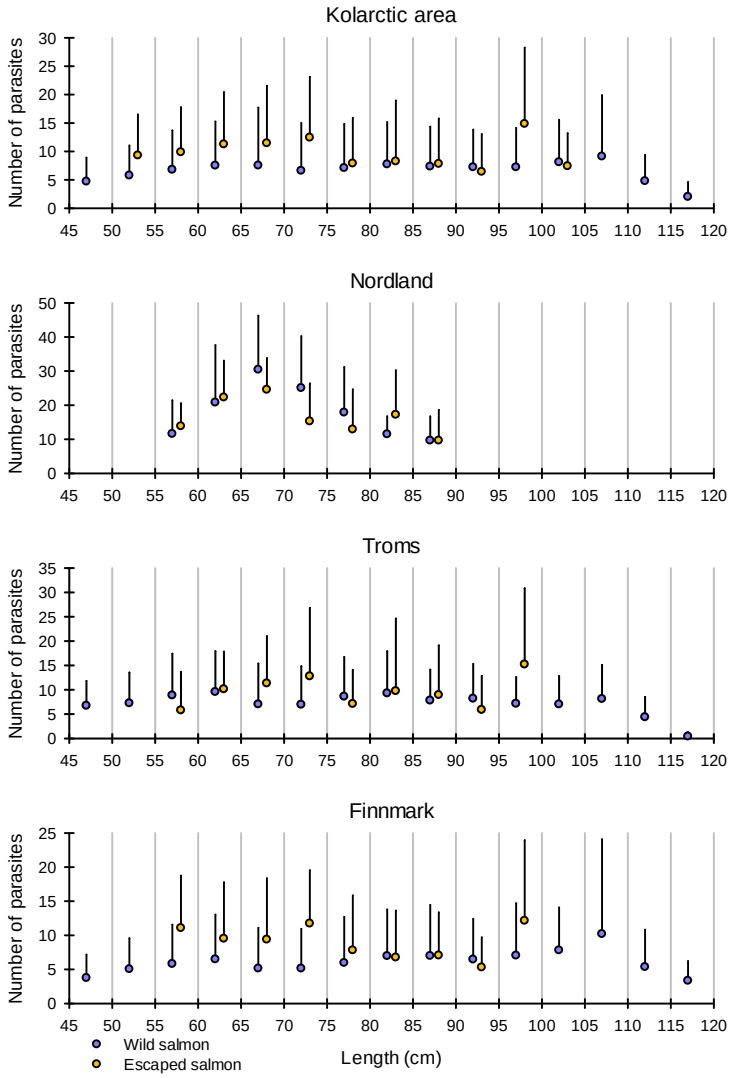


Figure 43. Mean numbers (+SD) of salmon lice in different sized wild and escaped salmon in Finnmark, Troms and Nordland and in the total Kolarctic area.

Fishermen were asked to count the numbers of salmon lice from all their catches. The mean numbers of lice are the minimum values. All the salmon were caught with nets and some lice certainly were falling when fishermen took salmon away from the net although salmon lice are usually attached strongly into the body of salmon. The mean numbers of salmon parasite did not differ so much with the increase of the fish length (Figure 43) in Troms and Finnmark. In Nordland the highest mean number of parasite was in salmon with the length of 65-70 cm.

Photos 65-66. Salmon sea lice hanging on the scales (photo on the left) and wounded area above the pelvic fin (photo on the right).

Photos 67-68. Salmon lice's are hanging in sheltered areas of the fish body like behind the dorsal fin (photo on the left) or on the sides of pectoral fin (photo on the right).

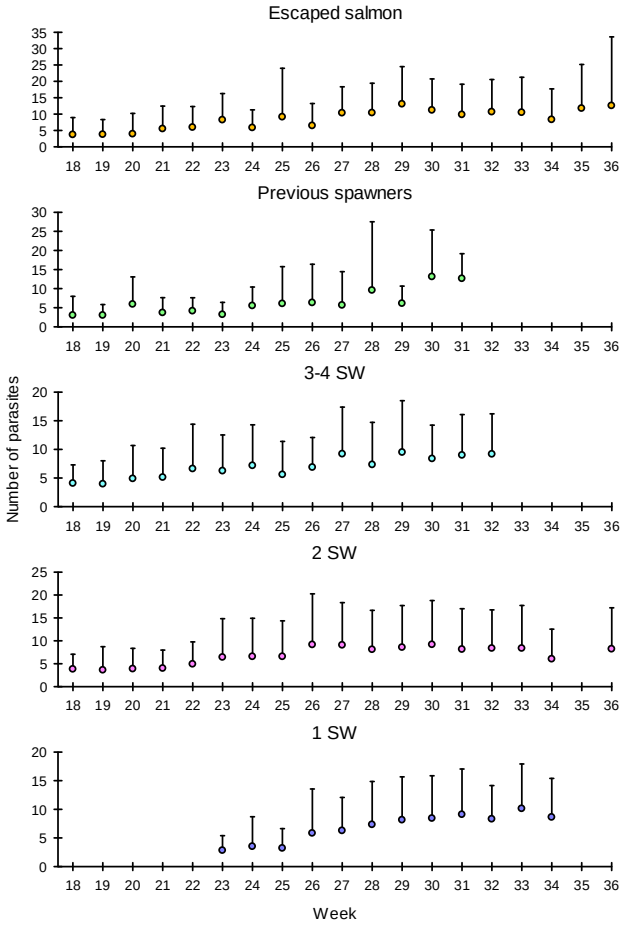


Figure 44. Mean weekly numbers of salmon lice in wild 1SW, 2SW, 3-4SW salmon and previous spawners and in escaped salmon in Kolarctic area.

The mean weekly numbers of salmon lice in salmon increased along the summer. Early in the summer in May the mean numbers of lice were c. 5 in wild and escaped salmon (Figure 44).

Photos 69-70. Counting of the numbers of salmon lice must do careful covering the whole fish body. Here Østein Christiansen is doing the work.

10. Smolt ages of salmon caught at sea in Northern Norway

Juvenile salmon are living their first 2-8 years in freshwater in Kolarctic area and then leaving rivers as smolts. Before juveniles are reaching smolt stage they have to undergo physiological and morphological changes to adapt to the life in saltwater conditions. Salmon must also change their behaviour from territorial fish in rivers to fish which is living at least partly in shoals. Smolt ages have large variation within and between rivers, between sea-ages of salmon and between years indicating different production levels in the rivers, different temperature regimes and also different genetics of salmon which are governing the growth rate and hence the smolt age.

The proportion of 4 year old smolts exceeded the proportions of all other smolt ages in all the salmon sea ages in all the areas studied (Figure 45). Smolt age distributions indicated that salmon with 2 smolt years had higher proportions in Nordland and Troms than in Finnmark. This might indicate that those fishes had origin from more southern areas outside Kolarctic area or they have been released as 2 year old smolts, which maybe was not possible to detect in the scale analysis. The proportion of 2-3 year old smolts increased towards southern latitudes and correspondingly the proportions of 5-6 year old smolts increased towards northern latitudes. This was found in 1SW salmon but especially in 2SW salmon. Smolt age distributions for 1-4SW salmon caught at sea in the three counties doesn't necessary indicate the smolt ages in the rivers within those areas because salmon might have origin outside these areas.

Photo 71. Juvenile salmon are growing in fresh water 2-8 years in the rivers of the Kolarctic area before they are smoltifying and migrating to sea for feeding and to get mature.

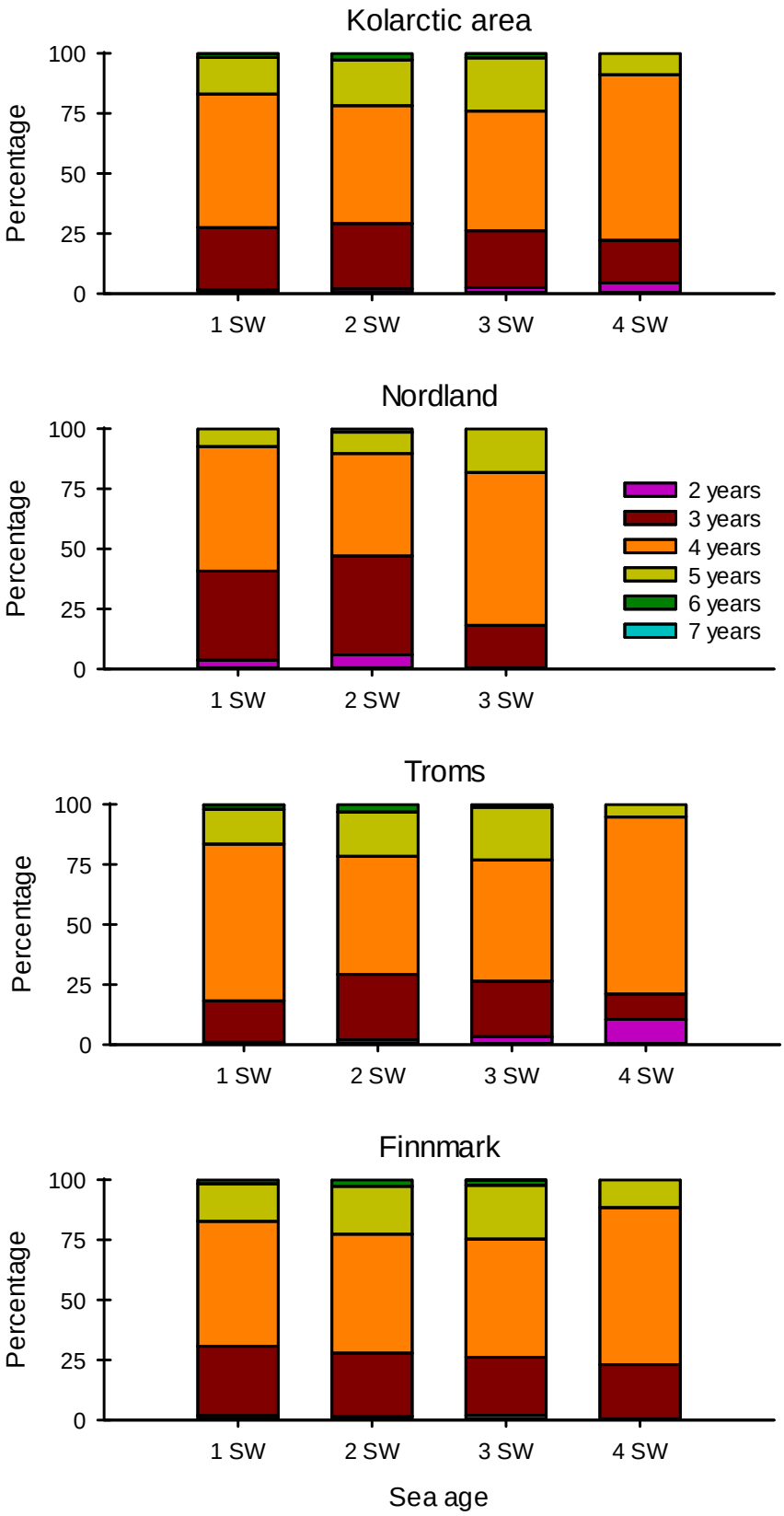


Figure 45. Smolt age distributions in Kolarctic area for 1-4SW salmon

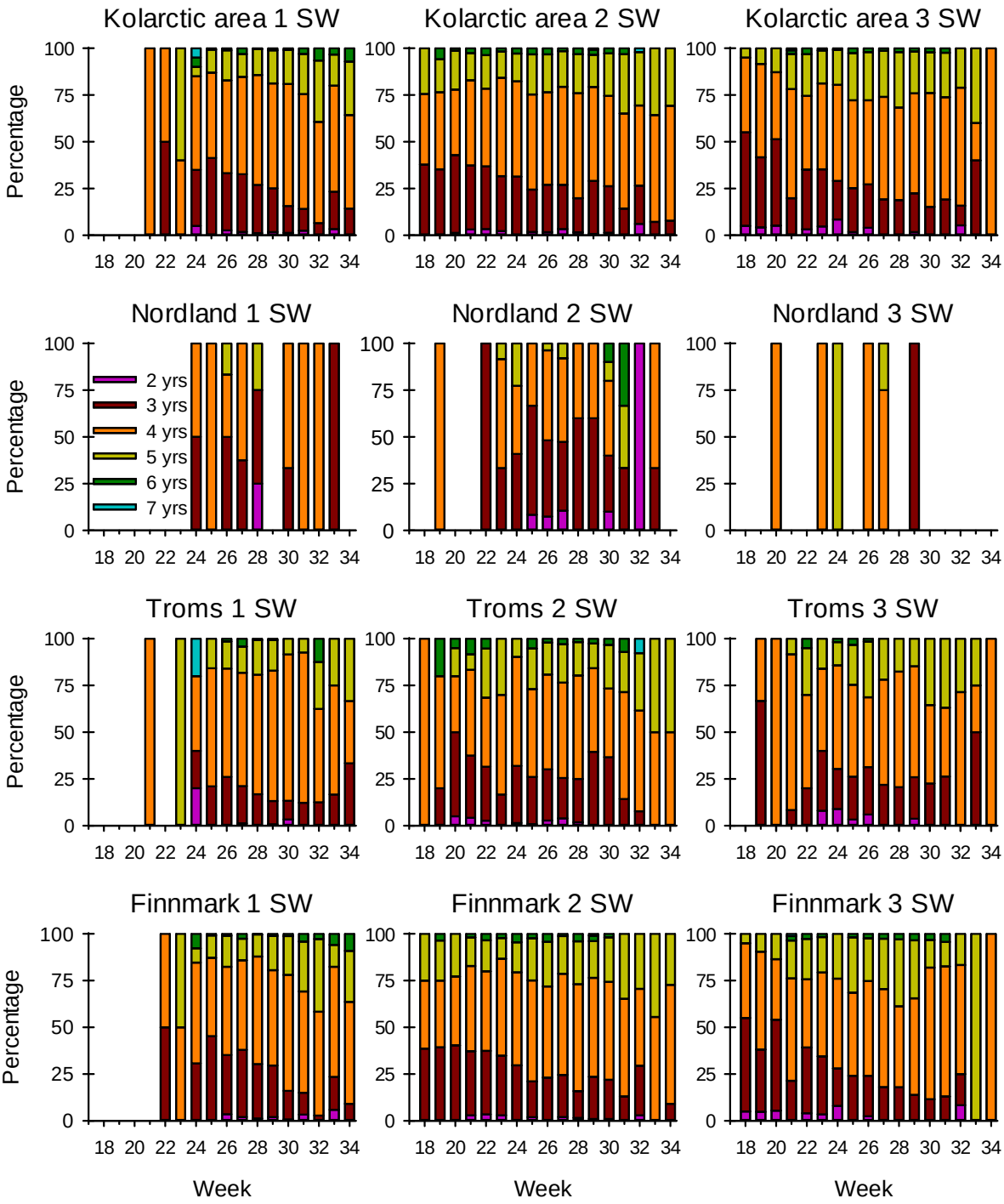


Figure 46. Weekly changes in the smolt-age distributions in Kolarctic area.

Salmon with the lowest smolt ages of 2-3 years in all the sea ages of 1-3SW fish are migrating first to the coastal areas. That was true especially in Troms and Finnmark from where it was enough material covering the whole salmon migration period (Figure 46). Correspondingly the proportions of smolts older than 4 years increased towards autumn. These regular changes in the smolt age distributions towards autumn might dependent from the different salmon stocks with different smolt ages migrating earlier or later in the season. It might be also possible that the first salmon with smaller smolt ages are the first fishes migrating

along the coast on their way into those rivers which are outside the Kolarctic area and where the smolt ages are generally lower.

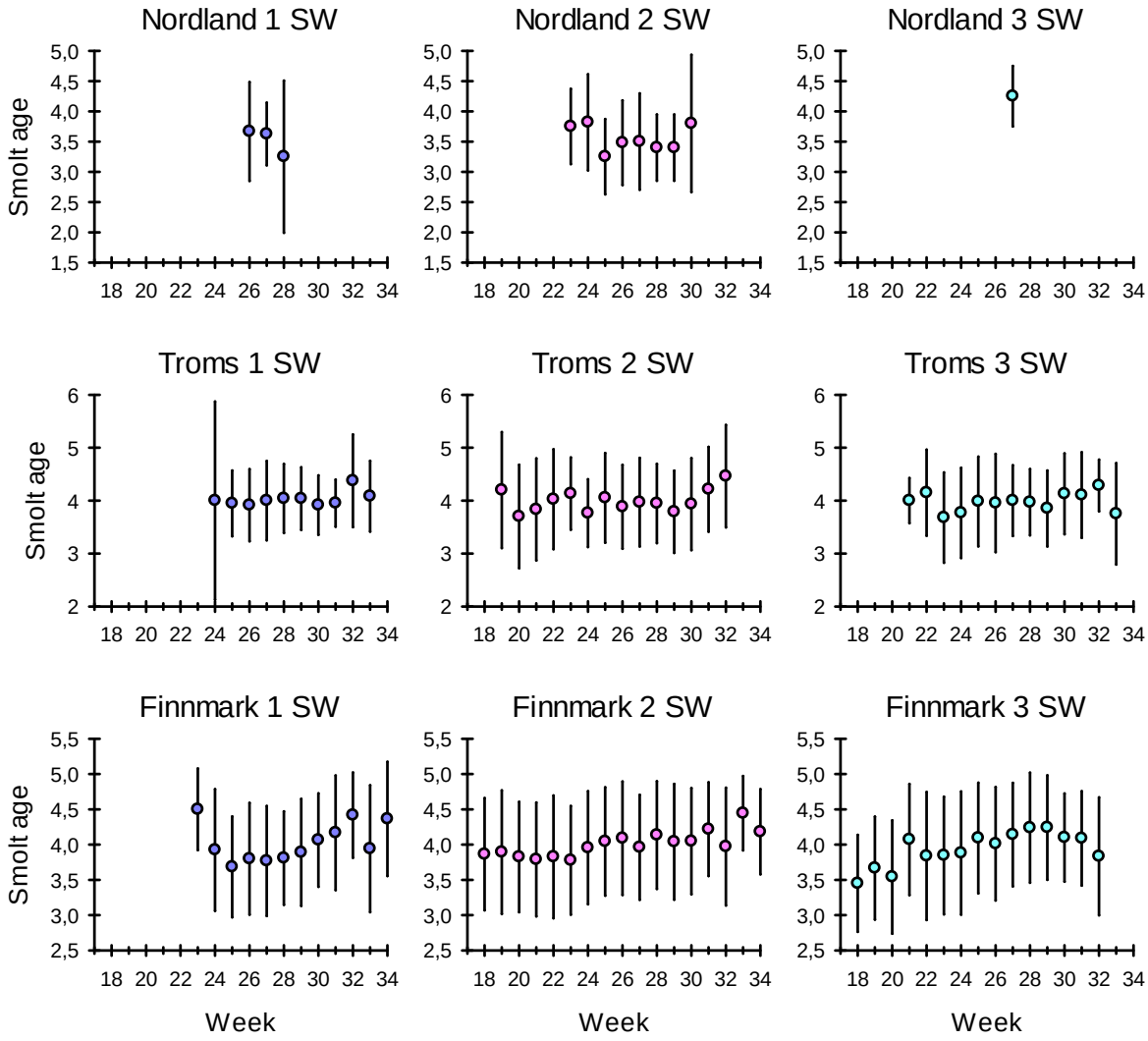


Figure 47. Weekly mean smolt ages in Kolarctic area for 1-3SW salmon.

Although the smolt age distributions had remarkable change throughout the summer in Finnmark and Troms the mean smolt ages did not change so clearly. In Finnmark the mean smolt ages, however, tended to increase slightly towards autumn (Figure 47). Mean smolt ages were c. 4 years in Finnmark and Troms and a little lower in Nordland. Changes in the mean smolt ages during the summer might reflect stock specific growth differences and hence different mean smolt ages during the various migration periods of these stocks.

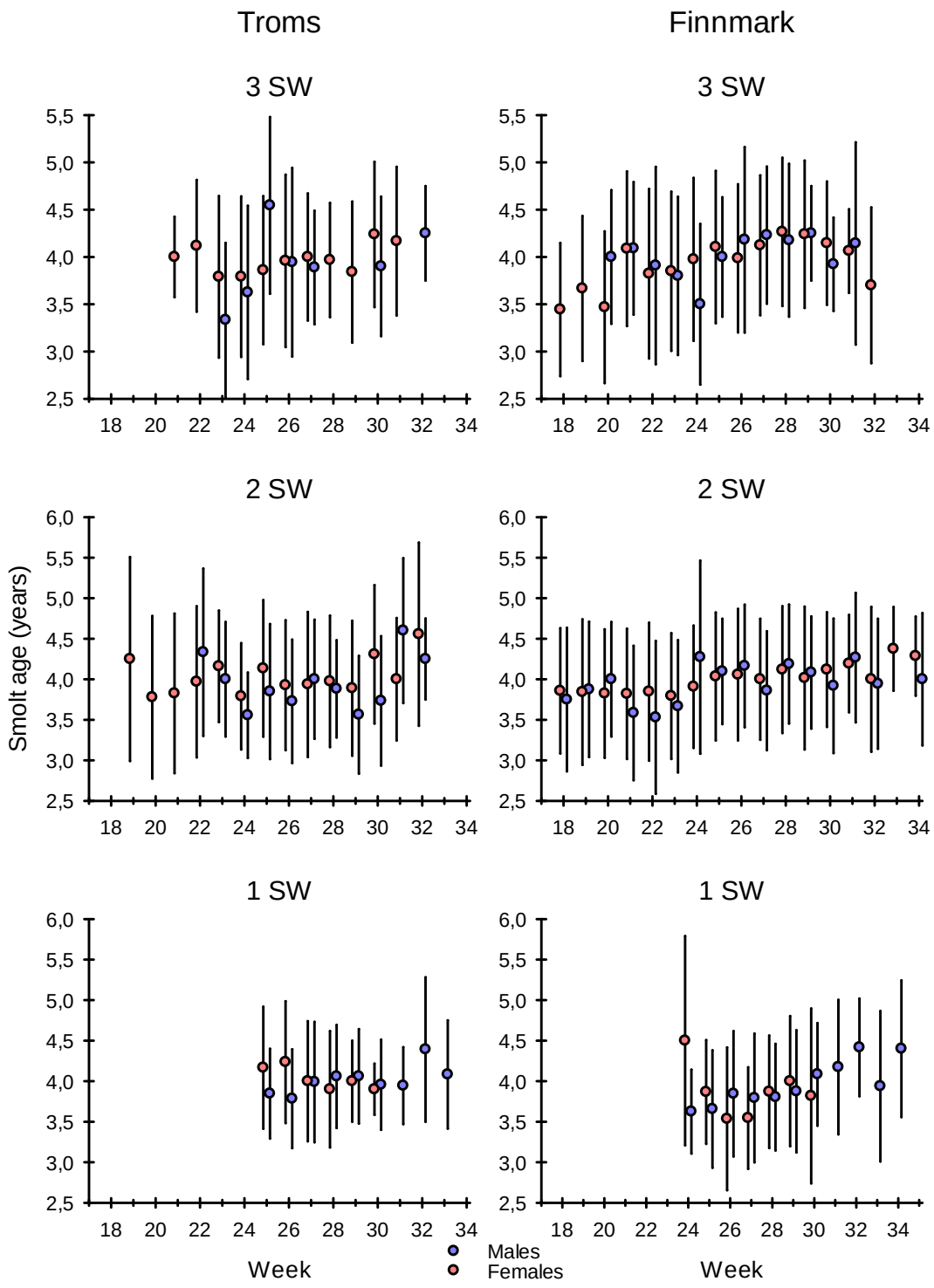


Figure 48. Mean weekly smolt ages for female and male salmon in the sea-age groups of 1-3SW in Troms and Finnmark counties.

Weekly mean smolt ages for females and males in 1-3SW salmon in Finnmark and Troms were close to the same during the entire migration period in summer (Figure 48). Reason for that might be that there are some hundred genetically different salmon stocks in the material analysed and therefore it is impossible to find differences between sexes.

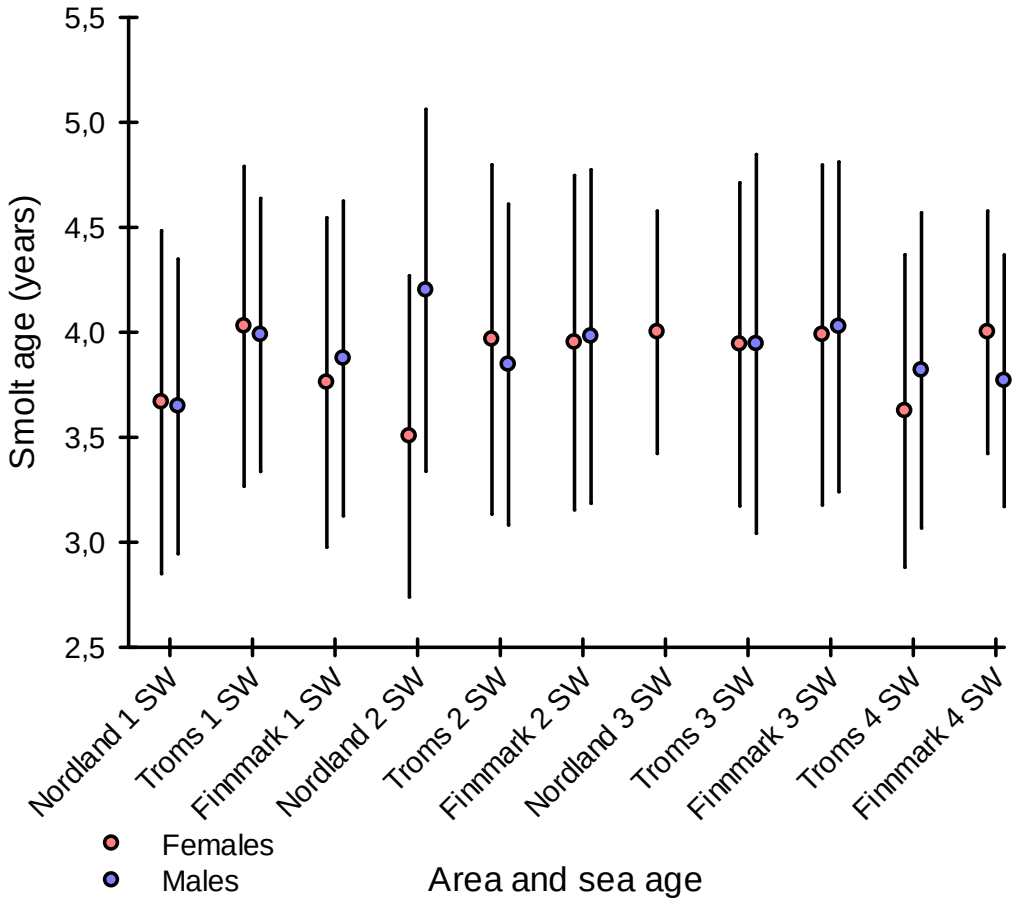


Figure 49. Mean smolt ages for 1-4SW salmon between sexes and areas

Figure 49 indicates that there are only small differences in the mean smolt ages between areas and between sea ages or between sexes. Mean smolt ages within Kolarctic area are not as high as expected to be in so northern areas and sometimes in extreme cold and oligotrophic river conditions. The mean smolt age of c. 4 years, however, highlights the quite slow renewing of salmon stocks where for example the improvements in the stocks after major regulatory measures introduced takes a long period. The mean smolt ages in 1-4SW salmon caught in the year 2011 and presented here are a combinations of maybe some hundreds of salmon stocks inhabiting at least within the area from Mid-Norway to Pechora River in Russia. There must be differences in the smolt ages between rivers and between sea-ages when analysing river specific data.

Photos 72-74. Salmon fishermen experienced high local knowledge on the migration of salmon, effects of wind direction to the catches, behaviour of salmon close to their fishing gears, mortality done by seals and otter. This experience has accumulated in most case during their whole life. Salmon fishing for these fishermen looks to give power for life and very rich cultural aspects. At home they were silent but when we went to sea they were talking all the time from salmon fishery and especially the long-term development of that kind of fishery.

Photos 75-76. After August 4th most of the fishermen closed their salmon fishery after three months hard work by hanging "gauntlet into nail" waiting for the sampling in 2012. Øystein Christiansen, Varangerfjord, Klubbvik, is collecting bend net into his salmon fishing boat.

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