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

Summary results from the coastal and fjord salmon fishery in the years 2011 and 2012 in Nordland, Troms, Finnmark and White Sea (Russia): timing of the salmon catches, wild and escaped salmon, sea- and freshwater ages, sex distributions and other biological parameters

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<u>Cover page photos:</u>
Above on the left: bag net in Trollfjord in Tanafjord. Above on the right: Fisherman Leif Ingilæ in Bugøynes, Varangerfjord – photos: Eero Niemelä
Below on the left: Russian coastal trap net fishery in Terskiy bereg White Sea. Below on the right: PINRO employee Vladimir Chernov sampling in Russia White Sea – photos: PINRO

All Russian photos: PINRO
All Norwegian photos: Eero Niemelä
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NINA Institute arranged the special permission from Norwegian Directorate of Nature Management (after July 1th 2013 called; Norwegian Environment Agency) for fishing outside the ordinary season.

Contents

Abstract

The coastal migratory patterns of wild salmon returning from their ocean feeding areas as well as the distribution of escaped salmon were studied in northern Norway and Russian Barents and White Sea areas, within the project "Kolarctic salmon 2011-2013" – *Trilateral cooperation on our common resource; the Atlantic salmon in the Barents region (KO197),* financed by the European Union Kolarctic ENPI CBC programme. A vast coastal area in northern Norway, from Lofoten in Nordland county through Troms county to the easternmost part of Finnmark county in the border area between Norway and Russia was covered by 39 and 53 professional salmon fishermen in the years 2011 and 2012, respectively, fishing for salmon from early May to early September. These fishermen collected information from each individual salmon in their catches, and took scale samples from the salmon for genetic, age and growth analysis and for wild salmon or escaped salmon detection. Scales from salmon were used for genetic analyses to determine the river/ region of origin for wild salmon, by comparing samples from the coastal catches to a genetic baseline of northern salmon rivers. Based on the timing of the appearance of different sea age groups of salmon (1SW (one sea winter, 2SW, 3SW, 4SW and previous spawners) in the 8300 salmon collected in 2011, and the 11200 salmon collected in 2012 it was possible to make inferences about the timing of the coastal migration of these age groups, both on the open coast and within the fjords. In this study, in 2011 and 2012, our intention was to cover the entire migration period of salmon from the beginning of May to the end of August or early September, which has historically been the main migration and fishing time of salmon. Professional fishermen lent their help in obtaining the material collected from salmon with ordinary fishing methods like bag nets and bend nets. There are several hundred salmon rivers in this Kolarctic salmon project area (Nordland, Troms and Finnmark in Norway; tributaries of the River Tana and upper areas of the River Neiden in Finland; Murmansk and Archangelsk regions, Karelia and Komi Republics in Russia) with genetically different stocks.

In Russia samples were collected from the traditional Pomor salmon fisheries in coastal waters of the White Sea. Coastal fisheries were operated in the Terskiy Bereg of Murmansk region and in the Zimniy Bereg of Archangelsk region. Sampling was conducted by PINRO scientists on fishing sites called "Tonya" during the fishing season from June to December. The great bulk of the samples were taken in September-October, in the period of the biggest salmon catches. Sampling was also done through research fishing in the estuaries of some rivers of Murmansk and Archangelsk regions, and from illegal coastal catches in the White Sea. There have been no coastal salmon fisheries in the Barents Sea for the last 50 years and only a small amount of fish were collected there in July 2011 during research fishing. The coastal fishery for salmon in the White Sea along the Karelian shore is prohibited; no research fishing was conducted in this area.

Main results

Wild Atlantic salmon as well as escaped salmon were caught on the coast and in fjord areas mainly from May to September in northern Norway. 1SW salmon comprised 19% of the total salmon catches in Nordland compared to 35% and 39% in Troms and Finnmark, respectively, in the period between May and end of August. 2SW salmon comprised 31% Troms and 35% in Finnmark of the total numbers of salmon, but in Nordland its proportion was as high as 49%. The percentage of previous spawners was quite low, 3%, in all counties.

Escaped salmon occurred in the catches in all counties, in all months, in all weeks and in almost all the fishermen's catches. Escaped salmon occurred most frequently in July (33%) in Nordland. In Troms their occurrence was also highest in July (46%), similar to Finnmark (40%), of the total escaped salmon catches during summer. Catches of escaped salmon increased steadily from May to August in the three counties in Northern Norway. Escaped salmon was also present in the catches in Nordland in high numbers in June as well as in August. In 2011, fishermen identified about 40% of escaped salmon as escaped in Nordland, 50% in Troms, and 60% in Finnmark. Of all the escaped salmon, fishermen succeeded in identifying approximately 55% as not wild salmon. Fishermen were most adept at identifying escaped salmon with a weight of 6-7 kilo and with a length of 75-85 cm. Fishermen succeeded in identifying 65-75% of escaped salmon as escaped salmon when the weight of escaped salmon was 4.5-8.5 kg. Escaped salmon were distributed in almost all the same weight and length groups as wild salmon. In the end of July escaped salmon made up as much as 25% of the total catch and increased to 50% at the end of week 33 in the year 2011.

The monthly timing of the salmon catches was more or less the same between Troms and Finnmark counties. For 1SW salmon, the highest number was observed in July in Troms and Finnmark at 64% and 66%, respectively, but 2SW salmon were caught earlier, in May-June, with 60% and 62%. Of the large 3SW salmon catches, 60% were made in May-June in Finnmark, Troms and Nordland. Within the catch of female salmon in Northern Norway, 2SW and 3SW fish dominated almost the whole official fishing season in June and July. 1SW fish entered the coastal fishery during week 21, especially males, and dominated the male salmon catches from week 26 to week 34. In Northern Norway, the catches were composed mainly of large salmon (2SW and older) until the end of week 26. In the whole of July the mass of 1SW salmon made up on average one quarter of the total catch.

In Finnmark, the timing of the migration of wild salmon differs a little between years. 2SW, 3SW salmon and previous spawners can be targets for the fishery through practically three summer months, but 1SW salmon can only be a target during a much shorter time period. In Finnmark wild salmon catches after the ordinary fishing time, August 4, were small although, all sea-age groups were present. The catch of escaped salmon was still high after the ordinary fishing time. Female 2SW and 3-4SW migrate simultaneously but in males 3-4SW salmon migrate before 2SW salmon. 1SW salmon catches accumulate faster than that of older wild salmon and 1SW salmon are clearly migrating later than older salmon.

In West-, Middle- and East-Finnmark differences can be observed in the timing of the peak migrations for 1SW, 2SW and 3-4SW salmon as well as for escaped salmon. The time frame when 1SW salmon were caught is much shorter than the time frame for 2SW and 3-4SW salmon catches. The proportion of 1SW fish is generally low in female salmon catches, being lowest in West- and Middle 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, especially in East-Finnmark, where it constituted approximately 90% of male salmon catches in weeks 27-29. Salmon catches accumulated slightly earlier in East-Finnmark for 1SW and 2SW salmon and clearly earlier for 3-4SW salmon compared to other areas in Finnmark. Escaped salmon appeared in the fishery earlier in East-Finnmark than in Middle- and West-Finnmark.

In Troms, the timing of the migrations of wild salmon differs a little between years. 2SW and 3SW salmon and previous spawners can be targeted by the fishery practically through June and July, but 1SW salmon can be targeted for a much shorter time period, mainly in July. The peak migration of 2SW and 3SW salmon takes place in four weeks (weeks 24-27). Combining the material collected before August 4 it indicates that the catch of 1SW females and 2SW females in Troms accumulated clearly earlier than that of males. There was no differences between sexes in the timing of 3-4SW salmon, but in escaped salmon females were caught earlier.

Results in Northern Norway indicated that the proportion of 1SW salmon for both males and females, increased with increasing latitude. The proportion of escaped salmon for both males and females, decreased with increasing latitude. The proportion of 3SW salmon was highest in Troms and very low in Nordland.

In the bag net fishery the proportion of 1SW salmon was higher than in the bend net fishery and this was especially visible in Finnmark and Troms catches. A natural explanation to this observed difference is that in bend nets the mesh sizes are larger than in bag nets, and therefore smaller salmon, like 1SW are caught more effectively in the bag nets.

In the entire Kolarctic area in 2012, males were the major sex in 1SW salmon (82%) but females comprised 74% of 2SW and 83% of 3SW salmon. In 1SW salmon the proportion of females declined with the increasing latitude; in Nordland, Troms and Finnmark 1SW females represented 31%, 21% and 16% of the totals, respectively, and female proportions decreased also towards the north in escaped salmon, being 70%, 44% and 38%, respectively in the three counties. Sex distributions changed throughout the migratory period in all wild salmon age groups and also in escaped salmon, moving towards a majority of males by the end of summer. Females had a clear majority especially in 3SW salmon but they also had high proportion in 2SW fish early in the summer. This indicates that female salmon generally entered to the coastal areas well before the migrating males.

Comparisons of length distributions of salmon caught with bend nets and bag nets indicate that in July there are no clear differences for males, but for females bend nets are selecting less small and more median sized salmon.

Due to different growth patterns in rivers with different environments, juvenile salmon reach smolt age and size after two to eight years. Hence, they migrate to the sea from Kolarctic project area during their third to ninth year of life. In the research area there were 22 different smolt age and sea-age groups for first time spawners and 33 smolt age and sea-age combinations for previous spawning salmon. The wide variety of age groups indicates that catches at sea do not originate only from a few spawning years. Catches are guaranteed from successful reproduction over many years and from the successful reconditioning of salmon from earlier spawning years. This great plasticity in age groups ensures that the genetic contribution of each year class to the next generation is distributed over a number of years.

In Russia the first period of fisheries were based on summer run fish in the early summer, whereas in autumn and winter months the catches consisted of autumn run salmon only. 77% of the samples were taken in August-October, in the period of biggest salmon catches. In total 2305 salmon were sampled, 1529 were from coastal areas and 776 were from estuaries

Analysis of samples from traditional fisheries in Murmansk region showed that the great bulk of catches consisted of 1SW salmon. Results from the smaller catches in June showed a greater proportion of 2SW salmon, up to 7,4%, whereas the bigger catches in September-October had very small proportion of 2SW salmon and previous spawner fish, around 0,5% for each group. No 3SW salmon or older fish were registered. A considerably higher proportion of 2SW salmon were found in illegal catches by nets in the coastal waters around the Umba river outlet: 20% of the catch in July and September, and over 30% in August.

Traditional Pomor coastal fisheries on the Zimniy Bereg were sampled in August and September. The age structure of salmon from Zimniy Bereg was identical to the age structure of salmon sampled in the Severnaya Dvina estuary where catches had a high proportion of multi sea winter (MSW) salmon and the majority of fish (over 70%) were 2SW salmon.

In Pechora only 14% of salmon were Grilse and about 3% of Pechora salmon were 4SW fish. In comparison with the Murmansk region, where previous spawner salmon were represented in the catches, there were no such fish in Archangelsk region and in the Pechora river at all.

No farm escapees were found in catches taken in the White Sea, both in Murmansk and Archangelsk regions.

Introduction

Atlantic salmon has a high socio-economic value in the Barents and White Sea areas, both through commercial and subsistent coastal fisheries, and recreational fisheries in rivers. The fisheries in these areas represent a significant cultural heritage, employing local and traditional knowledge and old harvesting methods. Presently, Atlantic salmon stocks in the North-East of the species range are highly important, as salmon stocks elsewhere on both sides of the Atlantic have declined in the last 50 years, while the Barents and White 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 to five years before returning to their home river to spawn. After spawning some salmon succeed in surviving and migrate as kelts (post spawners) to sea for reconditioning and then after one to three years they migrate along the coast back to their river of origin as previous spawners. Within the huge Kolarctic project area, from Nordland in Norway to Pechora in Russia, there are probably more than 200 genetically different salmon stocks. In the light of recent studies in the River Tana system, indicating that each tributary is fostering genetically diverged (Vähä et al 2007) and temporally stable (Vähä et al 2008) populations, we can predict Tana river system to foster up 35-40 unique populations.

During their return migration, salmon are exploited in coastal and river fisheries. These rivers in northernmost Norway, Finland and Russia support some of the world's largest wild Atlantic salmon stocks and resources. Seawater migration is the key element in the life history of the Atlantic salmon. Salmon from the Kolarctic project area are found, from earlier tagging results in large areas of the Norwegian and Barents Seas (Danilchenko, 1938; Bakshtansky, 1970; Hansen and Jacobsen, 2000; Rikstad and Niemelä, 2009). They migrate as far south as to wintering areas around the Faroe Islands (Hansen and Jacobsen, 2002). After reaching maturity at sea they return to their natal river to reproduce. Because of their well-known characteristic of returning to their natal river, though straying does occur, salmon inhabiting different rivers are mostly reproductively isolated from each other and, therefore, are significantly genetic differences may develop, as well as differences in morphology and behaviour. Behaviour in this context refers to the timing of return from the feeding grounds 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 (Berg, 1948), between the 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 potentially exploit a mixture of stocks from widely different areas, including fish from neighbouring countries. A coastal mixed-stock fishery can simultaneously exploit salmon from healthy stocks and stocks with reduced reproductive capacity.

In the Kolarctic salmon project (KO197) we study the time of migration of close to one hundred salmon stocks along the northern Norwegian coast and fjords. Some areas on the coast of north-west Russia's White Sea area are included. We are analysing, for example, the following parameters:

- smolt age, sex ratio and size of captured salmon. Age distributions in different fishing methods are also studied. This is activity 13 in the project; "Describe salmon ecology and management in the study area".

- 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 information indicates the general migratory pattern of the stocks and of the different sea-age groups. This is activity 14 in the project; "Describe the salmon catch composition in time and space". The activity consists of data collection and data analyses on the basis of all the adult salmon scale samples delivered from the commercial fisheries in the project area and the evaluation of the salmon catch composition in relation to time and space. A report is produced to indicate the salmon catch compositions within selected river fisheries and salmon caught at sea with different methods.
- how the fishery is exploiting these stocks in general, and by which methods and where. This information results in a migratory model, including exploitation rates and natural mortality estimates from the abundance estimates before they enter the fishing areas (pre-fishery abundance) and finally when they reach their river of origin and after river exploitation, resulting in the spawning stocks. This is activity 15 in the project; "Construction of a stock specific 'migration/exploitation' model for Atlantic salmon in the project area".

To succeed in producing the information mentioned above for developing and enhancing the management of the shared Atlantic salmon resource in the Barents region and for enabling a future adaptive and sustainable knowledge-based harvesting regime, it was important to organize accurate and cost effective sampling in cooperation with professional salmon fishermen. The sampling covered all fisheries, including both those on the outermost coast and the fisheries in fjords. Spatial and temporal coverage was a prerequisite for a successful study. This is activity 3 in the project.

Material and methods - Norway

Samples from the salmon fishery in 2011-2012 were collected from 19524 salmon, with 5%, 29% and 66% caught in Nordland, Troms and Finnmark, respectively (Table I).

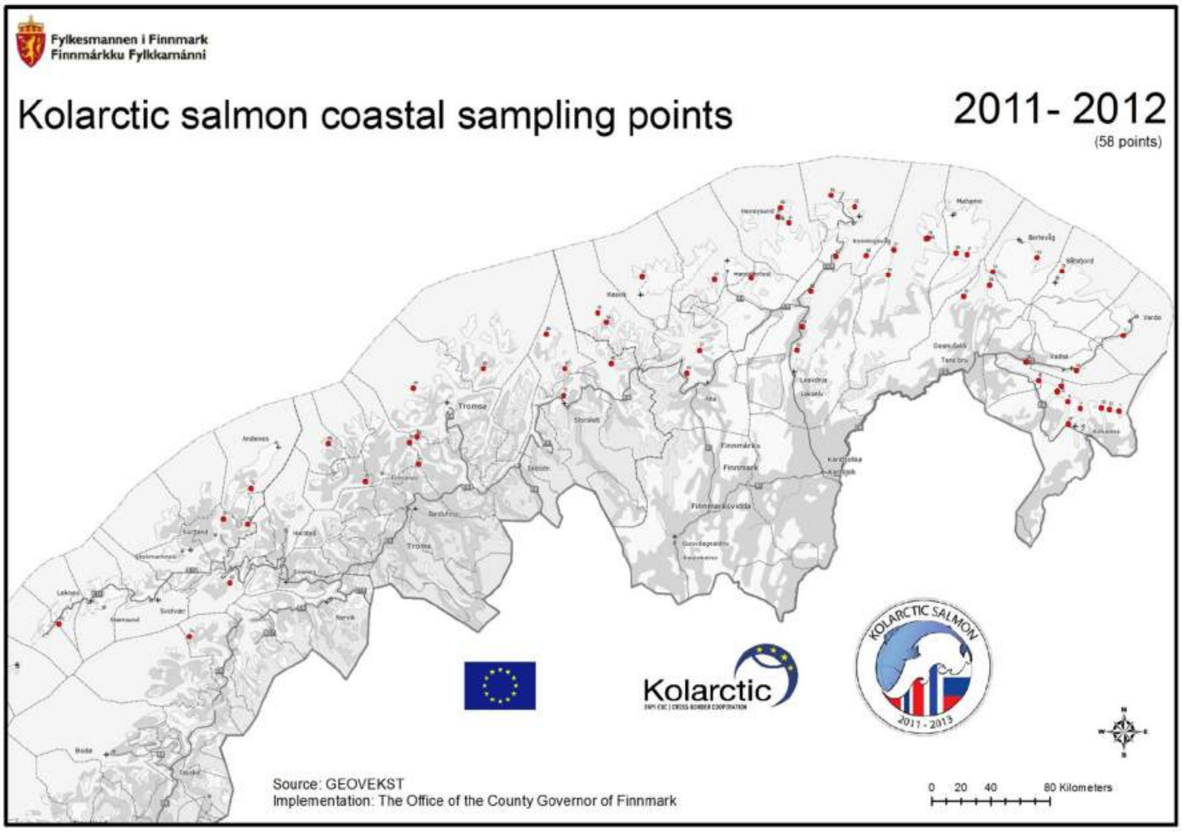


Figure 1. Salmon fishing sites (red points) at sea in the Kolarctic area in northern Norway in 2011 and 2012. Sites indicate the locations where sampling from the salmon catches took place from May to September. In the Kolarctic area there were 39 and 53 salmon fishermen in 2011 and 2012, respectively, who took samples from their catches.

In the Kolarctic salmon project we study the migratory patterns of salmon in the coast and fjord areas of northern Norway, where the captured salmon potentially originate from hundreds of rivers. Investigating migratory patterns includes clarifying the timing of capture of wild 1SW (one sea-winter salmon), 2SW, 3SW, 4SW salmon and previously spawned salmon (PS) in the catches as well as the timing of the escaped salmon (Esc) in the catches. The aim was to have continuous sampling covering the entire period during the time when salmon are migrating along the coastal areas, from early May to late September. In order to fulfil the goal of the Kolarctic salmon project and to have accurate documentation from the timing of different stocks entering this fishery in different areas and in fisheries, the fishermen serving this project received a special permission to catch salmon outside the official fishing season. Within this project, fishermen in Nordland and Troms counties also got a special permission to use bend nets, although normally this gear type is prohibited. Bag net is the only fishing method allowed for sea salmon fishing during the official fishing season today in Nordland and Troms. In Finnmark bag net and bend net are allowed. Special effort was made to include fishermen from the outermost coastal areas, where the catch reveals more precisely the timing of the migrations in general and the migrations of different stocks specifically, than catches in fjords (Figure 1).

All the fishermen were advised to take careful measurements from all their salmon catches, such as lengths and weights, and it was especially highlighted that they take the scale samples from the recommended area of the fish. Fishermen had to record information on scale bags which were designed especially for the Kolarctic project. Scales were collected from the recommended (ICES 2011) area of the fish to be certain of getting the correct ageing and growth measurements when the scales were analysed and measured. Fishermen classified the origin (wild/escaped) of the salmon using external and internal features, and a manual with photos of wild and escaped salmon helped in the identification process. The date of the capture, fishing method, sex of the fish and number of salmon lice was also recorded on the scale bag. Fishermen sent the scale bags in envelopes within two weeks of the catch to the Office of the Finnmark County Governor, or scale samples were collected by researchers while frequently visiting the fishermen.

The data recorded on the scale bags were transferred into data files and the first evaluation of the accuracy of the data took place by correcting false or missing information. All scale bags had a new number corresponding to the number in the data file. In this phase, five scales (only from wild salmon) were put into a new numbered scale bag and 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 taken from all 19500 scales. Impressions on plastic plates were taken from almost all individual salmon. After the scale impressions were available, ageing and discrimination between wild and escaped salmon took place. Work was conducted following the ICES scale reading working group's (2011) recommendations. The final task was the internal evaluation and correction of the basic scale data during which we compared the ages of salmon to the recorded lengths and weights.

Out of the 39 and 53 fishermen who were involved in the sampling over the whole season, five and nine ceased the sampling after May or in June (Figures 2 and 3) in 2011 and 2012, respectively. In 2011, the numbers of salmon caught from May to September were 275, 2411, and 5617 in Nordland, Troms and Finnmark, respectively, and in 2012 were 754, 3183, and 7283. The total mass of salmon caught in the Kolarctic project in 2011 and 2012 was 4, 25 and 54 tons in Nordland, Troms and Finnmark, respectively (Table II).

Photo 5. Norwegian fisherman Øystein Kristiansen puts the salmon scales into the scale bag.

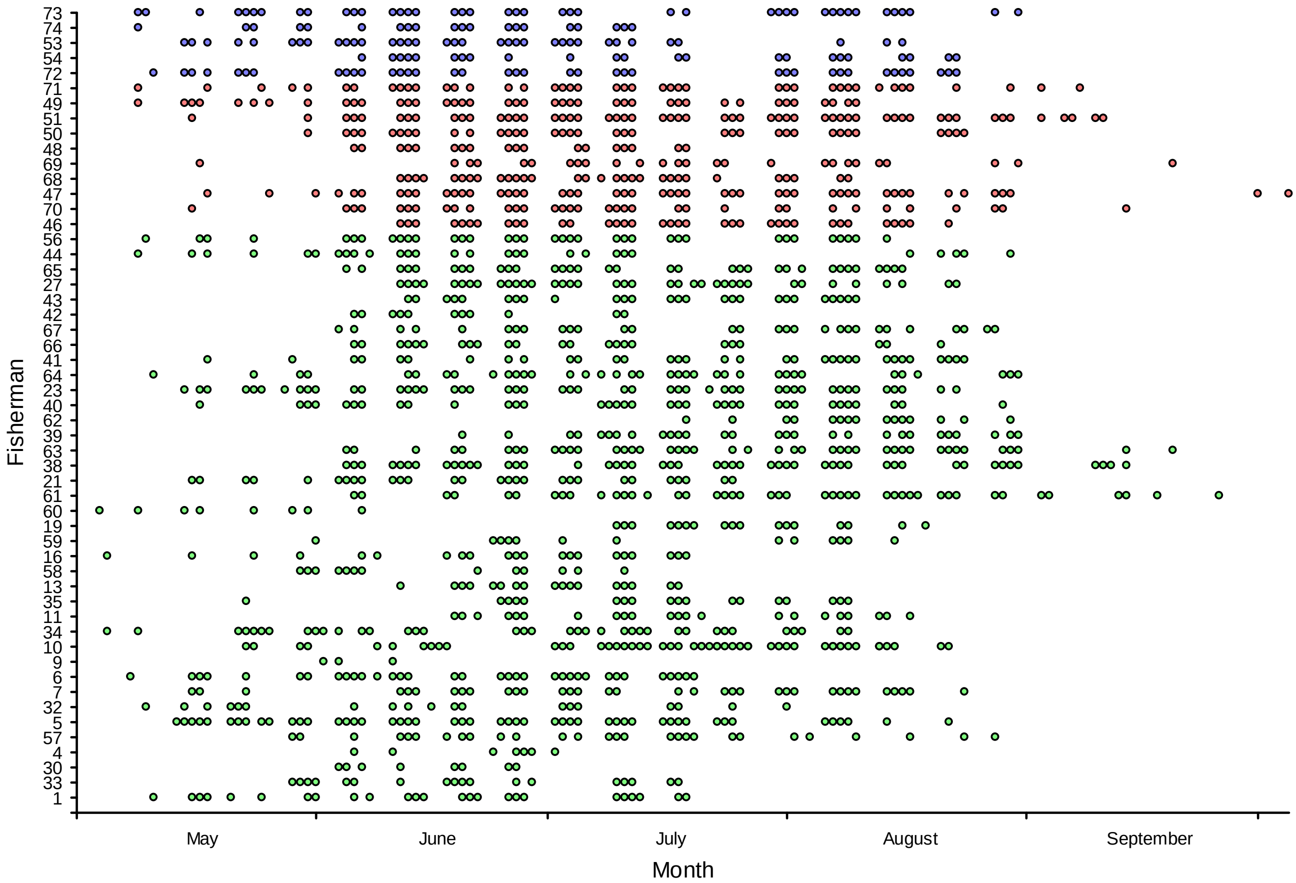


Figure 2. Dates when the salmon catch occurred in the fishery between May and October 2012. The numbers of fishermen (y-axis) from the number 73 to the number 1 are from west (blue= Nordland) to middle (red=Troms) to east (green=Finnmark). Salmon fishing started with special permission in the beginning of May instead of the ordinary start in the beginning of June in Finnmark or in the middle of July in Troms and Nordland.

Photos 6 and 7. Fisherman Ansten Mathisen in Havøysund and fisherman Øystein Kristiansen in Klubbvik (Nesseby, Varangerfjord).

Table I. Number of samples from the coastal and fjord salmon fishery in the Kolarctic project at sea in Norway in 2011-2012 by county, by month and by salmon sea ages of 1SW (one sea-winter), 2SW, 3SW, 4SW, previous spawner and escaped salmon. In parentheses the values indicate the monthly percentage for each sea age. In the total column are the numbers for each sea-age group of salmon and the percentage indicates 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	October	Total. total-
Nordland							
1SW salmon	3. (2)	90. (46)	64. (33)	39. (19)			196. (19)
2SW salmon	57. (11)	292. (59)	118. (23)	37. (7)			504. (49)
3SW salmon	7. (13)	27. (49)	16. (29)	5. (9)			55. (5)
4SW salmon	1. (100)						1. (<1)
Previous spawning salmon	8. (30)	12. (44)	3. (11)	4.			27. (3)
Kelt	1. (6)	11. (65)	5. (29)				17. (2)
Escaped salmon	14. (6)	67. (30)	75. (33)	69. (30)	2. (1)		227. (22)
Missing data from ages		1		2			3
Total salmon	**91. (9)**	**500. (49)**	**281. (27)**	**15. (15)**	**2.(<1)**		**1030**
Trout		*5*	*7*	*7*			*19*
Troms							
1SW salmon	1. (<1)	373. (19)	1246. (64)	313. (16)	10. (<1)		1943. (35)
2SW salmon	105. (6)	929. (54)	563. (33)	117. (7)	14. (<1)		1724. (31)
3SW salmon	34. (4)	478. (55)	302. (34)	66. (7)	2. (<1)		882. (16)
4SW salmon	2. (5)	25. (58)	15. (35)	1. (2)			43. (<1)
Previous spawning salmon	12. (9)	91. (69)	23. (18)	5. (4)			131. (2)
Kelt	5. (7)	31. (44)	23. (33)	11. (16)			70. (1)
Escaped salmon	23. (3)	147. (19)	354. (46)	230. (30)	7. (1)	3. (<1)	764. (14)
Missing data from ages		18	16	3			37
Total salmon	**182. (3)**	**2092. (37)**	**2542. (46)**	**746. (13)**	**29. (<1)**	**3. (<1)**	**5594**
Trout	*5*	*32*	*14*	*5*			*56*
Finnmark							
1SW salmon	6. (<1)	897. (18)	3310. (66)	759. (15)	22. (<1)		4994. (39)
2SW salmon	572. (13)	2214. (49)	1382. (31)	313. (7)	7. (<1)		4488. (35)
3SW salmon	278. (17)	697. (43)	508. (31)	129. (8)	6. (<1)		1618. (13)
4SW salmon	5. (5)	57. (58)	27. (28)	9. (9)			98. (<1)
Previous spawning salmon	57. (21)	159. (60)	41. (15)	11. (4)			268. (2)
Kelt	8. (5)	72. (43)	68. (41)	19.			167. (1)
Escaped salmon	88. (8)	267. (23)	456. (40)	333.	5. (<1)		1149. (9)
Missing data from ages	2	54	40	22			118. (<1)
Total salmon	**1016. (8)**	**4417. (34)**	**5832. (45)**	**1595.**	**40. (<1)**		**12900**
Trout		*6*	*17*	*5*			*28*
Pacific salmon		*1*	*3*	*2*			*6*

Photo 8. Alpo Länsman is punching scale envelope data into project database and on the same time evaluating the given information.

Table II. Total weight in kilos of salmon catches from the coastal and fjord salmon fishery in the Kolarctic project at sea in Norway in 2011-2012 by county, by month and by salmon sea-age of 1SW, 2SW, 3SW, 4SW, previous spawner and escaped salmon.

Sea-age	May	June	July	August	September	October	Total, total-
Nordland							
1SW salmon	5	205	152	90			455 (12)
2SW salmon	175	1007	420	128			1732 (45)
3SW salmon	46	197	121	41			406 (11)
4SW salmon	7						7 (<1)
Previous spawning salmon	37	59	18	22			136 (4)
Kelt	4	31	16				51 (1)
Escaped salmon	68	338	326	305	13		1054 (27)
Missing data from ages				8			8 (<1)
Total salmon	**342**	**1837**	**1063**	**594**	**13**		**3849**
Trout		*13*	*12*	*22*			*47*
Troms							
1SW salmon	2	828	2981	797	20		4615 (18)
2SW salmon	370	3910	2577	518	37		7416 (30)
3SW salmon	254	3876	2371	499	12		7015 (28)
4SW salmon	21	340	198	10			570 (2)
Previous spawning salmon	82	738	162	37			1019 (4)
Kelt	24	174	106	47	11		353 (1)
Escaped salmon	112	802	1766	1220	28	11	3941 (17)
Missing data from ages		49	48				109 (<1)
Total salmon	**865**	**10717**	**10209**	**3128**	**108**	**11**	**25038**
Trout	*11*	*76*	*38*	*11*			*136*
Finnmark							
1SW salmon	17	2073	7621	1695	49		11457 (21)
2SW salmon	2365	9597	6013	1322	32		19310 (36)
3SW salmon	2199	5785	4179	954	48		13169 (24)
4SW salmon	70	739	353	105			1271 (2)
Previous spawning salmon	364	1128	336	90			1922 (4)
Kelt	44	316	286	70			716 (1)
Escaped salmon	476	1583	2317	1607	17		6003 (11)
Missing data from ages	17	202	146	97			464 (1)
Total salmon	**5552**	**21423**	**21251**	**5940**	**146**		**54312**
Trout		*15*	*35*	*13*			*63*
Pacific salmon		*2*	*5*	*3*			*10*

Photo 9 a and b. Fishermen weighing their catch.

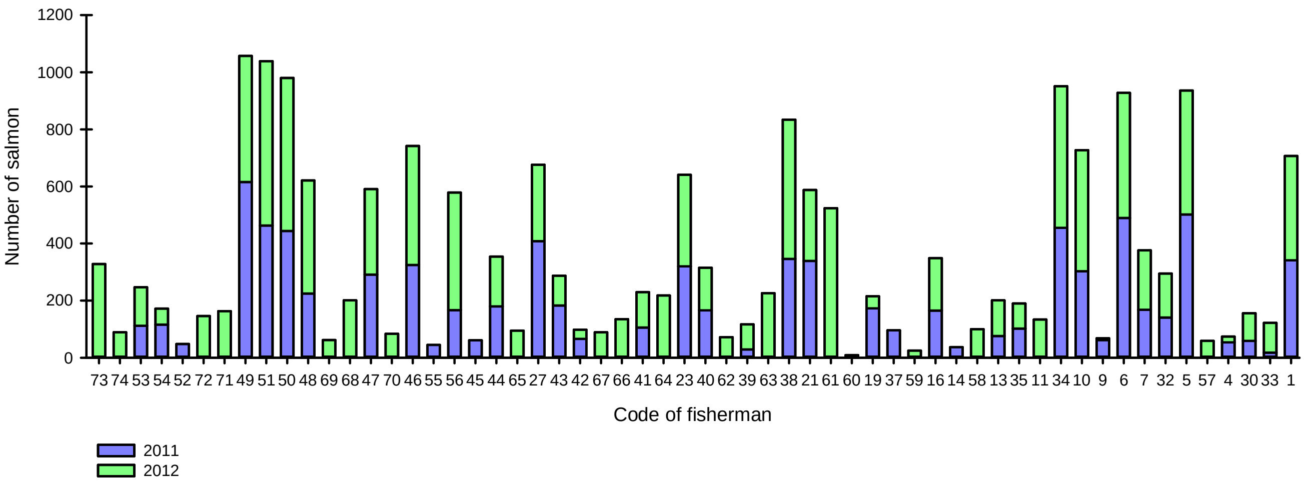


Figure 3. The number of Atlantic salmon scale samples for each fisherman from Nordland (from the left) to Finnmark (to the right) in 2011 and 2012.

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

Photo 10. Fisherman Erling Soløy (on the left is fishing in Lofoten, Nordland. (Photo: PINRO)

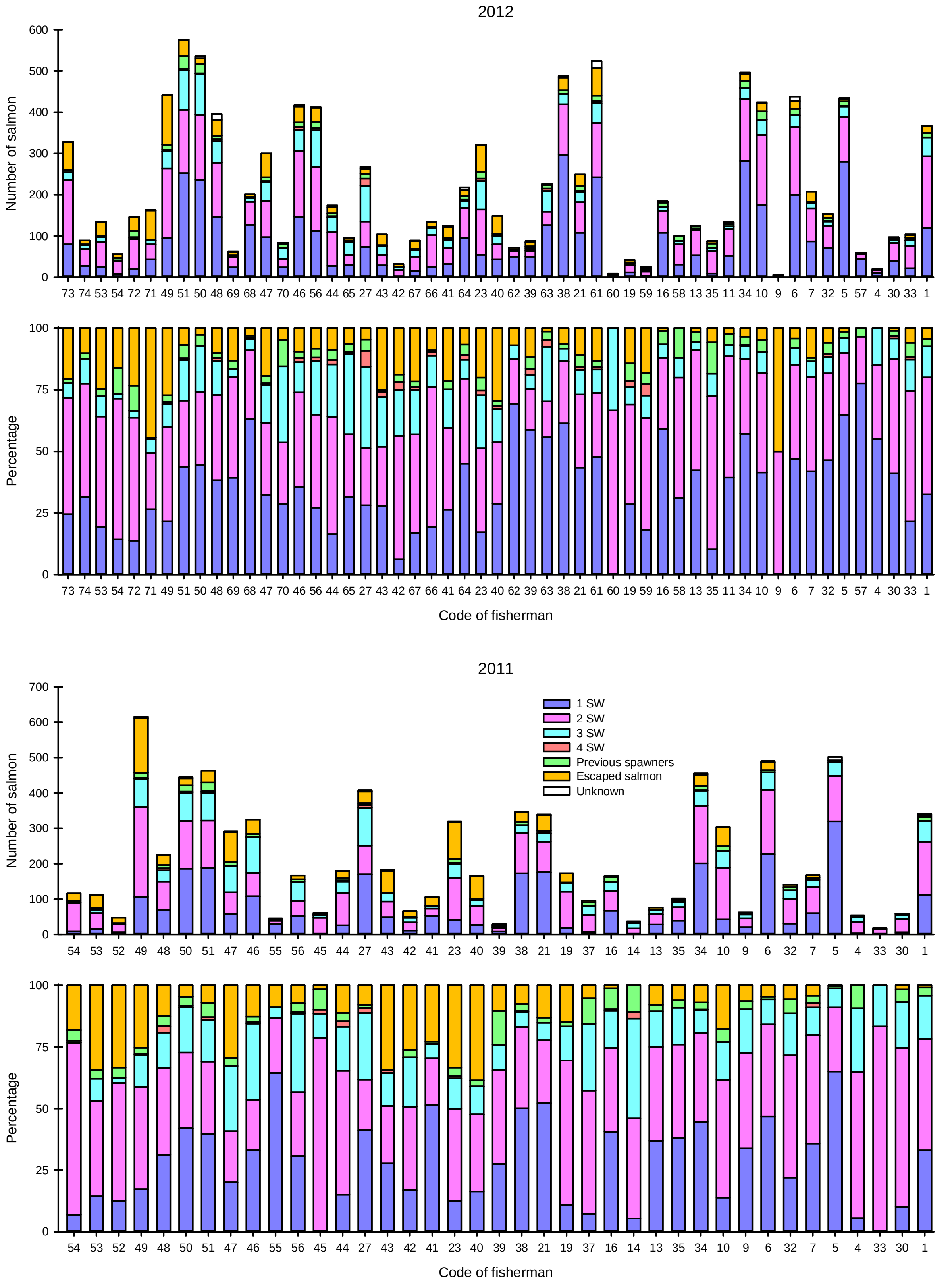


Figure 4. Number of salmon in the fishery in 2011 and 2012 and sea-age distributions and origin (wild/escaped) of salmon catches from the numbers of fish caught in the Kolarctic area in Norway from May to September - . The fishermen are coded and arranged from the Middle of Nordland (on the left) through Eastern Finnmark in the project period (on the right). See also Figure 1.

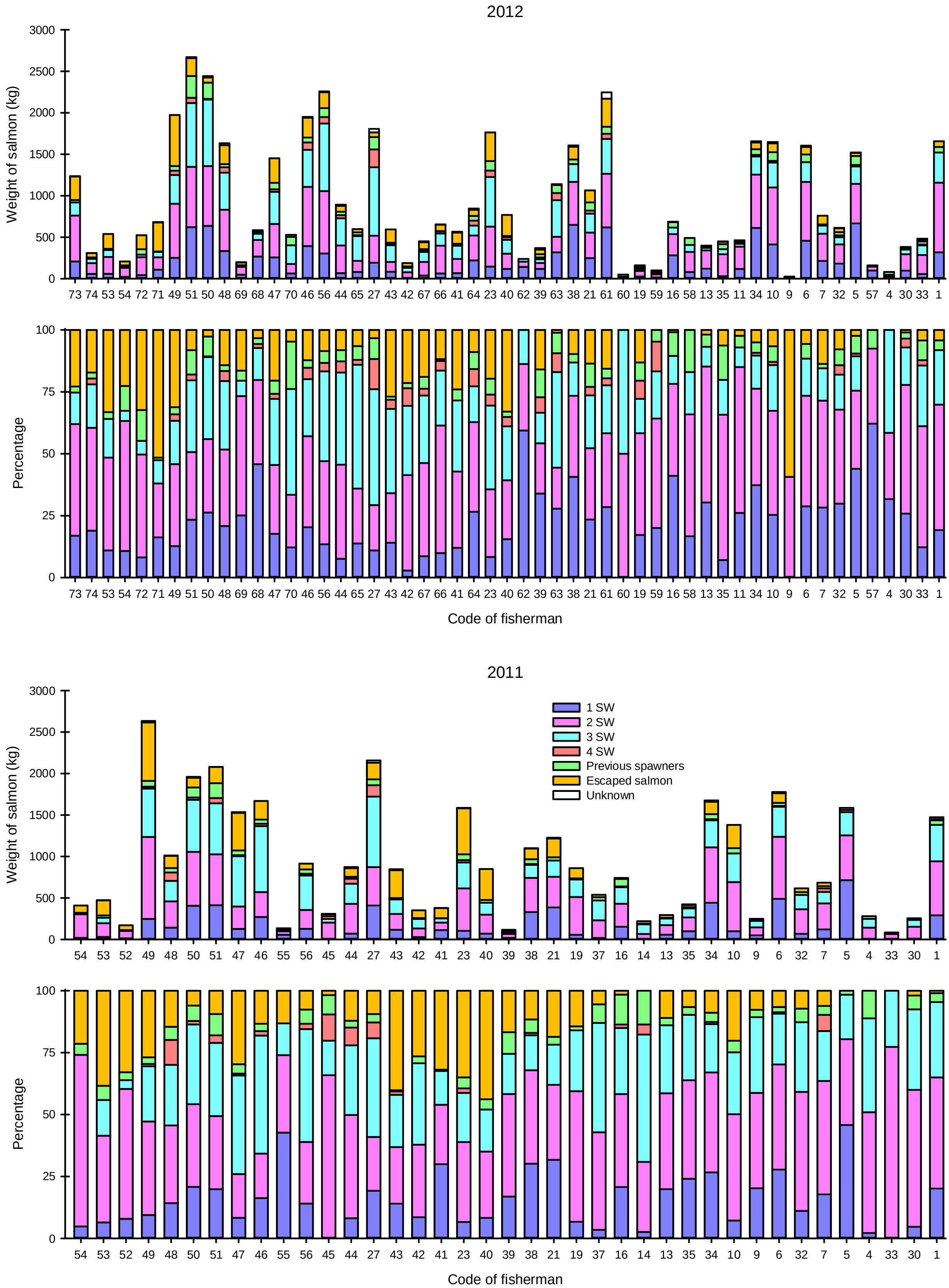


Figure 5. Sea-age distributions and origin (wild/escaped) of salmon catches from the weight of fish in the Kolarctic area of Norway from May to September. The fishermen are coded and arranged from the Middle of Nordland (on the left) through Eastern Finnmark (on the right). See also Figure 1.

Most of the fishermen took careful samples from all their catches. Figures 4 and 5 illustrate the sea-age distributions of salmon caught by each fisherman in terms of number and in terms of weight. Some fishermen did not catch the smallest salmon at all, or only in small numbers, in their fishery because they closed the fishery early in the season or they had large sized mesh in their bend nets which select mainly large fish of 2-3SW. Previously spawned salmon were found in the catches over the entire Kolarctic area, both 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 the east in northern Norway. In the easternmost areas of Varangerfjord the occurrence of escaped salmon was low, resulting partly from less fishing activity late in the prolonged season and probably also from the lower cage farming activity compared to other areas.

Sea-age distributions in the salmon catches between fishermen indicate differences in the mesh sizes in bend nets and in some areas a fishery was targeting more or less only multi-sea-winter salmon or mainly small salmon. Figure 5 illustrates clearly the importance of large salmon (MSW salmon, multi-sea-winter salmon) for the fishery as they constitute a large proportion of the catches when measured as weight. Figures 4 and 5 indicate the catch composition during the entire salmon migration period, not only the catch composition during the permitted fishing time in each county. Small 1SW salmon comprised a large proportion of the catches in numbers for many fishermen, but MSW salmon, however, constituted the highest value for them economically. 3SW salmon comprised a small proportion in numbers in 2011 but in weight it was remarkable. The catches of escaped salmon in weight highlight their very high proportion in the fisheries.

Photo 11. Fisherman Randolf Mikkelsen (Porsangerfjord) and two 1SW salmon

Material and methods – Russia

In Russia samples were collected from traditional Pomor salmon fisheries in coastal waters of the White Sea, research fisheries in estuaries of big rivers and from illegal catches. Coastal fisheries were operated by local fishermen from Pomor villages located on the Terskiy Bereg of Murmansk region and on the Zimniy Bereg of Archangelsk region. The only fishing gear used on the Terskiy Bereg was a trap net. No other fishing gears were allowed for coastal salmon fisheries in Murmansk region. Sampling was done by PINRO scientists on fishing sites called “tonya” during fishing season from June to December. Salmon were collected from coastal catches on 7 tonya in 2011 and from 8 tonya in 2012. All tonya (fishing sites) are located between Varzuga river in the West and Chapoma river in the East. The total range of the allowed fishing area is just about 100 km along the shore. The fisheries are operated during two periods: in June-July and in September-December. In the first period it’s based on summer run fish, whereas in autumn and winter months it based on fall run salmon. The biggest catches occur in September-October. Usually the fisheries close in the end of October – beginning of November once the fishing quotas are taken out. The great bulk of the samples were taken in September-October, in the period of biggest salmon catches. Every sampled fish was measured and weighed, opened for sex and biological group determination, scales were taken for age reading and adipose fin was conserved in 95% alcohol for genetic analysis. One fisherman fishing for White Sea herring west of Umba was asked to collect samples from salmon caught illegally in the Kandalakshskiy bay area in 2011 and 2012. Another illegal catch was screened in 2012. It was confiscated by authorities in August 2012 in the Ponoi river estuary. The area of illegal fishing was unknown but most likely salmon were harvested nearby Ponoi outlet in the coastal areas and in the Ponoi estuary. In total 514 and 737 salmon were collected from legal coastal catches and 49 and 229 were collected from illegal coastal catches in the White Sea in 2011 and in 2012, respectively. It’s not allowed to conduct commercial fisheries for salmon in the estuaries, and to collect samples in such areas scientific fishing was conducted. Sampling was done in the estuaries of Big Eina river and Varzuga river (Murmansk region) and Severnaya Dvina river (Archangelsk region). Salmon from Pechora river (Nenets autonomous okrug) were sampled from commercial in-river fishery with drift nets about 100 km upstream from the river mouth. In total 307 salmon were sampled in 2011 and 469 salmon were sampled in 2012 in these areas. The numbers of salmon collected in Russia are presented in Table III by area and by month. In total 2305 salmon were sampled, 1529 of them were from coastal areas and 776 were from estuaries.

Photo 12. Russian fishermen fishing in the White Sea (photo: PINRO)

Table III. Number of samples from the coastal and estuarine salmon fisheries in Kolarctic project at sea in Russia in 2011-2012 by region and by month

#	Area	June	July	August	September	October	November	December	Total
	Murmansk region								
1	Big Eina estuary		53						53
2	West of Umba coastal		43	85	20				148
3	Varzuga river estuary					105	70	55	230
4	Terskiy Bereg coastal	54	246		392	479		14	1185
5	Ponoi river estuary				130				130
	Total	**54**	**342**	**85**	**542**	**584**	**70**	**69**	**1746**
	Archangelsk region								
6	Zimniy Bereg coastal			61	5				66
7	Severnaya Dvina estuary			74	147	78			299
	Total			**135**	**152**	**78**			**365**
	Nenets autonomous okrug								
8	Pechora river			194					194
	Grand Total	***54***	***342***	***414***	***694***	***662***	***70***	***69***	***2305***

Areas of sampling are shown in the figure 6. No coastal salmon fishery has been allowed in the Barents Sea since late 1950th. No traditional Pomor salmon fisheries have been conducted in the coastal areas west of Varzuga river over a long period. There were no salmon fisheries in the Onega Bay of the White Sea. The coastal fishery for salmon along the Karelian shore was prohibited. No research fishing was conducted in such areas either except an exercise in estuary of Big Eina river in 2011.

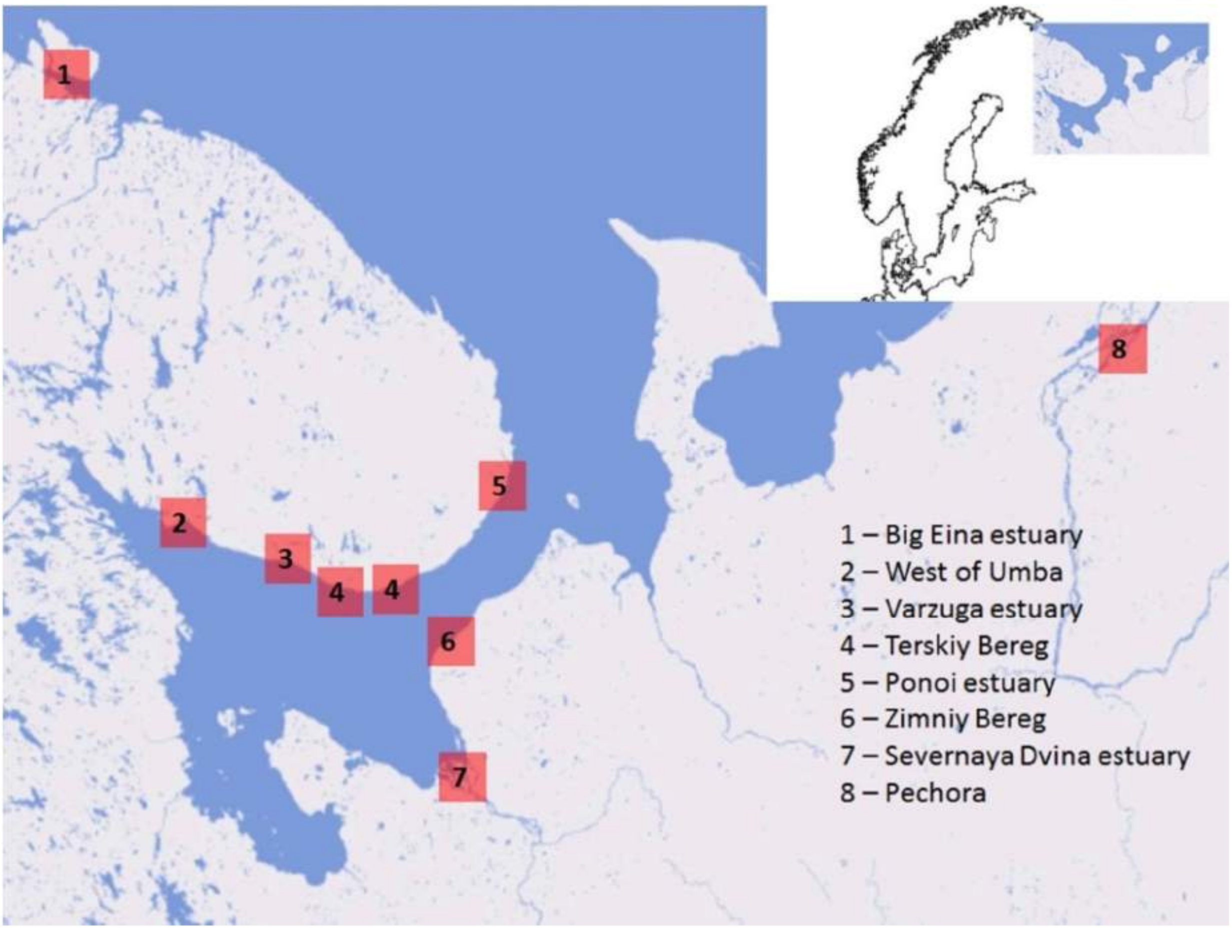


Figure 6. Map showing areas of adult fish sampling in Russia in 2011-2012.

Results and discussion - Norway

1. Large salmon dominated in catches in May and June, small salmon in July

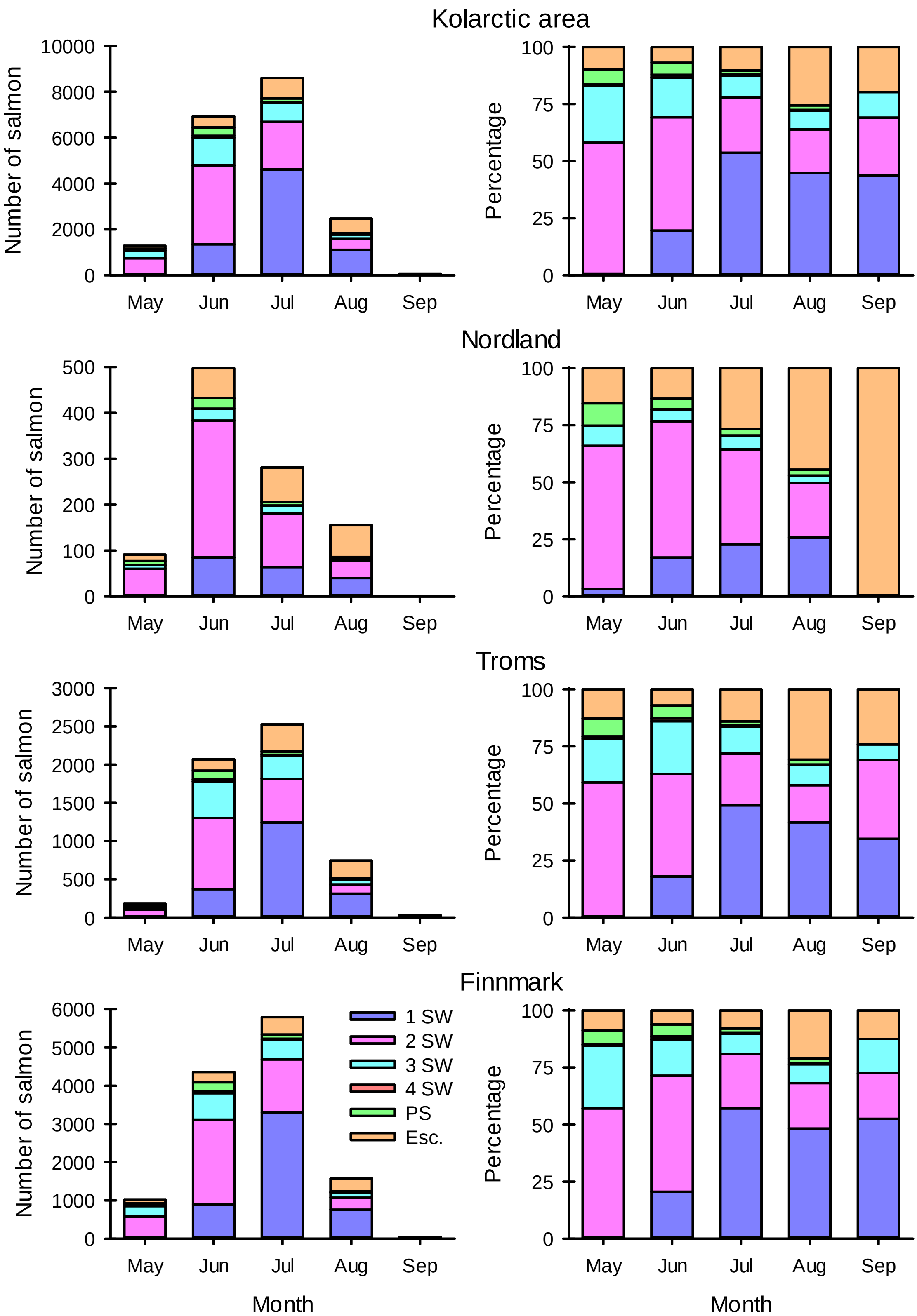


Figure 7. Number of samples for 1-4SW salmon, previous spawners (PS) and escaped salmon (Esc) in the Kolarctic project in northern Norway in 2011-2012.

Wild Atlantic salmon as well as escaped salmon are caught on the coast and in fjord areas mainly from May to the end of September in northern Norway (Nordland, Troms, Finnmark). Figure 7 gives an overview of the distribution of the catches in terms of number of salmon in the summer months in the Kolarctic area. Figure 7 also presents results from one of the Kolarctic project's activities, indicating the general migratory pattern. 1SW salmon comprised only 19% of the total salmon catches in Nordland compared to 35% and 39% in Troms and Finnmark, respectively (Table I). The possible reason for the observed low abundance and therefore the low percentage of 1SW salmon in Nordland catches can be due to that the sampling was not spatially and temporally representative in the coastal areas and is therefore not comparable with data from other counties. SSB (Statistics Norway/ Statistisk sentralbyrå) salmon catch data from Nordland, however, indicates that salmon smaller than 3 kilos amounted to approximately 35% in 2012 but the official fishing time was only two weeks, compared to the Kolarctic project's sampling period from May to September. In Troms and Finnmark, however, there were also some localities with low abundance and percentage of 1SW salmon (Figures 4 and 5). 2SW salmon made up in 31% Troms and 35% in Finnmark of the total numbers of salmon but in Nordland its share was as high as 49% (Table I). The percentage of previous spawners was quite low, 3%, in all counties. Escaped salmon in the salmon catches declined in percentage from May, to June, July, August and September with increasing latitude in the Kolarctic area and on average. Escaped salmon in the summer were found at the percentages of 23%, 14% and 9% in Nordland, Troms and Finnmark, respectively. Escaped salmon occurred most frequently in July (33%) in Nordland. In Troms their occurrence was also highest in July (46%), similar to Finnmark (40%), of the total escaped salmon catches during summer.

Photo 13. Salmon caught in Havøysund, Finnmark County, Norway.

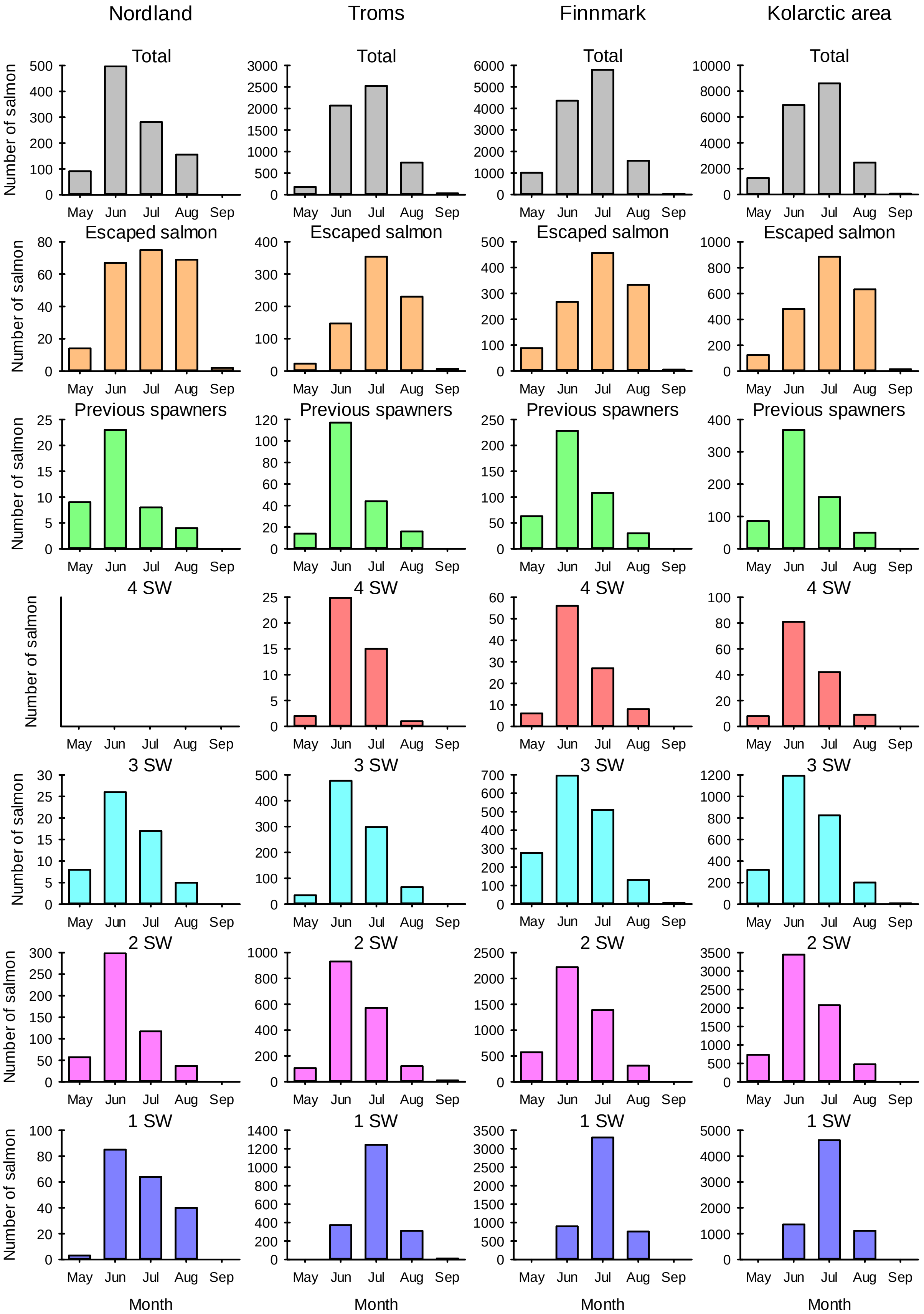


Figure 8. Monthly number of samples for 1-4SW salmon, previous spawners and escaped salmon in the Kolarctic project in northern Norway in 2011-2012. Samples were obtained from the salmon sea fishery.

The monthly timing of the salmon catches was more or less the same between Troms and Finnmark counties (Figure 8). This was true for wild salmon. The number of escaped salmon increased towards autumn in Finnmark but peaked in July in Troms. The results from Nordland County showed that the highest numbers of 1SW, 2SW, 3SW and previous spawners occurred in June catches. For 1SW salmon, the highest number was in July in Troms and Finnmark at 64% and 66%, respectively, but 2SW salmon were caught earlier, in May-June, with 60% and 62%. In May 2SW catch had a higher proportion in Finnmark (13%) than in Troms (6%) and the proportion in Nordland was (11%) (Table I). From the large 3SW salmon catches, 60% were in May-June in Finnmark, Troms and Nordland. The catch of previous spawners was also distributed over the whole summer but the catch in June with 50-60% in Nordland, Troms and Finnmark was remarkable compared to the catch in May with 7-20%. Catches of escaped salmon increased steadily from May to August in the whole Kolarctic area. Escaped salmon occurred in Nordland in high numbers in June as well as in August. The most important reason for the dramatic decline of escaped salmon catches after August is the waning interest of the fishermen in continuing their fishing for this project after the ordinary season, when there is usually a much lower number of wild salmon available for fishing than there is earlier in the summer. Fishermen also get tired after fishing salmon actively over three months (May, June, July) and the fishing effort was much less in the autumn (September) than in the summer (June-August).

Photo 14. Bend net in Varangerfjord, Finnmark CountyNorway.

2. Wide diversity in the age structures of wild salmon in the coastal fishery

Salmon caught in the coast and fjord areas in Northern Norway represent salmon stocks living in the rivers in Norway from Nordland in the west to the river Pechora in northwest Russia, including stocks from the Finnish side of the rivers Tana and Neiden. In northern Nordland and maybe also in the Troms area, some salmon caught in the coast areas are heading to the rivers in more western areas in mid-Norway or even to southern Norway. In the Tana River system alone there might be about 35-40 salmon stocks which are clearly separated genetically from each other, indicating a huge natural genetic resource which is unique among the salmon rivers in the world.

Rivers in the Kolarctic area represent a large variety of running water, from glaciers with very oligotrophic and cold rivers to the rivers where summer temperatures are close to the highest levels of the tolerance for the survival of juvenile salmon and where the benthic animal production is high, providing resources for the maximum growth of juveniles. These environmental factors, including genetics, determine the river-specific growth patterns of juvenile salmon. Due to different growth patterns and different heredity (genetics), in the Kolarctic area juvenile salmon reach smolt age and smolt size after two to eight years. Hence, they migrate to the sea during their third to ninth year of life. In the material collected in 2011 there were 22 different smolt age and sea-age groups for first time spawners. In addition, there were 33 smolt age and sea-age combinations for previous spawning salmon, which included alternate and consecutive previous spawners. The large diversity of these 55 age groups indicates that the catches in 2011 originated from the spawning of altogether ten years; 1998-2007. First time spawners in the catches represented salmon spawning from 2001-2007 and previous spawners represented salmon spawning from 1998-2005 (Figure 9). The 33 different age combinations of previous spawners add to the very high life-history variation of the Kolarctic Atlantic salmon stock complex. In addition to their role in life-history complexity, in 2011 previous spawners contributed to the commercial value of coastal salmon catches accounting for 2-11% of the catch during the official fishing time (in Nordland 11%, in Troms 2%, in Finnmark 5% in terms of numbers). The wide variety of age groups indicates that catches at sea do not originate only from a few spawning years. Hence catches are “ecologically” guaranteed from successful reproduction over many years and from the successful reconditioning of salmon from earlier spawning years. This great plasticity in age groups offers opportunity 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, a high abundance of various groups of repeat spawners, including large, maiden high-fecundity females, and improves catches.

Of first time spawning salmon in Nordland, Troms and Finnmark there were 12, 20 and 20 smolt age and sea-age groups, respectively, and of previous spawners there were 6, 25 and 30 age groups. The oldest salmon (age of 4.2S1S1S1+) was 12 years old, having been in fresh water 4 years, then spawning for the first time after feeding two full years at sea. Later this fish spawned twice more and always reconditioned one year between spawning. The most remarkable age groups in previous spawning salmon were fish which were returning to spawn for the second time after they had had their first spawning at the sea-age of 1SW, 2SW or 3SW followed by one full year’s reconditioning period at sea. The number of these previous spawners in the catches for the sea-age groups of 1S1, 2S1 and 3S1 were 86, 35 and 19, respectively. Interestingly, post-spawner salmon (kelts) descend after the spawning period (immediately after the spawning period late in the autumn or during the following spring) from the rivers in the Kolarctic salmon area to the sea for reconditioning, and some were caught in the coast and fjord fisheries at the end of the summer. This indicates that a proportion of post-spawners are reconditioning very close to the coast instead of migrating to the ocean feeding areas, which are the main growing areas for most of the salmon stock. Abrahamsen (1968) reported that from time to time feeding Atlantic salmon overwinter near the coast of northern Norway, though they usually migrate further away. Increasing numbers of these post-spawners might be reconditioning close to the coastal areas of northern Norway, especially in years with warmer sea temperatures in winter (Abrahamsen, 1968). Svenning et al. (2011) reported that some post-spawners from Finnmark rivers were caught late in the autumn and early winter in Varangerfjord, verifying the observations found by Abrahamsen (1968). According to Bakshtansky and Yakovenko (1976) two post-spawner fish of 1,923 kelts tagged with external tags in the Varzuga River (Terskiy Bereg of the White Sea) were later caught in the Barents Sea. One fish was caught north-east of Vesterålen on February 18 and other one nearby North Cape on June 15 (Bakshtansky, Yakovenko, 1976). With the increasing winter sea temperatures also in the Barents Sea in recent years, it might be possible that higher numbers of post-spawners are reconditioning close to the fjords in Finnmark. In the fishery in 2011 and 2012, however, there was very few post-spawners (kelts) caught with bag nets and bend nets in late spring and early summer, indicating that post-spawners did not migrate close to the shore areas where the salmon fishery operates. Later in July, August and September some post-spawners (kelts) originating from numerous rivers in Kolarctic salmon project area were caught in the coastal areas and especially in Varangerfjord.

Photo 15. Kelt descending Ponoi river in June (Photo: Sergey Prusov.)

Photo 16. Kelt from the Alta river, Norway (photo: Audun Rikardsen)

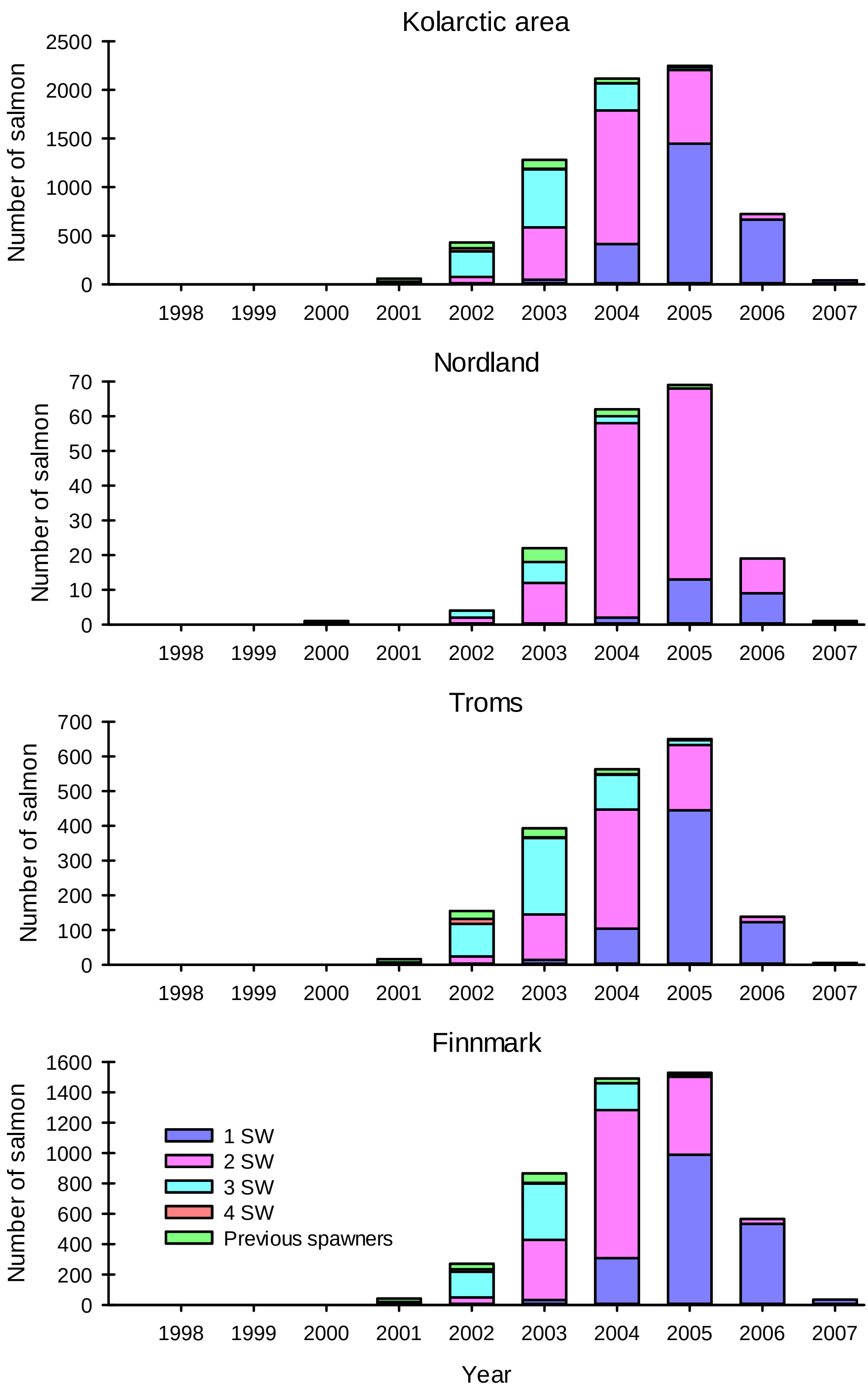


Figure 9. This figure illustrates the distribution of sea-ages of salmon caught in the Kolarctic project in the year 2011. Salmon catches in the Kolarctic area originated from the cohorts for first time spawners from the spawning years 2001-2007 and from the cohorts for previous spawners from the spawning years 1998-2005.

3. General migratory pattern for wild and escaped salmon at sea in the entire Kolarctic area in Northern Norway

In the beginning of May when the fishermen started to fish, few salmon were caught (Figure 10). It was expected, based on old historical information, that catches would be better in early May, at least in Finnmark. Based on the experiences of some of the oldest salmon fishermen it was expected that salmon belonging to the largest size group, larger than 7 kg, would be caught in this period. Unfortunately, weather conditions in most of the outermost coastal areas did not favour fishery, and strong winds eliminated the use of bend nets in some areas, in both years.

Within the catch of female salmon, 2SW and 3SW fish dominated almost the whole "official" fishing season in June and July. 1SW fish entered the coastal fishery during week 21, especially males, and dominated the male salmon catches from week 26 to week 34. Throughout almost the entire official fishing season, escaped salmon comprised approximately 10-15% of the weekly catches (female and male salmon catches combined) but their proportions started to increase clearly in week 31, rising to 25. In August, when most wild salmon have entered their natal rivers, the proportion of escaped salmon in the catches was high, exceeding almost 30% in week 33.

Photo 17. Fisherman Reidar Larsen, Tanafjord, Norway.

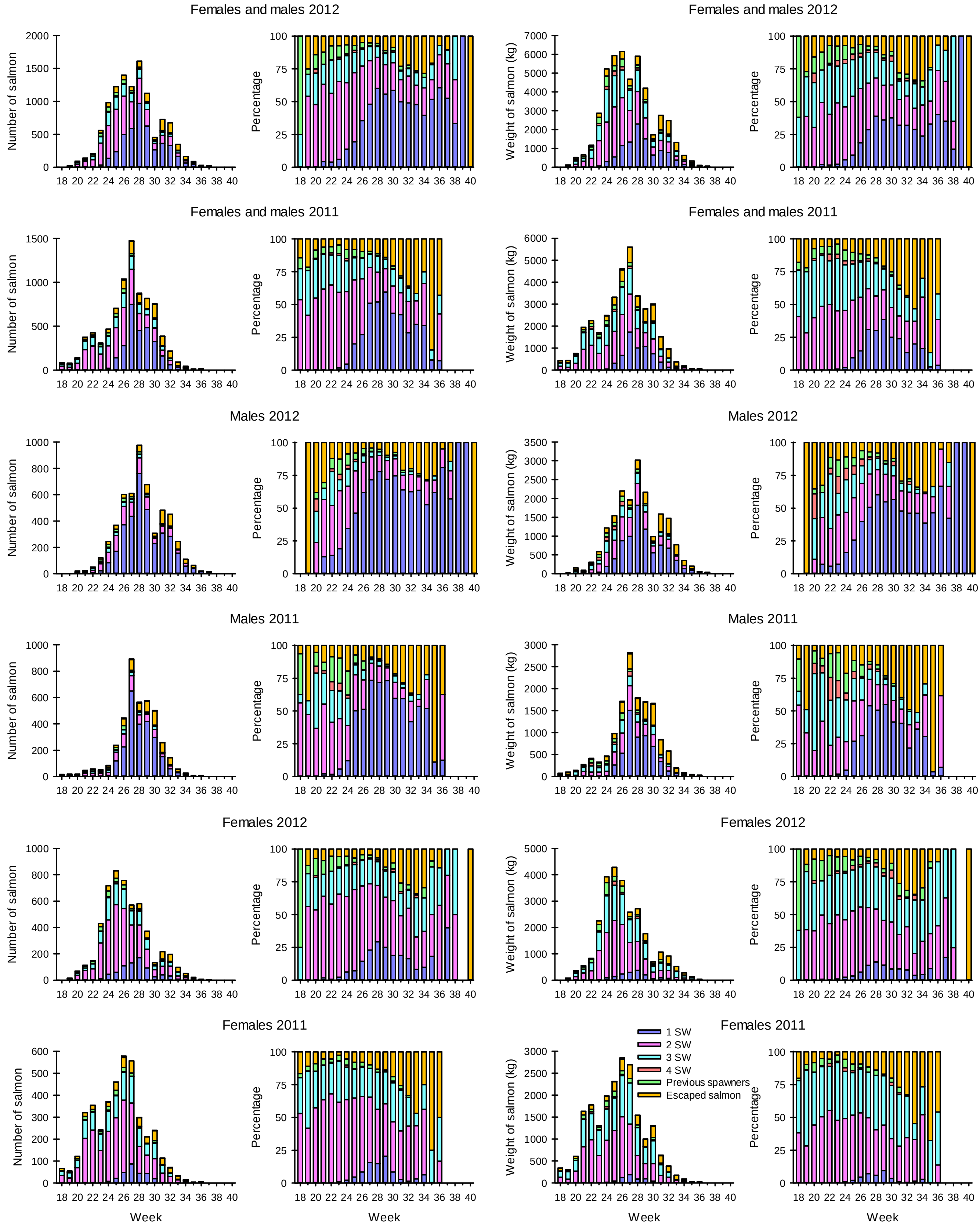


Figure 10. Weekly salmon catches in the Kolarctic area (Nordland, Troms, Finnmark) in 2011 and 2012 in terms of numbers (left) and of weights (right).

Salmon catches expressed as weights (Figure 10) for each sea-age gives a more informative picture of the economic value of medium and large sized salmon than if the data were expressed as numbers of salmon for each age group. The catch in terms of numbers is used when calculating the spatial and temporal exploitation of salmon between fishing methods, between the fisheries at sea and in the rivers, and for other purposes. In the Kolarctic area, the catches were composed mainly of large salmon (2SW and older) until the end of week 26, that is until the end of June. In the whole of July the mass of 1SW salmon made up on average one quarter of the total catch. Interestingly, in the end of July escaped salmon made up as much as 25% of the total catch and increased to 50% at the end of week 33 in the year 2011 (Figure 10). 1SW female salmon constituted only a small proportion, reaching approximately 10% in week 28. Previous spawning salmon comprised a stable proportion of the total catch throughout the entire official fishing season, being <10%, but comprising up to even 20% in some weeks in male salmon catches.

By comparing the information in Figure 10 (numbers and weight of salmon) we can observe that 1SW salmon do not contribute significantly in terms of weight compared to numbers. The economic value of MSW salmon in the sea catches can be easily observed in Figure 10. During the peak migration time of the smallest salmon in the Kolarctic area, 1SW salmon make up only about 25-30% of the catches in terms of weight compared to about 50% in terms of number of fish. These figures highlight the high value of MSW salmon from May to the end of July, not only from the point of view of economic value for sea salmon fisherman, but also from the point of view of the ecology of salmon. Large salmon, larger than 3 kg and older than 1SW, are usually female salmon that belong to a higher price category and, from an ecological point of view, will produce more juveniles than 1SW females.

In the Kolarctic project, fishermen tried to start fishing 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 to analyse the rivers of origin for all salmon caught in the coast and fjord areas. From Figures 11 and 12 it can be observed clearly that in the whole Kolarctic area, combining the data from Nordland, Troms and Finnmark, female salmon with sea-ages of 2, 3-4SW and previous spawners' earliest ascent was around the same time and that they were caught evenly throughout the entire summer. For males, the age groups of 3-4SW and previous spawners appeared earliest in the fisheries, but 2SW salmon clearly came later. Although escaped salmon were found in the catches throughout the entire summer, the majority of escapees were caught late in the season; however, escaped salmon was caught mostly before 1SW salmon. Figure 11 indicates the general migratory pattern for wild 1-4SW salmon, previous spawners and escaped salmon.

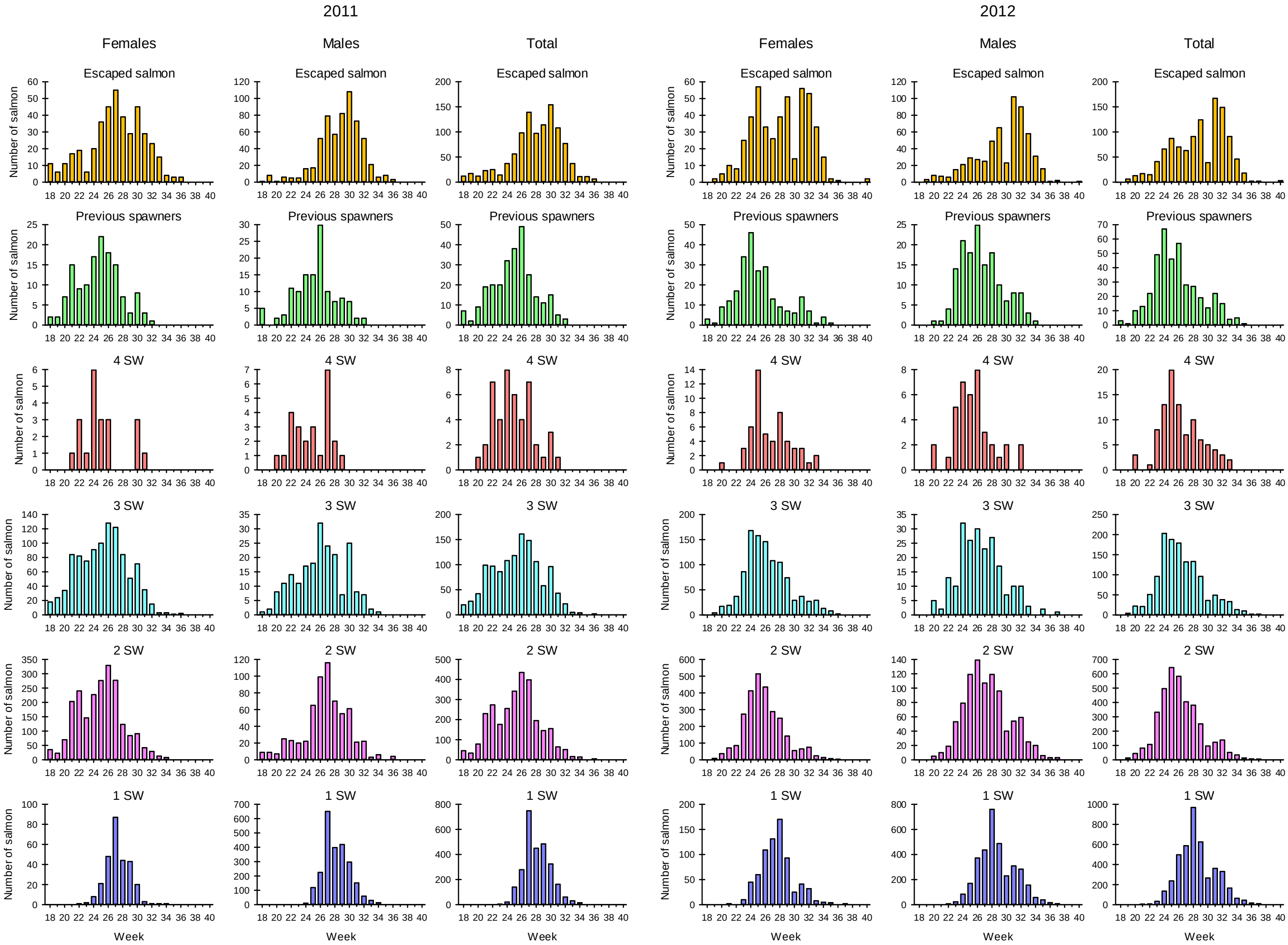


Figure 11. Weekly number of 1-4SW salmon, previous spawners and escaped salmon in the catches in the Kolarctic area in 2011 and 2012. The bars clearly indicate the start of the migration, peak migration and the time when the migration is over for each sea-age group of salmon.

Photo 18. Fisherman Kjell Ove Jenssen, Gjesvær North Cape

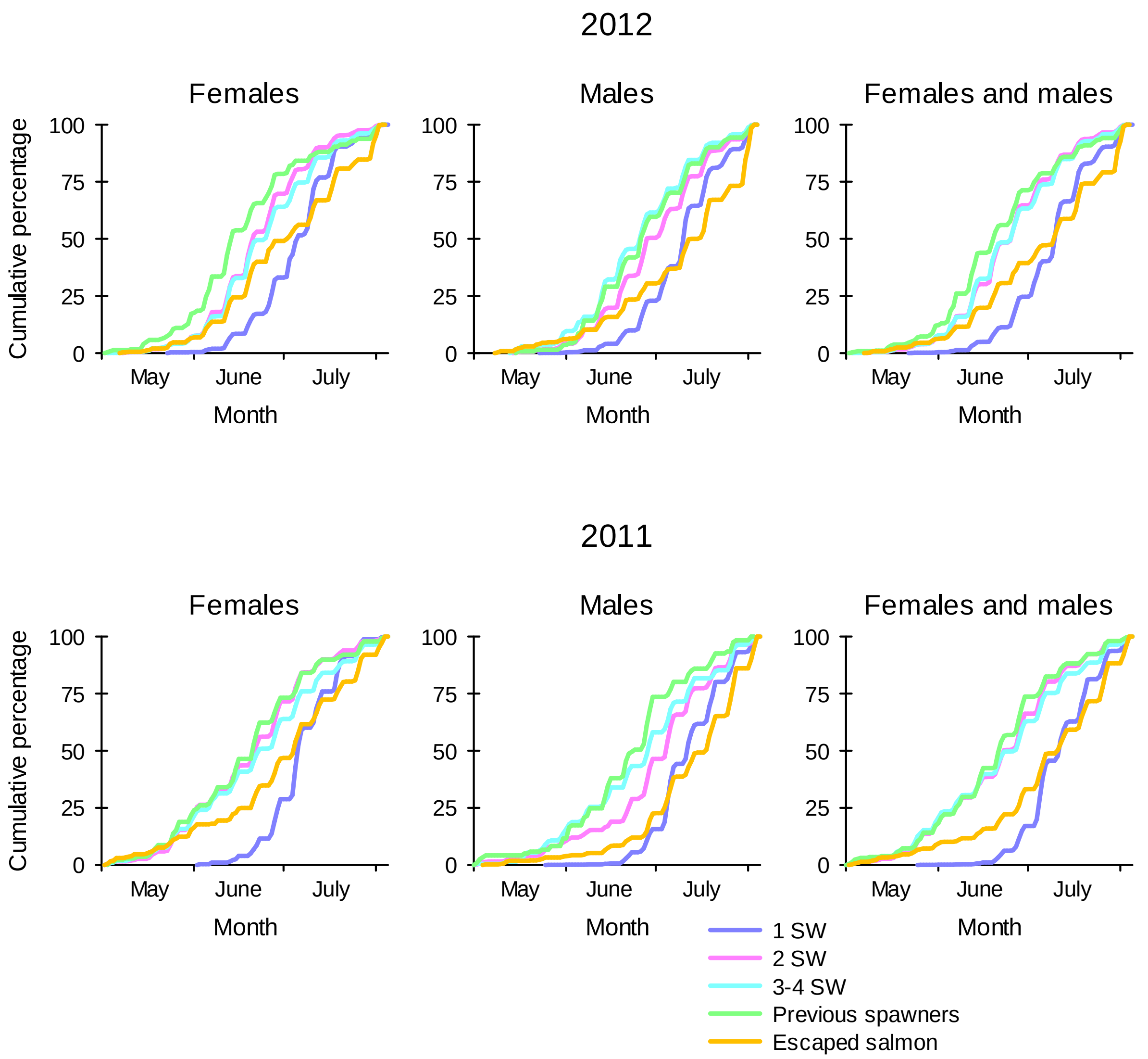


Figure 12. Cumulative percentages of the catch in terms of numbers for wild 1-4SW salmon, previous spawners and escaped salmon in the Kolarctic area for the time period from May 1 to August 4 in 2011 and 2012.

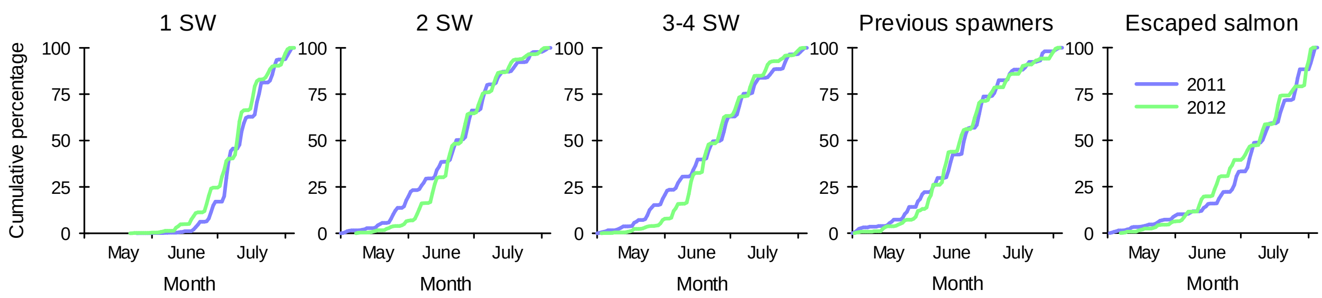


Figure 13. Cumulative percentage curves of the catch for 1SW, 2SW, 3-4SW, previous spawners and escaped salmon in the Kolarctic area, comparing 2011 and 2012 for the time period from May 1 to August 4.

Figure 13 indicates that there were some, though not great, annual variations in the timing of the catches. In 2012 the migration of 2SW, 3-4SW, and slightly also of previous spawners and escaped salmon, was initiated later than in 2011. The catch of 1SW salmon, however, took place earlier in the season in 2012 than in 2011.

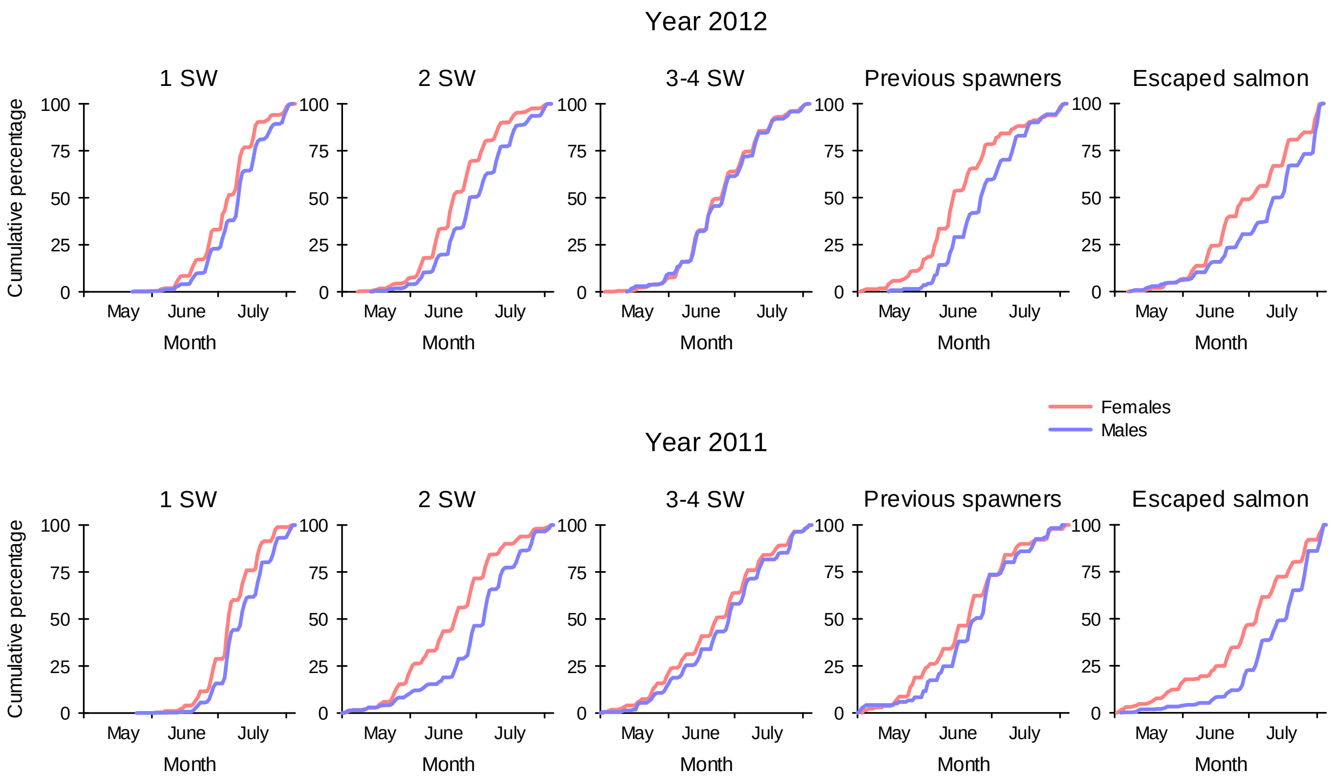
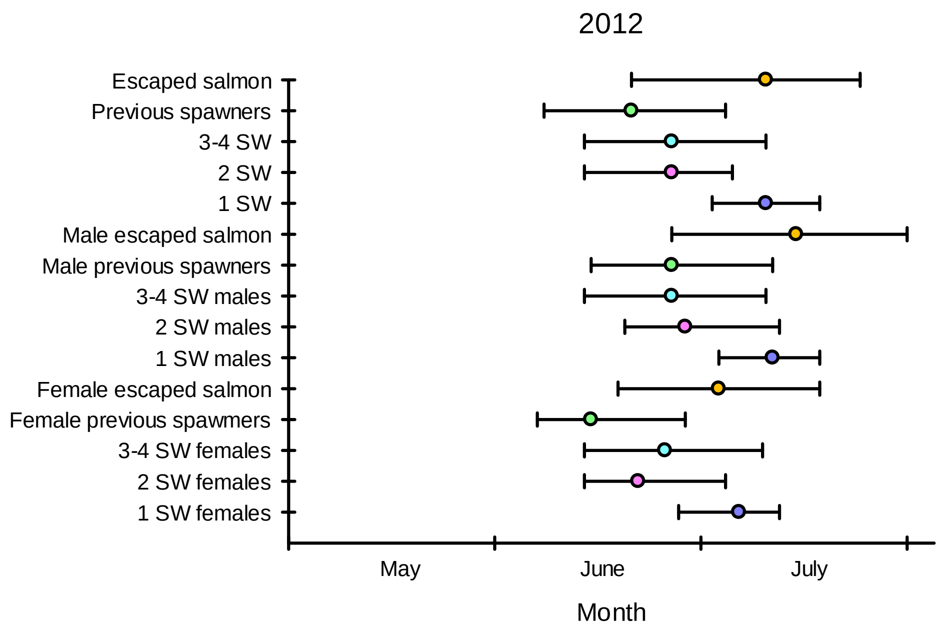


Figure 14. Differences in the cumulative percentage of female and male salmon catches in the Kolarctic area for the time period from May 1 to August 4.

For successful salmon management it is important to know the period when salmon of different sea-ages are migrating along the coastal areas as well as whether the time of catches is different between sexes. In 2011 and 2012 the differences between females and males in migration timing were consistent (Figure 14). Females were caught slightly earlier than males for 1SW, 2SW, previous spawners and for escaped salmon groups, but in 3-4SW salmon they were caught almost simultaneously.

The median date of catch with an interquartile range of 25% (lower interquartile range) and 75% (upper interquartile range) is one clear statistical parameter to indicate differences in the timing of migrations, especially in cases when the fishing season covers almost the entire migratory period from early May to the beginning of August. Figure 15 demonstrates clear differences in the median dates of the catches within the entire Kolarctic area between all sea-age groups for wild salmon and escaped salmon. In females, the earliest median dates were for previous spawners, with 2SW and 3-4SW salmon being around June 15-25. For 1SW salmon and escaped salmon the median date is around July 5. Here it should be emphasized that abundance of escaped salmon probably increases after August 4, which is the end date of the official fishing time in Finnmark. Therefore this median date of catch is not comparable to the corresponding dates of wild salmon (see also Figures 10 and 11). In male wild salmon the median dates of catch are more or less the same in 2011 and 2012 for previous spawners, 1SW and 3-4SW salmon. When analysing the material with the sexes combined, it is obvious that previous spawners migrated first to the coastal areas, followed by 2SW and 3-4SW salmon which are caught simultaneously, similar to 1SW and escaped salmon which are caught later in the summer.



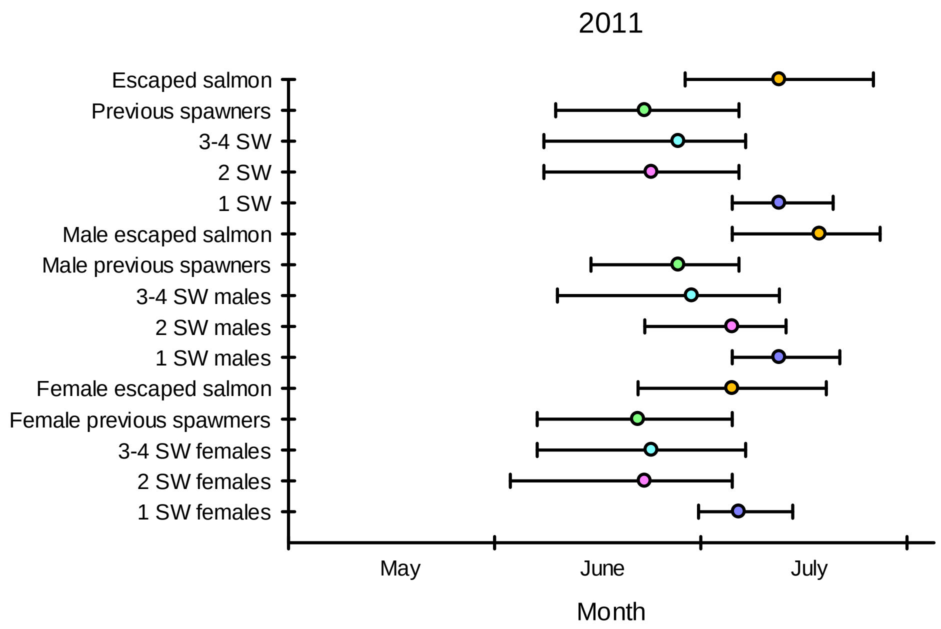


Figure 15. Median dates with 25% and 75% interquartile ranges of the catch in terms of numbers for wild 1-4SW salmon, previous spawners and escaped salmon in the Kolarctic area for the time period from May 1 to August 4. The median date is the date within the main migratory period when 50% of the catch was accumulated. The 25% interquartile date point is the date in the summer when 25% of the salmon were accumulated in the catch and 75% corresponds to the date when 75% of the salmon catch was accumulated.

4. Migratory pattern for wild and escaped salmon at sea in Finnmark

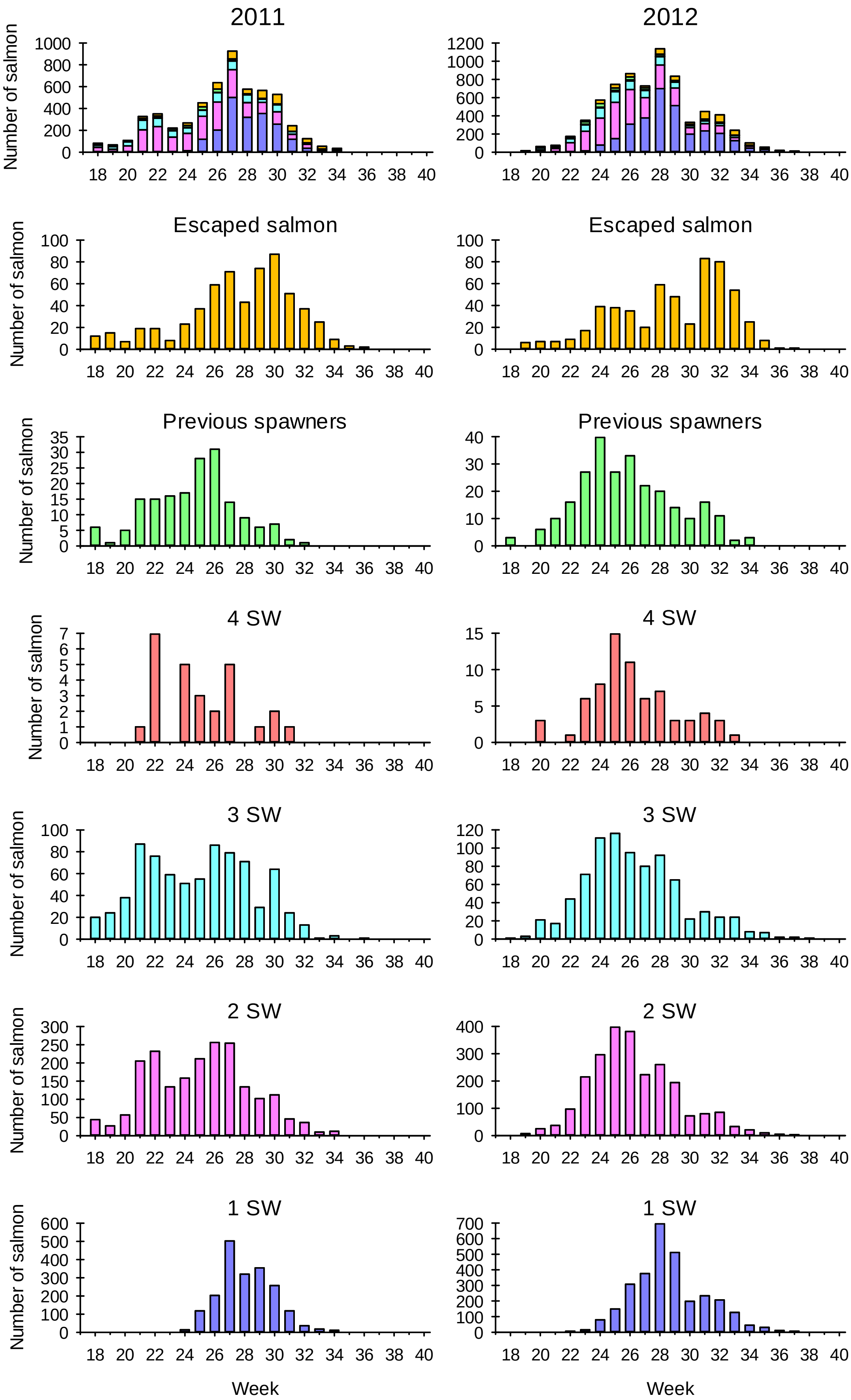


Figure 16. Weekly salmon catch in terms of numbers in Finnmark, sexes combined, in 2011 and 2012.

In Finnmark, the timing of the migration of wild salmon differs a little between years. For example, in 2011 fishermen already caught the first 2SW, 3SW salmon and previous spawners during the first week of May. Catches in very early May indicate that there was salmon migration before May. Information from the oldest salmon fishermen fishing in Kolarctic salmon project (pers. com. Ansten Mathisen) confirms that they caught large salmon in late April in the 1930s, and soon after it was possible to start bag net fishery. 2SW, 3SW salmon and previous spawners can be targets for the fishery through practically three summer months but 1SW salmon can be a target during a much shorter time period (Figure 16).

In 2011 the abundance of 2SW and 3SW salmon increased during the last two weeks of May followed by clear decline in the catches in early June. In 2012 the number of salmon in all sea ages increased steadily towards the peak migration followed by regular decline until the end of week 31. In Finnmark wild salmon catches after the ordinary fishing time, which is after August 4, were small although all sea-age groups were present. The catch of escaped salmon was still high after the ordinary fishing time in the year 2012.

Figure 17 confirms the simultaneous migration of 2SW and 3-4SW salmon presented in figure 16 in which sexes were combined. Female 2SW and 3-4SW migrate simultaneously but in males 3-4SW salmon migrate before 2SW salmon. 1SW salmon catches accumulate faster than that of older wild salmon and 1SW salmon are clearly migrating later than older salmon. The catch of male escaped salmon accumulates slowly, especially in the beginning of the fishing season as compared to their female counterparts. The significant overlapping in the cumulative catch development of 2SW and 3-4SW salmon can help management when tailoring sea-age specific regulations for the fishery.

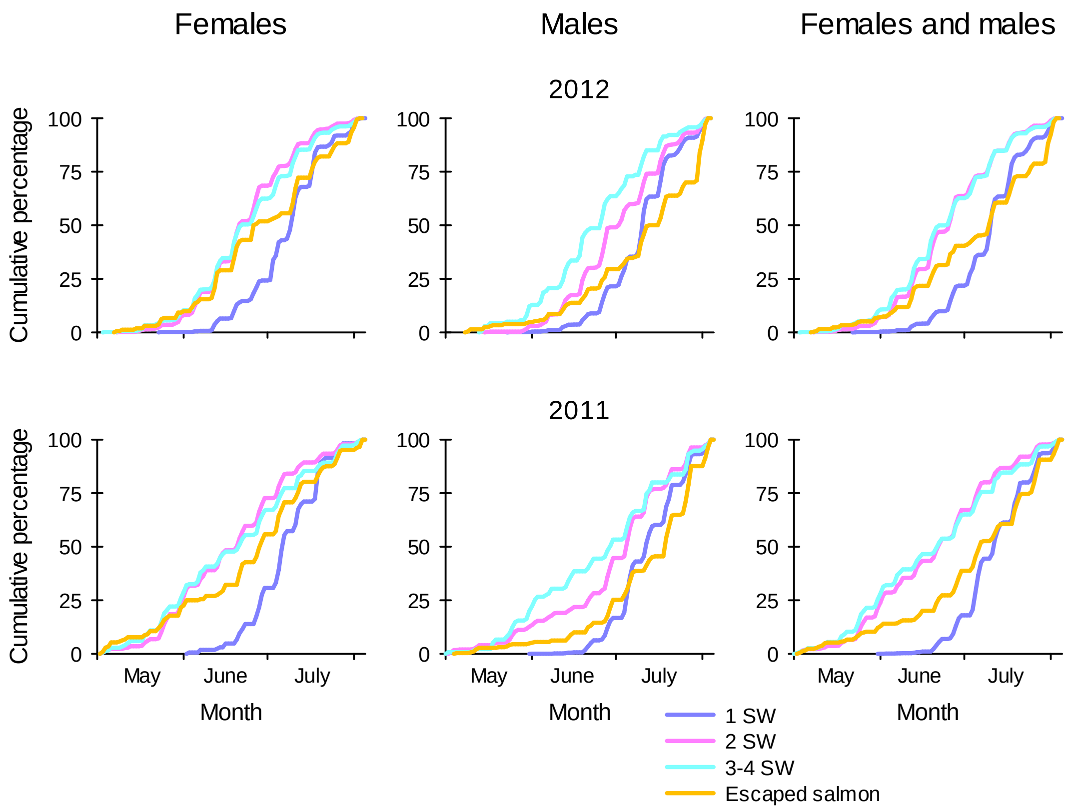


Figure 17. Differences in the cumulative percentage curves of the catches of 1SW, 2SW, 3-4SW and escaped salmon in the coastal fishery in Finnmark from May 1 to August 4 in 2011 and 2012.

The migration periods of wild and escaped salmon in Finnmark differed between 2011 and 2012 such that in the year 2012 migrations of 2SW and 3-4SW salmon commenced later than in the year 2011 (Figure 18). One sea-winter salmon, which normally migrate later than older salmon, migrated similarly in both years. Interestingly, escaped salmon also migrated similarly in both years

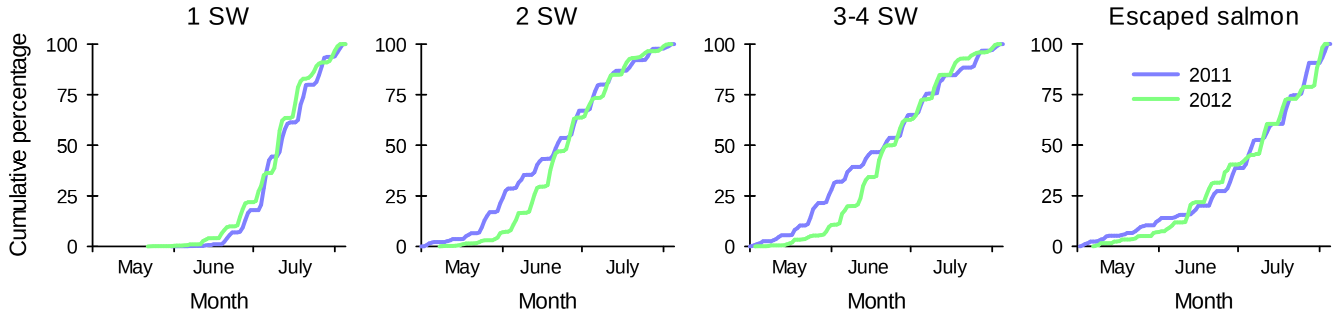


Figure 18. Cumulative percentage curves of the catches for 1SW, 2SW, 3-4SW and escaped salmon between 2011 and 2012 in Finnmark for the time period from May 1 to August 4.

Combining the material collected before August 4 indicates that the catch of 2SW females and escaped salmon in Finnmark accumulated earlier than that of males in 2011 and 2012. The same differences in the cumulative catches between sexes were that female catches accumulated some earlier than male catches in 1SW and 3-4SW salmon in 2011 and in 2012 (Figure 19).

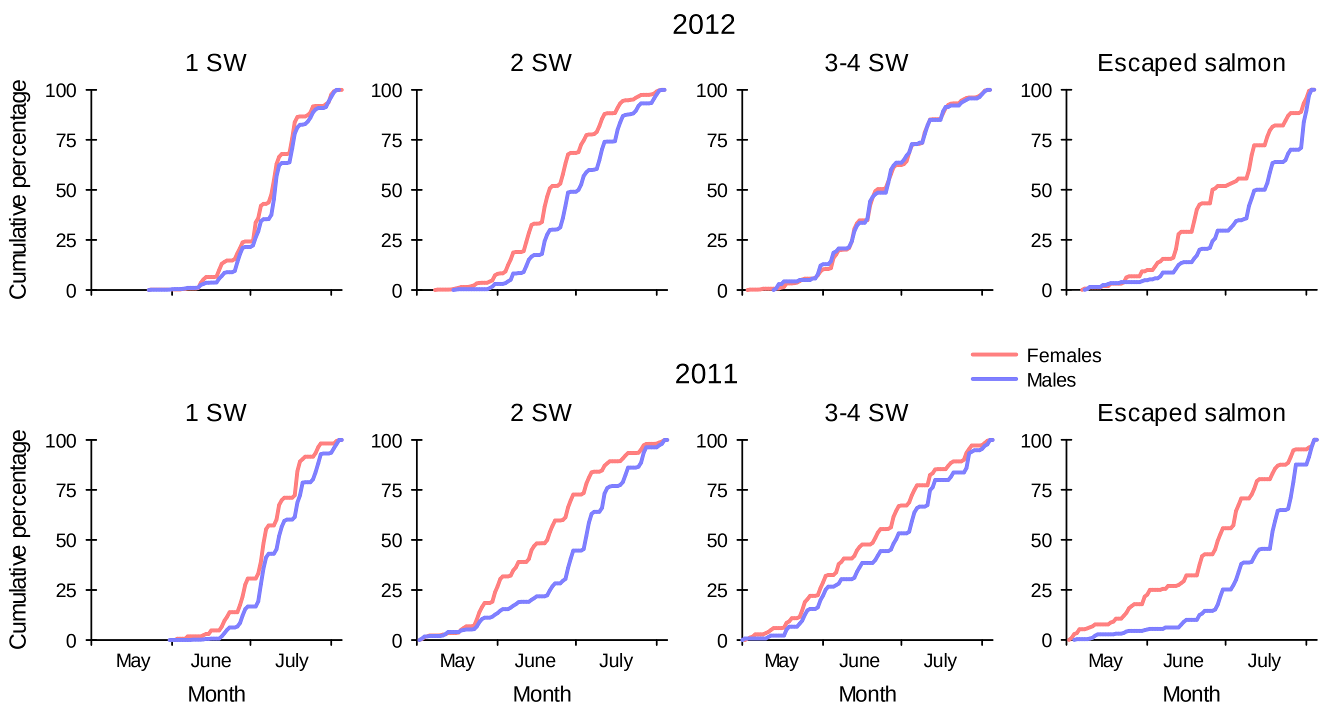


Figure 19. Cumulative percentage curves of the catches in Finnmark for 1SW, 2SW, 3-4SW and escaped female and male salmon in 2011 and 2012 for the time period from May 1 to August 4.

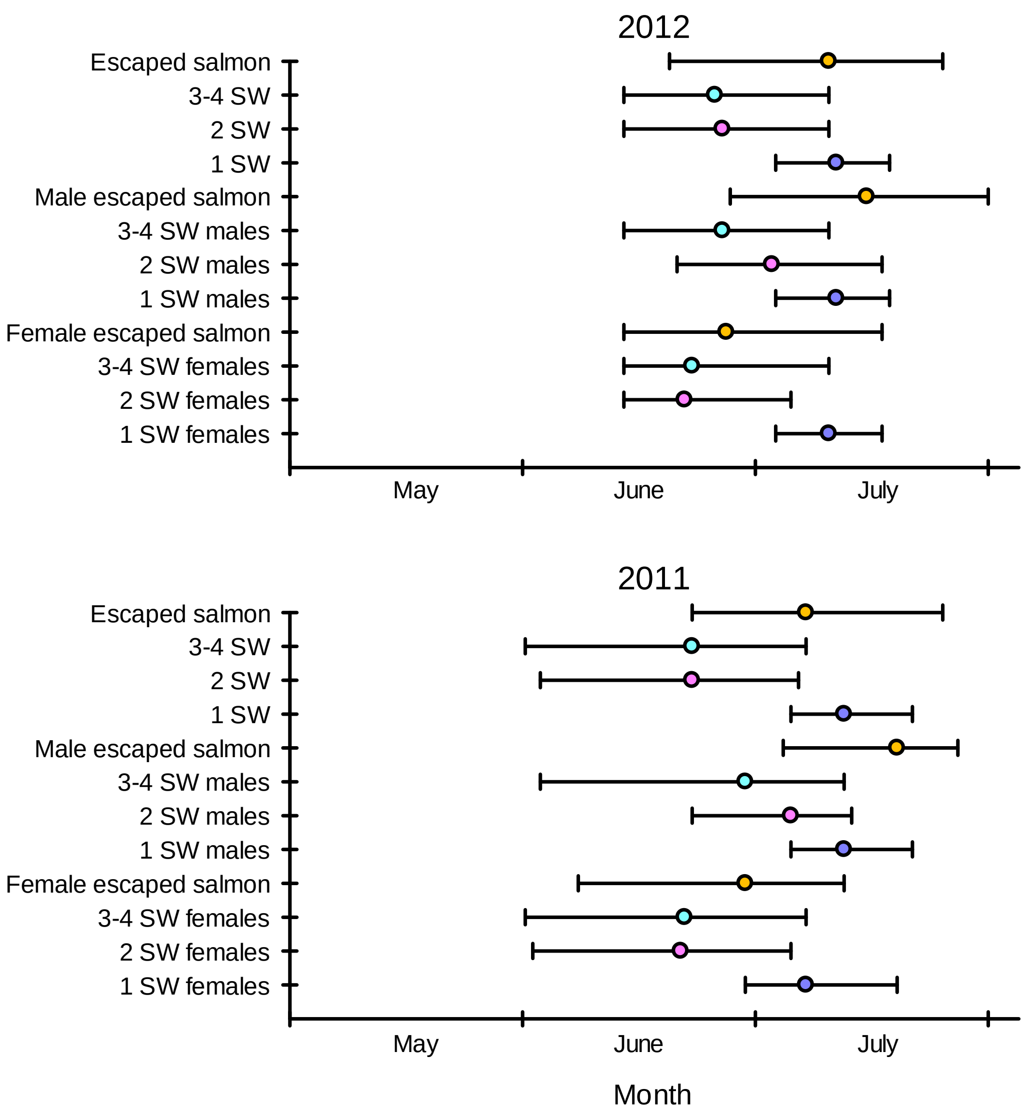


Figure 20. Median dates and 25% and 75% interquartile ranges of the catches in Finnmark for 1SW, 2SW, 3-4SW and escaped female and male salmon and sexes combined in 2011 and 2012 for the time period from May 1 to August 4.

Median dates of the catches in Finnmark between May and August 4 were almost identical in 2011 and 2012 (Figure 20). This indicates that the timing of the migrations of various sea ages was almost the same in both years. In both years fishing regulations at sea were the same and one possible environmental parameter which could affect differences in the timing is sea temperatures in the north. Environmental factors might have caused some delay in the migrations of 2SW and 3-4SW salmon in 2012. The duration of the interquartile range in the catches of 1SW females and males is much shorter than that of 2SW, 3-4SW and even than that of escaped salmon. Fifty per cent of the catch is accumulated during the lower and upper interquartile period and if that combined interquartile period is long, like for 2SW and 3-4SW salmon, it indicates that those sea-age groups of salmon are targets for a long period of time in the fishery. As the interquartile range of 1SW salmon is short, the peak migration of those fish is fast and intensive (see also figure 16) and its duration was a little less than two weeks in July in the year 2012.

5. Migratory pattern for wild and escaped salmon at sea in Troms

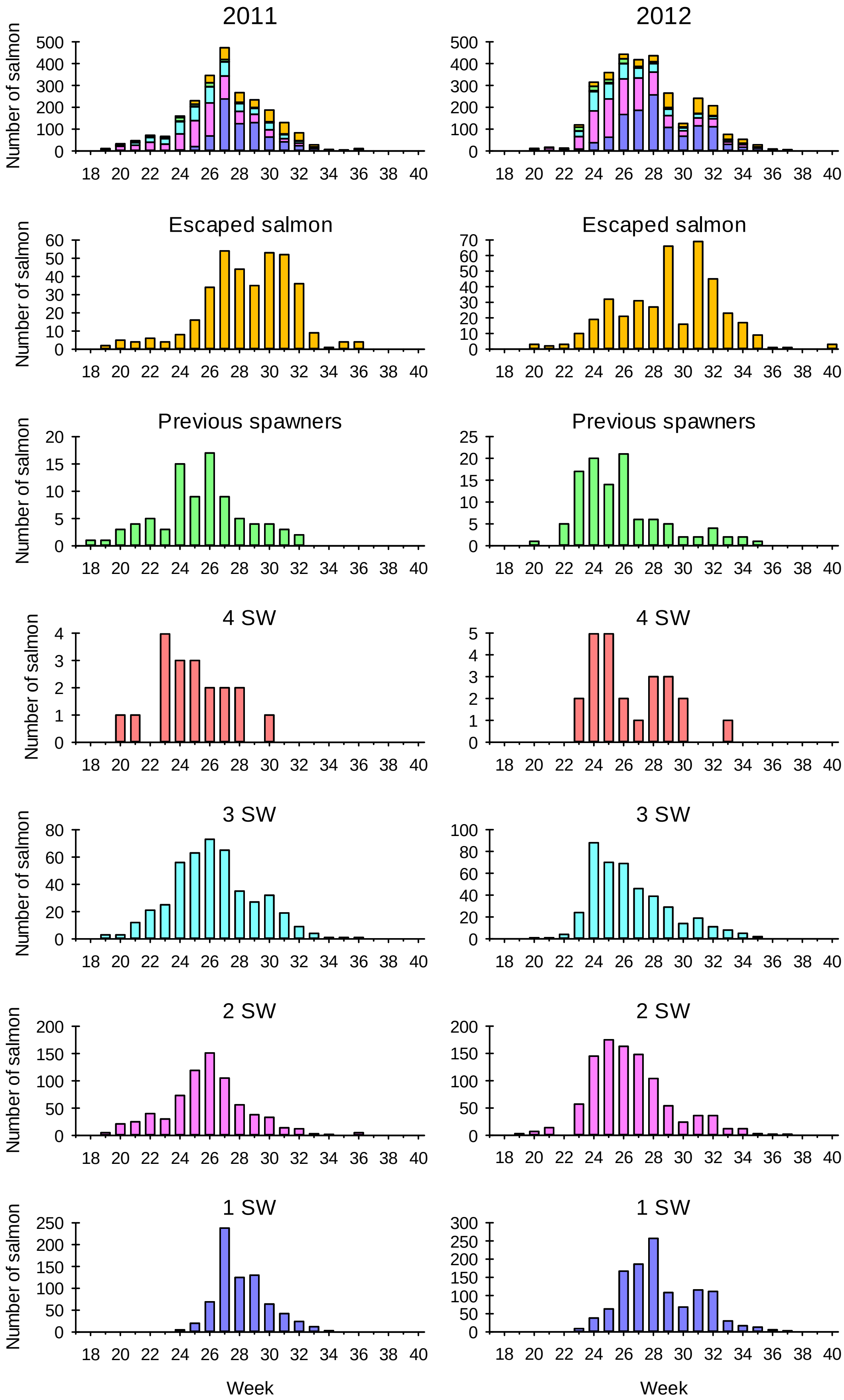


Figure 21. Weekly salmon catches in terms of numbers in Troms, sexes combined, in 2011 and 2012.

In Troms, the timing of the migrations of wild salmon differs a little between years. For example, in 2011 fishermen caught the first 2SW and 3SW salmon in the second week of May but previous spawners in the first week of May. Historically the catches in May have been very low in general and salmon migrations have been reported to commence around in the middle of June. 2SW and 3SW salmon and previous spawners can be targeted by the fishery practically through June and July but 1SW salmon can be targeted for a much shorter time period, mainly in July (Figure 21). The highest activity in the migrations of 2SW and 3SW salmon takes place in four weeks (weeks 24-27). Escaped salmon occurred in the catches from early May with increasing abundance to the end of August. It is most probable that there are escaped salmon present in the coastal areas also after August, but very few wild salmon.

In the year 2011 the abundance of 2SW and 3SW salmon increased slowly in the catches from the end of May onwards, but in the year 2012 their numbers increased quickly after week 23. The development in the total catches in the year 2011 illustrates more or less normal timing of salmon migrations but the figure for the year 2012 is affected by unfavourable environmental conditions. The most active migration period for salmon in Troms takes place between the weeks 24-28. After the ordinary fishing season, August 4, all the wild salmon sea-age groups are present, as well as escaped salmon, until the end of August. The catch of escaped salmon was still high after the ordinary fishing season.

Figure 22 confirms the simultaneous migrations of 2SW and 3-4SW salmon in Troms observed also in figure 21 where sexes were combined. Female 2SW and 3-4SW are migrating simultaneously, but in males, 3-4SW salmon are migrating before 2SW salmon, as in in Finnmark. 1SW salmon are migrating clearly later than older salmon. The catches of female and male escaped salmon are accumulating slowly, especially in the beginning of the fishing season compared to their wild counterparts.

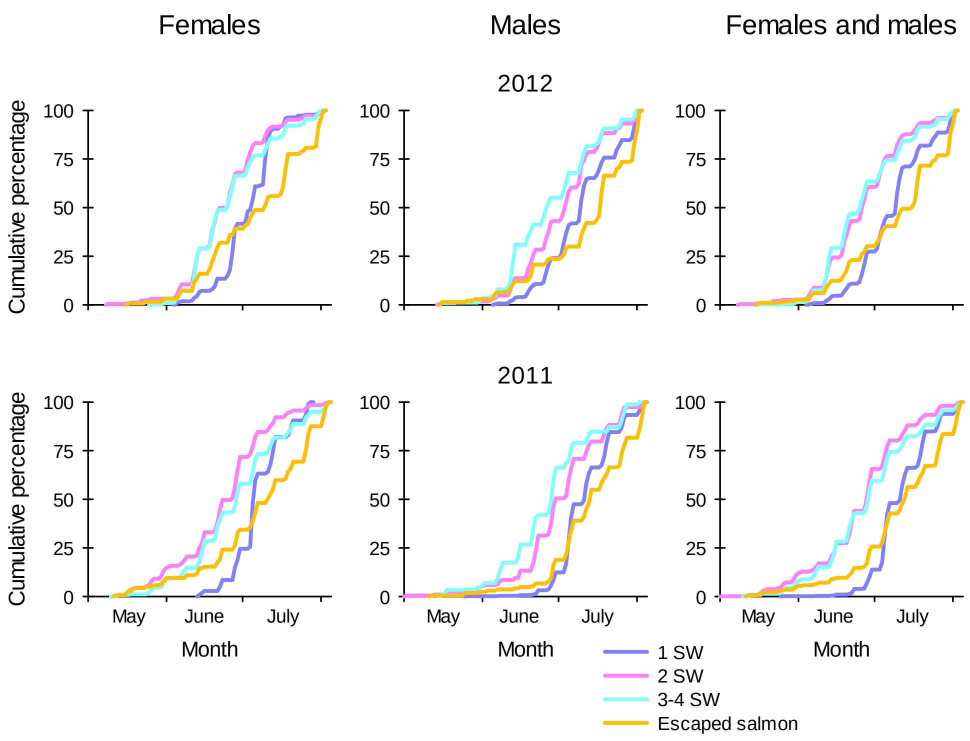


Figure 22. Differences in the cumulative percentage curves of the catches between 1SW, 2SW, 3-4SW and escaped salmon in 2011 and 2012 in Troms for the time period from May 1 to August 4.

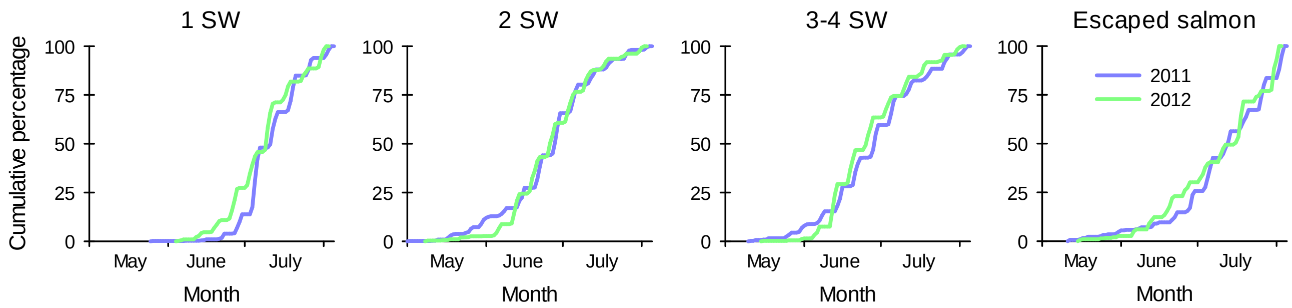


Figure 23. Cumulative percentage curves of the catches for 1SW, 2SW, 3-4SW and escaped salmon between 2011 and 2012 in Troms for the time period from May 1 to August 4.

The migration periods of wild and escaped salmon in Troms differed slightly between 2011 and 2012. In the year 2012, the migrations of 1SW salmon commenced earlier, and the migration of 2SW and 3-4SW salmon commenced later than in the year 2011 (Figure 23). The occurrence of escaped salmon in the catches was almost similar in both years.

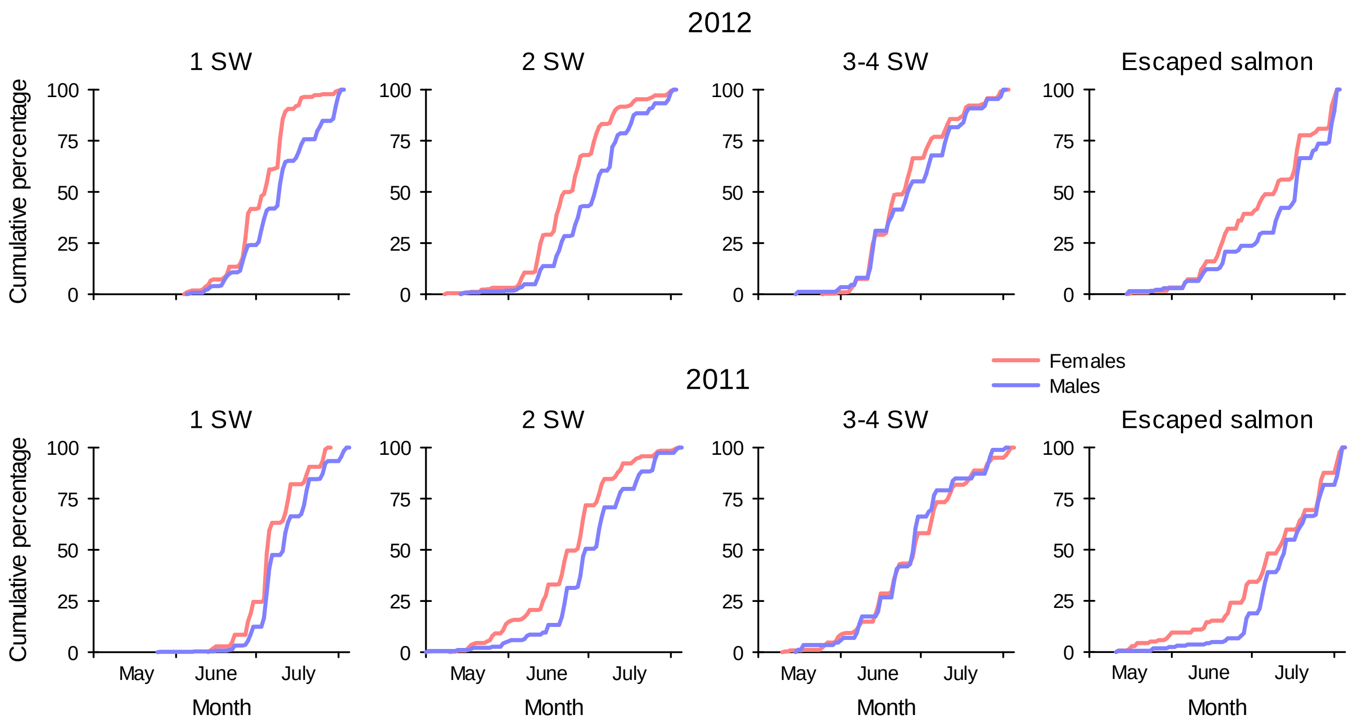


Figure 24. Cumulative percentage of the catches for 1SW, 2SW, 3-4SW and escaped female and male salmon in 2011 and 2012 in Troms for the time period from May 1 to August 4.

Combining the material collected before August 4 it indicates that the catch of 2SW females in Troms accumulated clearly earlier than that of males in 2011 and 2012 (Figure 24). In 1SW female salmon catches also accumulated earlier than male catches, but only slightly. There was no differences between sexes in the timing of 3-4SW salmon, but in escaped salmon females were caught earlier.

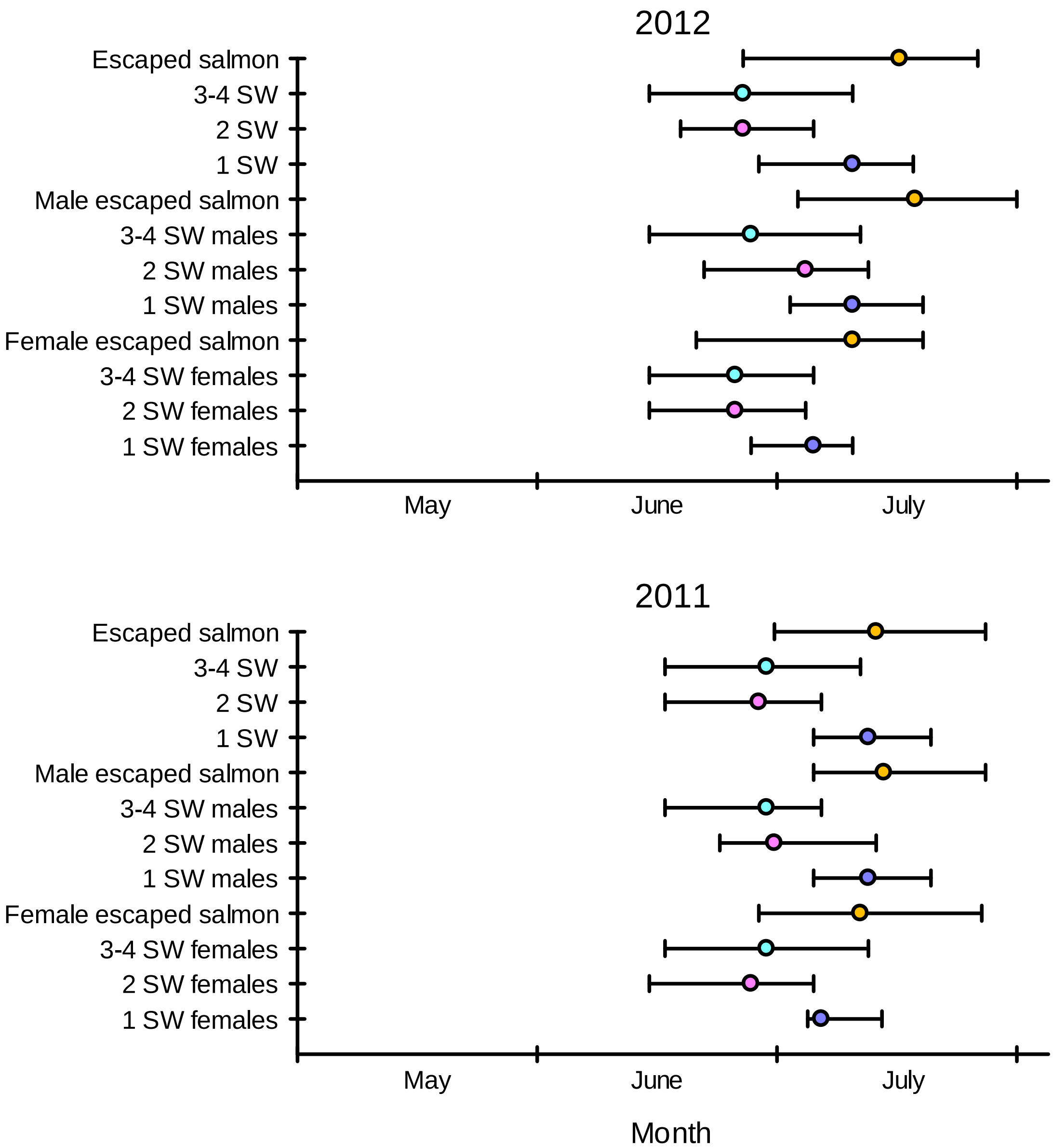


Figure 25. Median dates and 25% and 75% interquartile ranges of the catches in Troms for 1SW, 2SW, 3-4SW and escaped female and male salmon and sexes combined in 2011 and 2012 for the time period from May 1 to August 4.

Median dates of the catches in Troms between May and August 4 were almost identical when sexes were combined in 2011 and 2012 (Figure 25). The timing of female and male salmon migrations in various sea-ages was almost the same in both years. Fishing regulations at sea were the same in both years and various environmental parameters including sea temperatures could affect the timing of catches in the north. In the year 2012 there were more fishermen and also more fishing sites to collect salmon material from, which could affect into the timing of salmon catches. Environmental factors might have caused to the slight delete migrations of 2SW and 3-4SW salmon in 2012. The duration of the interquartile range in the catches of 1SW females and males is much shorter than it of 2SW, 3-4SW and even of escaped salmon in the year 2011.

6. Migratory pattern for wild and escaped salmon at sea in Nordland

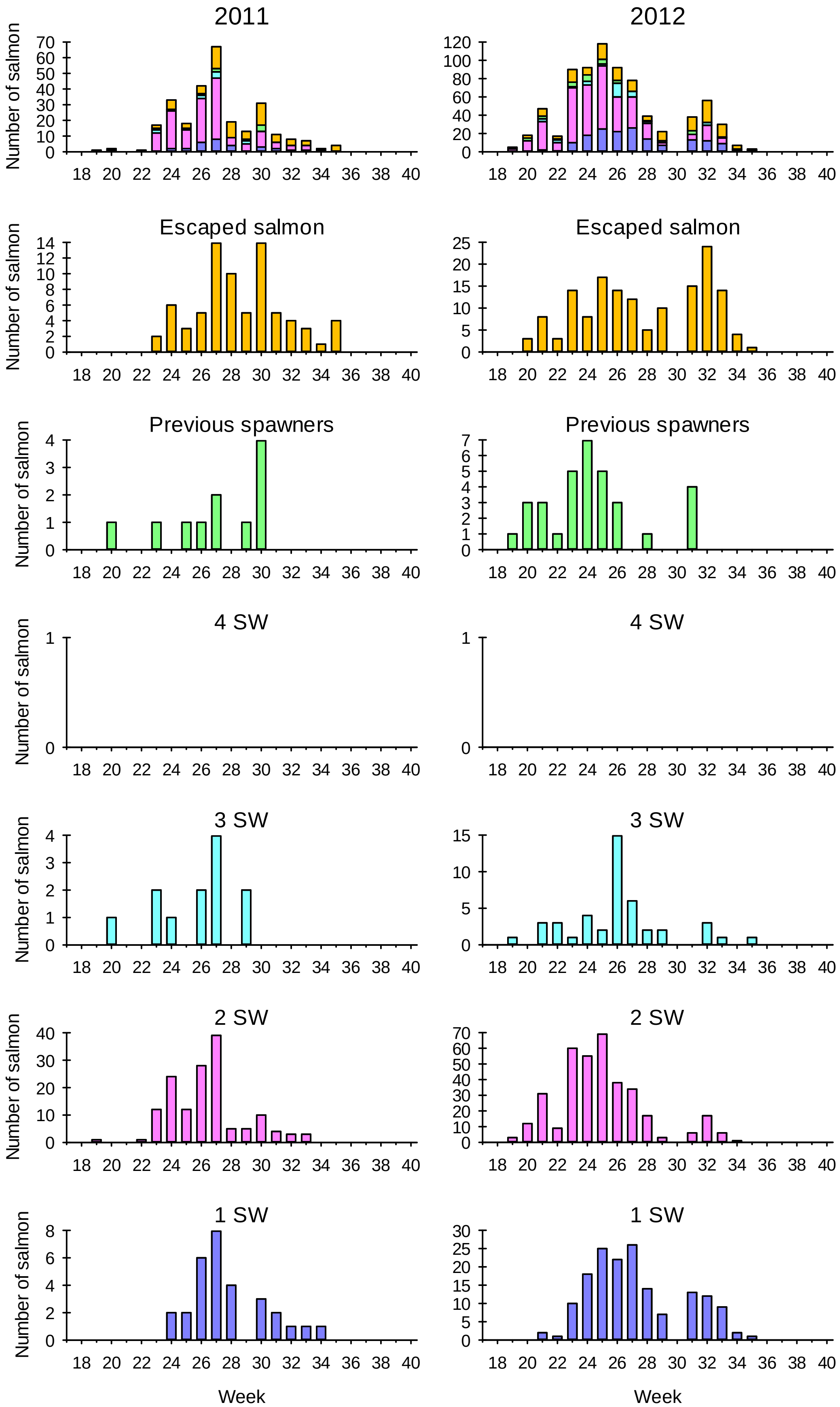


Figure 26. Weekly salmon catches in terms of numbers in Nordland, sexes combined, in 2011 and 2012.

In Nordland, the timing of the migrations of wild salmon differs a little between years. The low number of samples collected in 2011 (n=c. 270) from May to the end of August is not sufficient for drawing further conclusions, especially concerning migrations for the sea-age groups 1SW, 3SW and previous spawners. 2SW and 3SW salmon, like previous spawners as well as escaped salmon, can be targets for the fishery throughout May to the end of August (Figure 26). Some migration peaks can be observed for 1SW salmon in weeks 25-27, for 2SW salmon in weeks 23-27, for 3SW salmon in weeks 26-27 and for previous spawners in weeks 23-25. Escaped salmon occurred in variable amounts in all months in the catches, but some increase can be seen towards autumn in the year 2012 when there was better coverage of sampling and more fishermen participating in the research fishery. It is probable that there is escaped salmon present in the coastal areas also after August, as in Troms and Finnmark, but very few wild salmon.

Figure 27 illustrates the migration periods of salmon in Nordland. Cumulative catches are more or less the same as those found in Troms and Finnmark.

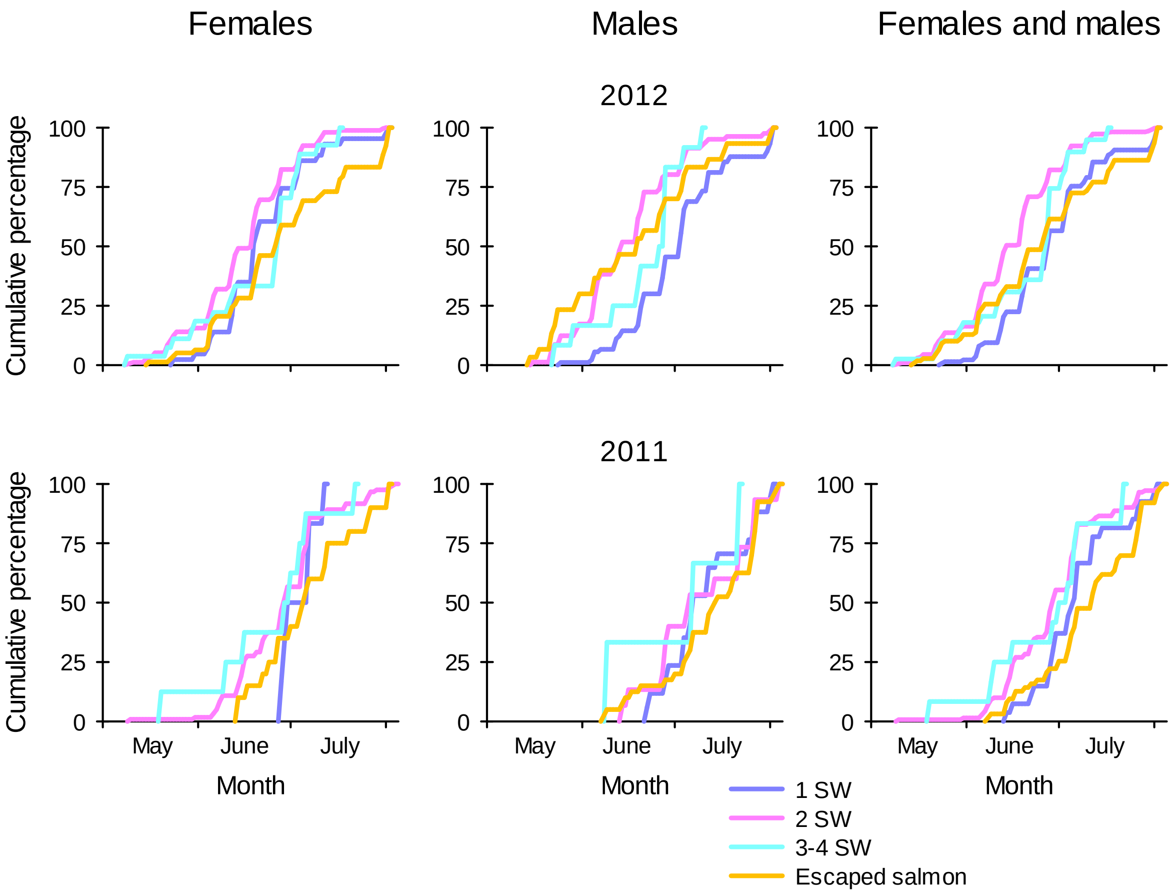


Figure 27. Cumulative percentage curves of the catches of 1SW, 2SW, 3-4SW and escaped salmon in 2011 and 2012 in Nordland for the time period from May 1 to August 4.

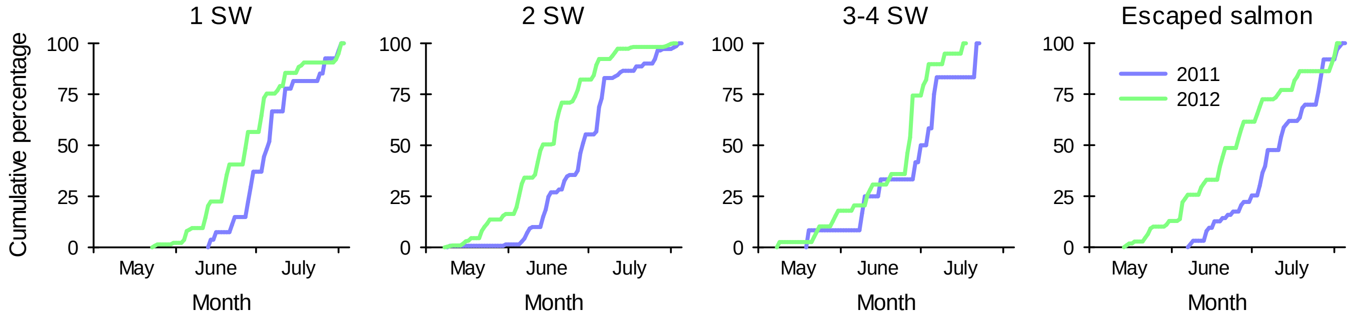


Figure 28. Cumulative percentage curves of the catches for 1SW, 2SW, 3-4SW and escaped salmon between 2011 and 2012 in Nordland for the time period from May 1 to August 4.

The migration periods of wild 1SW and 2SW salmon and escaped salmon in Nordland differed significantly between 2011 and 2012. These groups of salmon appeared earlier in the catches in 2012 than in 2011 (Figure 28). This difference in the timing of the catches between the years is partly explained by the increased number of fishermen and larger spatial coverage of sampling sites in 2012.

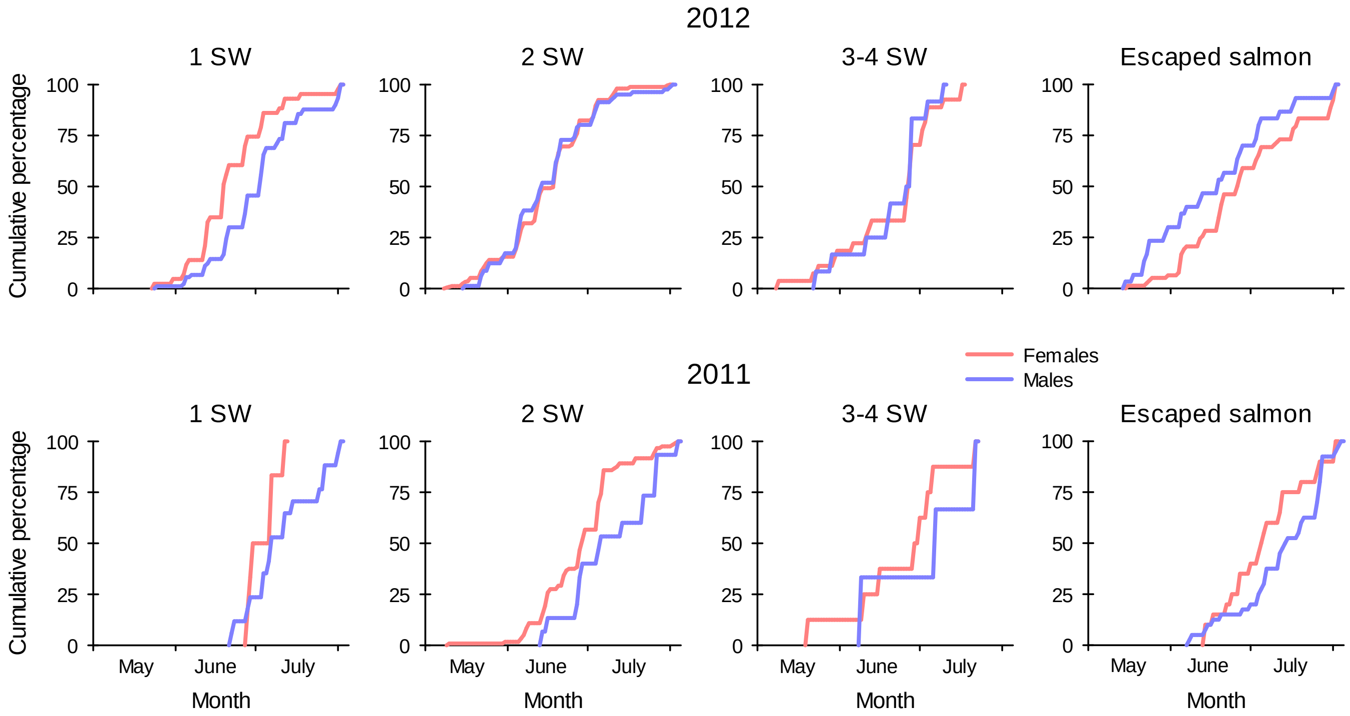


Figure 29. Cumulative percentage of the catches for 1SW, 2SW, 3-4SW and escaped female and male salmon in 2011 and 2012 in Nordland for the time period from May 1 to August 4.

Looking at the combined material collected before August 4, there are indications that the catch of 1SW females in Nordland clearly accumulated earlier than that of males in 2012 (Figure 29). No difference in the timing between sexes was found for 2SW and 3-4SW salmon in 2012, but in escaped salmon males occurred earlier in the catches.

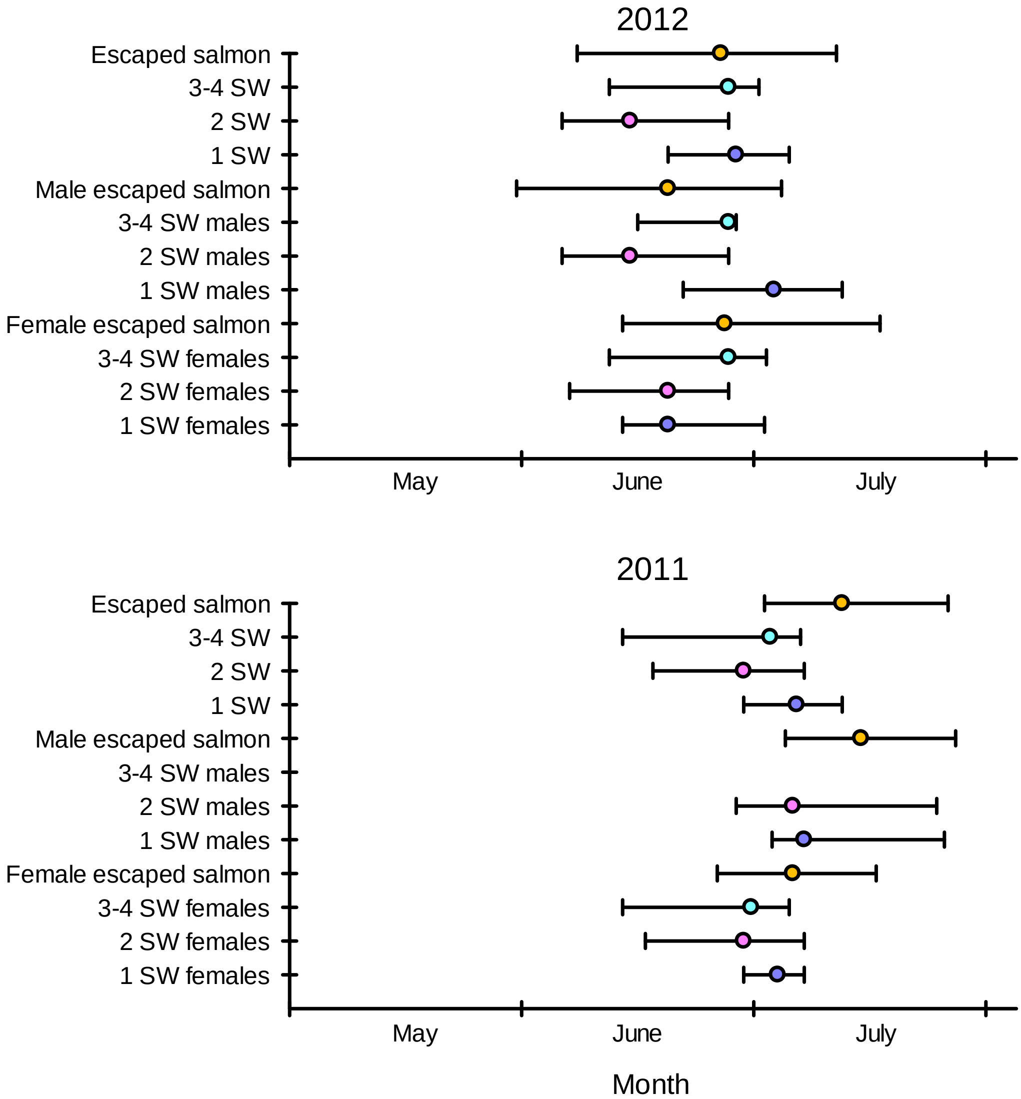


Figure 30. Median dates and 25% and 75% interquartile ranges of the catches in Nordland for 1SW, 2SW, 3-4SW and escaped female and male salmon and sexes combined in 2011 and 2012 for the time period from May 1 to August 4.

From May 1 to August 4 the median dates of the catches in Nordland between females and males were almost identical in 2012 in the age groups of 2SW and 3-4SW salmon (Figure 30). Fishing regulations at sea were the same in both years. Issues affecting differences in the timing could be increased sea temperatures in the north, and better spatial coverage of sampling (with higher numbers of fisherman collecting material). The duration of the interquartile range in the catches was almost the same for females in 1SW, 2SW and 3-4SW salmon and for males in 1SW and 2SW salmon in 2012.

7. Catch composition in West-, Middle- and East-Finnmark

Finnmark can be divided into three distinct areas, West- (from Loppa to Porsanger), Middle- (from Lebesby to Berlevåg) and East-Finnmark (from Båtsfjord to Sør-Varanger), and the timing of salmon catches differs between areas. The differences can be observed in the differences in the timing of the peak migrations for 1SW, 2SW and 3-4SW salmon as well as for escaped salmon (Figure 31). Small annual variations are obvious in the migration patterns for all sea-age groups. The time frame when 1SW salmon were caught is much shorter than the time frame for 2SW and 3-4SW salmon catches.

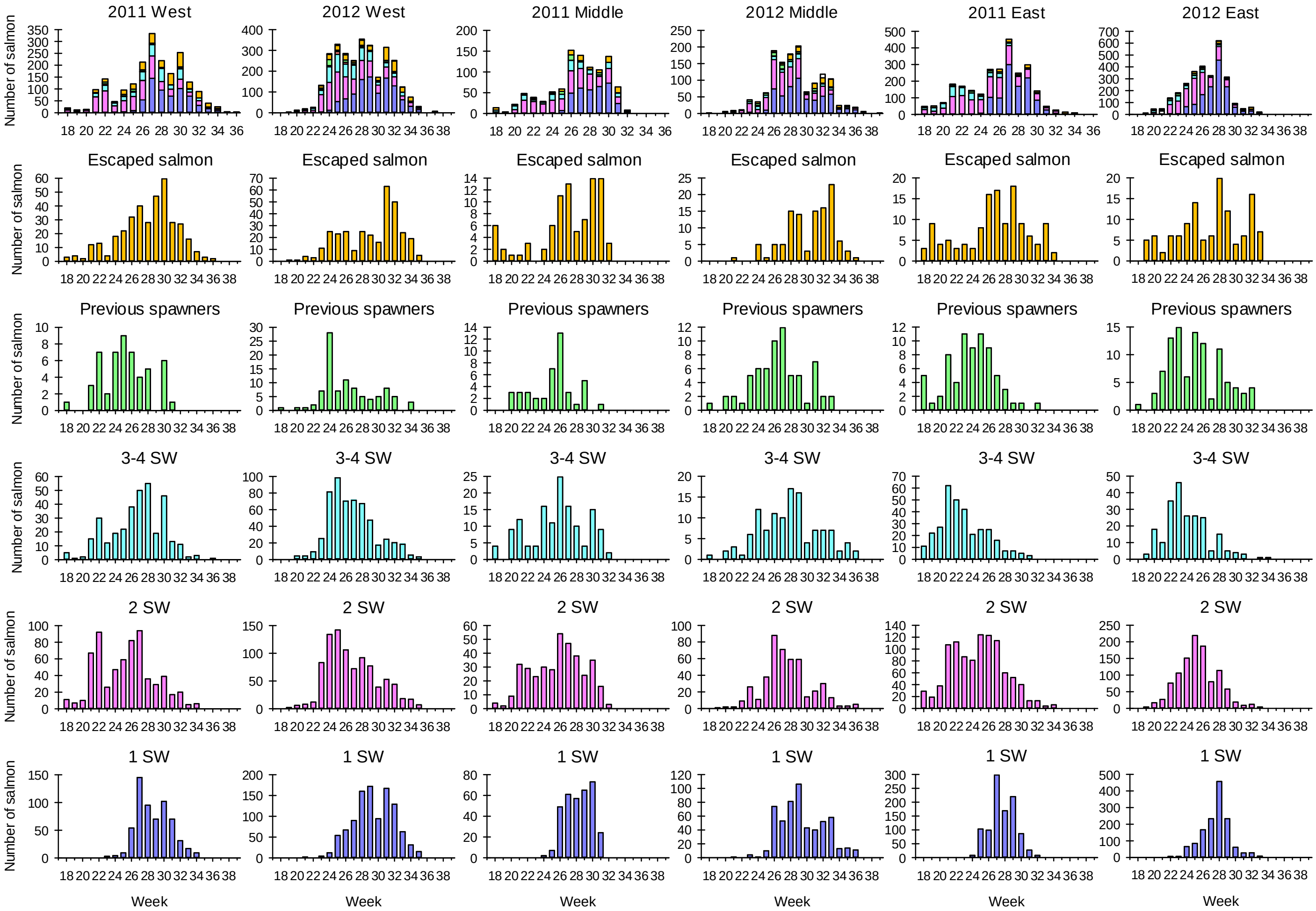


Figure 31. Weekly numbers of 1-4SW salmon, previous spawners and escaped salmon in the catches in West- (from Loppa to Porsanger), Middle (from Lebesby to Berlevåg) and East-Finnmark (from Båtsfjord to Sør-Varanger) in 2011 and 2012. The bars clearly indicate the start of the migrations, peak migrations and time when the migrations are over for each sea-age group of salmon.

The proportion of 1SW fish is in general low in female salmon catches, being lowest in West- and Middle Finnmark and highest in East-Finnmark (Figure 32). In East-Finnmark the proportion of 1SW females was almost 50% in female salmon catches in week 29. In male salmon catches the proportion of 1SW fish is very high in the middle of the summer in all Finnmark areas, especially in East-Finnmark, where it constituted approximately 90% of male salmon catches in weeks 27-29.

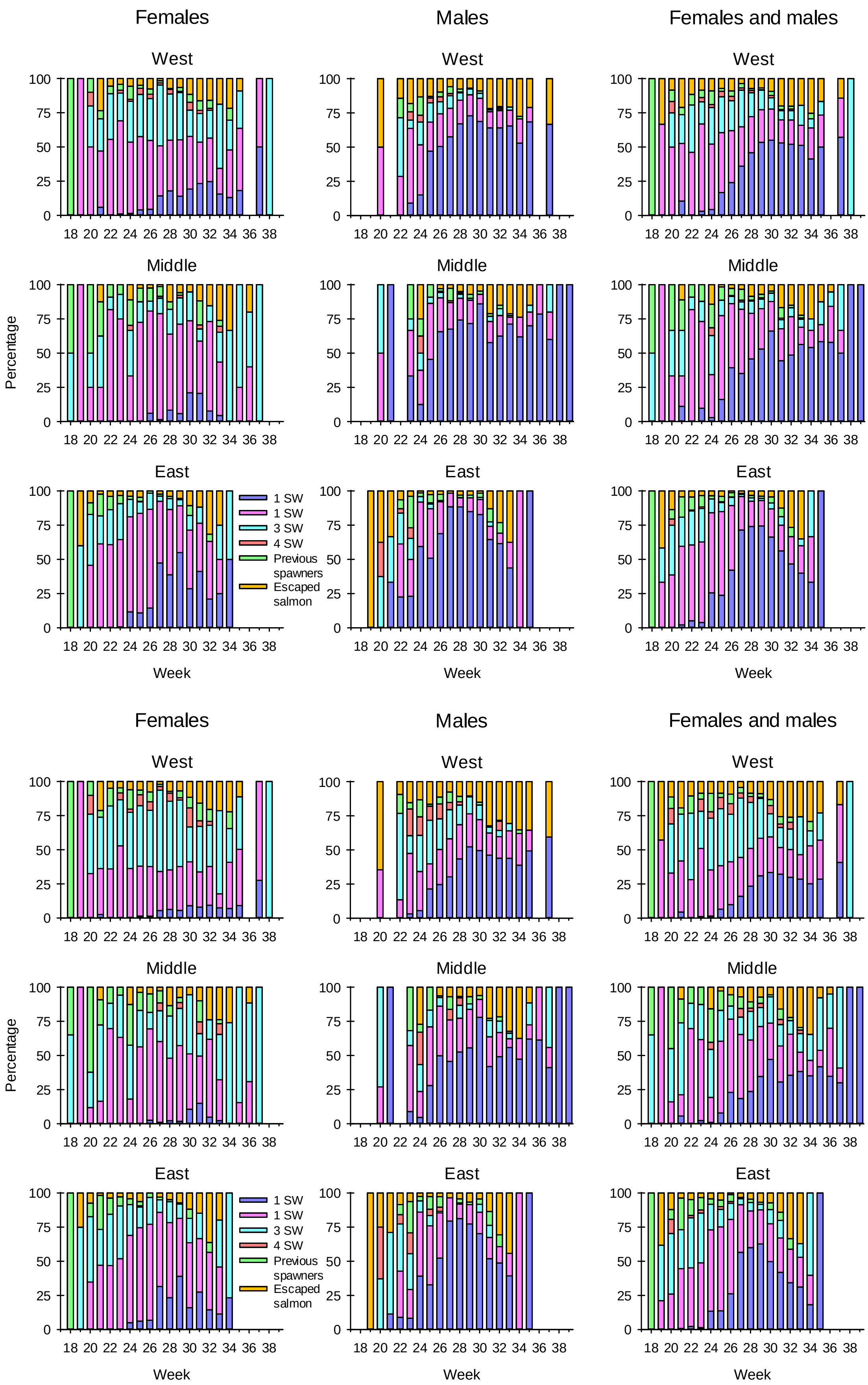


Figure 32. The proportions of 1-4SW salmon, previous spawners and escaped salmon in the weekly catches in West-, Middle- and East-Finnmark in 2012. The figure on top is based on numbers of salmon and the bottom figure shows kilos of salmon catches for the time period from May 1 to the end of September.

Figure 33 indicates that the accumulated catches of 1-4SW and escaped salmon differ between the three areas in Finnmark. This figure indicates differences in the migratory timing of different salmon stocks caught within those areas. Salmon catches accumulated slightly earlier in East-Finnmark for 1SW and 2SW salmon and clearly earlier for 3-4SW salmon compared to other areas in Finnmark. Escaped salmon appeared in the fishery earlier in East-Finnmark than in Middle- and West-Finnmark.

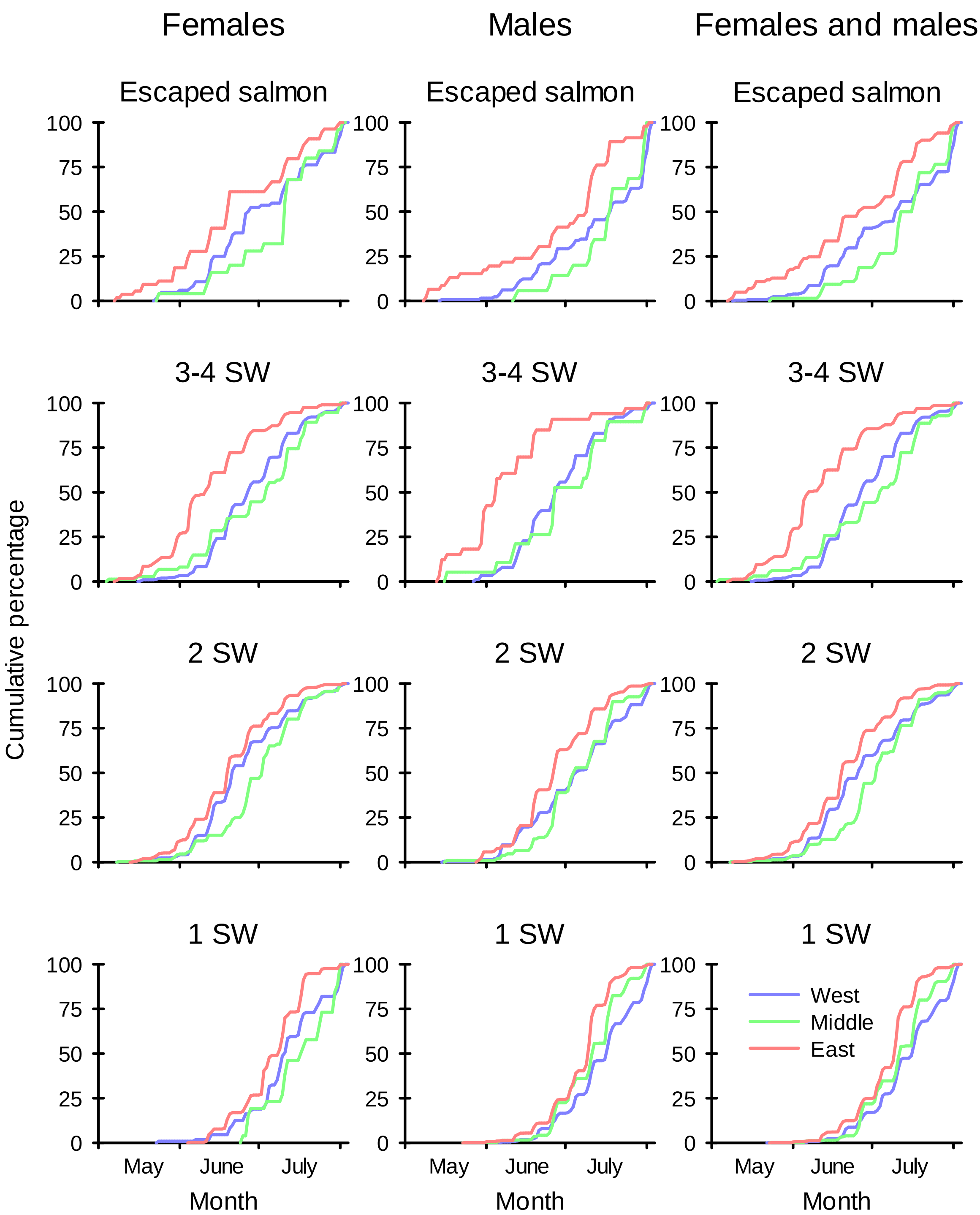


Figure 33. Differences in the cumulative percentage curves of the catches between West-, Middle- and East-Finnmark for 1SW, 2SW, 3-4SW and escaped salmon in the year 2012 for the time period from May 1 to August 4.

Similar differences between the median dates of catches for 1SW, 2SW, 3-4SW and escaped salmon which were found between the three northern counties can also be found between the three areas of Finnmark (West, Middle and East) (Figure 34). Median dates of the catches of female and male salmon were in general earlier in East-Finnmark than in Middle- and West-Finnmark in all sea-ages of wild salmon and in escaped salmon.

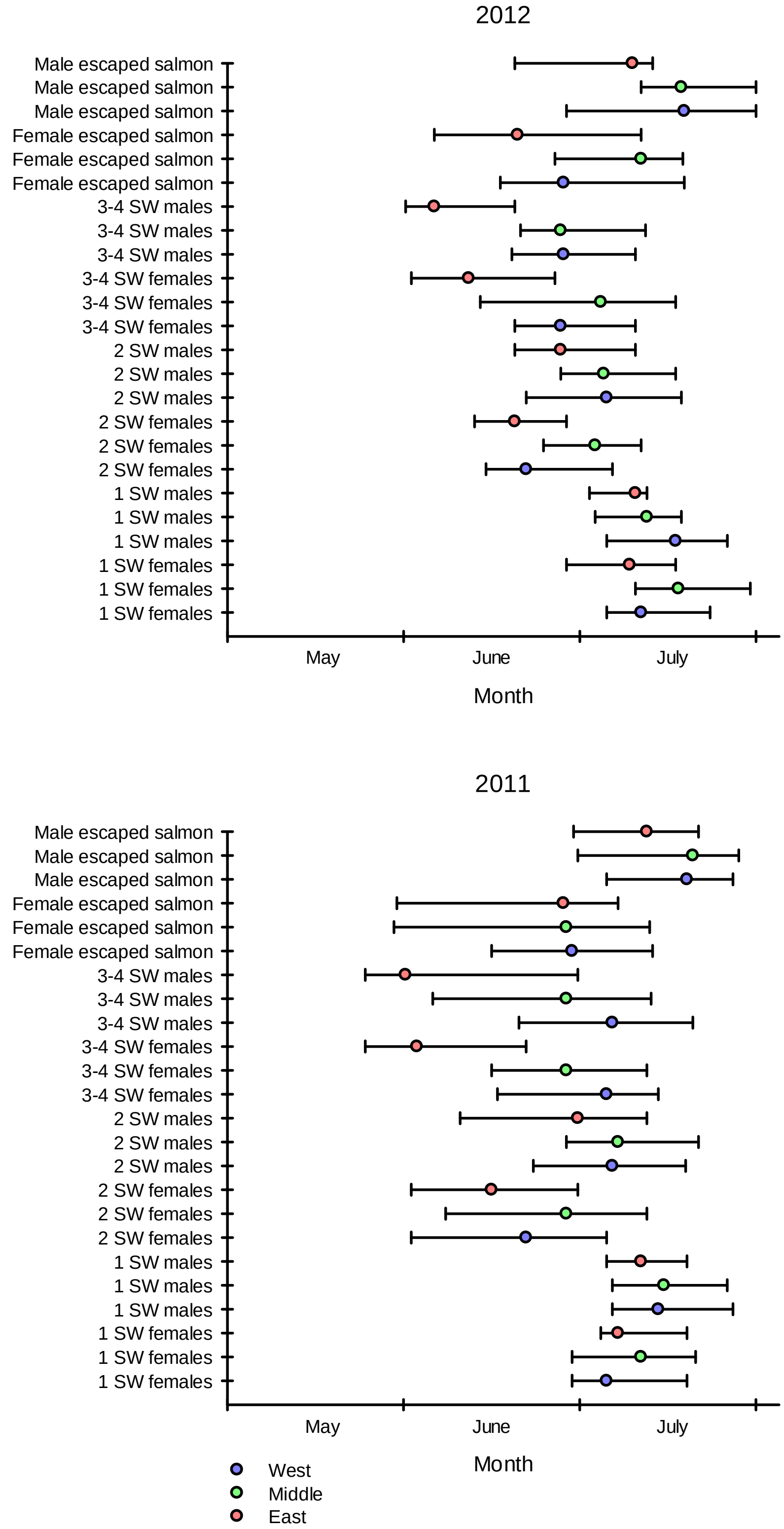


Figure 34. Median dates and 25% and 75% interquartile ranges of the catches in West-, Middle- and East-Finnmark in 2011 and 2012 for the time period from May 1 to August 4. Catches are 1-4SW and escaped salmon.

8. Conclusions on the migratory patterns in Kolarctic counties

Salmon catches in 2012 in the entire Kolarctic area had one clear peak during week 28 (Figure 10) and for females the peak was three weeks earlier than for males. In MSW female salmon catches, especially in Finnmark, there was a steady increase in the number of large salmon from week 20 to week 25 followed by a steady decrease towards autumn (Figure 35). In all Kolarctic areas, escaped salmon contribute to the weekly catches and with especially high proportions in female salmon catches in Nordland at the end of the season (Figure 35). In the Kolarctic area, MSW salmon make up the majority of female salmon catches throughout the entire season (Figure 10) and in male salmon catches MSW salmon make up more than 50% until the beginning of week 25 in Finnmark and week 26 in Troms and Nordland. During the five weeks from week 27 onwards (to the end of ordinary fishing time) 1SW salmon make up around 50% of the catches in Finnmark and Troms. After the ordinary fishing time, from August 4 onwards, there is still some (though minor) migration of wild 1SW, 2SW and 3SW salmon, and especially escaped salmon, and in all areas the proportion of escaped salmon is high.

Photo 19. Fisherman Arnt-Ivar Ring, Altafjord, Finnmark County, Norway

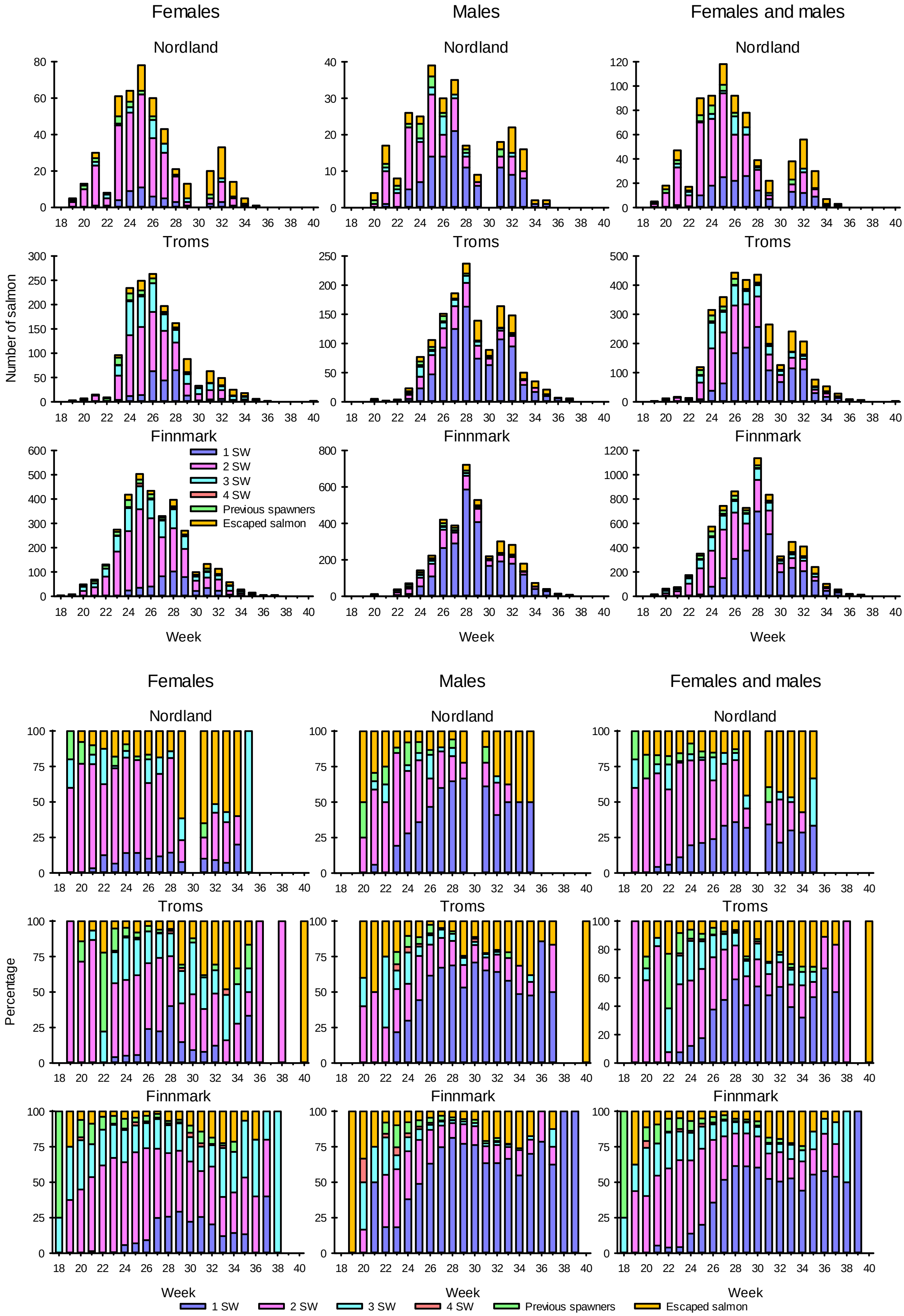


Figure 35. Summary figure from the weekly salmon catches and sea-age distributions for the time period from May 1 to September in Nordland, Troms and Finnmark in 2012.

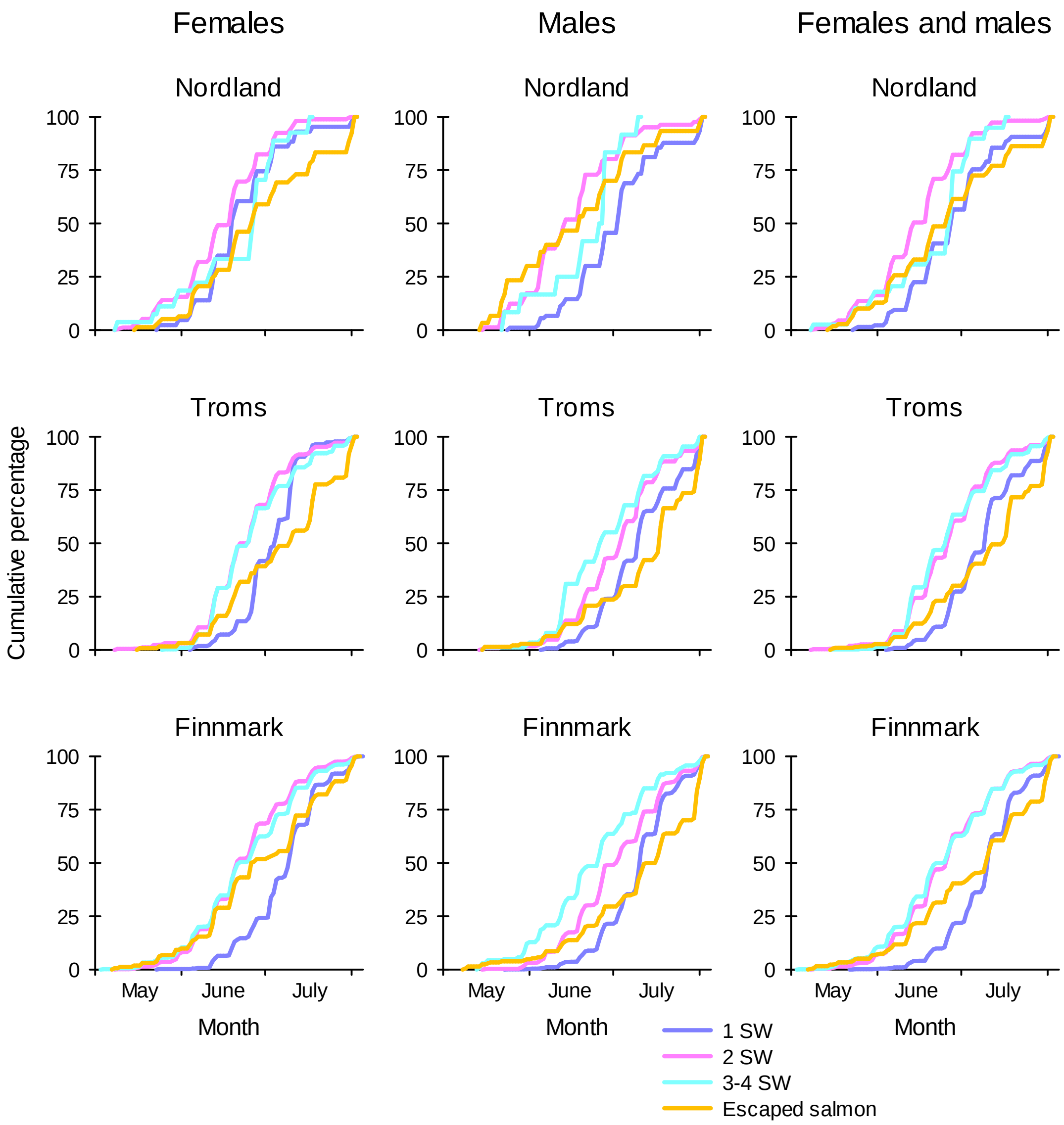


Figure 36. Summary figure from the cumulative catches for the time period from May 1 to August 4 in Nordland, Troms and Finnmark in 2012.

Cumulative percentages over time of the catches in Finnmark and Troms were similar for females and males in 1-4SW salmon and escaped salmon (Figure 36). That indicates a similar migratory behavior of wild salmon for all sea-age groups and for escaped salmon within a larger geographical area in Northern Norway. Data from Nordland in 2012 indicate, for example, that 2SW salmon are entering the coastal areas earlier than 3-4SW salmon, and that escaped male salmon were captured earlier in the summer.

Females and males in 1SW and 3-4SW salmon migrate at almost the same time in Troms and in Finnmark (Figure 37). In 2SW salmon, however, females migrate earlier than males in Troms and Finnmark. In Nordland females in 1SW salmon are migrating earlier than males. In escaped salmon, females tend to migrate earlier than males in Troms and Finnmark but in Nordland male escaped salmon catches accumulated earlier than female catches.

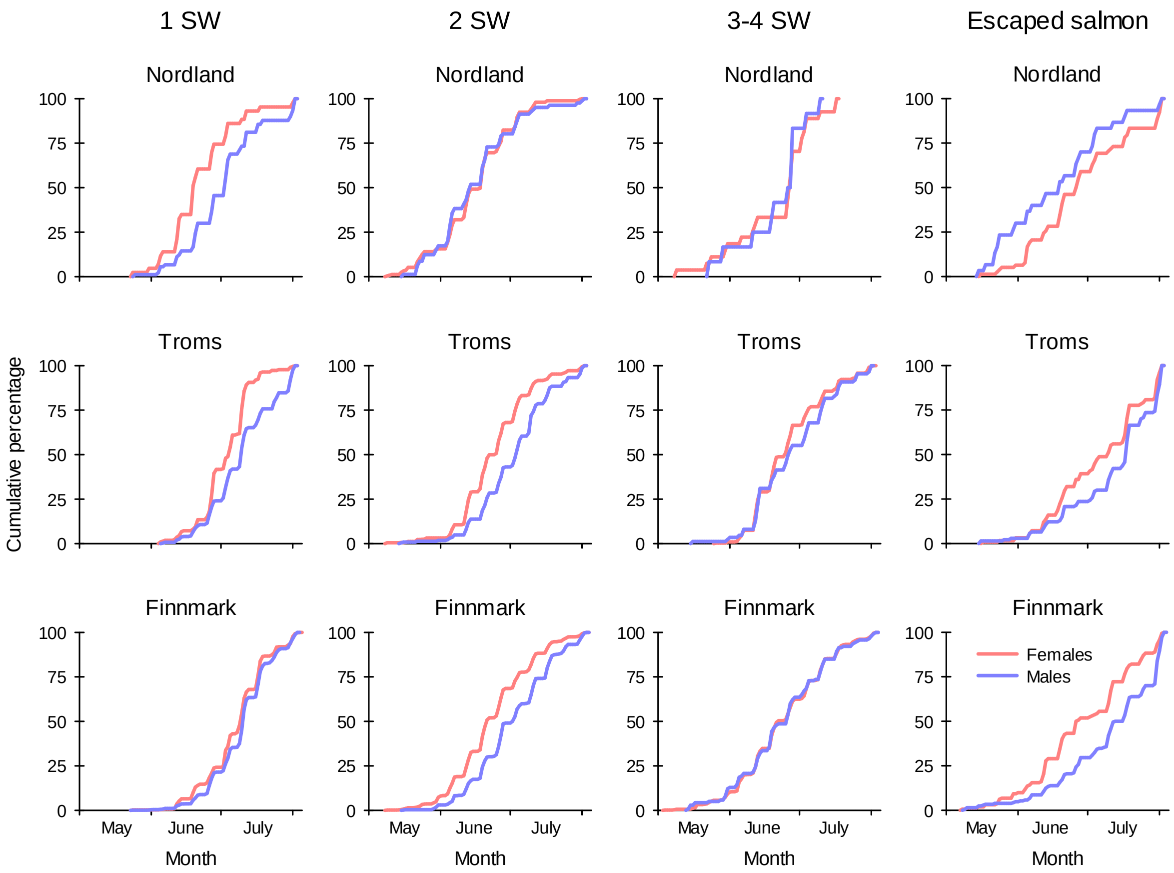


Figure 37. Summary figure from the cumulative percentages of the female and male salmon catches from the number of salmon in Nordland, Troms and Finnmark for the time period from May 1 to August 4 in 2012.

Photo 20. Fisherman Jakob Mikkelsen, Kiberg in Vardø Municipality, Finnmark Norway

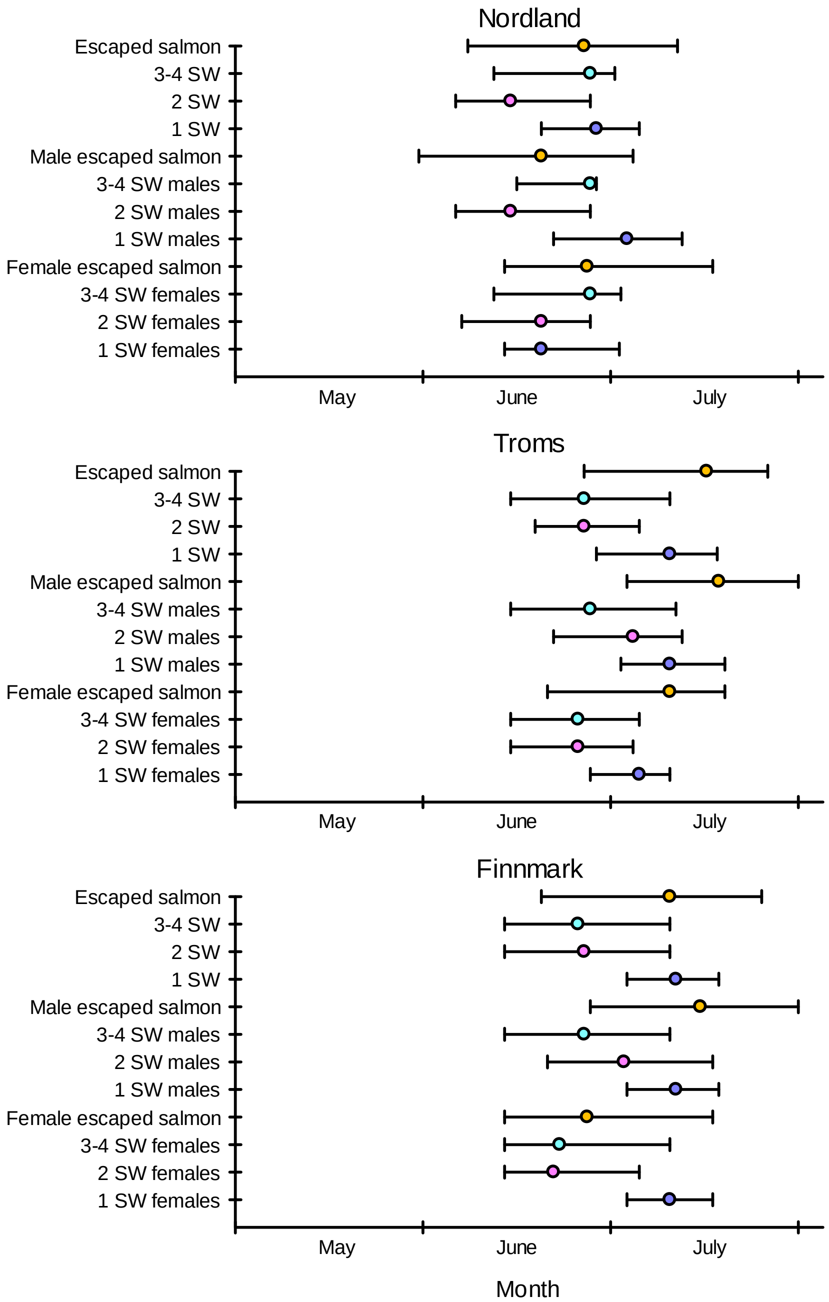


Figure 38. Summary of the median dates and the 25% and 75% interquartile range of the catches for the time period from May 1 to August 4 in Nordland, Troms and Finnmark in 2012.

Median dates with 25% and 75% interquartile ranges of the salmon catches can be used as a tool for management purposes to regulate, if necessary, the fishery before, after or during peak migration. Figure 38 with the median dates of the catches confirms the different migration periods between sea-age groups which were observed from the cumulative catches illustrated in figure 36. Median dates of catches in Finnmark and Troms have especially high similarity among all the sea ages of wild salmon and escaped salmon. It is noteworthy that the interquartile period, especially in Finnmark, is much shorter in 1SW female and male salmon than in 2SW, 3-4SW and escaped salmon. This indicates that the main proportion of 1SW salmon catch accumulates in a shorter time frame than other sea-age groups and escaped salmon. Figure 39 clearly illustrates the peak migration periods which overlap between geographical areas, sea ages and sexes.

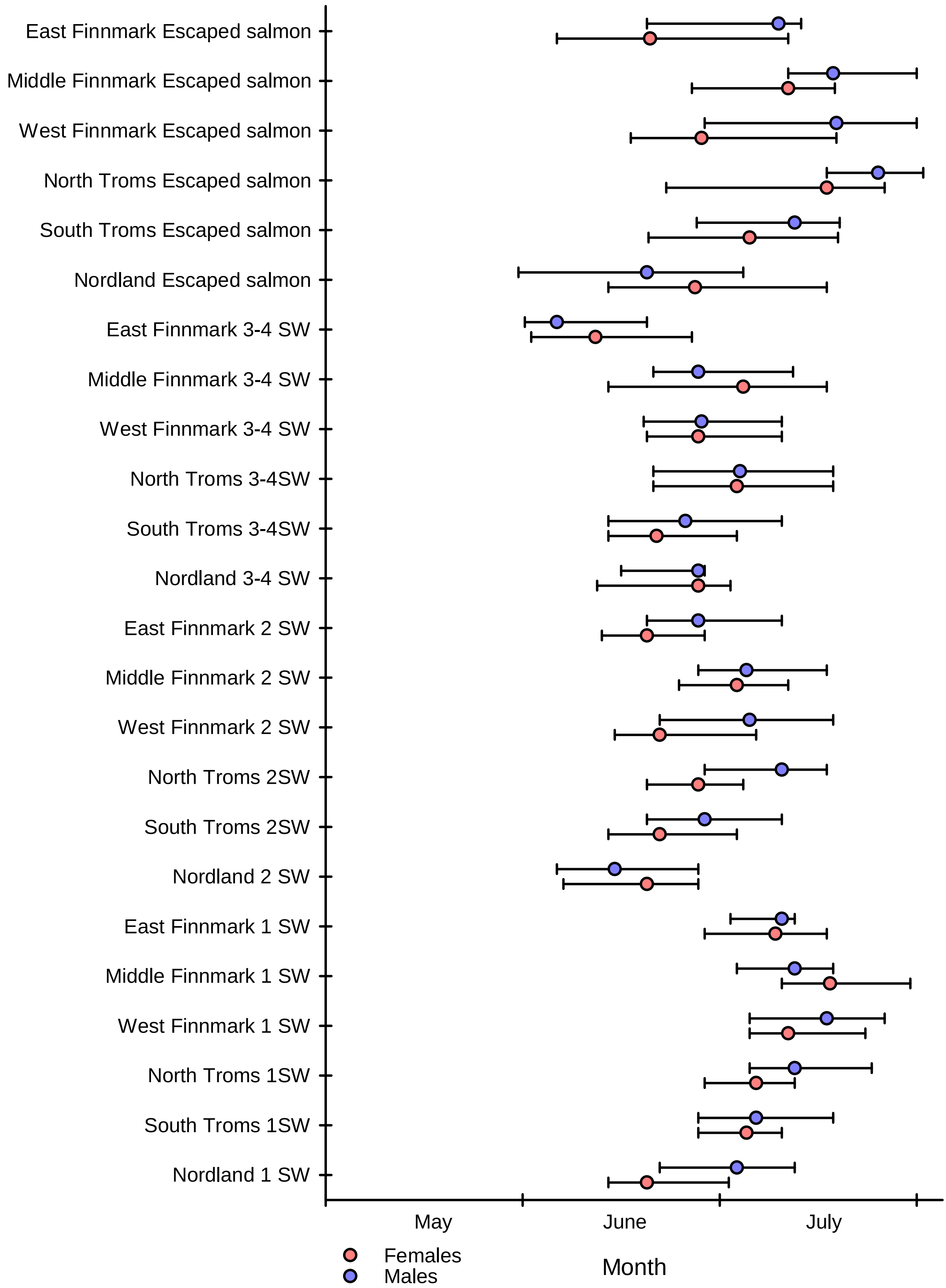


Figure 39. Summary of the median dates and the 25% and 75% interquartile range of the catches for the time period from May 1 to August 4 in Nordland, Troms and Finnmark in 2012.

9. Catches in bag net and bend net fishery composed of six "groups" of salmon

In the Kolarctic area in northern Norway, salmon catches included six groups of salmon; 1SW, 2SW, 3SW, 4SW, 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 and 2012 during the whole summer period from May to early September (Figures 40 and 41):

- The proportion of 1SW salmon in the catches, both males and females, increased with increasing latitude
- The proportion of escaped salmon, both males and females, decreased with increasing latitude
- In 2012 every fifth salmon in Nordland was an escaped fish, in Troms every tenth salmon and in Finnmark a little less than every tenth salmon was an escaped fish
- The highest proportion of 2SW salmon was caught in Nordland
- The proportion of 3SW salmon was highest in Troms and very low in Nordland
- In the bag net fishery, the proportion of 1SW salmon was much higher than in the bend net fishery and this was especially true in Finnmark and Troms
- In the bend net and bag net fishery in Finnmark, the proportion of MSW females were almost equal regardless of , whereas in Troms, a higher proportion MSW females were captured in bend nets versus bag nets
- In bend nets the mesh sizes are larger than in bag nets, and therefore smaller salmon, like 1SW females, may escape from bend nets (swim through the mesh)
- In bag nets with the minimum allowed mesh size of 58 mm (from knot to knot), most salmon sea-age groups will be caught. Except for the smallest 1 SW salmon, with a weight of 0.6-1.5 kg, because they swim through the mesh.

Photo 21. Bend net in Neidenfjord, Finnmark Norway

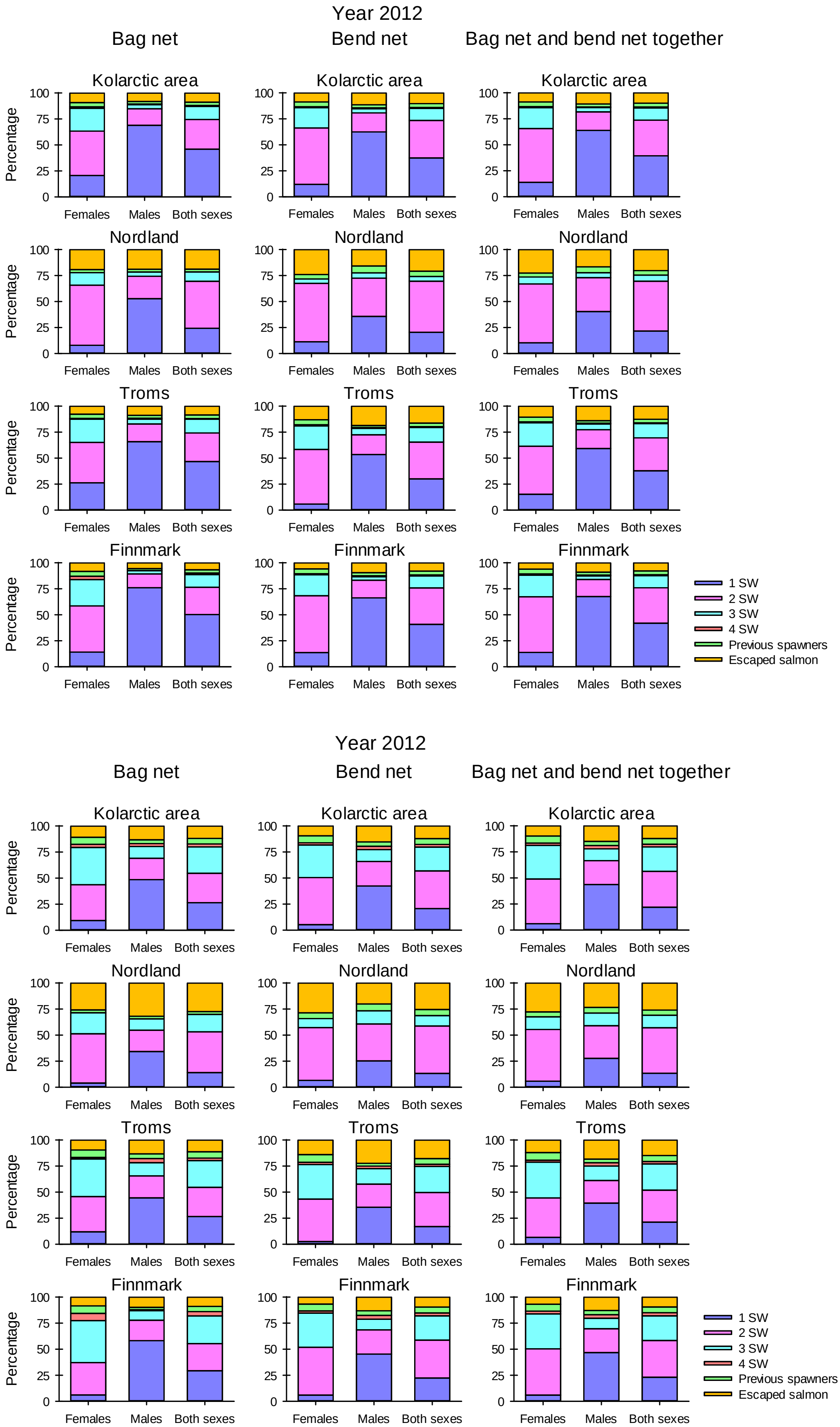


Figure 40. Sea-age distributions of salmon catches in 2012 by number (figure on the top) and in weight (figure on the bottom) in Nordland, Troms and Finnmark in bend nets and bag nets for the time period from May 1 to September.

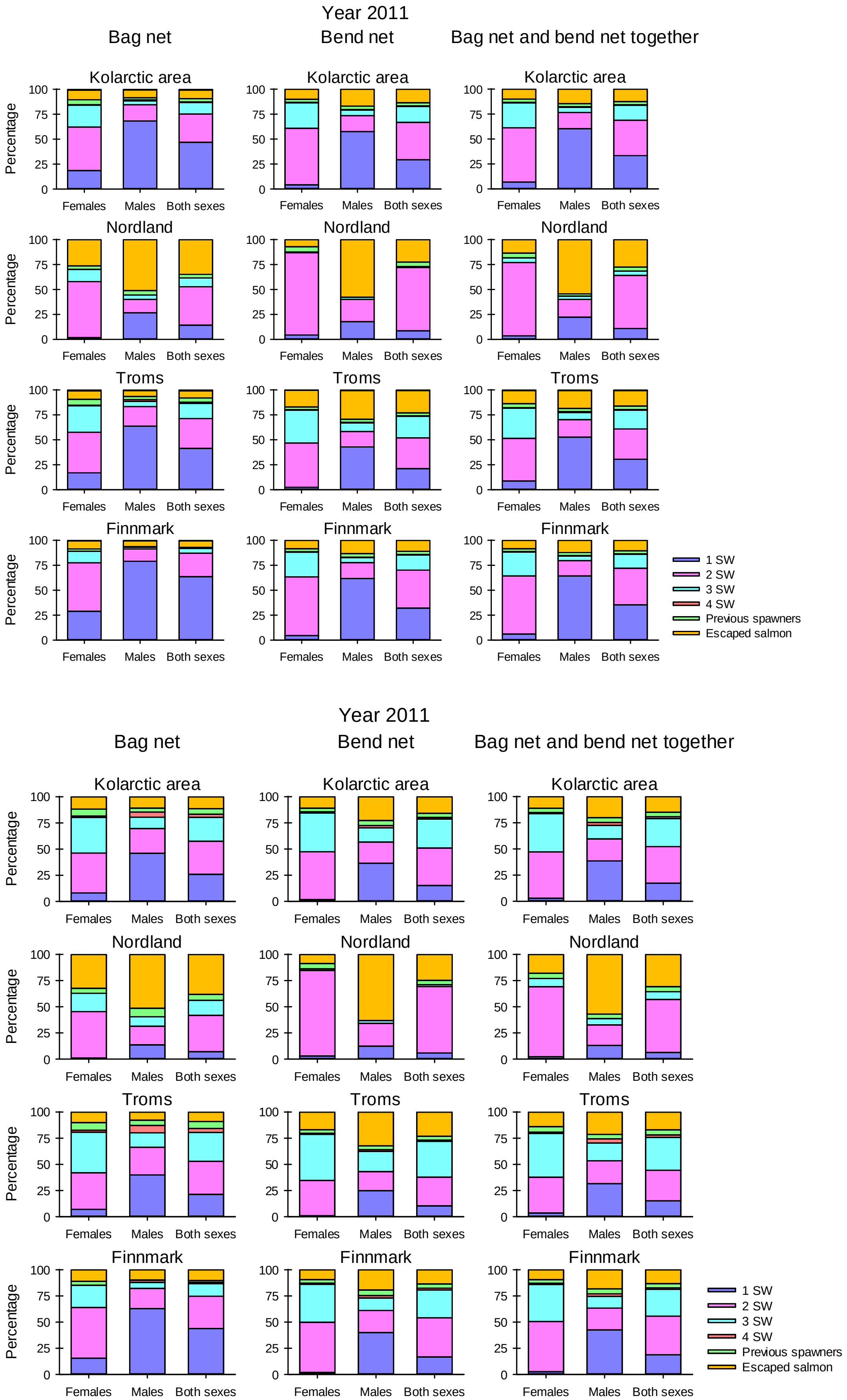


Figure 41. Sea-age distributions of salmon catches in 2011 by number (figure on the left) and weight (figure on the right) in Nordland, Troms and Finnmark in bend nets and bag nets for the time period from May 1 to September.

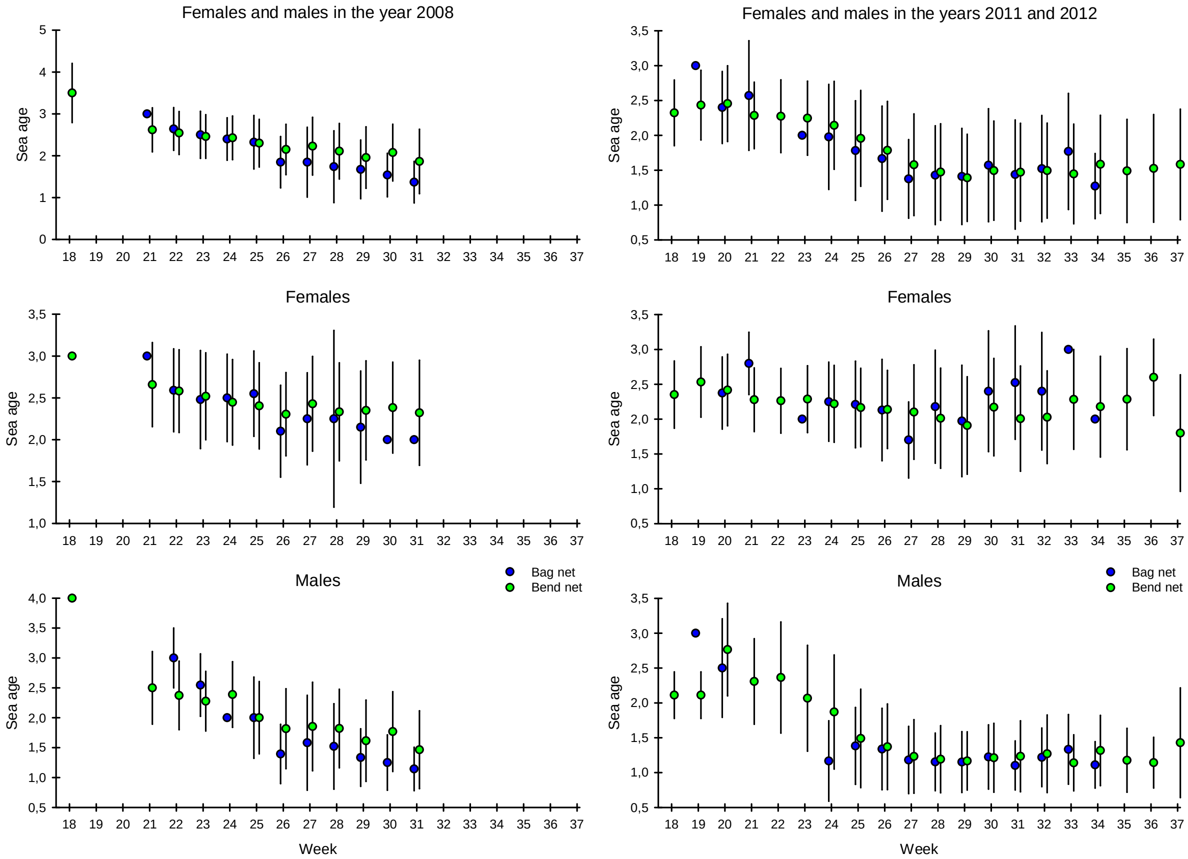


Figure 42. Mean sea-ages of salmon (sea-ages 1-4SW included) caught in Finnmark with bag nets and bend nets in the years 2008 (figure on the left) and in the years 2011 and 2012 (figure on the right) in Kolarctic salmon project fishery.

The mean sea-ages declined throughout the summer, especially for male salmon, in Finnmark in the year 2008 and in the years 2011-2012. The reason for the declining was changes in the sea-ages towards higher abundance of younger salmon in the catches from the weeks 24-26 onwards. In May the means sea-ages were almost the same for bag nets and bend nets (Figure 42). In the years 2011-2012 the mean sea-ages were slightly higher between the weeks 23 and 27 in the bend net fishery than in the bag net fishery indicating the occurrence of some selective fishery. From early July in the years 2011-2012, week 28, onwards it was not possible to observe differences in the mean sea-ages between bag nets and bend nets when material from females and males was combined. Material from the year 2008, however, indicates that the mean sea-ages of salmon in bend net fishery were higher than in bag net fishery from the last week of June to the first week of August.

10. Sex distributions in wild and escaped salmon catches

Knowledge of the sex ratio, especially the proportion of females, in wild 1-4 SW salmon, previous spawners and escaped salmon catches is one of the most important ecological factors related to the management of the fishery and thereafter to juvenile production. Sex ratio information is not yet used effectively in salmon management. It should be used as an argument for much better and successful management of salmon fishery at sea and in the rivers when reducing spatial and or temporal exploitation of medium and large size female salmon of weakened stocks.

The material from salmon collected in the Kolarctic project concerning sex ratios covers the entire migratory period of salmon in the coastal areas and hence it reliably indicates the mean values for each age group presented here. In Nordland County the proportion of females exceeded clearly that of males in the total wild salmon catches. The main reason for that was the lower abundance and proportion of 1SW salmon in the catches compared to the Troms and Finnmark catches. In Nordland the fishery is targeted more towards MSW salmon, where the proportion of females is higher than in 1SW salmon. In Troms and Finnmark females and males in the total wild salmon catches represented equal proportions. In the entire Kolarctic area in 2012 males were the major sex in 1SW salmon (82%) but females comprised 74% of 2SW and 83% of 3SW salmon. The proportion of females exceeded males also in 4SW salmon constituting 58% (Figure 43). These sex ratios indicate the mean values from the entire salmon migratory period between May and September. During the ordinary, and much shorter, fishing season, values are not the same and may 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 31%, 21% and 16% of the totals, respectively, and female proportions decreased also towards the north in escaped salmon, being 70%, 44% and 38%, respectively in the three counties. The higher proportion of females in 1SW salmon in Nordland and Troms compared to Finnmark might be caused by the fishing method used. In Nordland and Troms the only method allowed in salmon net fishery at sea is bag net fishing, which is usually conducted with small 58 mm sized mesh nets. Therefore, the bag net method is selecting smaller 1SW salmon of which the proportions of females is higher compared to larger 1SW salmon with high proportions of males. In Finnmark, however, the usual fishing method is bend net fishing with larger mesh sizes than those used in bag nets. These bend nets are therefore selecting larger 1SW salmon of which the proportion of males exceeds that of females. In Nordland, Troms and Finnmark the proportion of males in previous spawners was 45%, 34% and 40%, respectively. In Finnmark the proportions of females in 2SW and 3SW salmon were 75% and 85% and in Troms county 73% and 81%.

Photos 22 a and b Escaped salmon on the left (lots of black spots on the gill covers, gill cover is also shortened and the pectoral fin is eroded) and wild salmon first time spawner on the right (very few black spots on the gill covers and no erosion of the gill cover).

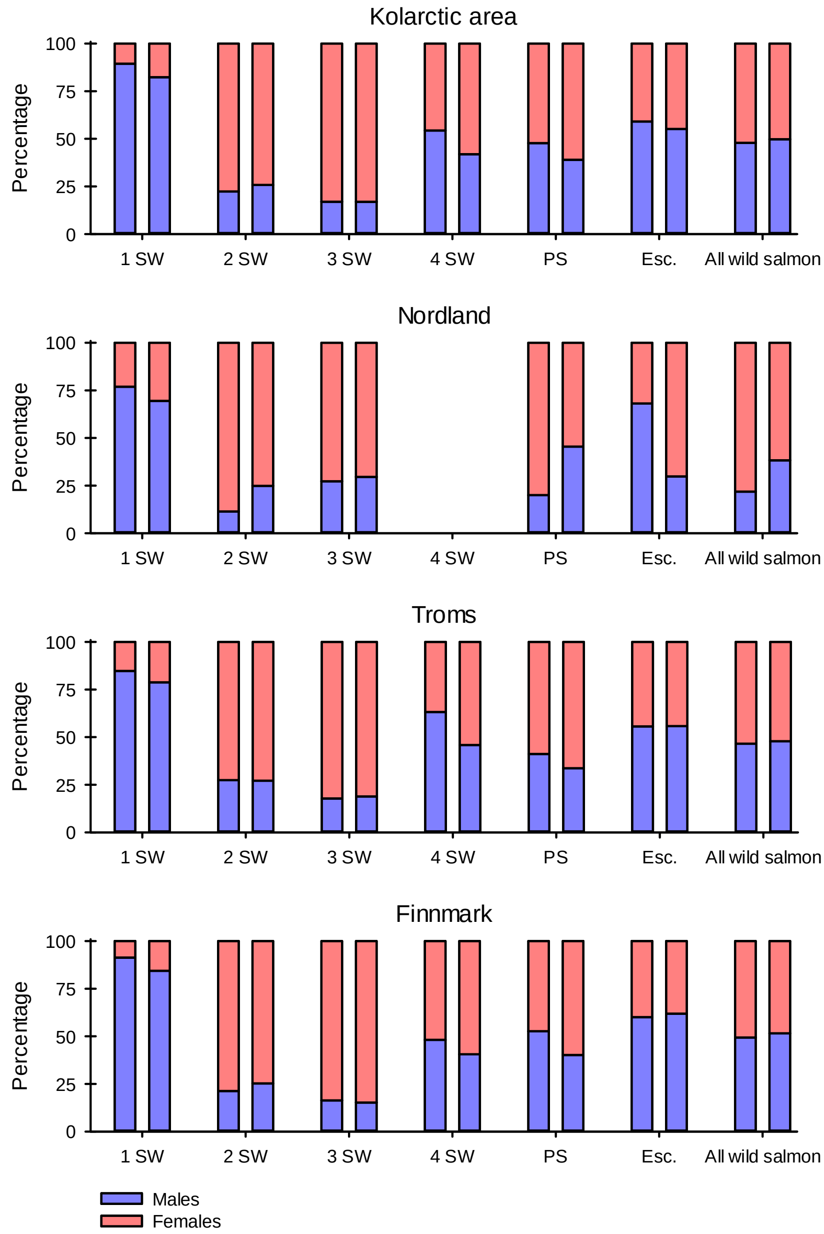


Figure 43. Sex ratios for virgin salmon in 1-4SW and previous spawners and for escaped salmon in the Kolarctic area in Norway in 2011 and 2012. The bars on the left side for each age group are for 2011 and on the right for 2012.

Sex distributions changed throughout the migratory period in all wild salmon age groups and also in escaped salmon, moving towards a majority of males by the end of summer (Figure 44). Females had a clear majority especially in 3SW salmon but they also had high proportion in 2SW fish early in the summer. This indicates that female salmon generally entered to the coastal areas well before the migrating males. 1SW salmon males almost exclusively migrated into the coastal areas later in the season. Interestingly, females, also in previous spawners, were the majority sex until the end of June. In the wild salmon catches, with all sea ages combined, females dominated clearly until the second to last week of June followed by a steady decline in their 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 remained around 25% through to the end of September.

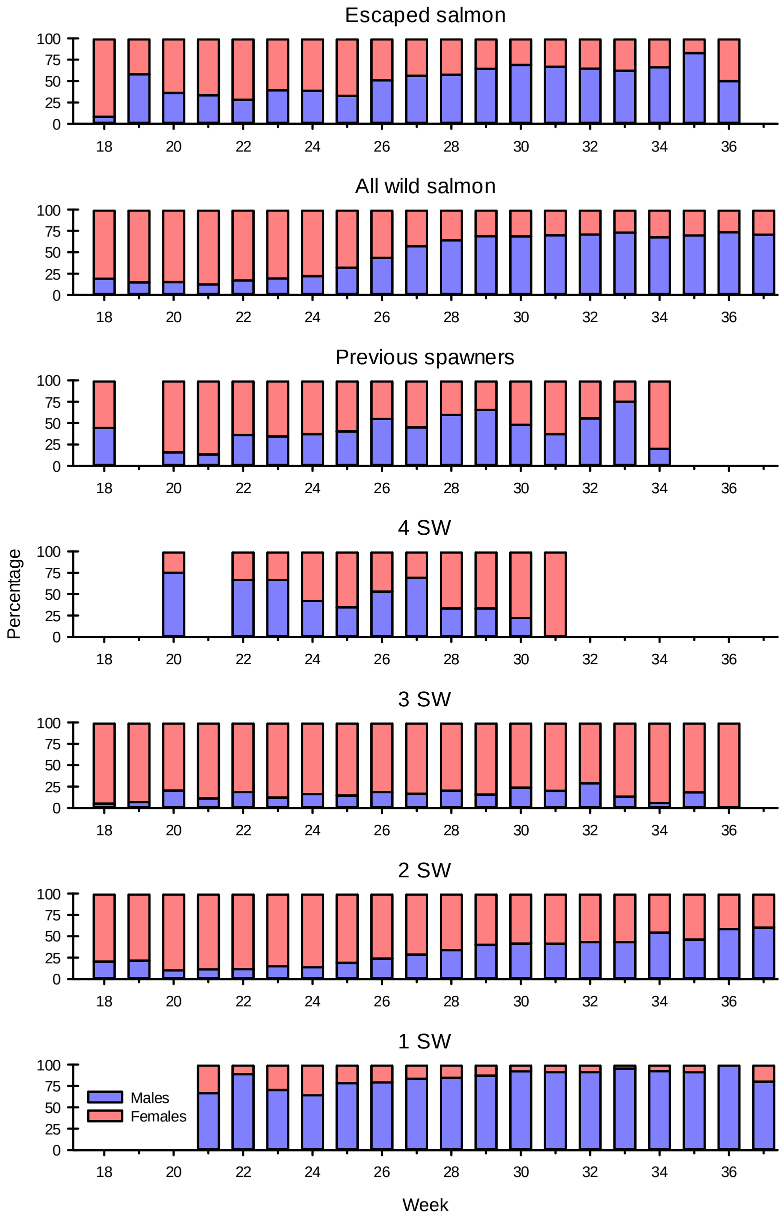


Figure 44. Weekly sex ratios in the Kolarctic area in 2011-2012.

Photo23. Male (1.9 kg) and female (5.8 kg) wild salmon.

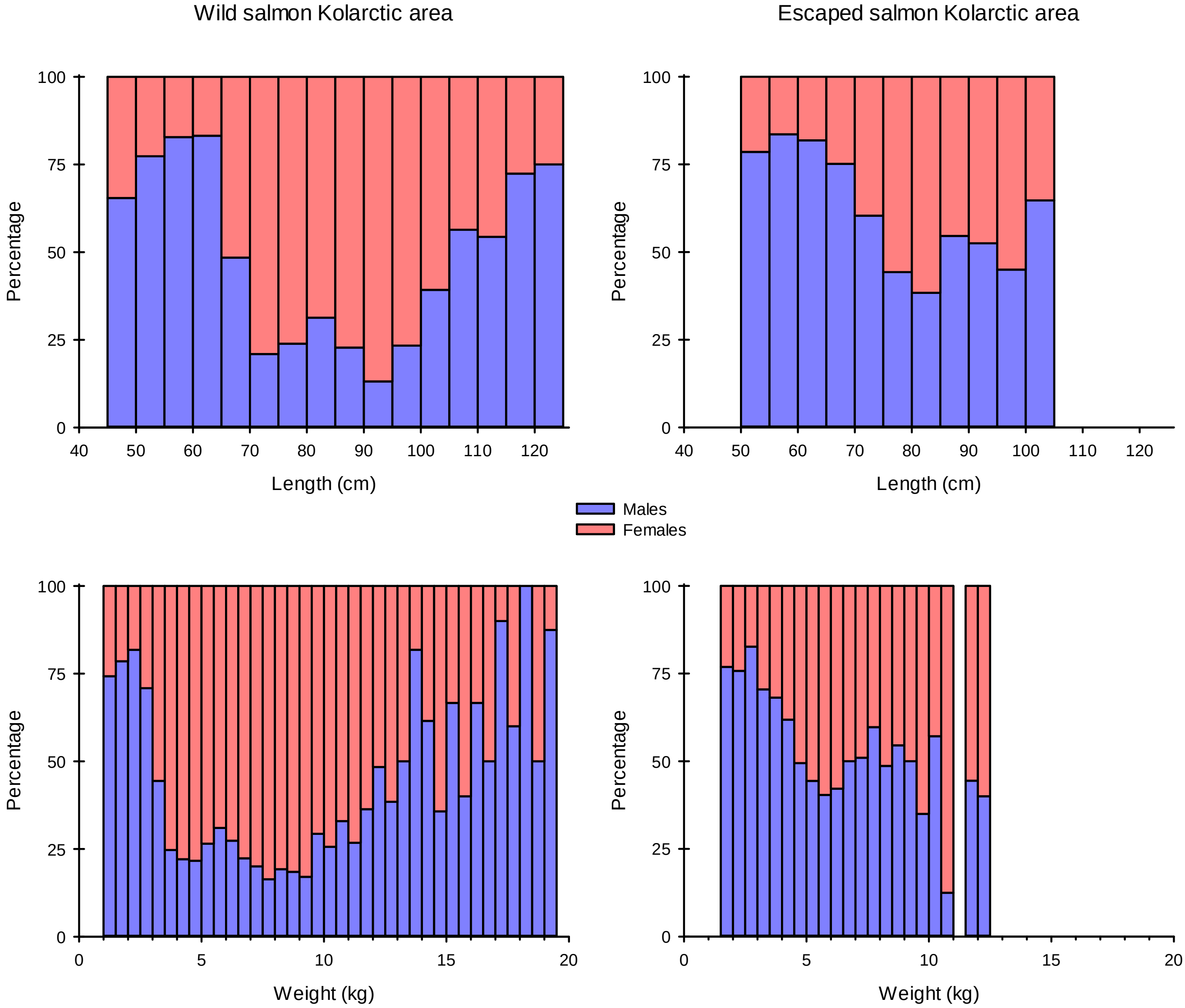


Figure 45. Sex ratios for wild salmon of 1-4SW fish and previous spawners and for escaped salmon for different weights and lengths of fish captured in 2011 - 2012 in the Kolarctic area in Norway.

The proportion of females varies greatly among different age- and length groups of wild salmon (Figure 45). In general, the occurrence of females was low (c. 25%) in salmon smaller than 3 kilos, corresponding to a length smaller than 65 cm. In fish from 3.5 kilos up to 12 kilos, females exceeded the proportions of males, being 70%-80%. The proportion of females clearly declined in salmon above a size of 12 kg and a length of more than 100 cm.

Sex ratios in escaped salmon vary more among size groups compared to wild salmon, although there are not big differences in the proportions of females between all wild and all escaped salmon catches in the Kolarctic area (see Figure 43). The proportion of females in escaped salmon catches increased with increasing length and weight which is opposite to the development of wild salmon.

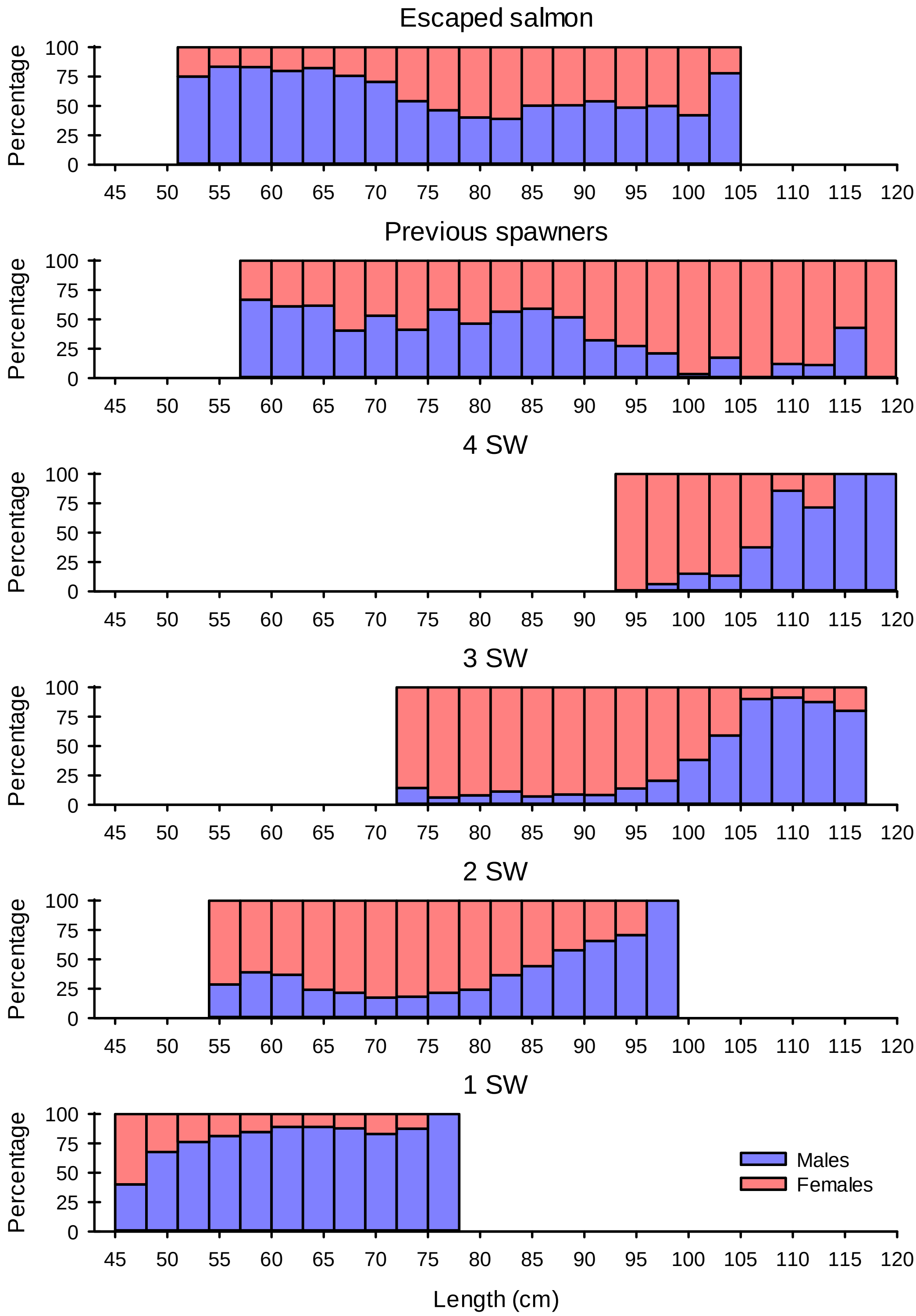


Figure 46. Sex ratios against the length of wild and escaped salmon in the Kolarctic area in Norway in 2011 - 2012.

Sex ratios change in each of the sea-age groups of salmon according to the length of fish. This is most pronounced for 3SW salmon where the largest fish were almost all males. But females exceeded males clearly in smaller 3SW salmon up to the length of approximately 100 cm (Figure 46). Within the smallest 1SW salmon (below ca. 50 cm) the proportion of females exceeded that of males but then decreased to 10% in 1SW salmon with lengths between 55 cm and 75cm. In 2SW salmon the proportion of females also declined with the increasing length of fish from 75 to 95 cm.

11. Sea-age composition within the three size groups of salmon

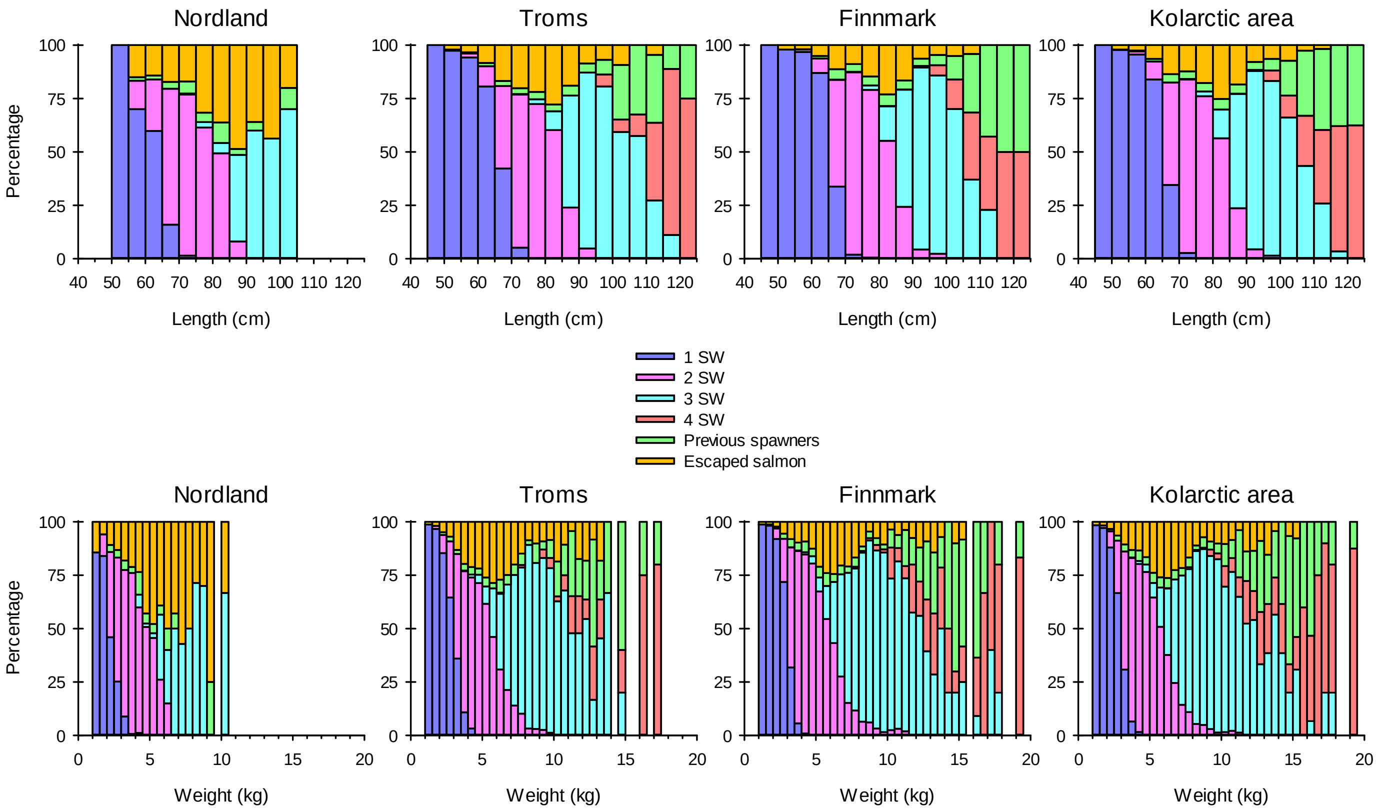


Figure 47. The proportions of wild 1SW, 2SW, 3SW, 4SW salmon, previous spawners and escaped salmon in the length and weight groups in three counties and in the entire Kolarctic area in the salmon catches caught between May and September in 2011 and 2012.

There are up to three wild salmon sea-ages and escaped salmon in the same length and weight groups in the three counties (Figure 47). The proportions of escaped salmon cover almost all the size groups with high prevalence in all the counties. The high proportions of escaped salmon reveal its important occurrence within the medium size salmon catches.

In the Norwegian official catch statistics, salmon smaller than 3 kg have been assumed to be fish with the sea-age of one sea winter, also called grilse. Salmon with the sea-age of 2SW belong to the size group of 3-7 kg salmon and salmon of 3SW to the size group of larger than 7 kg. The growth of salmon at sea, however, has greatly varied annually and has declined in later years. Therefore some 2SW fish belong to the smallest size group as well as some previous spawners and escaped salmon (Figure 48). More than half of salmon belonging to the size group of smaller than 3 kg which were caught before week 24 in Troms and Finnmark were actually 2SW fish. From week 26 onwards in Finnmark and Troms most salmon belonging to the size category of smaller than 3 kg were 1SW fish, coinciding with the time period of 1SW fish migrations between approximately June 15 and August 4. The size category of 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. In the summer the maximum percentage of 2SW salmon within the weekly catches of 3-7 kg salmon was about 75%. The proportion of 1SW salmon increased steadily and clearly in Finnmark from week 24 to week 31. During the last week of the official fishing time before August 4, around 30% of the salmon catches in the size category of 3-7 kg fish were escaped salmon in Finnmark (Figure 47). In Troms County the proportion of 2SW salmon in the size category of 3-7 kg declined steadily from 70% at the very beginning of July to less than 25% on August 4, while the proportion of escaped salmon in the end of July and beginning of August, was as high as 40% from the fish in this size category. In Western Finnmark the proportion of escaped salmon was approximately 30% in the size group of 3-7 kg salmon from the end of the official fishing time and through the end of August (Figure 49).

Figures 48 and 49 indicate 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 it is assumed that all the fish in the official catch statistics which belong to the smaller than 3 kg size group are 1SW salmon, or all the fish in the size group of 3-7 kg are 2SW salmon, wrong conclusions could be drawn when estimating, for example, the status of salmon stocks, especially for 2SW and 3SW salmon.

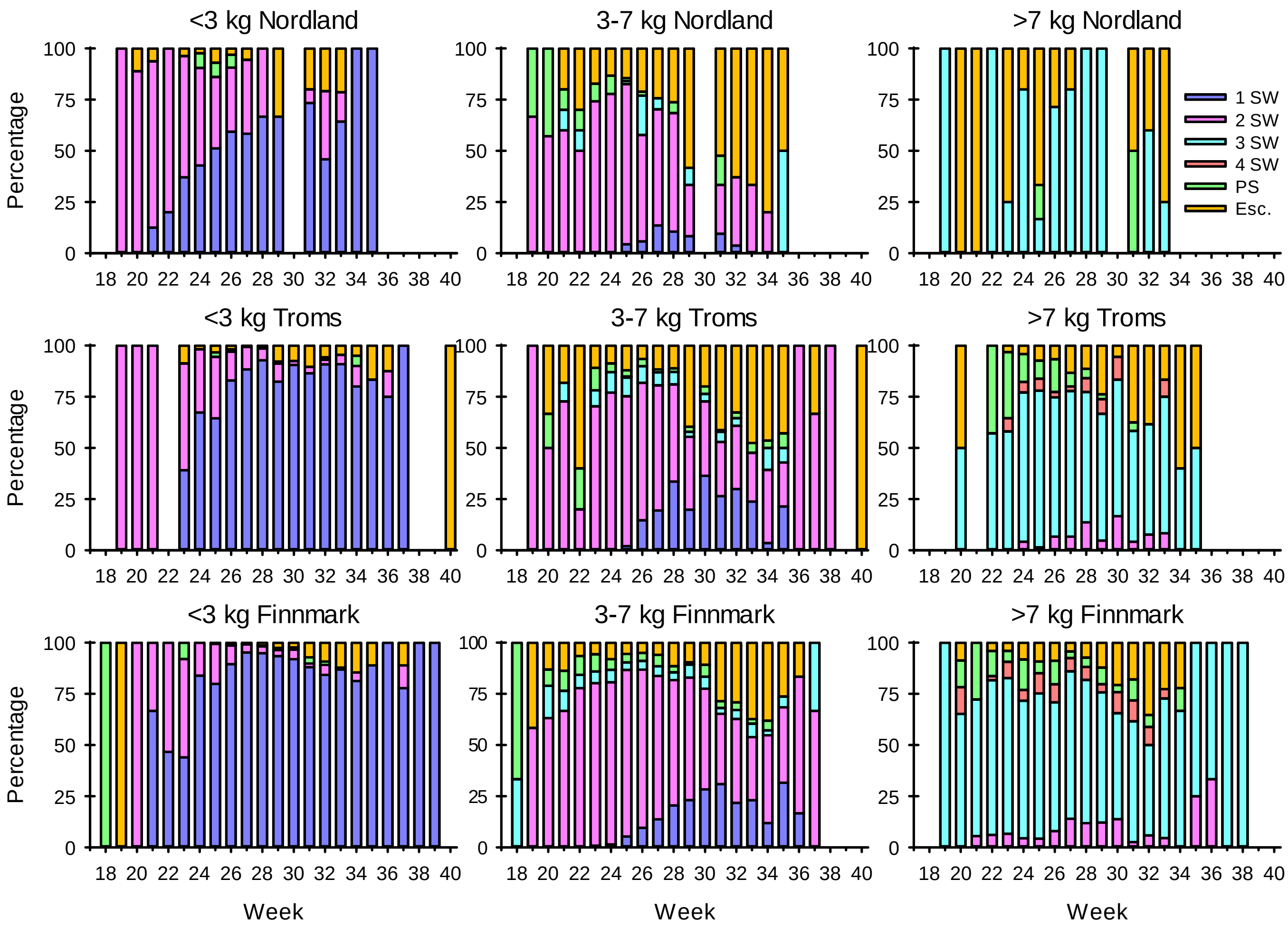


Figure 48. Sea-age distributions in three size groups of salmon in terms of numbers in the Kolarctic area.

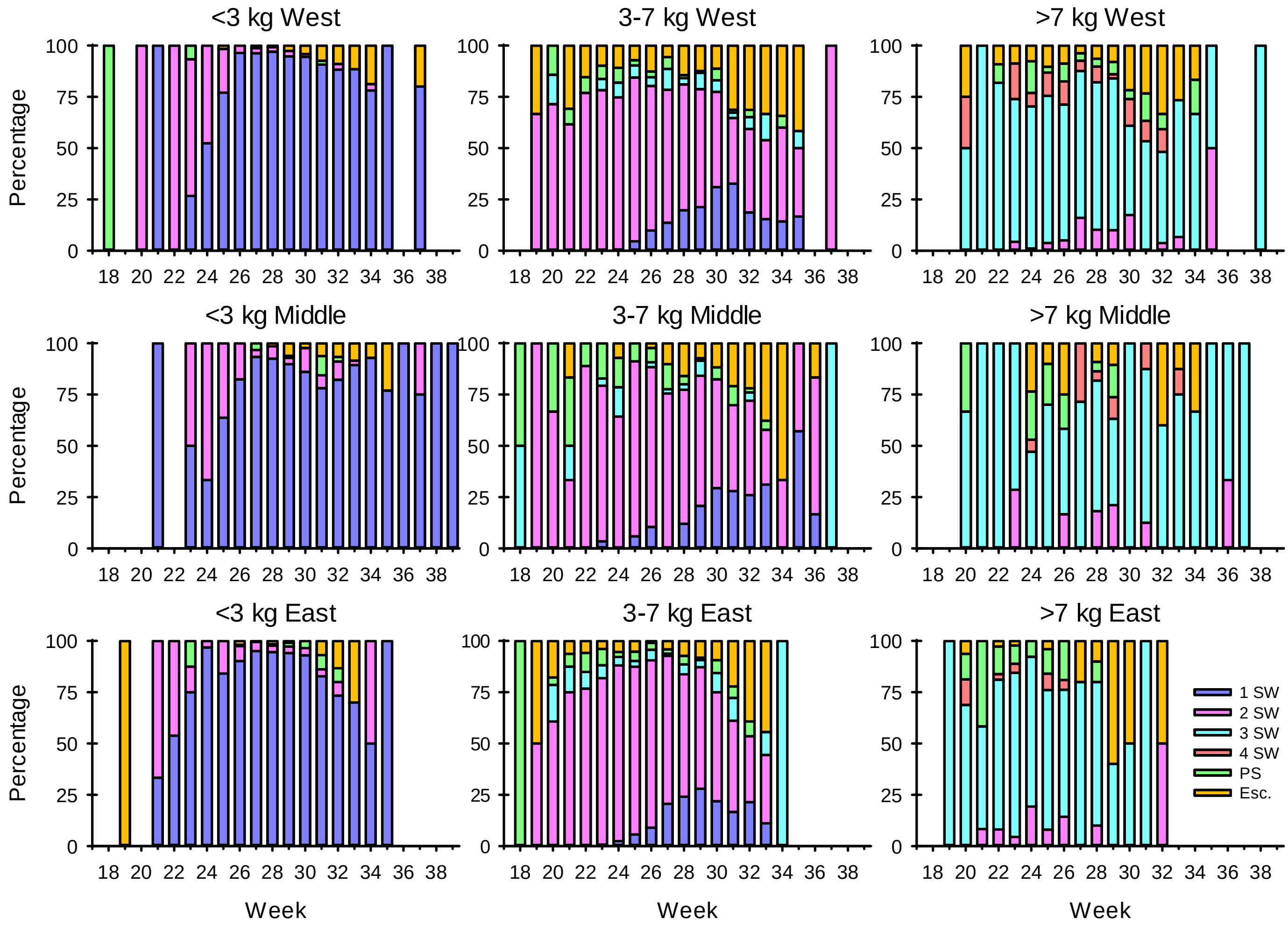


Figure 49. Sea-age distributions in three size groups of salmon in terms of numbers in West-, Middle- and East-Finnmark.

The proportions of sea-age groups among salmon below three kilos are about the same in West-, Middle- and East-Finnmark throughout the entire fishing period, i.e. from early May to late August (Figure 49). In the size group of 3-7 kg salmon there was a higher proportion of escaped salmon in West-Finnmark than in Middle- and East-Finnmark throughout most of the official fishing time. Remarkable information from the fishery research in 2012 was that in East-Finnmark almost 40-45% of salmon belonging into the size group of 3-7 kg were escaped salmon in weeks 32 and 33 and a little less in West- and Middle-Finnmark.

12. Length and weight of salmon

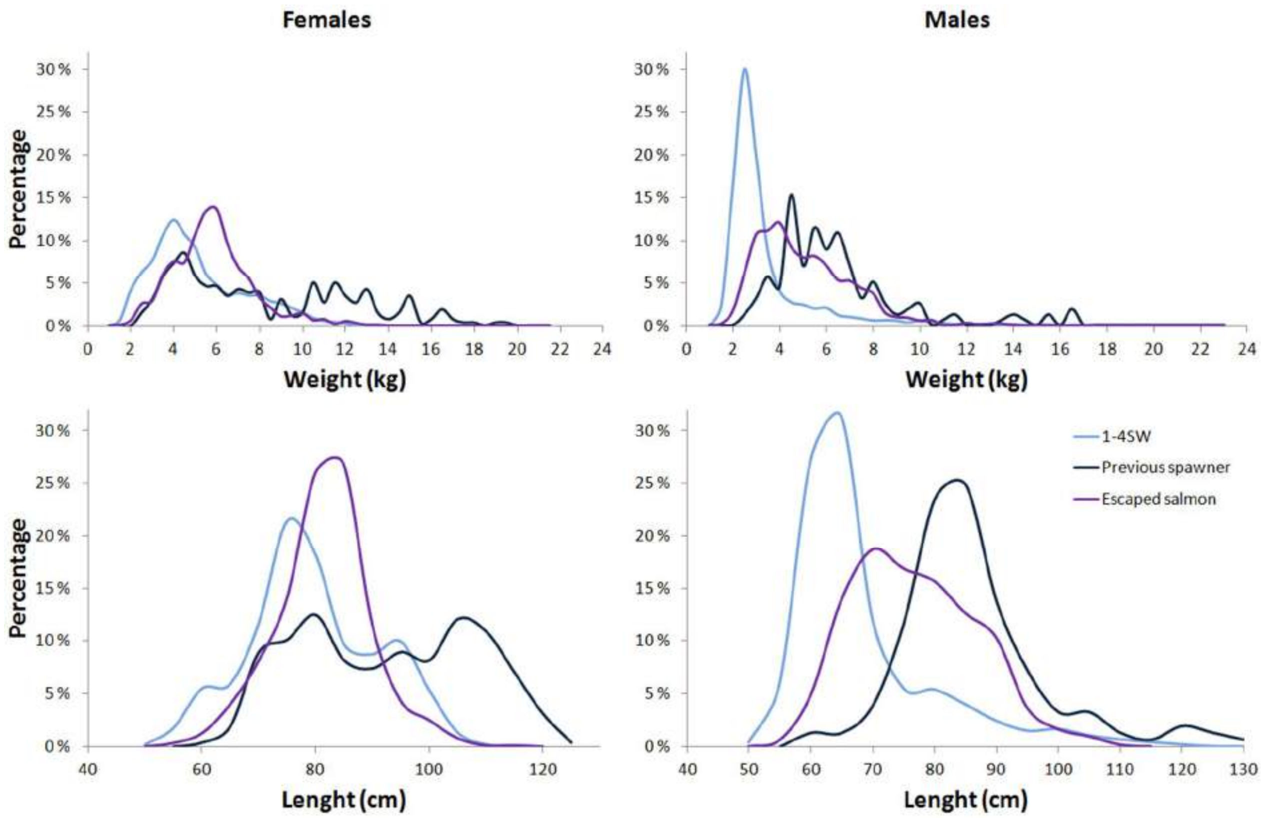


Figure 50. Length and weight distributions for wild 1-4SW salmon, for previous spawners and for escaped salmon in the Kolarctic area in Norway in 2011 - 2012, fishing methods combined.

Due to the differences in the sea-age distributions between sexes, length and weight distributions differ between females and males in wild salmon catches (Figure 50). The proportions of small sized 1SW salmon are more numerous among males that in female catches, while females dominates among 2SW and 3SW salmon. In the length distribution of wild female salmon, three size groups can quite clearly be identified, but in males only one clear size group, 1SW, can be separated. In length and weight distributions of female escaped salmon there is only one peak but in the distributions of males the peaks are not clear. Length and weight distributions of previous spawners are almost the same compared to first time female spawners, but these distributions clearly differ in male salmon.

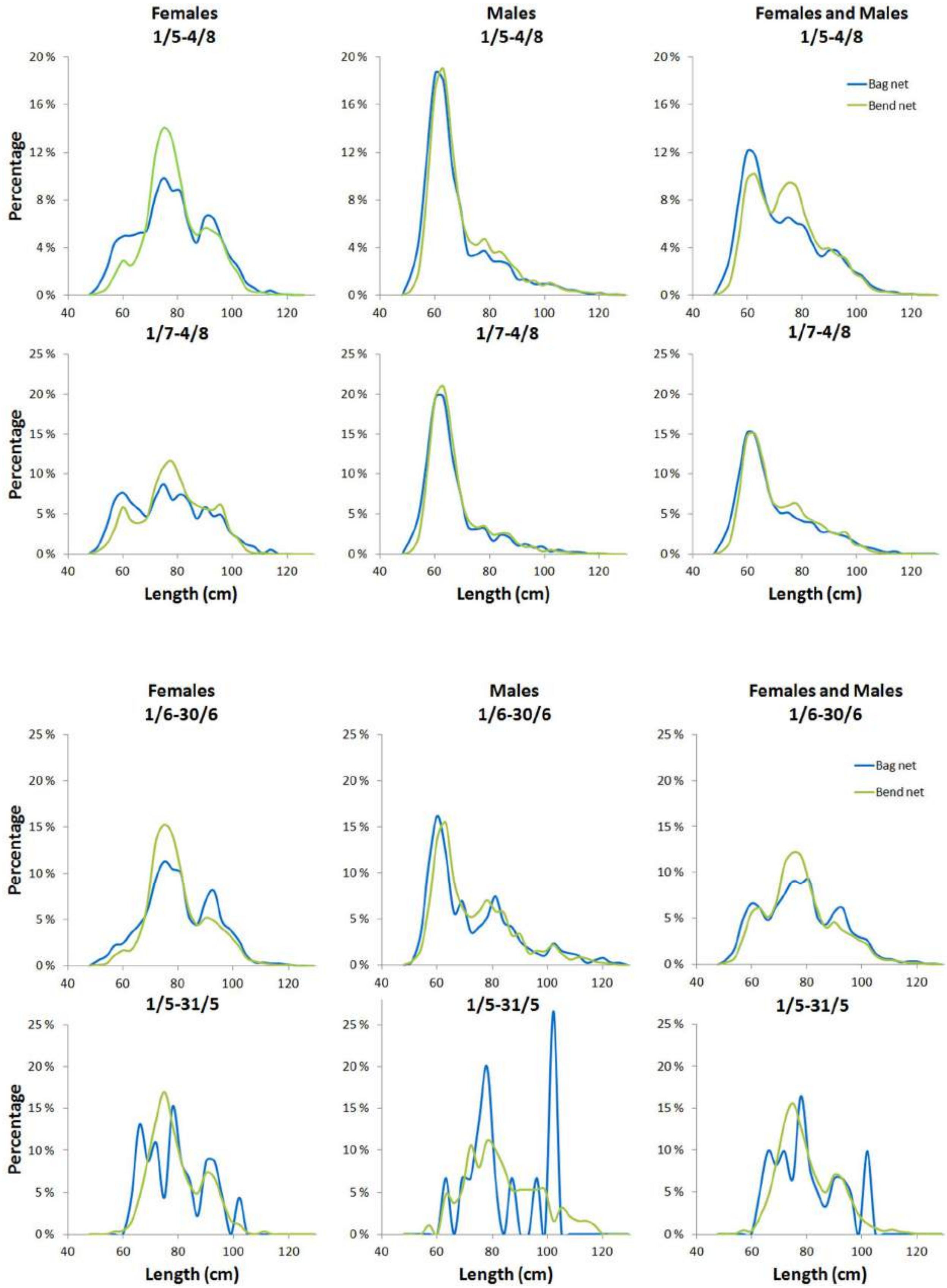
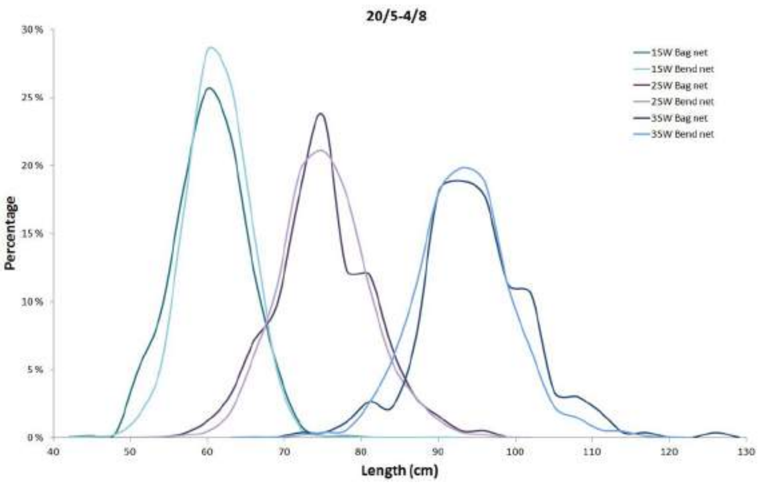


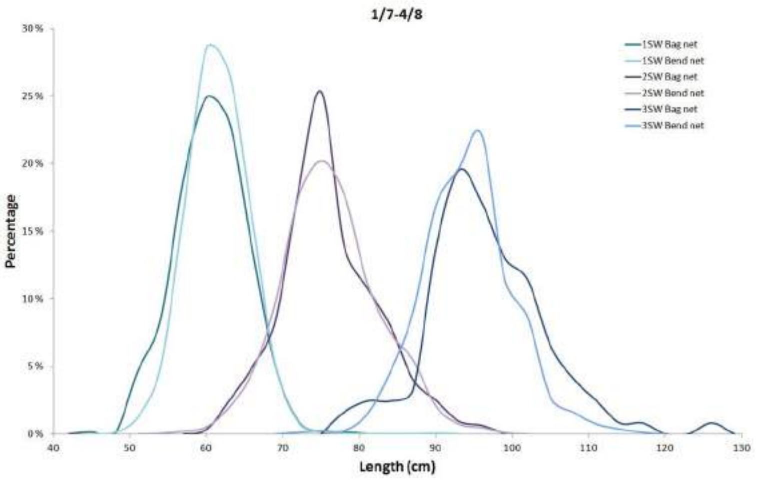
Figure 51. Length distributions for salmon (wild and escaped salmon combined) between bag nets and bend nets during summer periods in the Kolarctic area in Norway in 2011 - 2012.

Length distributions of salmon caught with bend nets and bag nets indicate that there are no clear differences for males throughout the season. For females on the other hand, bend nets seem to be selecting more median sized salmon (2SW) than the bag nets, throughout the season (Figure 51). The explanation behind the observed selectivity can be that fishermen in their bend net fishery select and change different mesh sizes during the season, probably to optimise their catch. In the bag net fishery they use the mesh size 58-60 mm from knot to knot. Generally fishermen use bend nets with a mesh sizes between 62-68 mm. Early in the season when large salmon are migrating along the coast, fishermen can use nets with mesh sizes up to 70 mm.

From the total catch between May and the beginning of August in the Kolarctic area, bend net fishery seems to target larger salmon than bag net fishery. The average size of salmon caught with the two gear types is shown in figures 63 and 65.

Photo 24. Bag net and fisherman Eilif Hansen in Bugøynes Sør-Varanger Municipality, Finnmark Norway





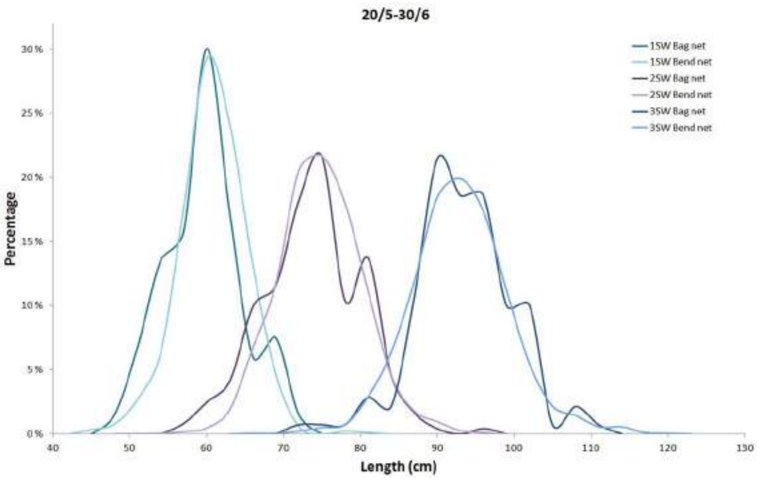


Figure 52. Percentage length distributions for 1SW, 2SW and 3SW salmon caught with bag nets and bend nets in Finnmark in the years 2008, 2009, 2011 and 2012.

Figure 52 indicates that bend net fishery is targeting into larger 1SW salmon in June than bag net does. In July and early August bend net fishery is also targeting to larger 1SW salmon than bag net fishery. Bend net fishery is therefore catching more males in 1SW salmon than bag net fishery does (See figure 45). The selective fishery is affecting also in the smallest 2SW salmon in June when bag net fishery is targeting more to smaller fishes than bend net fishery.

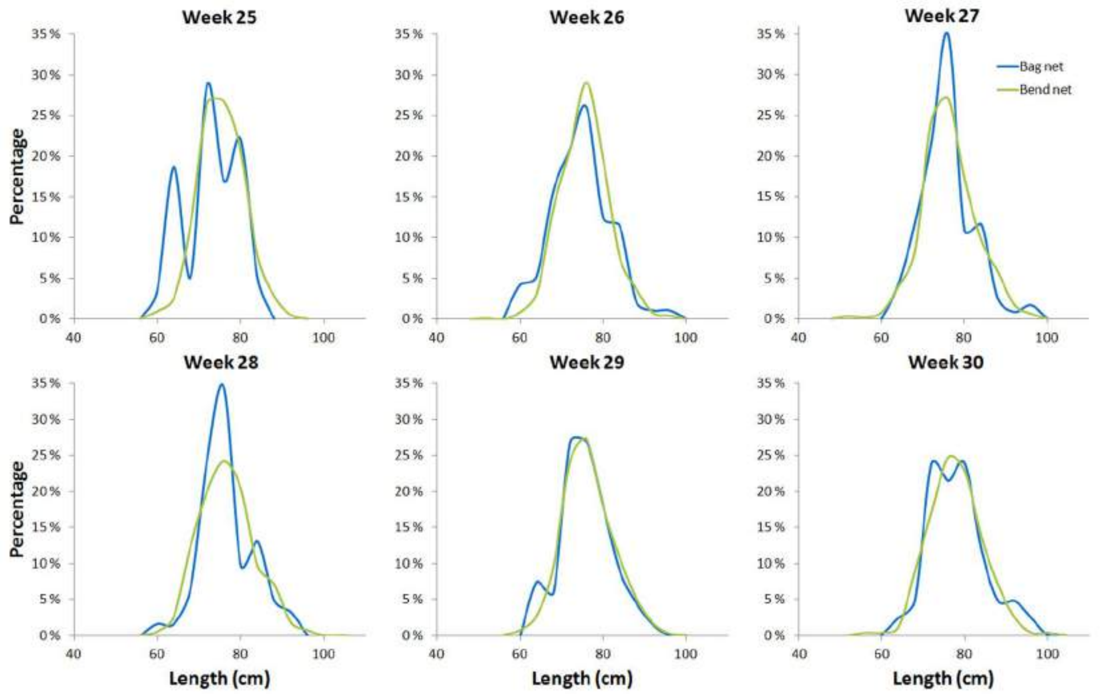


Figure 53. Weekly percentage length distributions for 2SW salmon caught with bag nets and bend nets during their peak migration periods in Finnmark in the years 2008, 2009, 2011 and 2012.

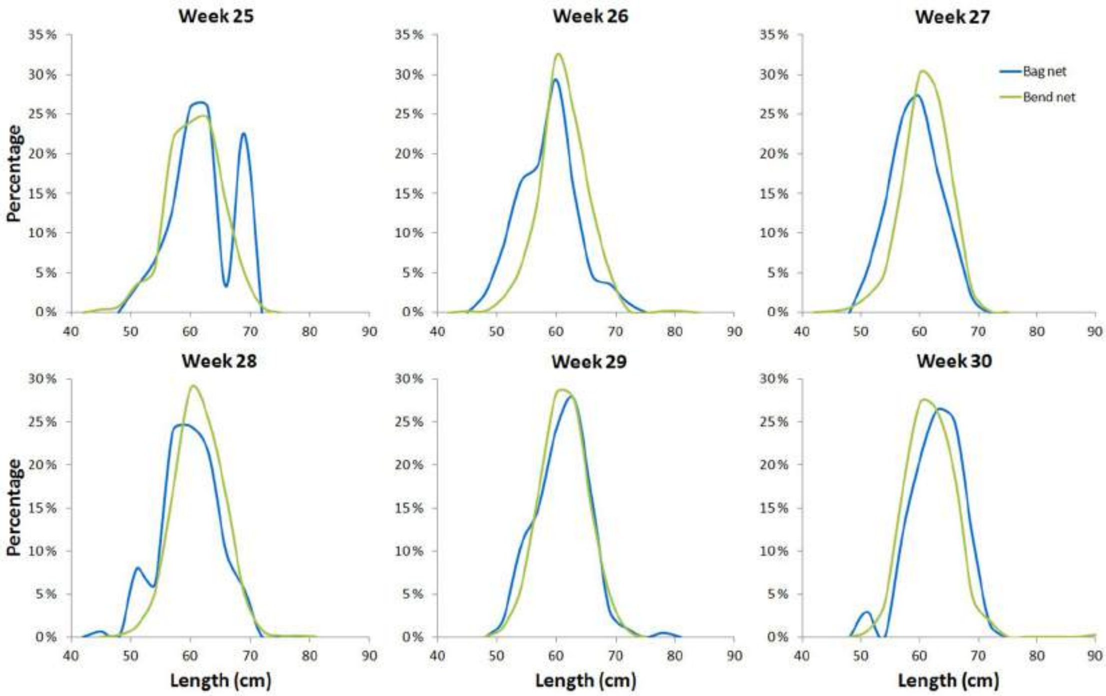


Figure 54. Weekly percentage length distributions for 1SW salmon caught with bag nets and bend nets during their peak migration periods in Finnmark in the years 2008, 2009, 2011 and 2012.

Weekly size distribution indicates that bend nets are selecting larger 1SW fish in the weeks 26-28 than bag nets, in Finnmark. For 2SW salmon the size selection between fishing gear during the weeks 25-30 is not clear (figures 53 and 54).

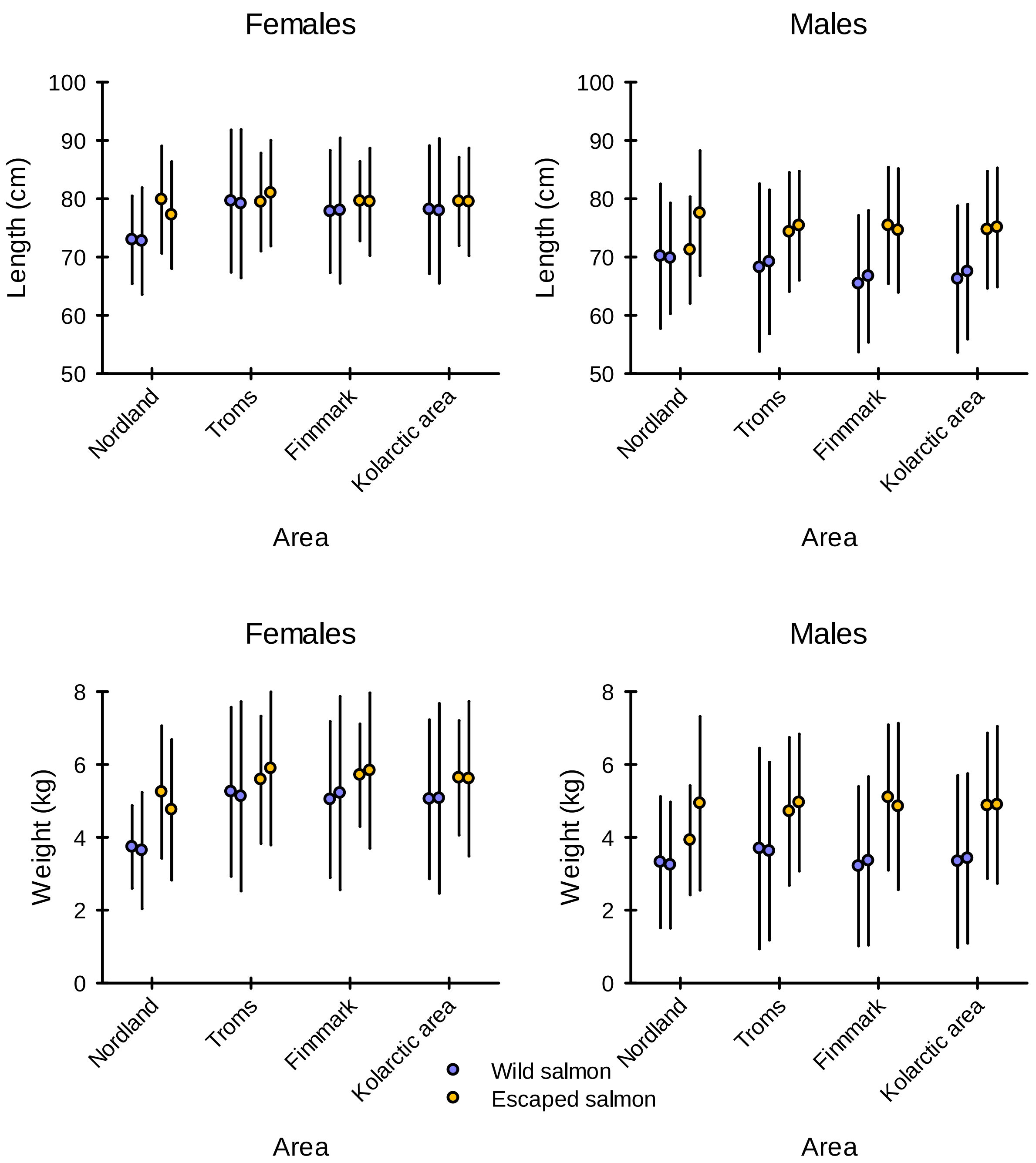


Figure 55. Mean sizes of wild and escaped salmon in the catches from May to the end of September. Plots on the left indicate data from 2011 and on the right from 2012.

In Nordland, Troms and Finnmark the mean lengths and especially weights of escaped male salmon were clearly larger than those for wild salmon. Also mean lengths and especially weights of escaped female salmon were larger than those for wild salmon (Figure 55). In the catches escaped salmon look much fatter than their wild counterparts of the same length. Mean sizes of wild and escaped salmon did not differ between 2011 and 2012.

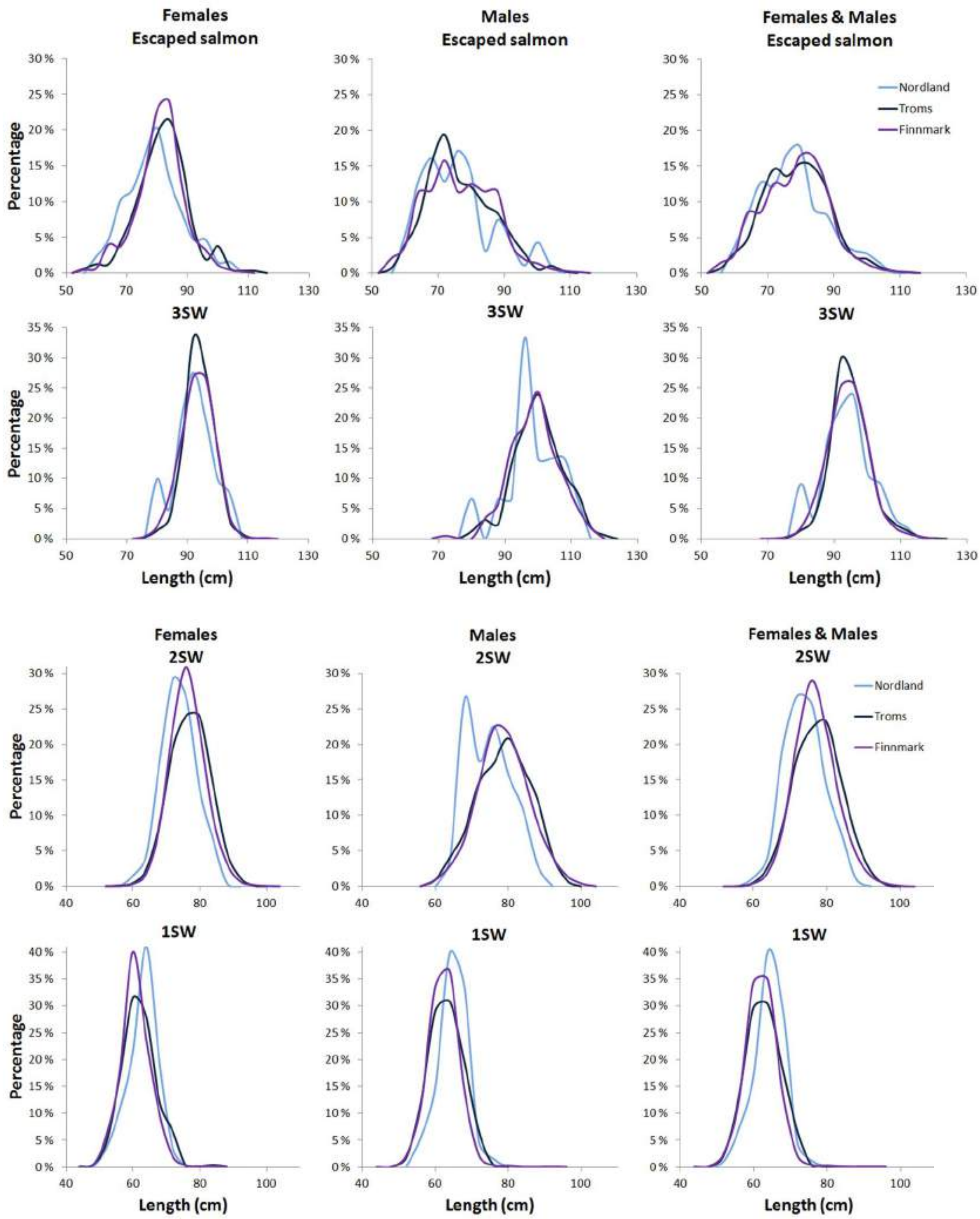
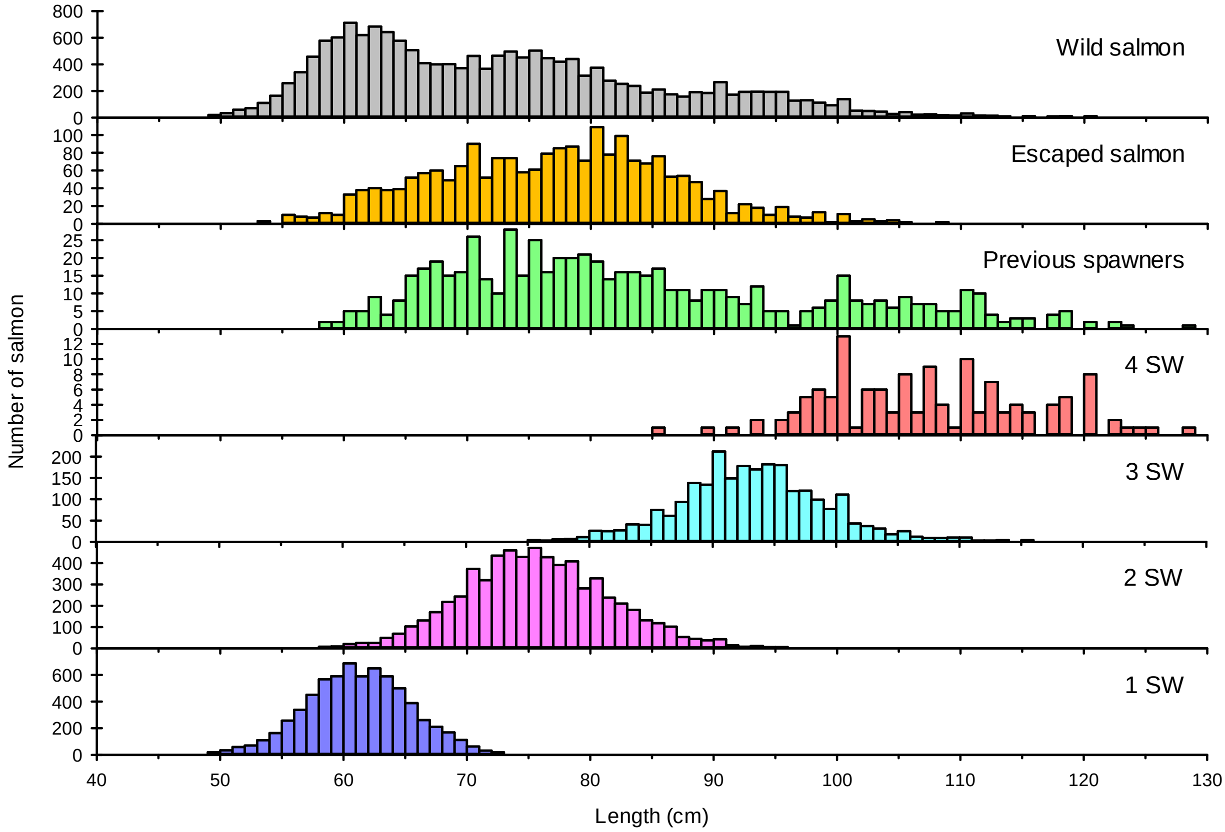


Figure 56. Length distributions of wild 1-3SW salmon and escaped salmon in Nordland, Troms and Finnmark in 2011 - 2012.

In all the three counties in northern Norway the length distributions of salmon captured were fairly similar for the sea-age groups 1SW, 2SW and 3SW and also for escaped salmon (Figure 56). Length distributions of escaped salmon span a wide range and overlap with the wild 1SW, 2SW and 3SW salmon length distributions. The size distributions of 1SW and 2SW salmon between three counties give a general picture of size selective fishery indicating that in Finnmark the size of 1SW salmon in the catches is smaller than in Nordland and Troms and the size of 2SW salmon is larger in Finnmark and Troms catches than in Nordland. The differences in the size distributions between counties are affected by fishing gears used, mesh sizes used, the timing of the sampling in the summer and growth differences in the stocks exploited within these areas.



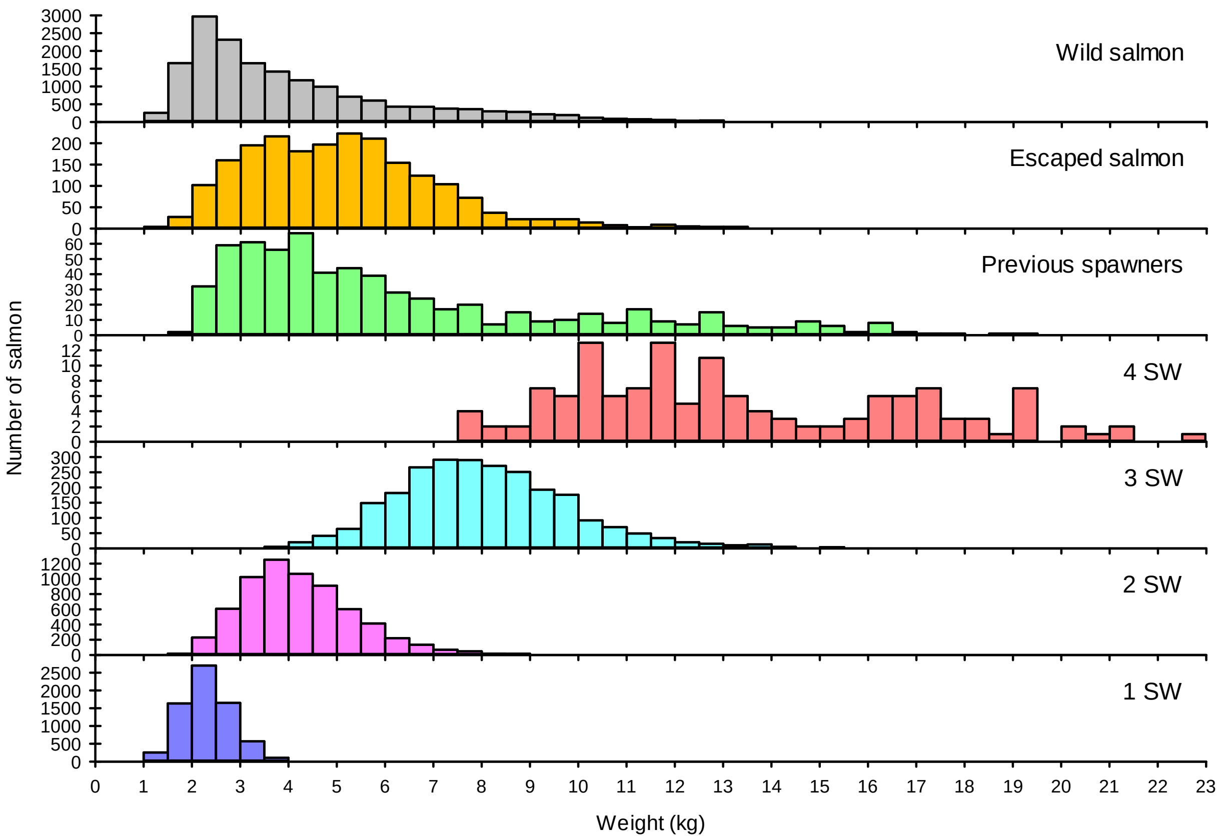


Figure 57. Length and weight distributions for wild and escaped salmon caught in May-September in the Kolarctic area in 2011-2012.

Length distribution, combining all the lengths of wild 1SW-4SW salmon, gives a crude view of the ages of salmon available to the fishery (Figure 57). There is, however, extensive overlapping in the lengths and weights between the ages of 1SW and 2SW, 2SW and 3SW, and 3SW and 4SW salmon that makes it impossible to use length and weight groups to identify ages of salmon from the material collected during three to five summer months. Length and weight distributions of previous spawners and escaped salmon combined into the wild salmon distributions increase the difficulty of separating sea ages in the salmon catches. The wide range of the distributions in each sea-age group is depends on the different salmon stocks included in the data and the large time span in the collection of the material; from May to September.

Photo 25. Fisherman Steinar Magnussen in Jarfjord, Sør-Varanger.

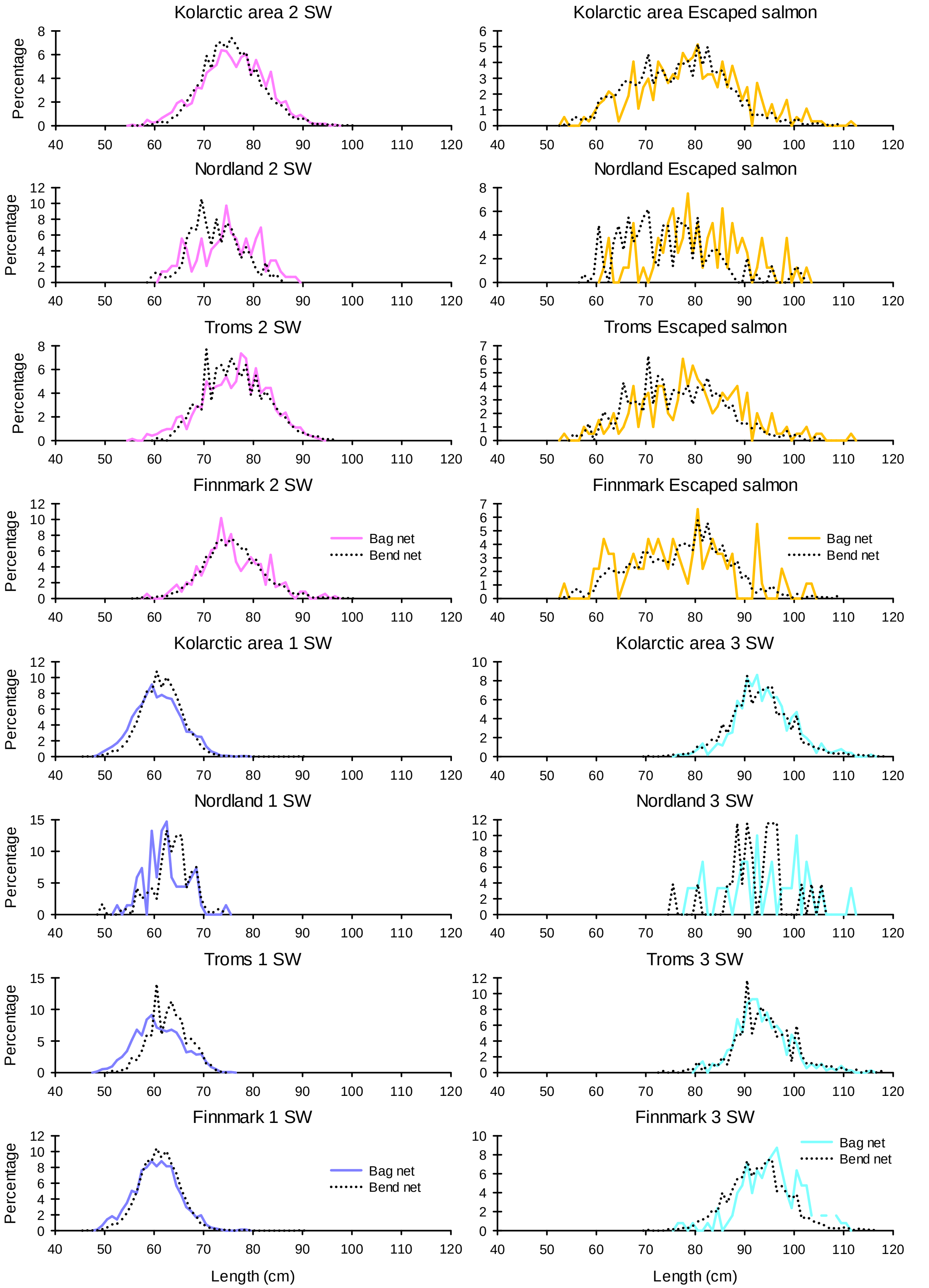


Figure 58. Length distributions of salmon caught with bag nets and bend nets in Nordland, Troms and Finnmark in 2011-2012.

The two salmon fishing gear type, bag net and bend net, have different ways of catching fish. The oldest method is bag net fishing. It usually catches live salmon in a bag, at least those fish which are older than 1SW. In bag nets fish are gathered into a special chamber or chambers into which salmon must swim through a narrow opening(s). The smallest 1SW fish can escape through the mesh but the largest 1SW fish will remain in the net when trying to escape through the mesh and usually they die after short period. Thus, bag nets are somewhat selective fishing gear, with higher fishing effort on the smallest fish in the 1SW salmon group.

Bend nets catch salmon only with the mesh when salmon try to escape out of the gear. The salmon attach onto the gillnet. Fishermen use variable mesh sizes in the bend nets during the season. Early in the season when 3SW and 4SW salmon are migrating along the coastal areas, fishermen use larger mesh sized nets to more effectively capture 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 knots. The smallest 1SW salmon especially can escape these nets.

The length distributions of 1SW salmon caught with bag nets and bend nets throughout the period from early May to the beginning of September indicate that there are not remarkable differences in the sizes of salmon captured by these two gear types (Figure 55). Bend net fishery seems, however, to target slightly larger 1SW salmon than the bag net fishery, which especially can be observed in the Troms and Nordland catches. A possible explanation to these observed differences in the size distributions might be that the two gear types have not been used at the same time of the summer and therefore the figure does not indicate exactly the possible size selective fishing of bend nets. In Finnmark, size distributions of 2SW salmon indicate that bend nets catch a little larger salmon than bag nets and that bag nets catch larger 3SW salmon than bend nets. In the catch of escaped salmon, no clear differences can be observed in the size distributions between the two methods. This current Kolarctic research fishery was not designed to carefully examine the possible selectivity between bag net and bend net fisheries. Therefore these results presented here should be handled with care.

Photo 26. Fisherman Finn-Hjalmar Seipæjærvi, Bugøynes Varangerfjord.

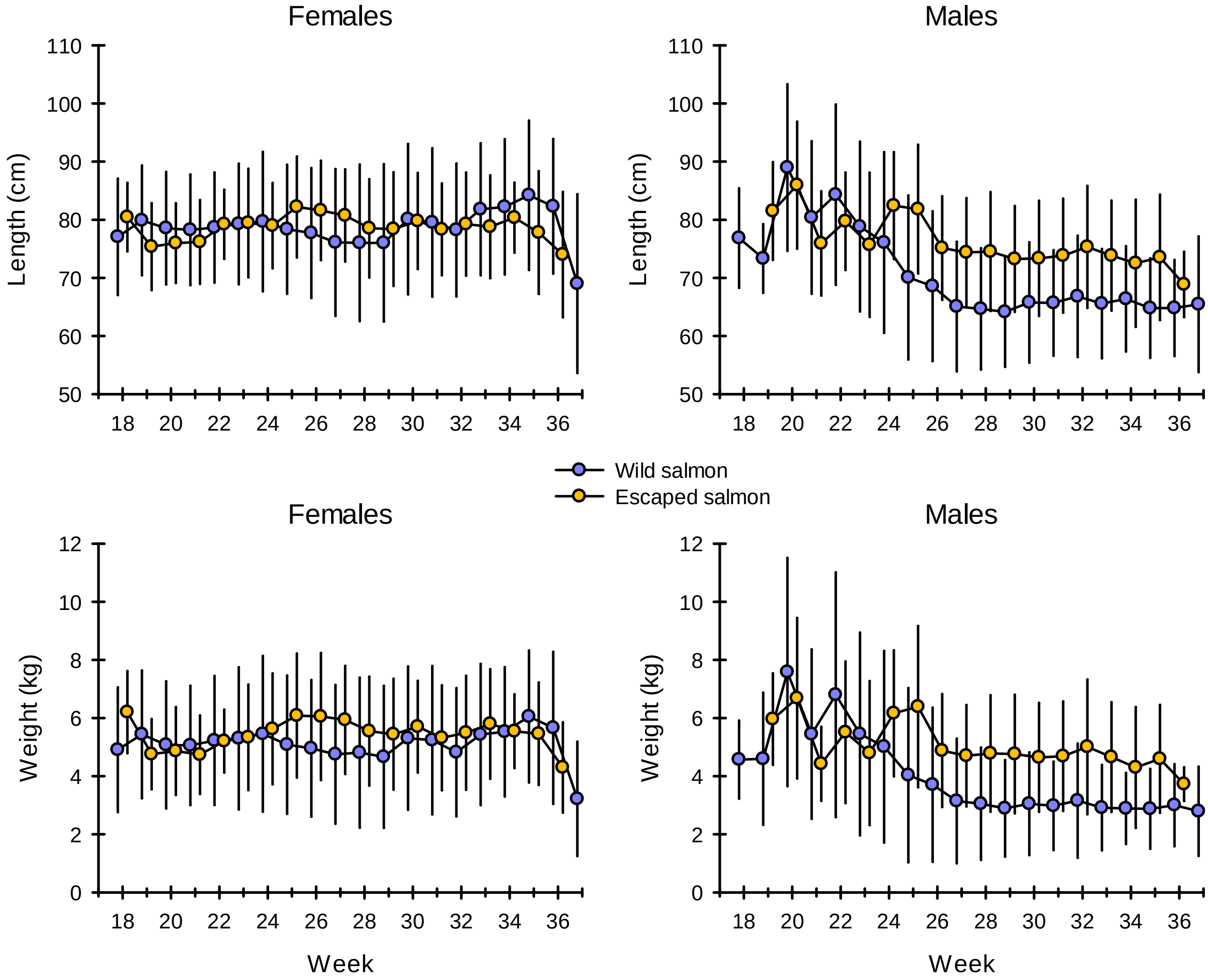


Figure 59. Weekly mean lengths and weights of wild and escaped salmon in 2011-2012 in the Kolarctic area. In wild salmon all sea-ages, including previous spawners, are combined.

The weekly mean lengths and weights of wild and escaped female salmon caught in the Kolarctic area were almost unchanged throughout the period from May to early September (Figure 59). One reason for this is the small change in the weekly sea age distributions of wild female salmon during the entire migration period, which could affect the weekly mean size in female salmon catches (Figure 10). The low abundance and thereafter the low proportion of female 1SW salmon only in the middle of the summer did not substantially affect the mean size of females.

In male salmon, however, the weekly mean size of wild salmon declined from week number 20 to week number 28, and thereafter the mean size stayed fairly stable to week 37. This declining of the mean size of wild salmon is caused by the high abundance and proportion of 1SW males in the catches over the 10 weeks (Figure 10). In male escaped salmon the weekly mean size varied early in the season due to their low abundance in the catches and the size declined slightly towards autumn.

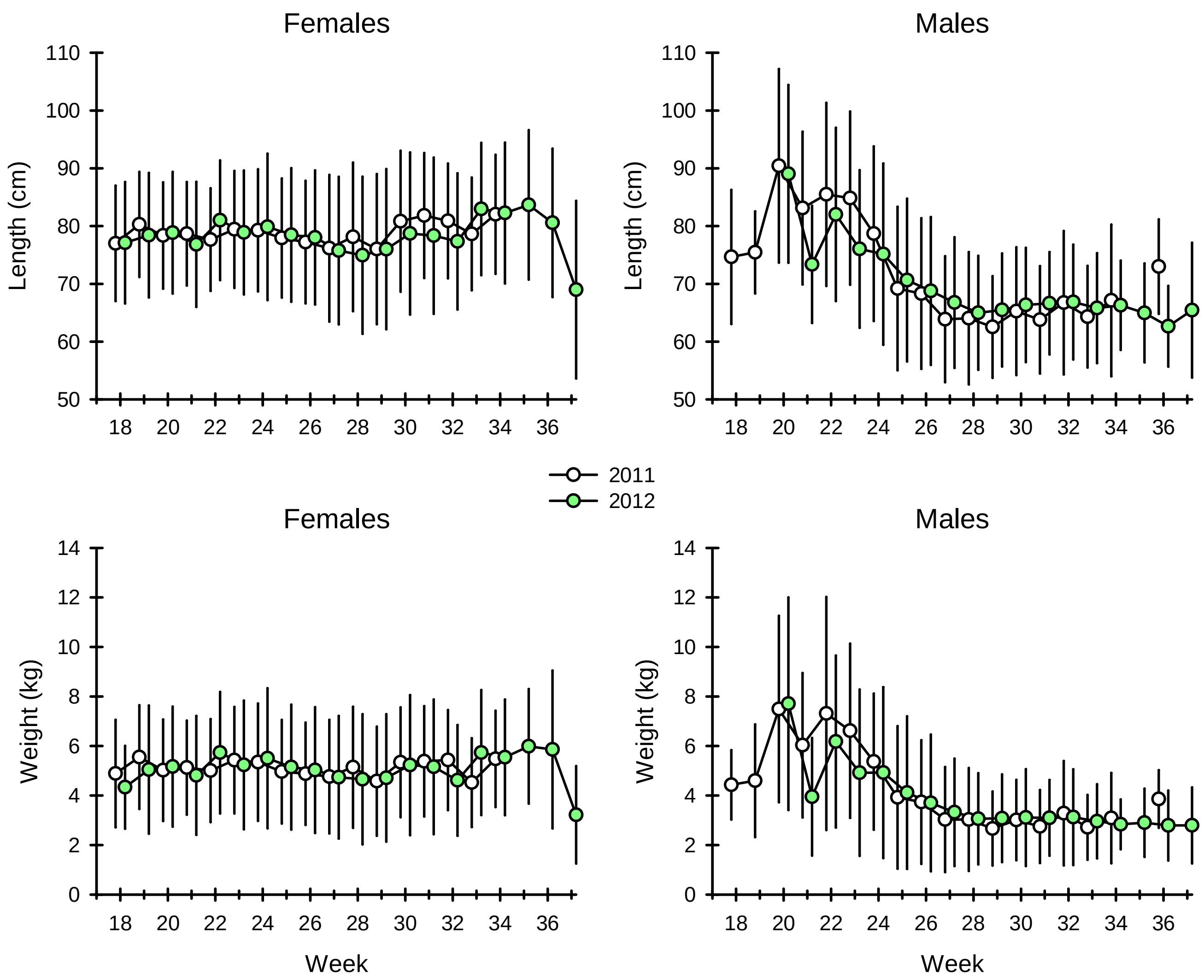


Figure 60. Mean weekly weights and lengths with SD of wild salmon (1-4SW and previous spawners) in the Kolarctic area in 2011 and 2012

Mean weekly sizes of wild salmon were identical in 2011 and 2012 for both sexes in the whole Kolarctic area. The size of males was slightly larger in 2012 than in 2011 from week 24 onwards (Figure 60).

Photo 27. Wild salmon: pectoral fins and the tail are not eroded; gill cover is not shortened and very few black spots below the lateral line.

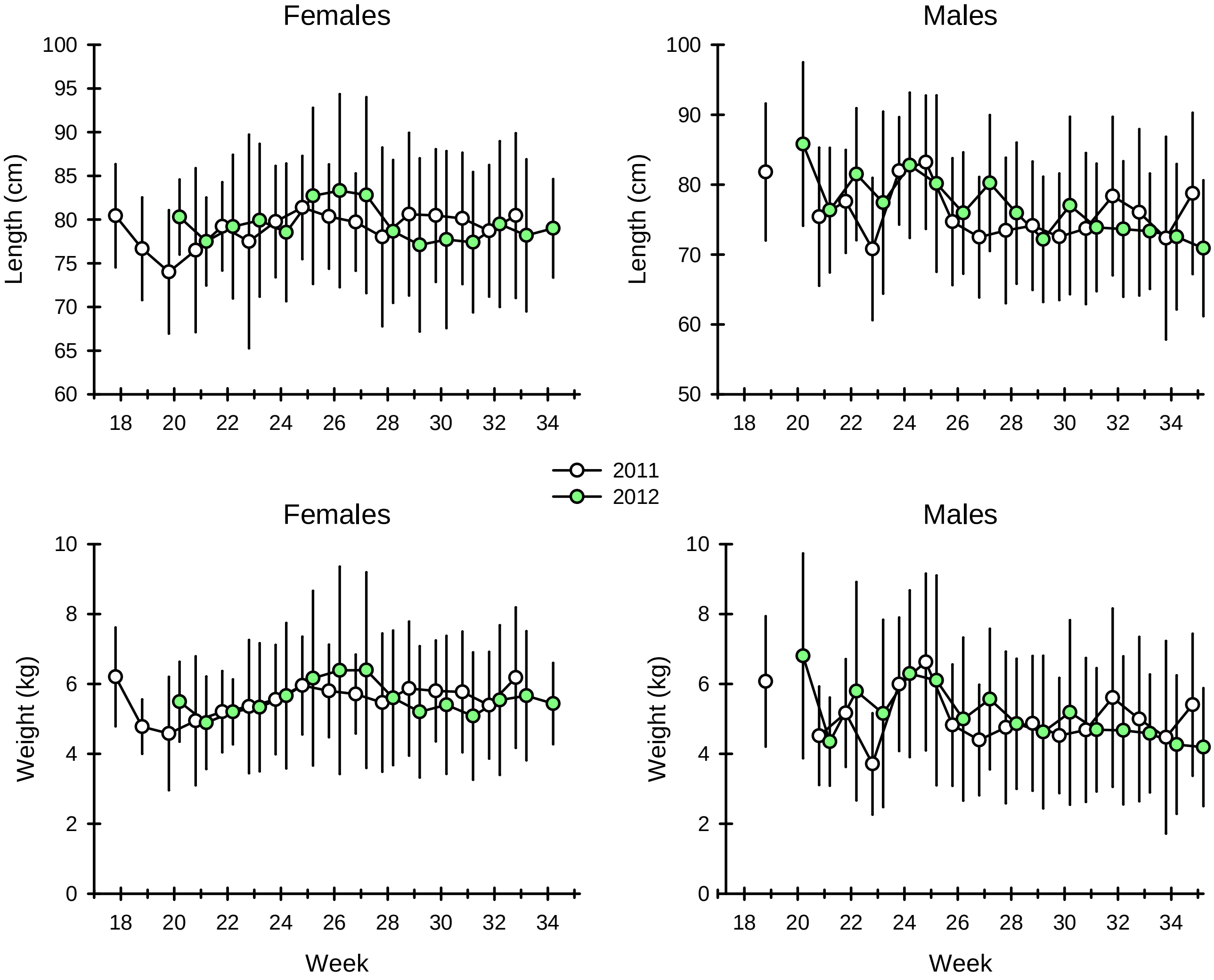


Figure 61. Mean weekly weights and lengths with SD of escaped salmon in the Kolarctic area in 2011 and 2012.

Mean weekly sizes of escaped salmon were almost identical in 2011 and 2012 for both sexes in the whole Kolarctic area (Figure 61).

Photo 28. Escaped salmon pectoral fins are eroded and shortened; tail is eroded and rounded, gill cover is shortened and there are numerous black spots on the gill covers and below the lateral line.

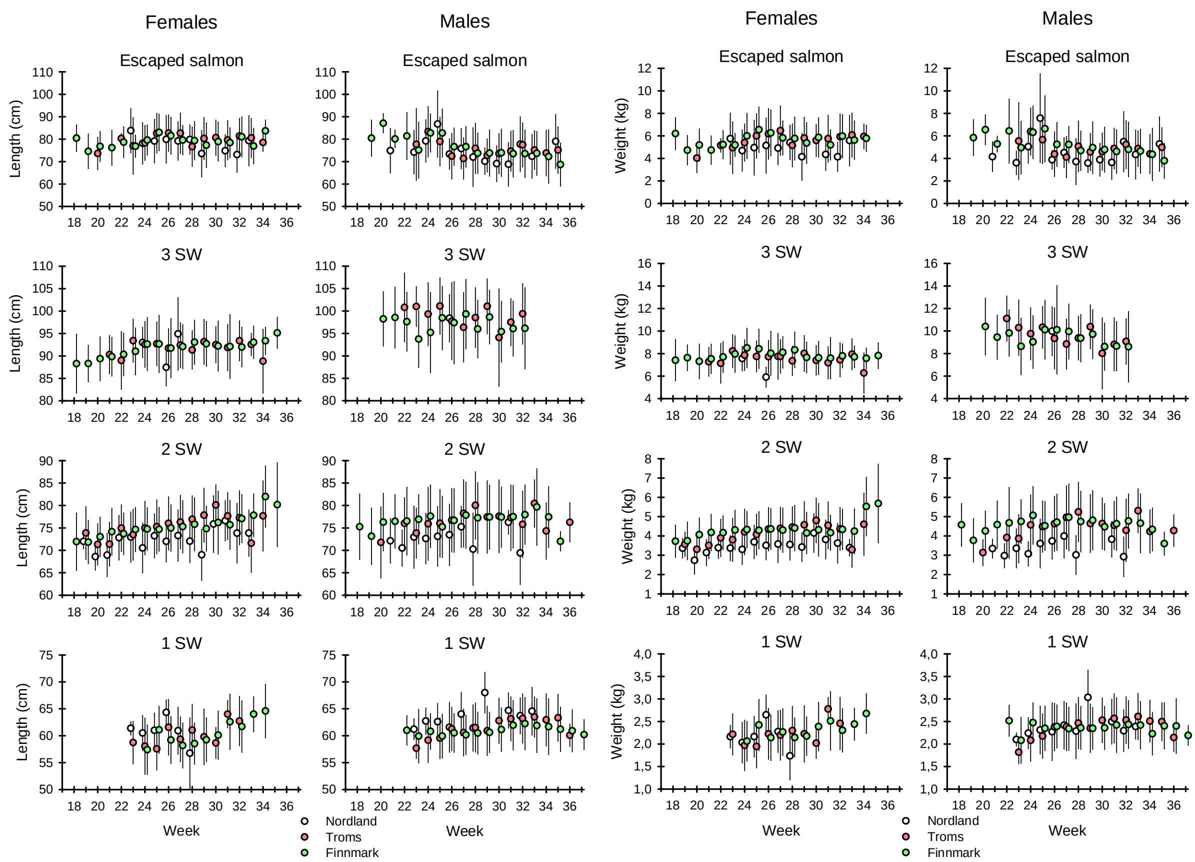


Figure 62. Mean weekly lengths (SD) and weights (SD) of wild 1-4 SW salmon and escaped salmon in the Kolarctic area from 2011 and 2012 combined.

The salmon captured in the coastal areas in Nordland, Troms and Finnmark probably originated from more than 150 stocks. It is believed that each of these stocks is migrating within a fairly narrow time frame along the coastal line and therefore the mean weekly sizes of salmon do not differ much in each sea-age group. The most obvious observation was the clear increase in the weekly mean sizes of 2SW females in all the counties (Figure 62). There was also a slight increase in the mean weekly length of female 3SW fish. The larger weekly mean lengths of 2SW females at the end of the fishing period might be explained by these fish being so called late running salmon which have had some additional growth during the third summer at sea. The increase in the size of 1SW salmon captures towards autumn may has increased the catchability of 1SW salmon, especially in bend net fishery. The increase in the size of salmon captured, in each sea-age groups towards autumn – may be explained by the difference in the migration periods of the various stocks as the stocks migrating later have continued their growth. Differences in the weekly mean weights and lengths between the three counties can be explained by the differences in stocks components.

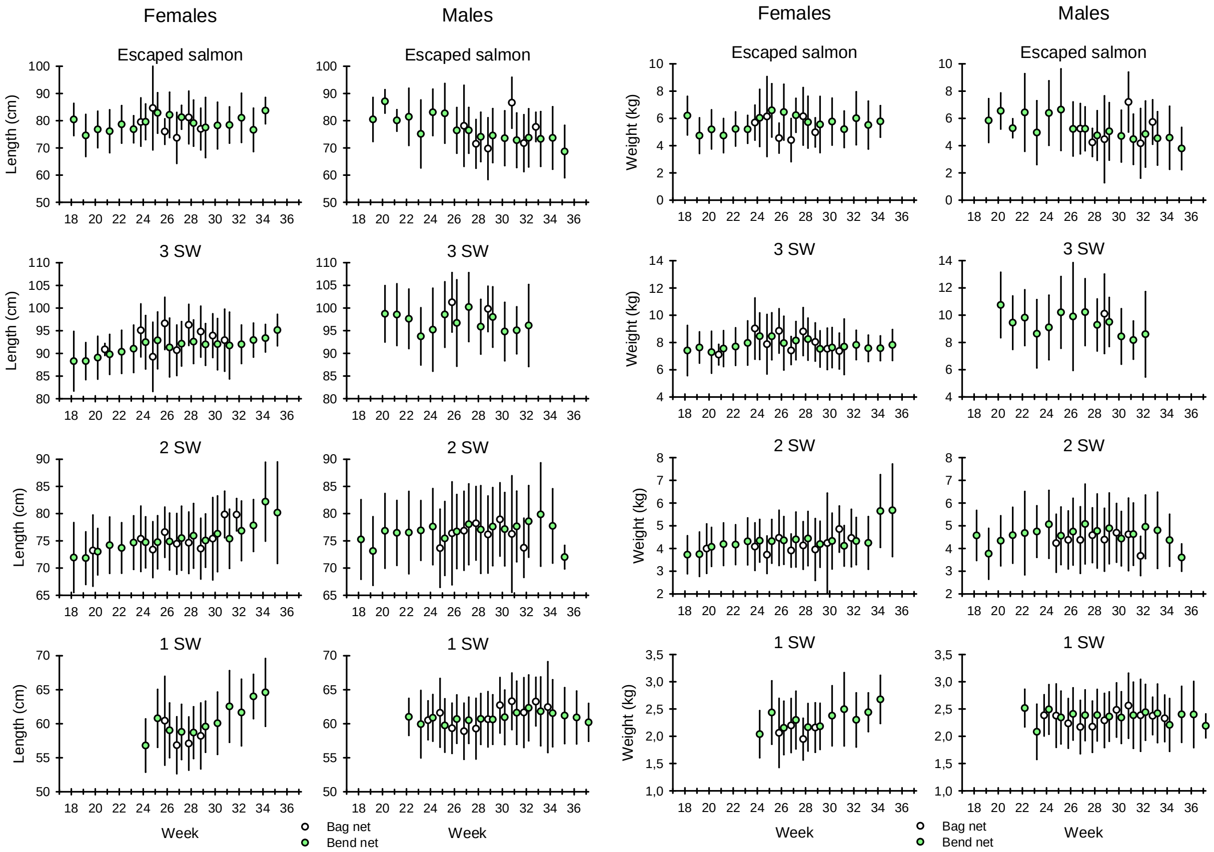


Figure 63. Mean weekly lengths (SD) and weights (SD) of wild 1-4SW salmon and escaped salmon caught with bag nets and bend nets in Finnmark combining the material from 2011 and 2012.

Based on the salmon scale samples collected in Finnmark, it seems that the mean weekly sizes of 1SW and 2SW female and male salmon in bag net and bend net fishery differ slightly in that bend nets catch slightly larger fish (Figure 63). These differences can be caused, for example, by the use of varying mesh sizes in bend nets during the fishing period.

Photos 29 a and b. Sampling in field laboratories, Porsangerfjord. Josef Samuelsen (on the right) Repvågstranda.

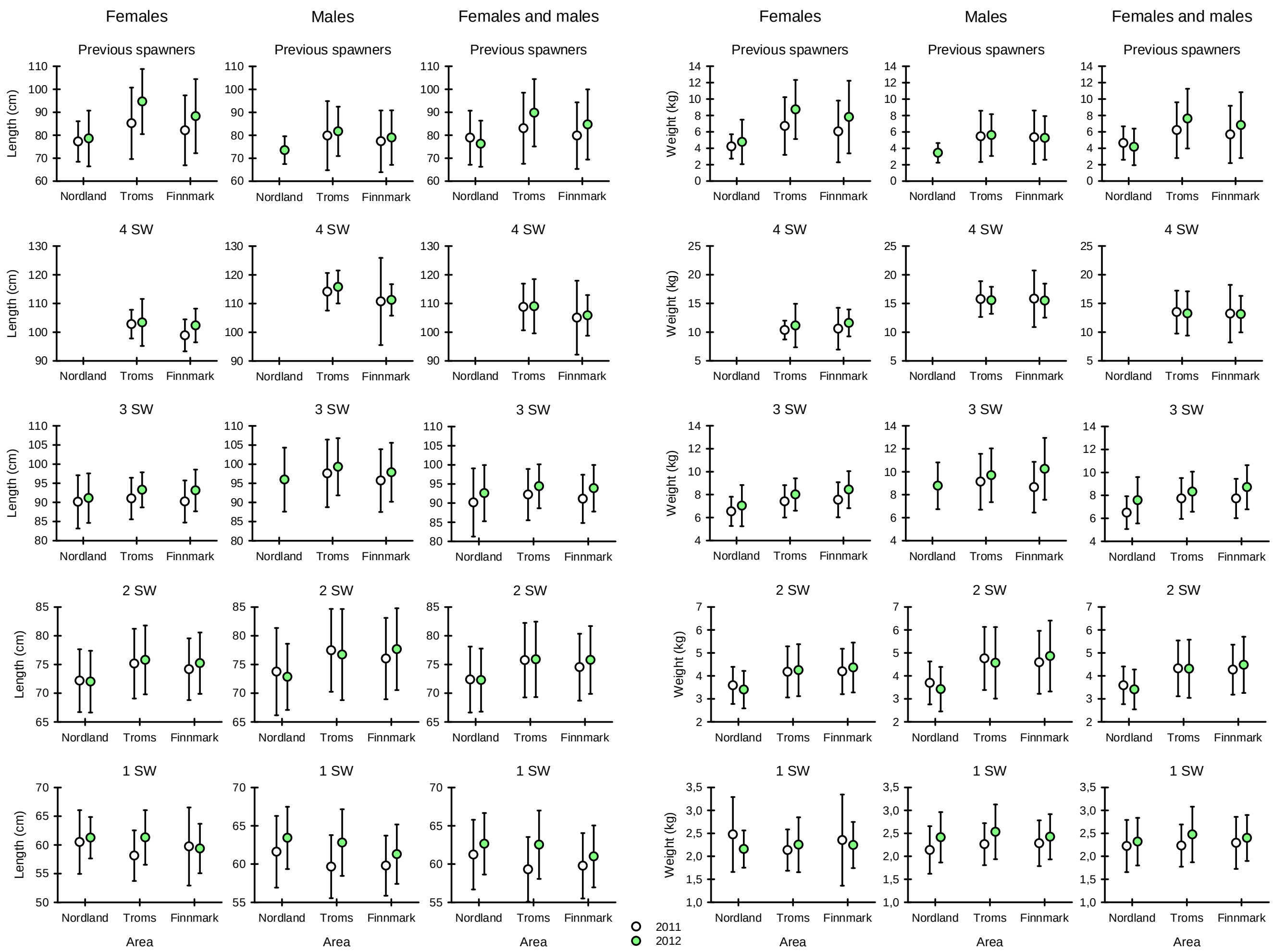


Figure 64. Mean lengths (figure on the left) and weights (figure on the right) of wild 1-4 SW salmon and previous spawned salmon in 2011 and 2012 in the Kolarctic area from May to August 4.

Mean lengths and weights of 1SW, 2SW, 3SW, 4SW and previous spawned salmon were almost the same or a little larger in 2012 than in 2011 (Figure 64). The size of 2SW salmon was larger in Troms and Finnmark than in Nordland, which can be caused by the different fishing time.

Photo 30. Wild salmon in good condition.

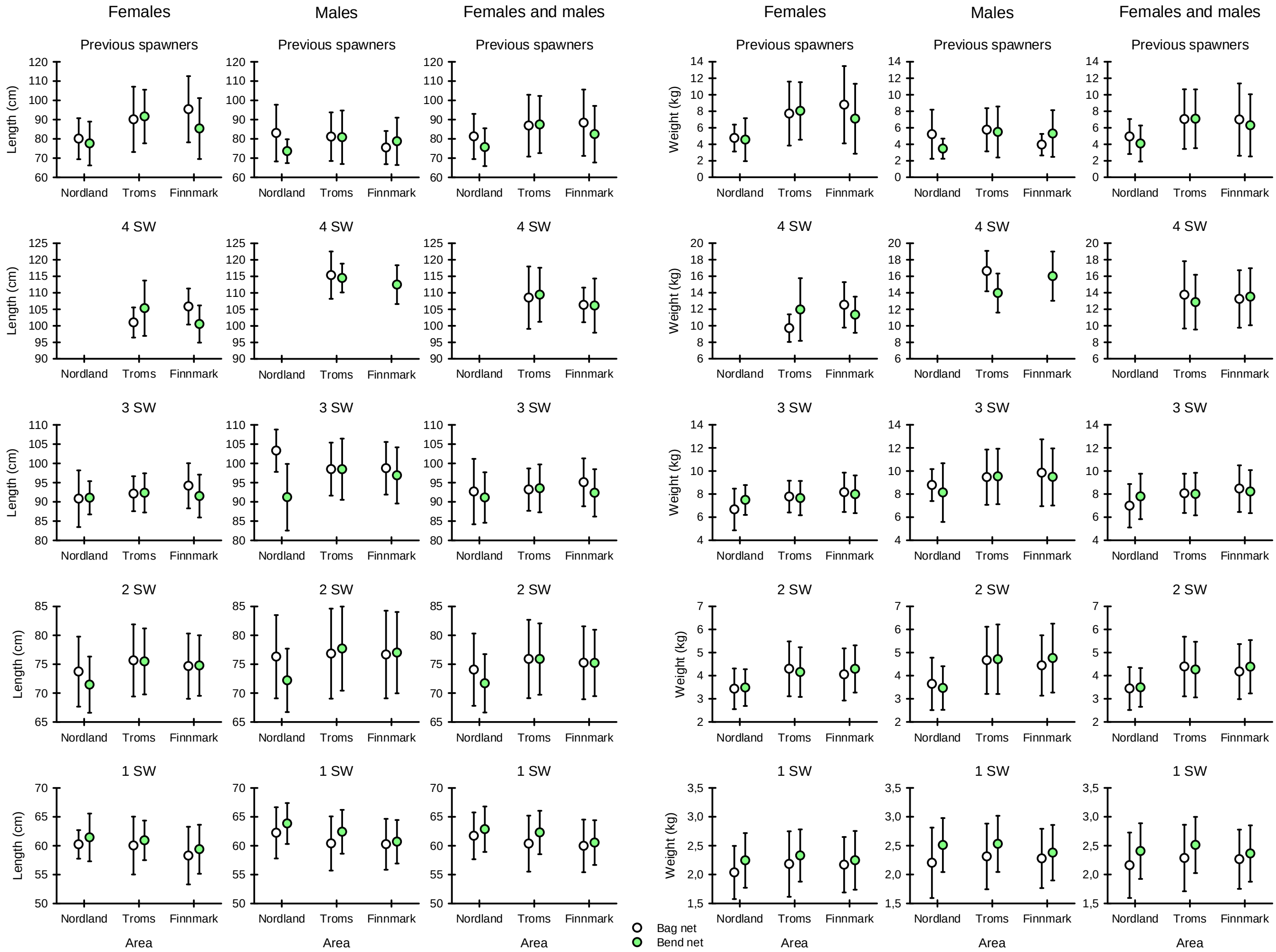


Figure 65. Mean lengths and weights of wild salmon in bag net and bend net fishing in northern Norway between May to August 4 in 2011-2012.

Bend nets selected larger 1SW salmon than bag nets in Nordland, Troms and Finnmark in terms of length and weight of fish when the material from the entire summer was combined (Figure 65). In Finnmark and Troms there were no clear differences in the mean sizes of 2SW salmon between bag net and bend net catches when the material was combined from the summer. One reason for the size differences in 1SW salmon between the fishing methods can be differences in the time when these methods were used. If bend nets were used more effectively at the end of the season than bag nets, then it is obvious that this explains the larger size of 1SW salmon. In the end of the fishing season 1SW salmon are larger than early in the summer due to the additional growth they have during the summer.

13. Escaped salmon in the salmon fishery in Northern Norway

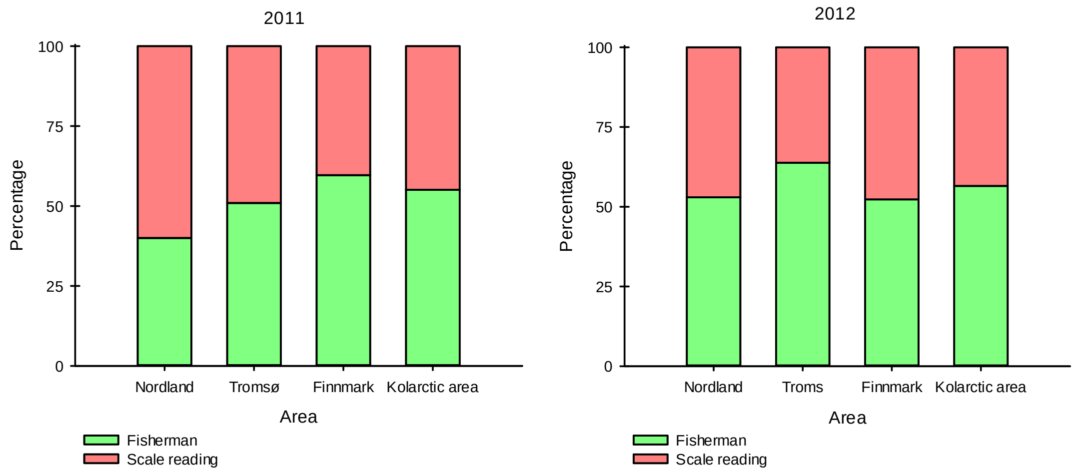


Figure 66. Proportions of escaped salmon identified by fisherman and by scale reading from all escaped salmon in 2011 and 2012. Green indicates the proportions of escaped salmon identified by fishermen out of all escaped salmon which were identified be scale reading. Red color indicates the proportions of escaped salmon identified only by scale reading.

Escaped salmon occurred in the catches in all the counties (Figure 7), in all months (Figure 8), in all weeks (Figure 10) and in almost all the fishermen's catches (Figure 4). Most of the fishermen in Finnmark who were collecting material from their salmon catches for the Kolarctic project were instructed to differentiate escaped salmon from their wild counterparts. In Nordland and Troms escaped salmon have been found in the catches over many years due to extensive salmon cage production and due to escaped salmon from these cages. Escaped salmon have been part of the catches in the Kolarctic area since the early 1980s. Therefore, it was expected that fishermen should be able to differentiate between wild and escaped salmon. In Norway there have also been many official brochures with informative photos to inform all salmon fishermen what the escaped salmon looks like. In general, salmon fishermen recognized only half of the actual abundance of escaped salmon which were later identified by scale analysis (Figure 66). Only very few wild salmon were identified wrongly by the professional fishermen as escaped salmon. Careful scale reading in the laboratory found approximately the double amount of escaped salmon, compared to what the fishermen earlier had identified as wild salmon. There were some clear differences between the counties in making the correct identification of the escaped salmon. In 2011, fishermen identified about 40% of escaped salmon as escaped in Nordland, 50% in Troms, and 60% in Finnmark. In 2012 some additional fishermen participated in the project and collected material. This might have affected the results in identification, at least in Nordland and Troms. Comparison between these two years in Nordland and Troms might be biased. From all the escaped salmon, fishermen succeeded in identifying approximately 55% as not wild salmon. This means that if fishermen have to report the numbers of escaped salmon in their catches they can identify only half of the total.

There were clear changes in the accuracy of the identification of escaped salmon in the catches between weeks (Figure 67). Early in the summer fishermen succeeded better in identifying salmon to be escaped fish than later in the summer. An obvious reason for this might be that early in the season fishermen had fewer fish to study on a daily basis, compared to the period of peak catches, when they had to measure and make observations from a higher numbers of fish each day. Early in the summer fishermen succeeded in identifying almost 75% of the total of escaped salmon to be escaped fish. Another reason for the observed variation in the identification success may be the size of the fish (figure 68). With the increased size of escaped salmon the identification accuracy improved.

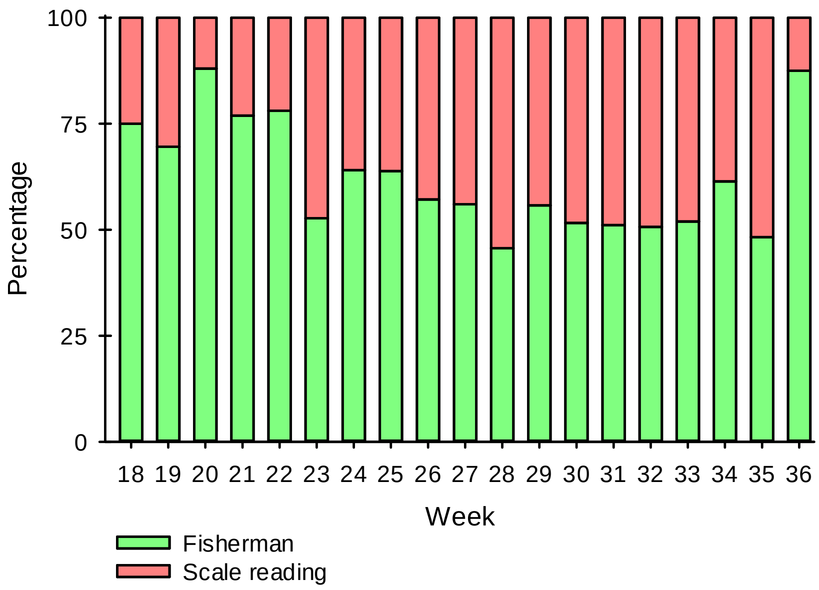


Figure 67. Weekly accuracy of identifying escaped salmon in the catches in the Kolarctic area.

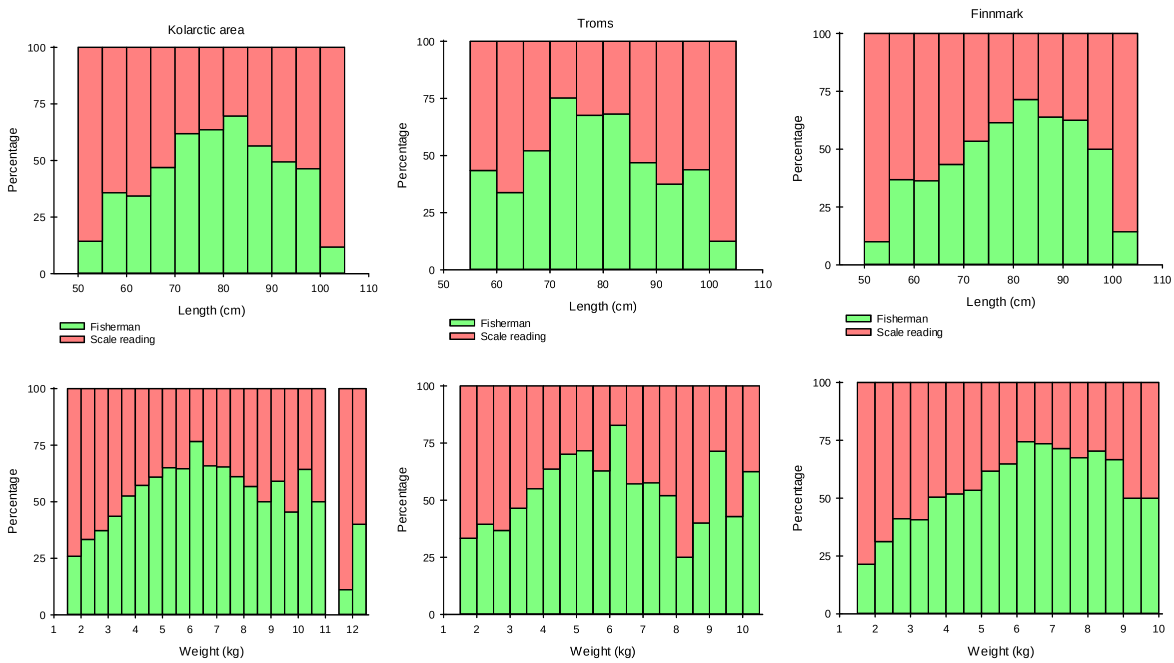


Figure 68. Recognition of salmon as being escaped salmon by fisherman and by scale reading in each size group of escaped salmon. Fishermen more precisely identified salmon as escaped salmon with the increased size of fish.

Juvenile salmon which are used for cage culture at sea are grown for the first 8-10 months in freshwater tanks. Juveniles are grown in large schools and their growth in length and weight is fast compared to growth in natural conditions. Due to the high population density and unnatural living conditions in tanks, juvenile salmon have some erosion on the edges of pectoral and dorsal fins. The tail can also be rounded already in the smolt phase. After release into the net pens at sea, smolts start fast seawater growth which takes 1-2 years before they will be slaughtered. The longer time the salmon are in the net pens, the larger and clearer are the damages, especially on the fins, and the clearer is the shortening of the gill cover, as compared to those of wild salmon. Therefore, it was understandable that fishermen could not recognize the smallest escaped fish as escaped fish because these fish had not been in cages for a long time (Figure 68). From Figure 66 it can be easily seen that the identification becomes more accurate with the increase in the length and weight of escaped salmon. Fishermen were most accurate at identifying escaped salmon with a weight of 6-7 kilo and with a length of 75-85 cm. This might indicate that these fish had stayed in net pens a rather long time before escaping and that during that period they had experienced clear erosions of fins and gill covers. If salmon escape soon after transfer into salt water, from some months to not more than one year, it is more difficult for fishermen to identify it as escaped salmon. Fishermen succeeded in identifying 65-75% of escaped salmon as escaped salmon when the weight of escaped salmon was 4.5-8.5 kg. Fishermen in Troms and Finnmark succeeded in making the identification in the same way with the increasing size of escaped fish.

Photo 31. Fisherman Øysten Kristiansen (Nesseby, Varangerfjord) sampling an escaped salmon

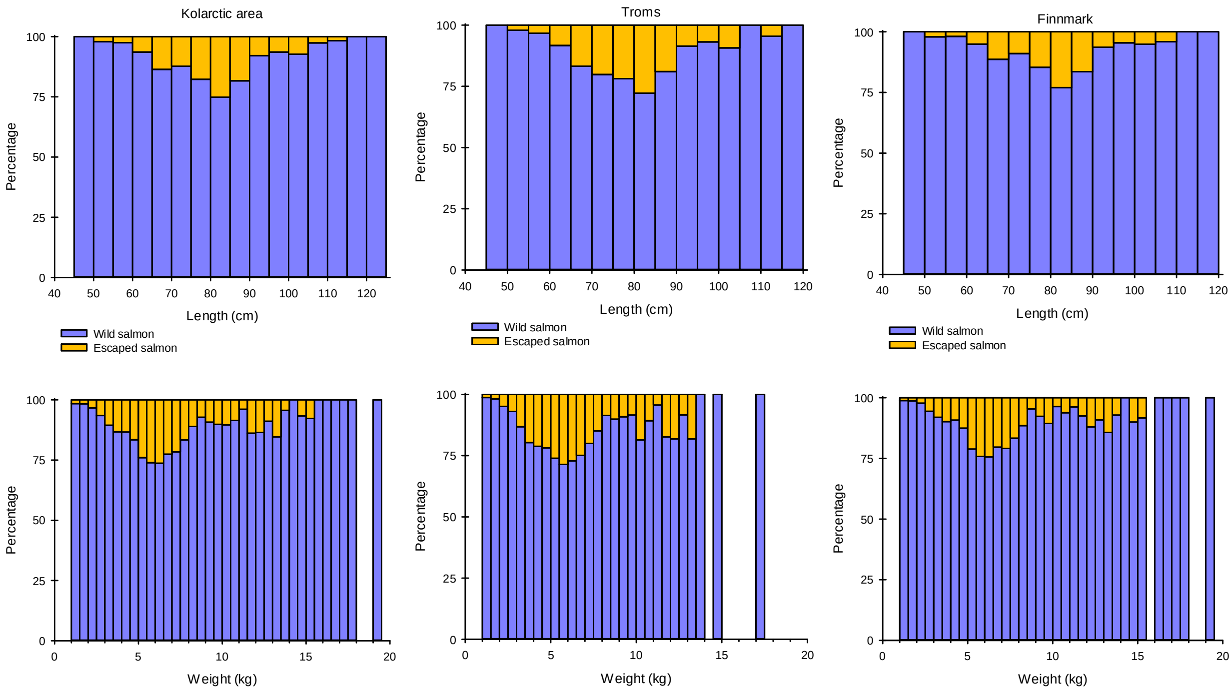


Figure 69. Proportions of escaped salmon and wild salmon (first time spawners and previous spawners) in different length and weight groups in the Kolarctic area at sea in 2011-2012. Note that the proportion of escaped salmon is very low in one sea winter salmon length and weight groups (below two kilos) but highest in 2SW age groups (between three and seven kilos).

Escaped salmon were distributed in almost all the same weight and length groups as wild salmon (Figure 69). In the Kolarctic area the proportion of escaped salmon was 25% in the weight group of 5-7.5 kg, which corresponds to a length of 75-90 cm. The high proportion of escaped salmon mainly in the above mentioned size group could have two possible explanations. If the escape from net pens takes place in their very early ocean life phase then these escaped salmon might migrate immediately to oceanic feeding grounds, avoiding being captured like small sized wild salmon in the coastal areas. Therefore their proportions are low in small size group salmon. Probably the most likely explanation to this observation is that farmed salmon have been bred for late maturation for over 10 generations, so they are not likely to return as 1SW fish. If cage culture salmon escape in their later life phase, their natural mortality might not be as high as with salmon escaping in a younger life phase and therefore their proportion is higher in larger fish. Another and maybe the more important factor is that there are not many wild 2SW and 3SW salmon in the weight groups of 5-7.5 kg and therefore the proportion of escaped salmon is large.

14. 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 the northern hemisphere. This parasite lives on salmon, trout and rainbow trout, and therefore it is called an ectoparasite. The larvae of this parasite can be attached to the salmon already in a very early phase of sea life as a smolt or post smolt. The parasites mainly attaches onto such places of the fish body where they are "sheltered" against the water current. The parasite feeds off mucus and sucks blood from the fish. If the numbers of parasites are high they can negatively affect the survival and growth of the host, especially in the post smolt phase.

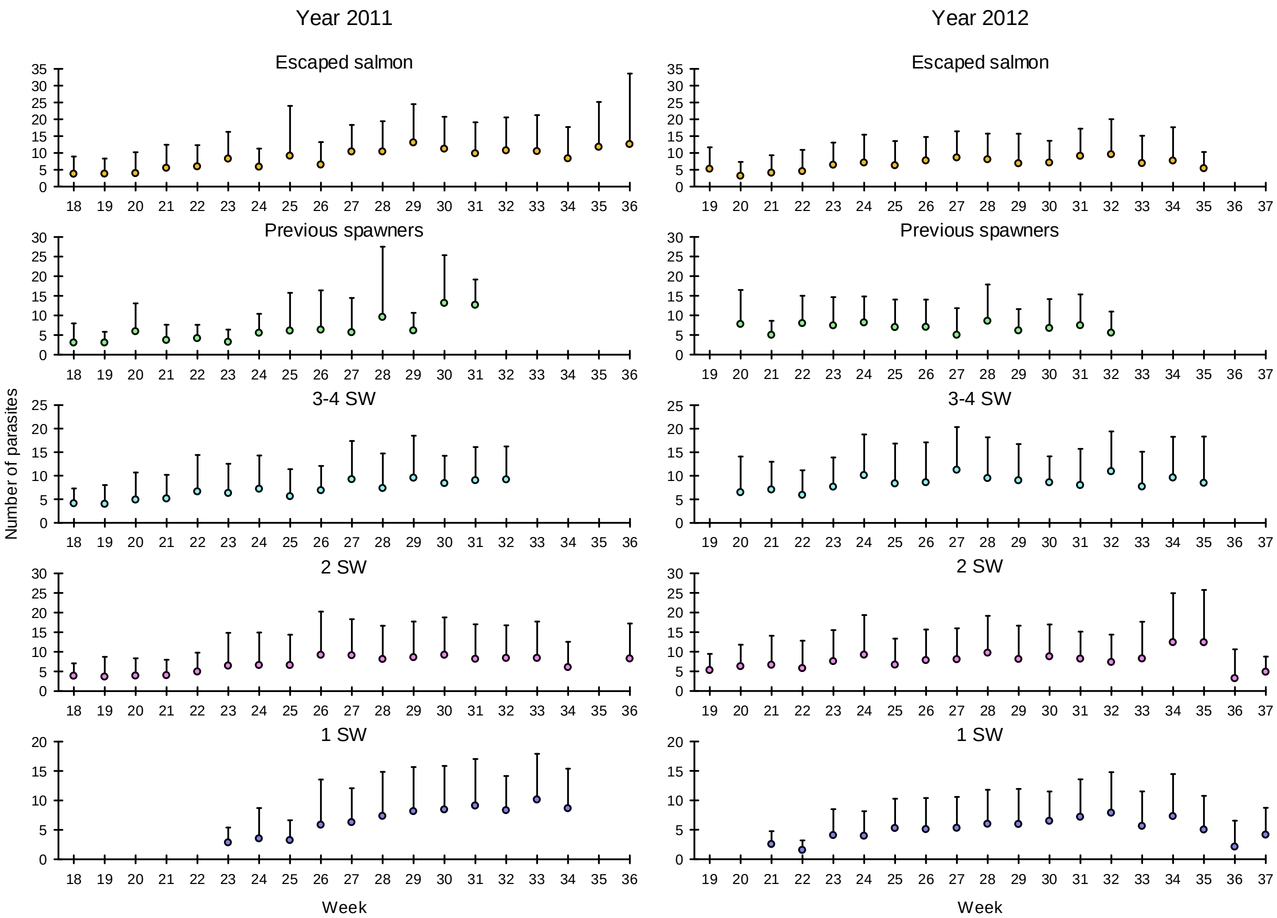


Figure 70. Mean weekly numbers of salmon lice in wild and escaped salmon in the Kolarctic area in 2011 and 2012.

The abundance of lice on the salmon caught increased throughout the summer for most sea age groups. Early in the summer in May, the mean numbers of lice per fish were around five in wild and escaped salmon (Figure 70). The highest number of salmon lice recorded on single escaped and wild salmon was 99 and 89, respectively. Salmon with the highest numbers of lice were caught mainly in Troms county. One interesting observation was a previously spawned female salmon, with the sea-age of 3S1+ years was infected with 74 lice. This indicates that this female fish visited freshwater to spawn, stayed there almost one year, and thereafter descended back to seawater for reconditioning. During the post spawning period of almost one year at sea, over 70 lice attached to it. Normally post spawners are in weaker condition compared to first time spawners, and therefore lice infections may cause additional mortality.

Photo 32. Salmon lice (females with egg sacks).

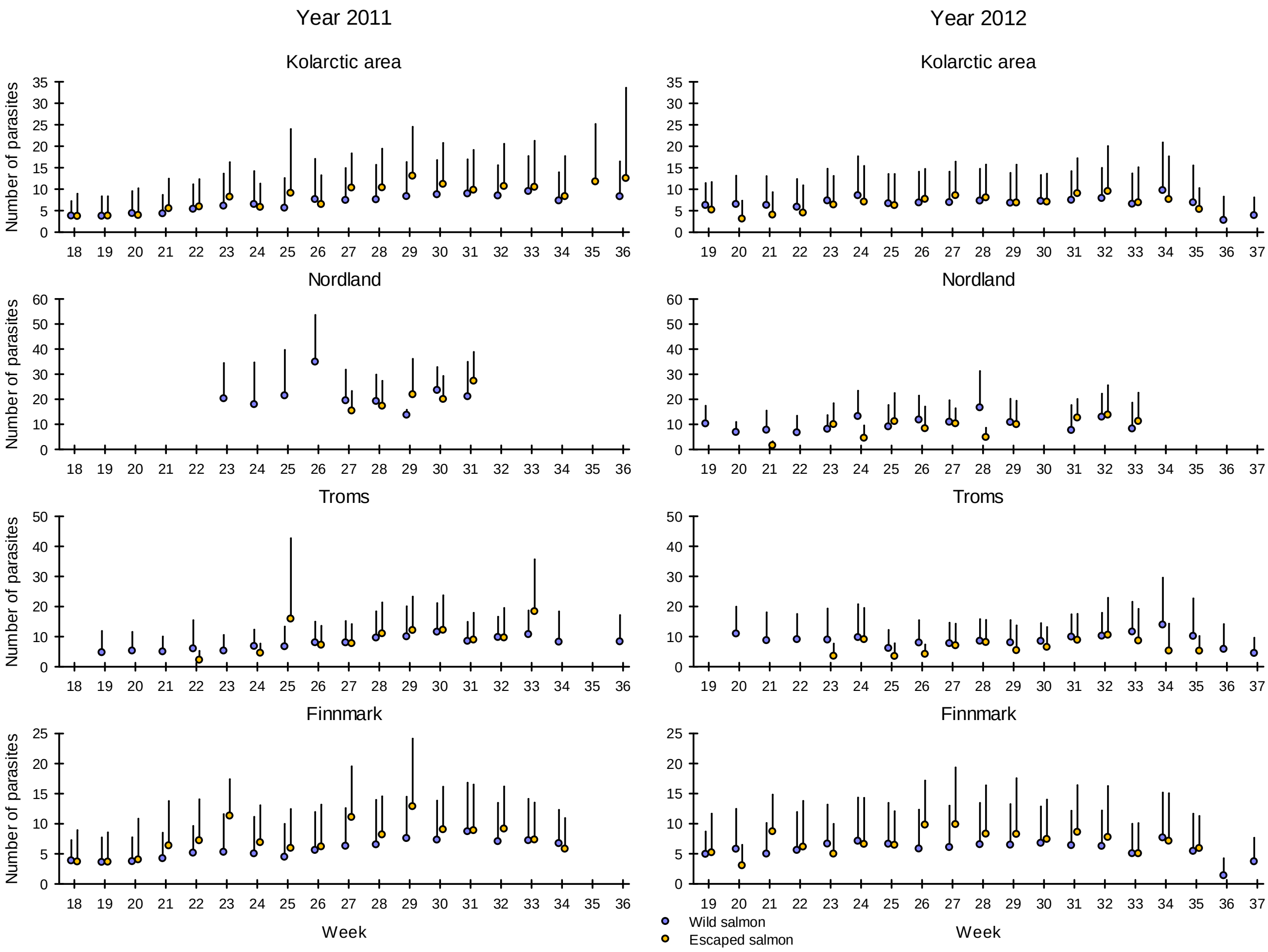


Figure 71. Weekly mean numbers of salmon lice on wild salmon and escaped salmon.

Fishermen were asked to count the numbers of salmon lice from all their catches. The mean numbers of lice presented in Figure 71 are the minimum values. All the salmon were caught with nets and some lice certainly fell off when fishermen took the salmon out of the net, although salmon lice are usually strongly attached onto the body of salmon. The weekly mean numbers of lice in wild and escaped salmon were almost the same throughout the summer. The mean numbers of salmon parasites increased in wild and escaped salmon with increasing length of fish in Troms and Finnmark, especially in 2012 (Figure 72). In Nordland the highest mean numbers of parasites were in salmon with the length of 65-70 cm.

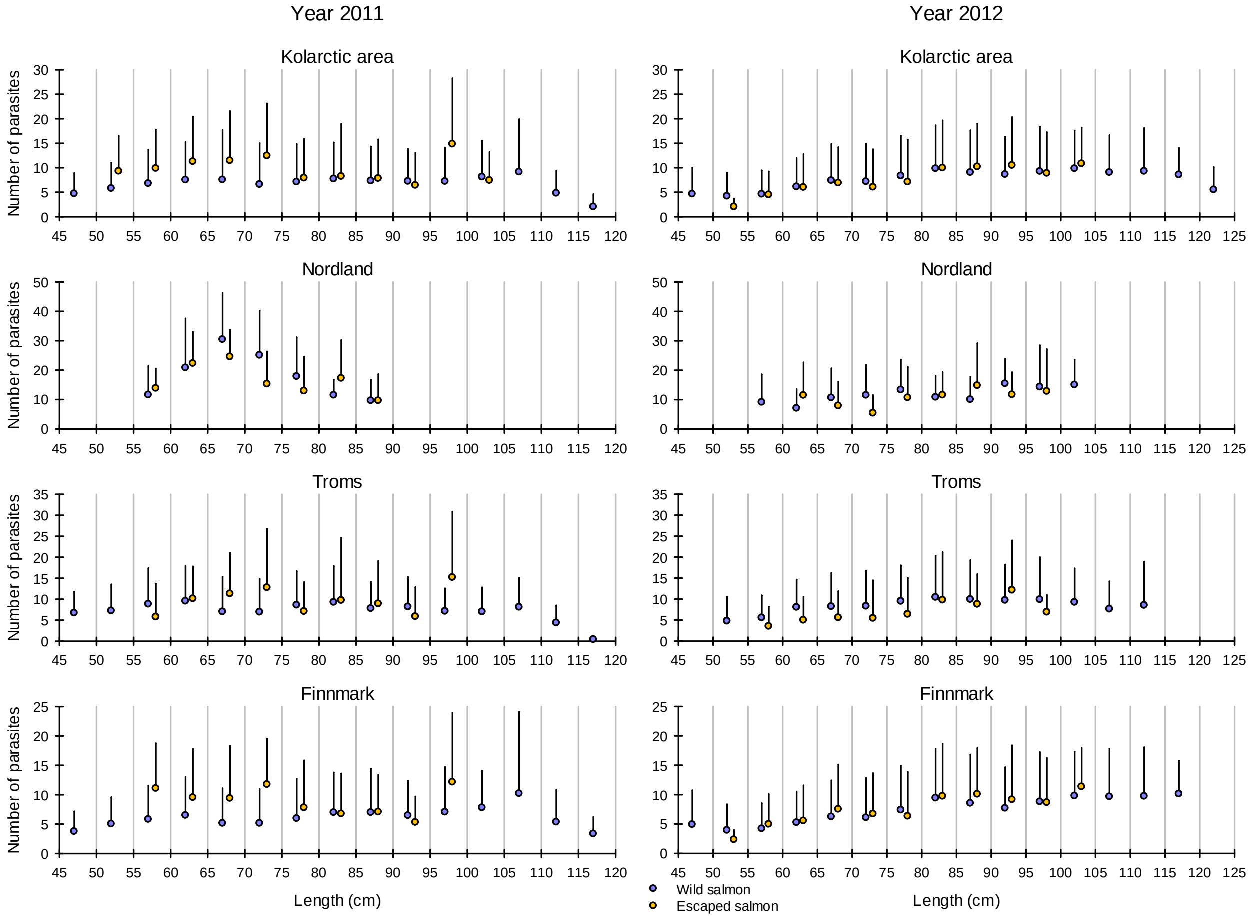


Figure 72. Mean numbers of salmon lice in different length groups of salmon.

Photo 33. Palmer Johnsen is counting lice.

15. Smolt ages of salmon caught at sea in northern Norway

Juvenile salmon live their first 2-8 years in freshwater in the Kolarctic area, and then leave the rivers as smolts. Before juveniles reach smolt stage they have to undergo physiological and morphological changes to adapt to life in saltwater conditions. Salmon must also change their behaviour from territorial fish in rivers to fish which live at least partly in shoals. There is large variation in smolt age 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 genetic composition of salmon which influence the growth rate and hence 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 73). Smolt age distributions indicated that salmon of two smolt years had higher proportions in Nordland and Troms than in Finnmark. This might indicate that those fish originated from more southern areas outside the Kolarctic area or very few of them might 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 does not necessarily indicate the smolt ages in the rivers within those areas because the salmon might have originated outside these areas.

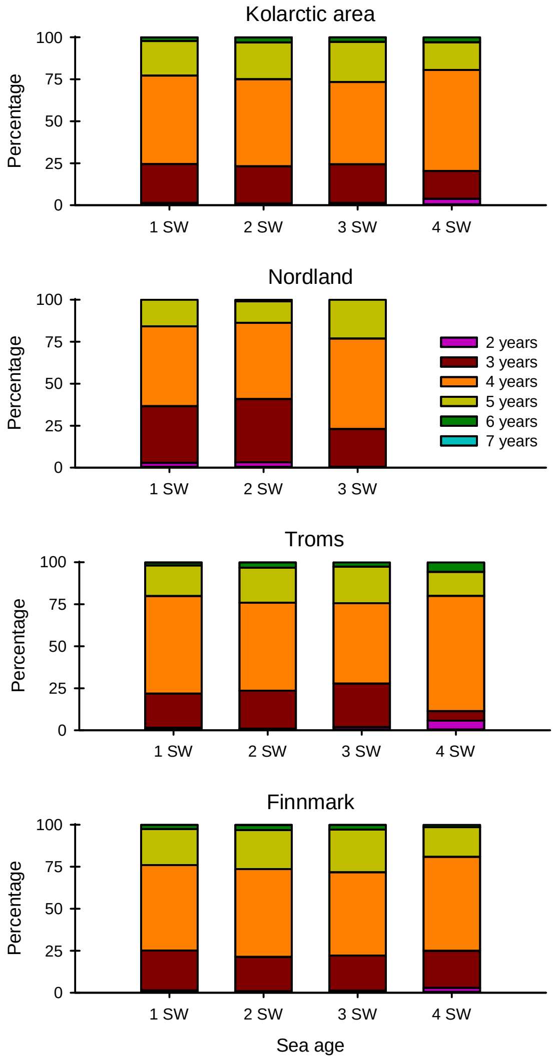


Figure 73. Smolt age distributions in the Kolarctic area in 2011 and 2012.

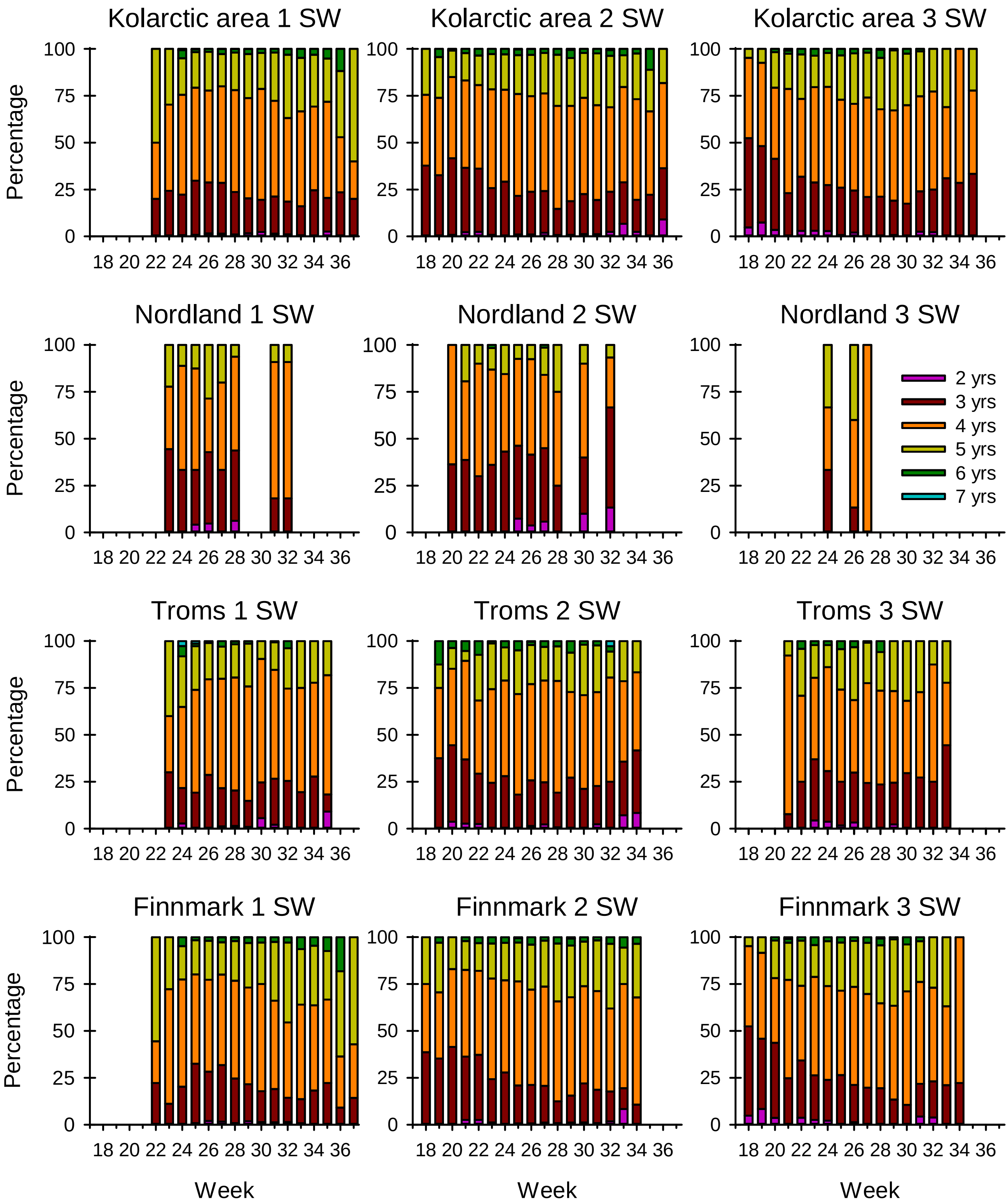


Figure 74. Weekly changes in the smolt-age distributions in the Kolarctic area in 2011 and 2012.

Salmon with the lowest smolt ages of 2-3 years among 1-3SW fish occur in the catches in larger proportions early in the summer than they do later in autumn. This was true especially in Troms and Finnmark where there was enough data covering the whole salmon migration period (Figure 74). Correspondingly, the proportion of fish of smolt age higher than 4 years increased towards autumn. These regular changes in the smolt age distributions towards autumn might be caused by different salmon stocks with different smolt ages migrating earlier or later in the season.

Photo 34. 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.

Photo 35. Russian researcher from PINRO sampling salmon juveniles for genetic analyses. (photo: PINRO)

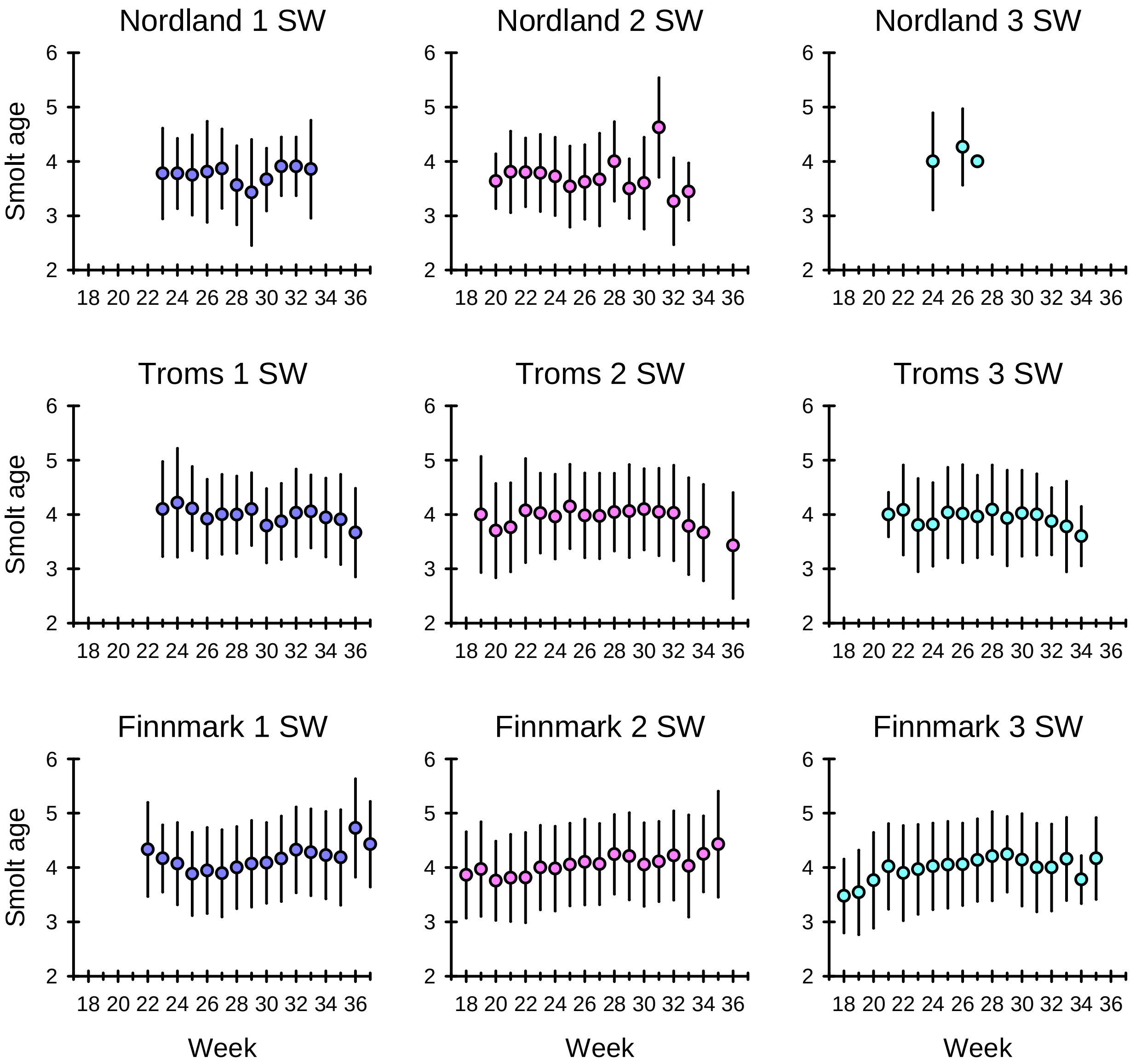


Figure 75. Weekly mean smolt ages in the Kolarctic area in 2011 and 2012.

Although the smolt age distributions changed markedly throughout the summer in Finnmark and Troms, there was not any clear change in mean smolt age. In Finnmark the mean smolt age, however, tended to increase slightly towards autumn (Figure 75). Mean smolt age was about 4 years in Finnmark and Troms and a little lower in Nordland. Changes in the mean smolt age during the summer might reflect stock specific growth differences and hence different mean smolt ages during the various migration periods of these stocks.

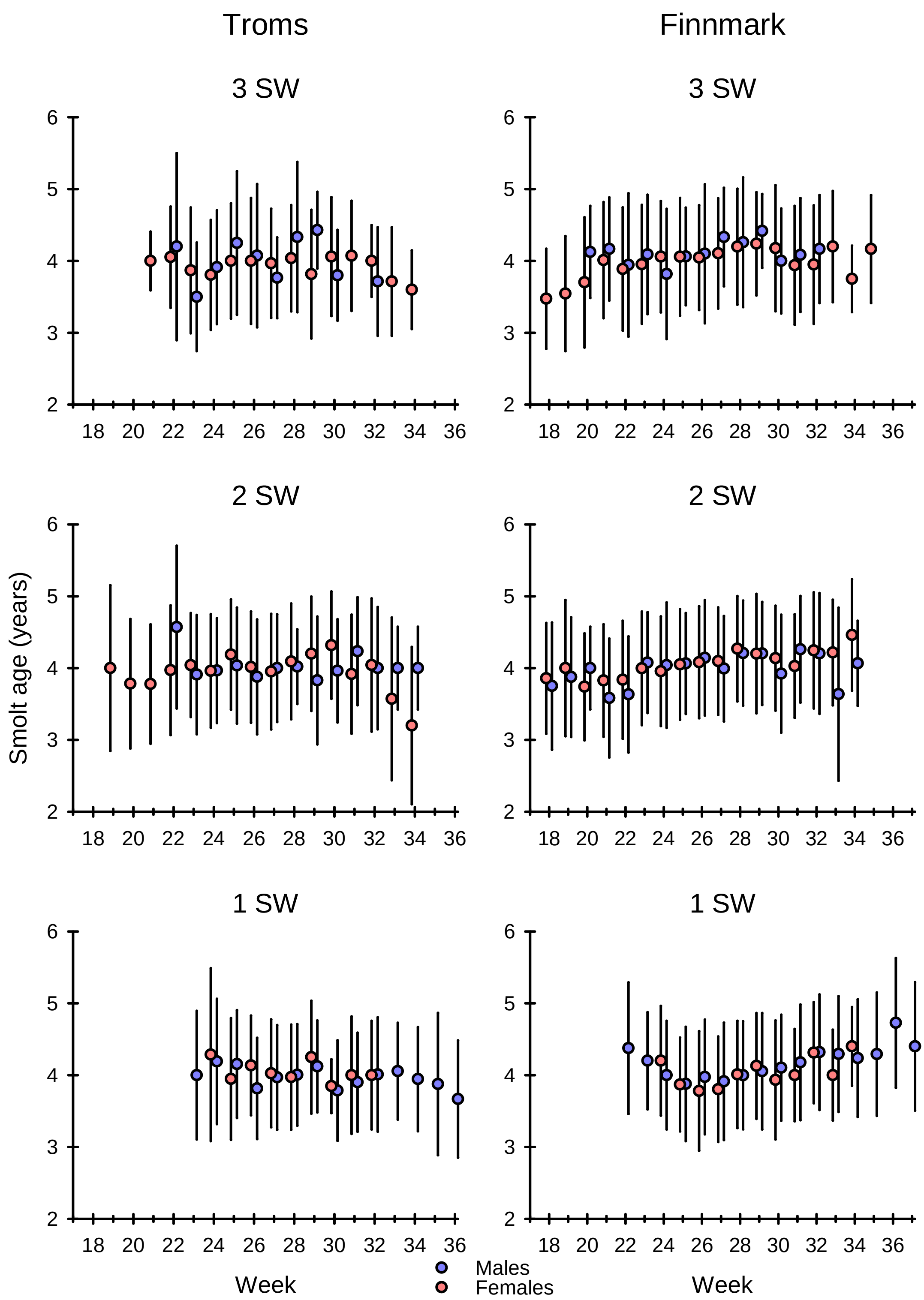


Figure 76. Weekly mean smolt ages for female and male 1SW-3SW salmon in Troms and Finnmark counties in 2011 and 2012.

Weekly mean smolt ages for females and males in 1-3SW salmon in Finnmark and Troms were very similar during the entire migration period in summer (Figure 76). A slight increase in the mean smolt ages for females and males can be observed, especially in Finnmark, towards autumn. One possible explanation for this may be that salmon stocks with higher smolt age might migrate later.

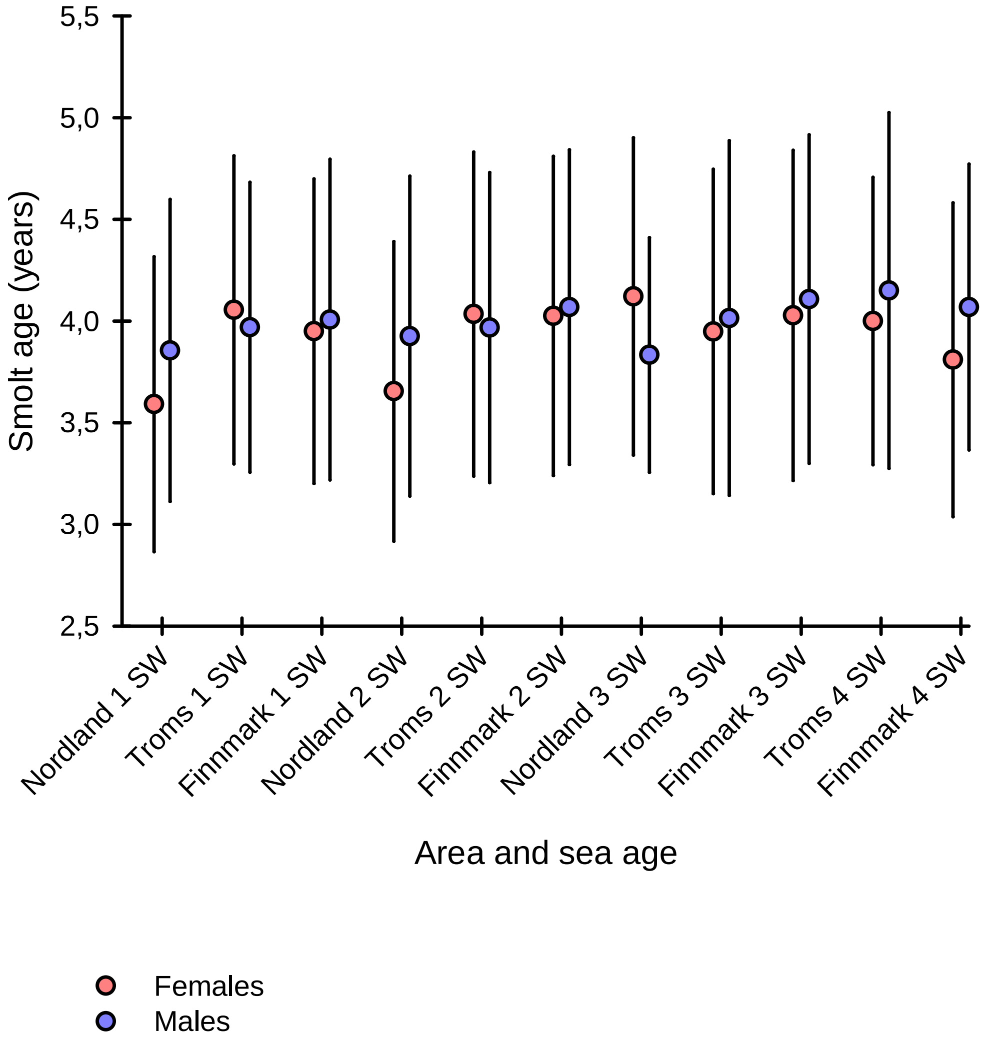


Figure 77. Mean smolt ages for 1-4SW salmon between sexes and areas in 2011 and 2012.

Figure 77 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 the Kolarctic area are not as high as expected in such northern areas and in sometimes extremely cold and oligotrophic river conditions. The mean smolt age of about four years, however, highlights the fairly slow renewal of salmon stocks. This means, for example, that improvement in stocks after major regulatory measures are introduced takes a long period of time. The mean smolt ages in 1-4SW salmon caught in 2011 and 2012 and presented here are combinations of approximately 150 salmon stocks inhabiting the area from Lofoten in Norway to Pechora in Russia. There are differences in the smolt ages between rivers and between sea ages when analysing river specific data.

Results - Russia

16. Age structure of the catches

Analysis of Atlantic salmon samples from traditional Pomor salmon fisheries in Murmansk region showed that the great bulk of catches consisted of 1SW salmon. Results from the smaller catches in the fishery in June showed a greater proportion of 2SW salmon, up to 7,4%, whereas the bigger catches from the period September-October had very small proportion of 2SW salmon and repeat-spawner fish, around 0,5% for each group. No 3SW salmon or older fish were registered (Figure 78).

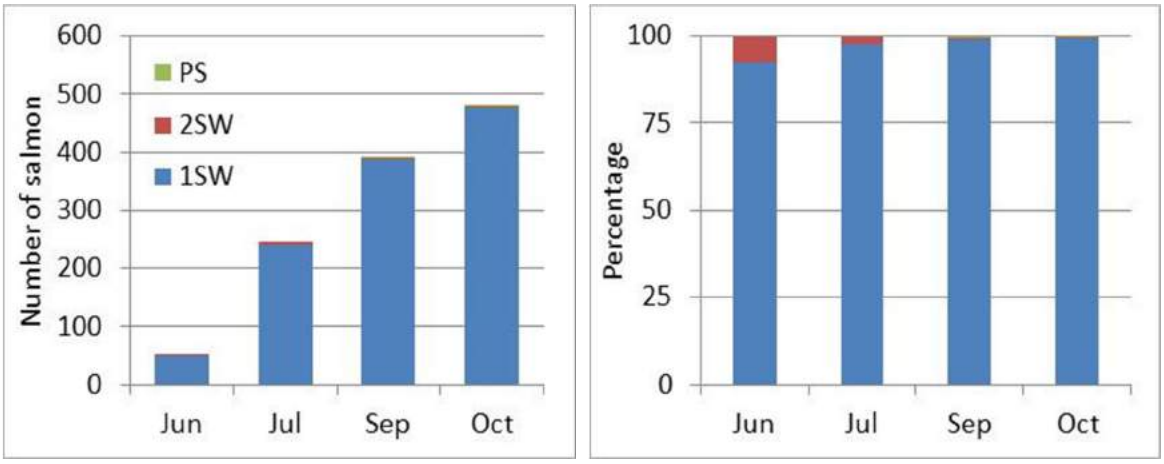


Figure 78. Number of samples and sea age distribution for Atlantic salmon sampled in Terskiy Bereg coastal area, Russia 2011-2012 (PS – previous spawner)

In the mouth of the Varzuga river, salmon from other rivers were expected to occur. Salmon were caught in October-December by gill nets. In overall, the age structure of estuarine salmon was rather similar to salmon caught in coastal fisheries. However the proportion of 2SW salmon in catches taken in October was slightly higher in the estuary (4, 8%) than in the sea (0, 5%). All fish taken in December were 1SW. No 3SW salmon or older fish were registered (Figure 79).

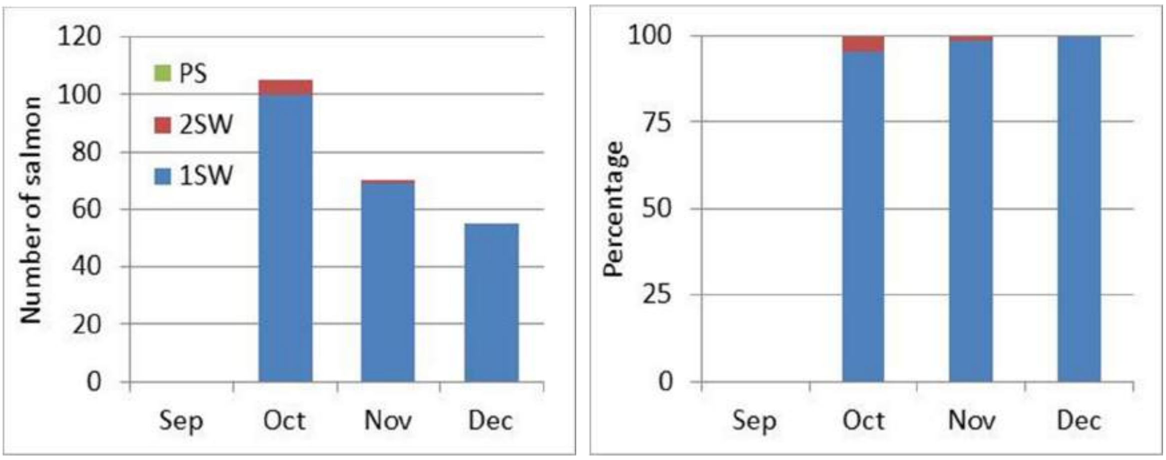


Figure 79. Number of samples and sea age distribution for Atlantic salmon sampled in Varzuga estuary, Russia 2011-2012.

The large scale illegal fishery for Atlantic salmon occurred in the coastal waters around the Umba river outlet. There was considerably higher proportion of 2SW salmon were found in illegal catches by nets than in the legal coastal fishery by fishing traps. 2SW salmon constituted 20% of the catch in July and September, and over 30% in August (Figure 80).

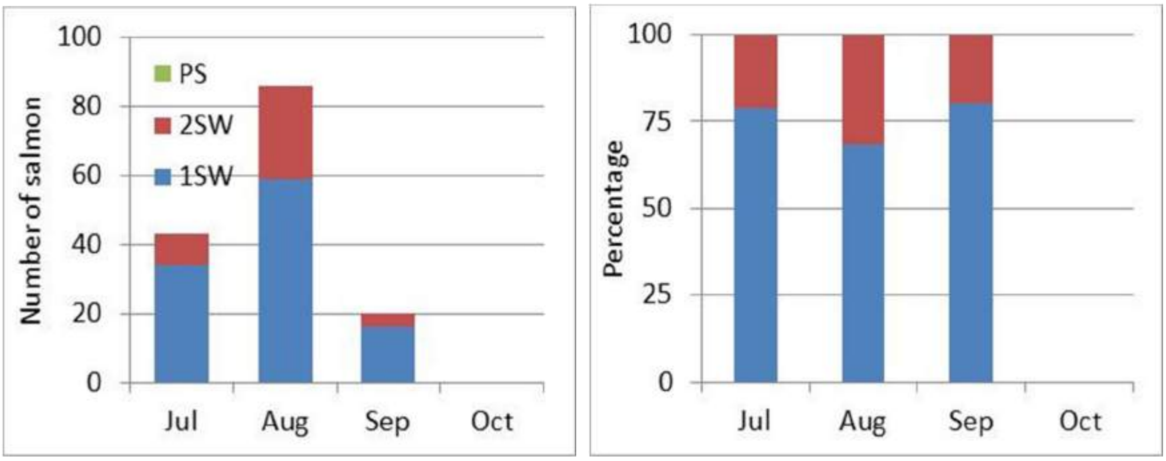


Figure 80. Number of samples and sea age distribution for Atlantic salmon sampled in West of Umba coastal, Russia 2011-2012.

The probable explanation for this is the age structure of the Umba salmon population, as the Umba has more MSW fish than other salmon rivers of the White sea area of Murmansk region. Another explanation could be the selectivity of fishing gears. 130 fish from illegal catches confiscated in August 2012 in the Ponoi river estuary were analyzed. There were 78% of grilse, 18% of 2SW salmon and 5% of repeat-spawner salmon in the catches. The age structure of the catch was very similar to the age structure of Ponoi salmon, where a higher proportion of repeat-spawner fish occurred due to highly developed recreational catch-and-release fishery in the river. No 3SW salmon or older fish were registered (Figure 81).

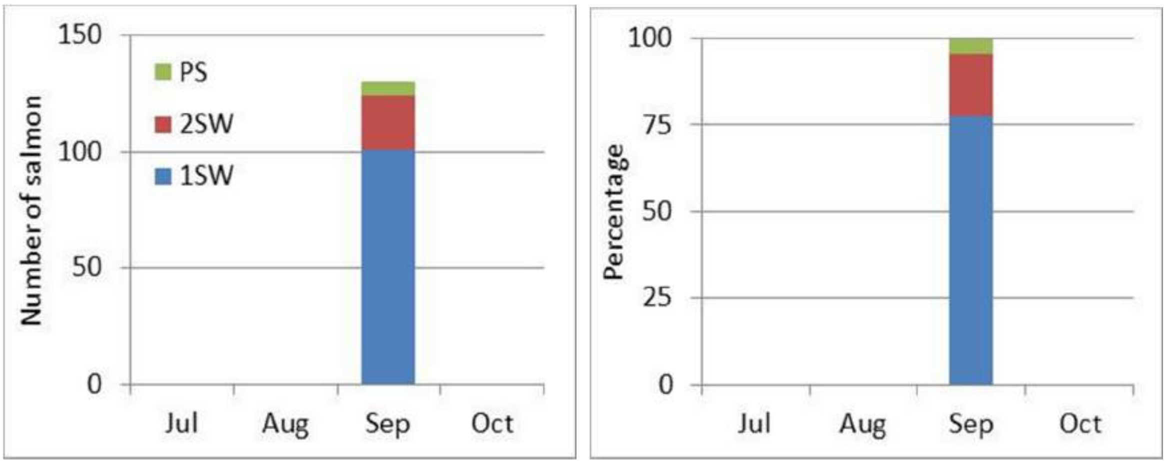


Figure 81. Number of samples and sea age distribution for Atlantic salmon sampled in Ponoi estuary/ coastal, Russia 2011-2012.

Catches of salmon from the estuary of Severnaya Dvina river and from Pechora had a high proportion of MSW salmon. The majority of fish (over 70%) in September and October were 2SW salmon. Catches taken in August had a higher proportion of grilse (1SW) and 3SW salmon, 40 and 10% correspondingly (Figure 82). In Pechora only 14% of salmon were grilse. About 3% of Pechora salmon were 4SW fish, the age group that had not been seen in other areas. There were no repeat-spawner salmon in catches both in Severnaya Dvina river and from Pechora.

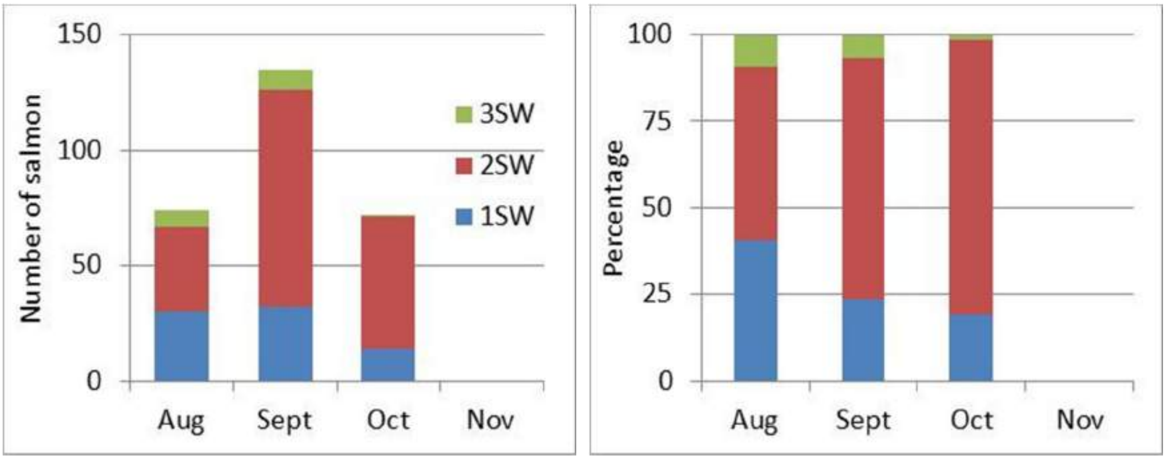


Figure 82. Number of samples and sea age distribution for Atlantic salmon sampled in Severnaya Dvina estuary, Russia 2011-2012.

Traditional Pomor coastal fisheries in Zimniy Bereg, Archangelsk region were sampled in August and September when fisheries were in operation. The age structure of salmon was identical to the age structure of salmon sampled in the Severnaya Dvina estuary (Figure 83).

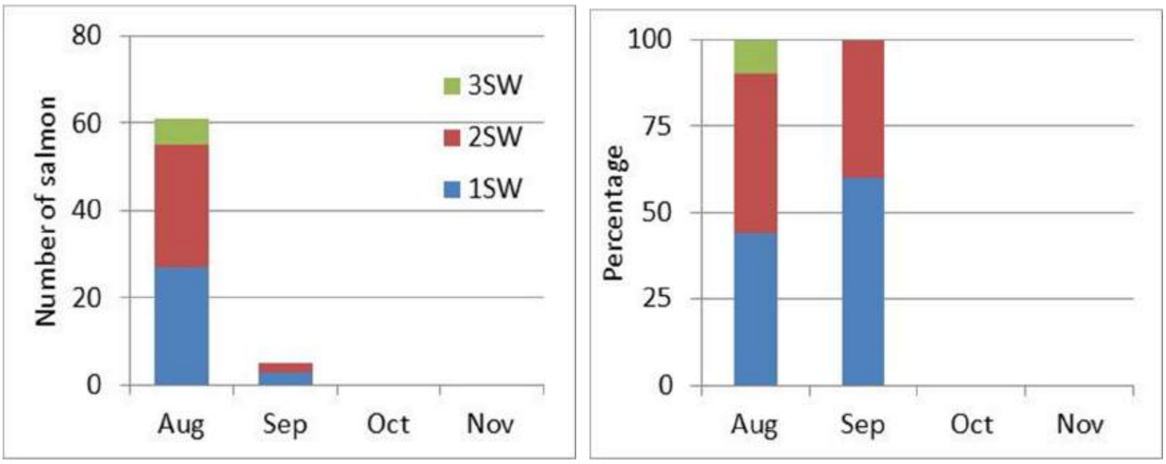


Figure 83. Number of samples and sea age distribution for Atlantic salmon sampled in Zimniy Bereg coastal, Russia 2011-2012

In comparison with the Murmansk region, where repeat-spawner salmon were represented in the catches, there were no repeat-spawner salmon in catches taken in the Archangelsk region and in the Pechora at all (Figure 84). This indicates the high exploitation rate of salmon populations contributing to the fisheries in Archangelsk region and Nenets autonomous okrug.

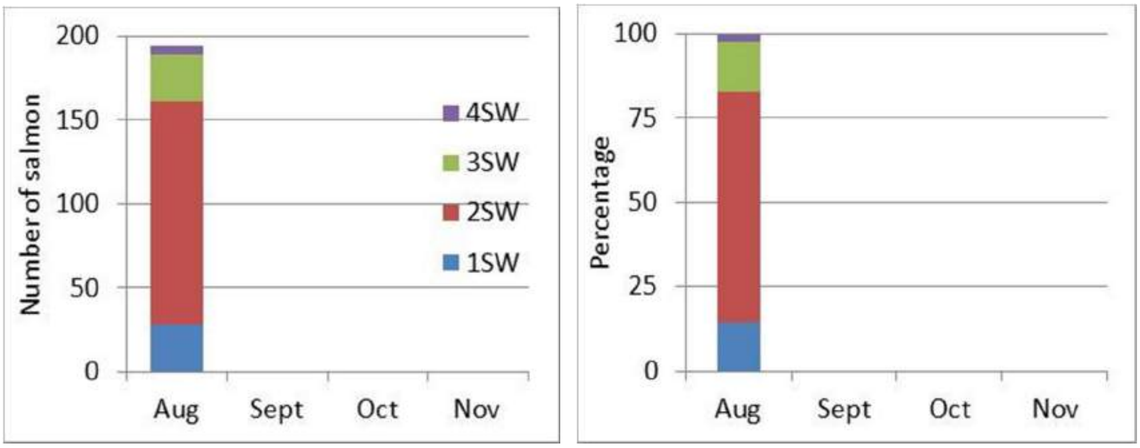


Figure 84. Number of samples and sea age distribution for Atlantic salmon sampled in Pechora, Russia 2011-2012.

No farm escapees were found in catches taken in the White Sea neither in Murmansk nor in Archangelsk regions. The only farm escapee was found in the research catch of 53 salmon taken in the estuary of Big Eina of Rybachiy Peninsula in 2011. This escaped salmon could be from a Norwegian farm or from a Russian farm located in the Pechenga bay.

Photo 36. A costal trap net, Terskiy Bereg. Photo PINRO

17. Smolt age distributions

Juvenile salmon live for 2-7 years in fresh water before they go out in the sea as smolts. Salmon from White Sea rivers spend less time in freshwater in comparison with those from Barents Sea rivers. Most of the fish from the White Sea rivers of Murmansk region become smolts at age of 2 and 3 years whereas salmon from White Sea rivers of Archahgelsk region migrate to the ocean after 3 and 4 years spent in freshwater. Most of the salmon from rivers draining into the Barents Sea smoltificate at age 3, 4 and 5 years.

Salmon sampled at the Terskiy Bereg, in the Varzuga estuary and west of Umba spent 2, 3 and 4 years in rivers, with higher proportion of 3 years old fish. The proportion of fish that had spent two years in fresh water was relatively high and varied around 25% (Figures 85-87).

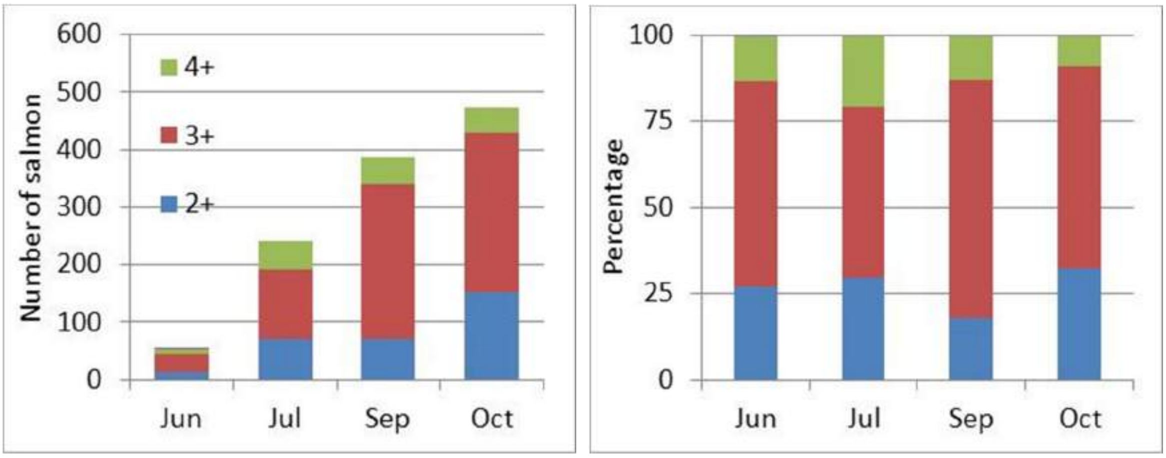


Figure 85. Smolt age distributions for Atlantic salmon sampled in Terskiy Bereg coastal, Russia in 2011-2012.

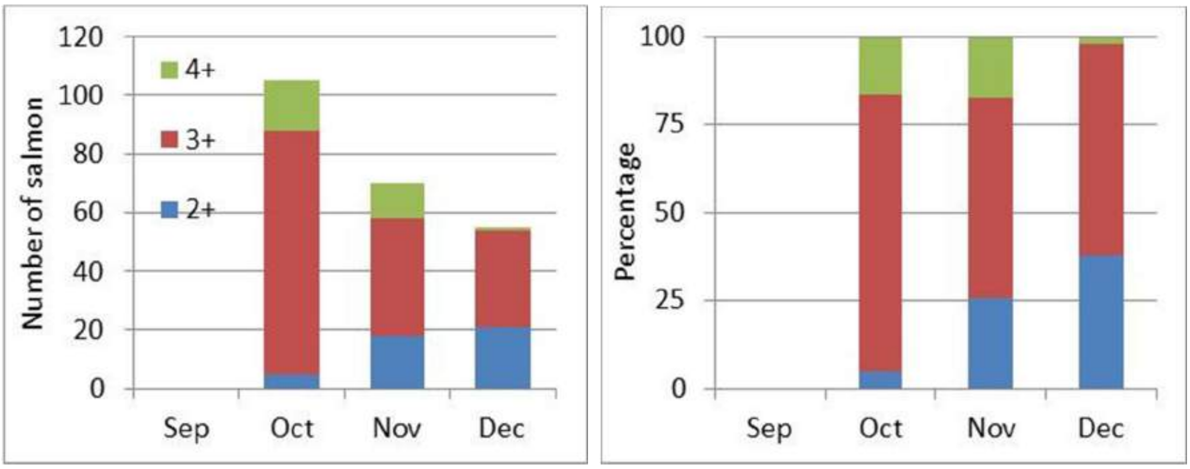


Figure 86. Smolt age distributions for Atlantic salmon sampled in Varzuga estuary, Russia in 2011-2012.

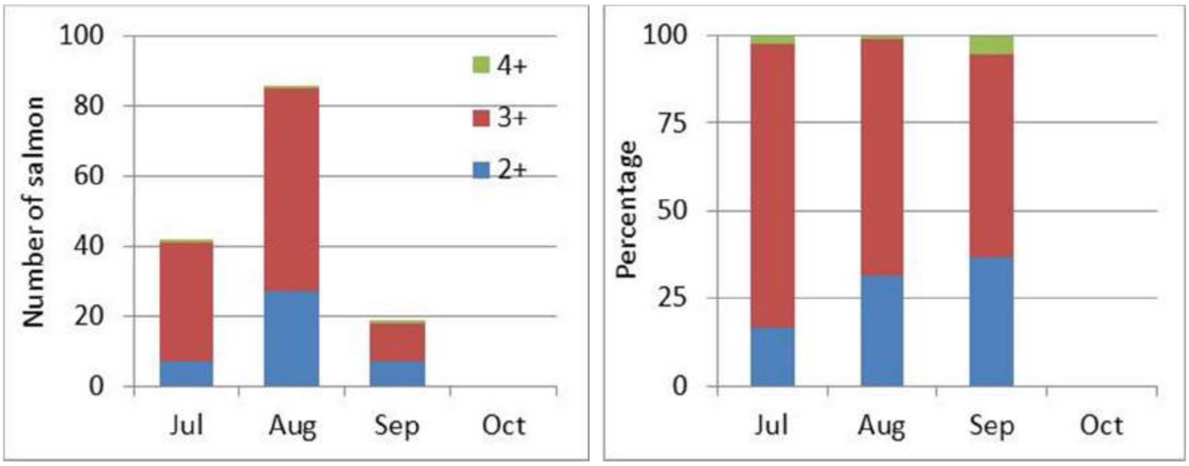


Figure 87. Smolt age distributions for Atlantic salmon sampled in West of Umba coastal, Russia in 2011-2012.

Salmon from the Ponoi area had bigger variation in smolt age. There were fish with 2, 3, 4 and 5 years spent in rivers. 2+ and 5+ fish constituted a minor proportion in catches, whereas 3+ and 4+ salmon constituted over 90% (Figure 88).

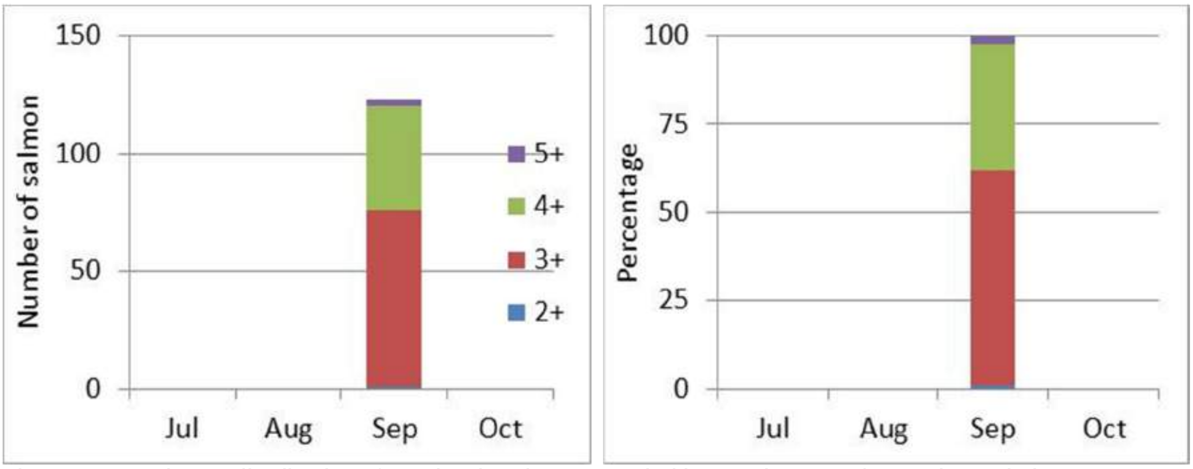


Figure 88. Smolt age distributions for Atlantic salmon sampled in Ponoi estuary/coastal, Russia in 2011-2012

Fish from Pechora had the same proportion of 3+ and 4+ smolt age as those for Ponoi but there were no 2+ fish at all (Figure 89).

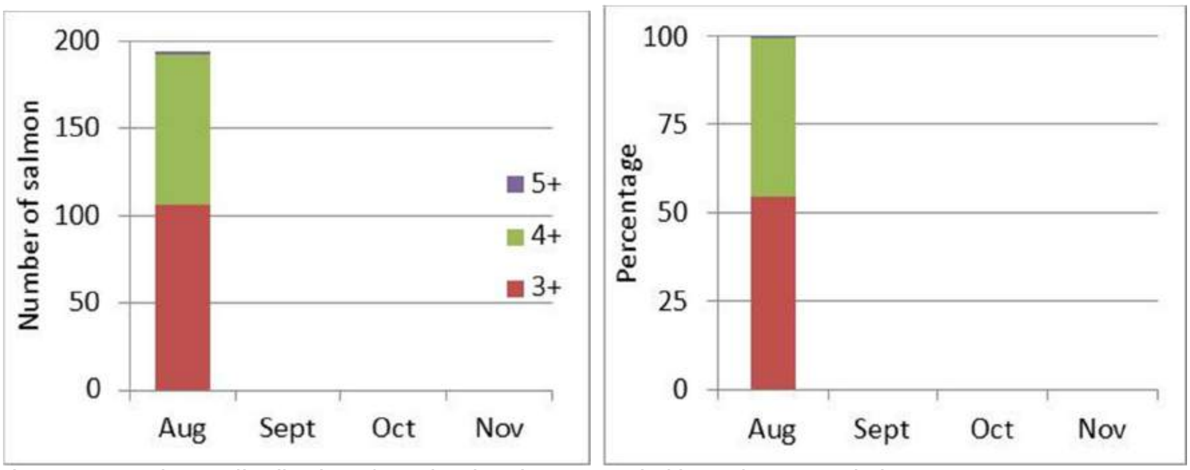


Figure 89. Smolt age distributions for Atlantic salmon sampled in Pechora, Russia in 2011-2012.

Among salmon sampled in the Archangelsk region fish with smolt age 3+ dominated and constituted over 90% both at Zimniy Bereg and in Severnaya Dvina (Figure 90-91).

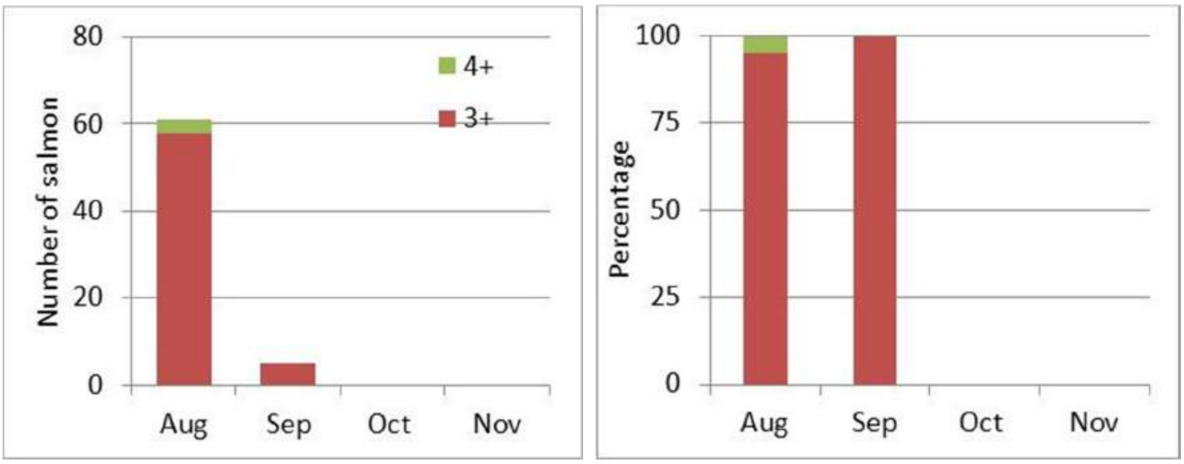


Figure 90. Smolt age distributions for Atlantic salmon sampled in Zimniy Bereg coastal Russia in 2011-2012.

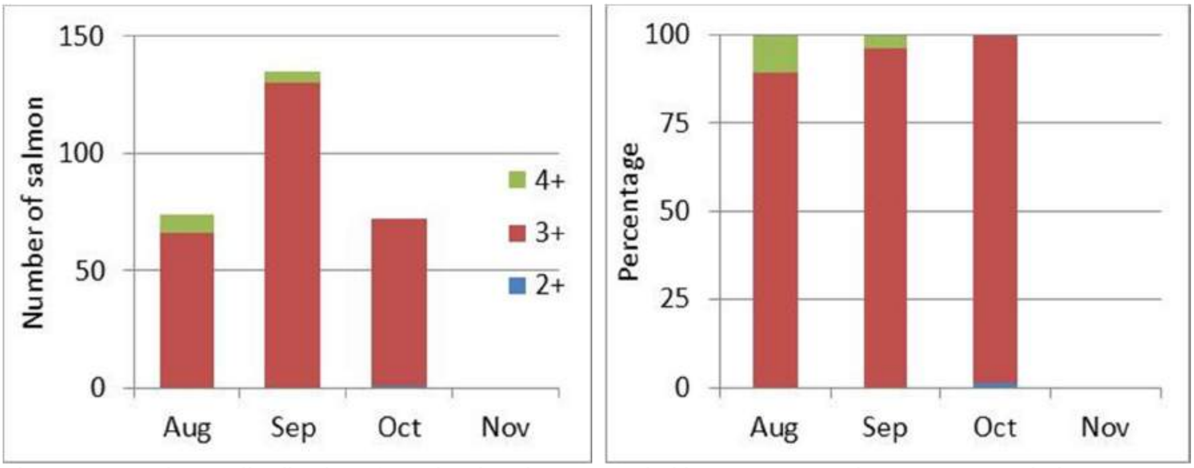


Figure 91. Smolt age distributions for Atlantic salmon sampled in Severnaya Dvina estuary Russia in 2011-2012.

Photo 37. Autumn run fish from research fishery, Varzuga river estuary. Photo: PINRO

18. Length and weight of salmon

A trap net is the only gear allowed in the coastal salmon fisheries in the Murmansk region. The mesh size of the gear is small enough to keep the salmon alive in the trap. All salmon entering the trap are caught, so the selectivity of the gear is minimal. Most of the salmon sampled here were in 1SW fish. The size distribution of salmon taken by traps in Terskiy bereg were a good representation of the size distribution of autumn run salmon from White Sea rivers of the Murmansk region, such as Varzuga and Ponoi. The size distributions of salmon from Varzuga estuary and from Ponoi estuary taken by gill nets were rather similar to those from the coastal areas in Terskiy bereg (Figure 92-95).

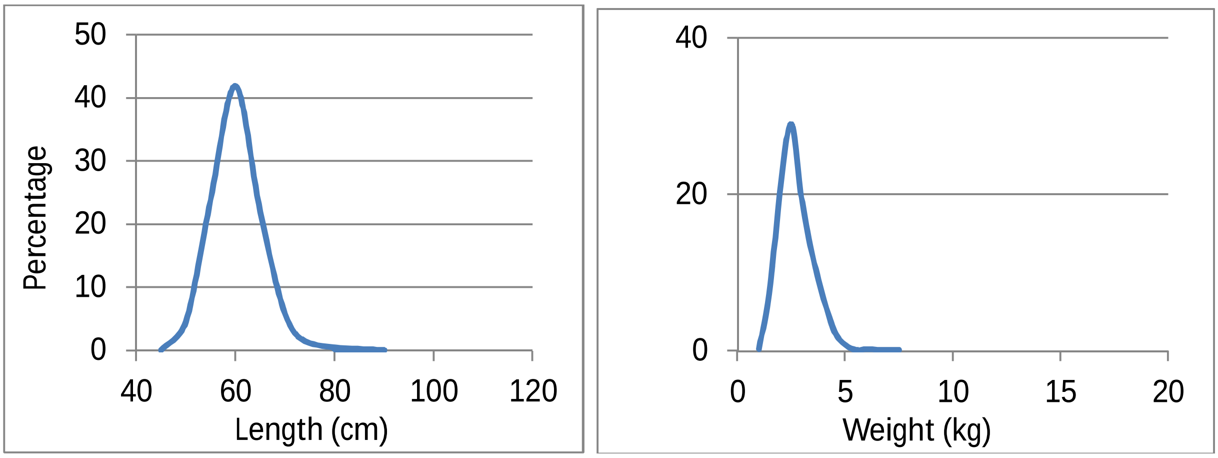


Figure 92. Length and weight distributions for Atlantic salmon sampled in Terskiy Bereg coastal, Russia in 2011-2012.

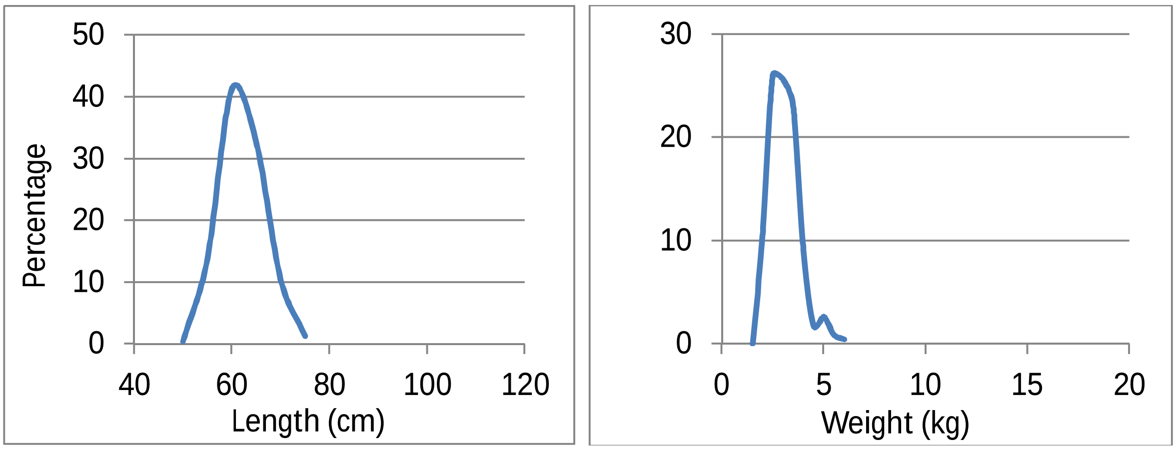


Figure 93. Length and weight distributions for Atlantic salmon sampled in Varzuga estuary, Russia in 2011-2012.

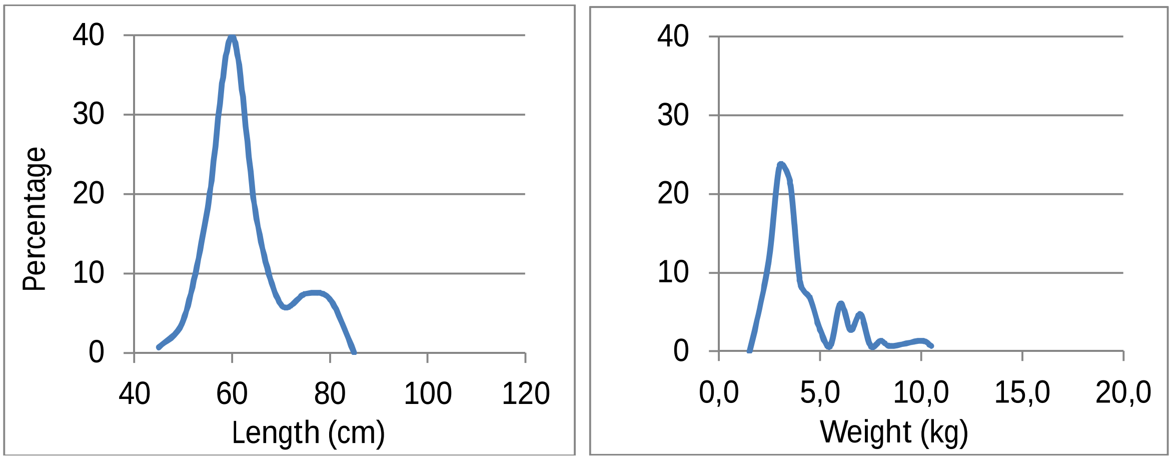


Figure 94. Length and weight distributions for Atlantic salmon sampled in West of Umba coastal, Russia in 2011-2012.

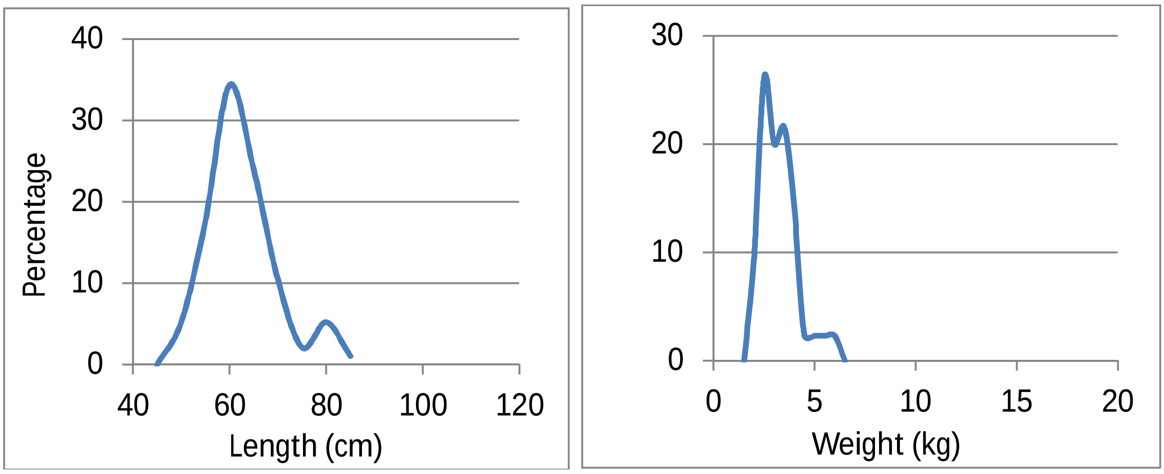


Figure 95. Length and weight distributions for Atlantic salmon sampled in Ponoi estuary/ coastal, Russia in 2011-2012.

Photo 38. White Sea autumn run grilse (1SW), photo PINRO

On the other side of the White Sea, in the Archangelsk region, gill nets are allowed in coastal fisheries and widely used, as well as trap nets. This fishing method could affect the size distributions in catches of salmon from the coastal fishery at Zimniy Bereg, which differs a lot from the size distribution of salmon taken in Terskiy Bereg. The presence of bigger fish in Zimniy Bereg could also be explained by age structure of salmon populations from the White Sea rivers of Archangelsk region such as Severnaya Dvina. The size distribution of salmon from Severnaya Dvina estuary taken by trap net was similar to that from the coastal fishery in Zimniy Bereg but had less 1SW fish (Figures 96-98).

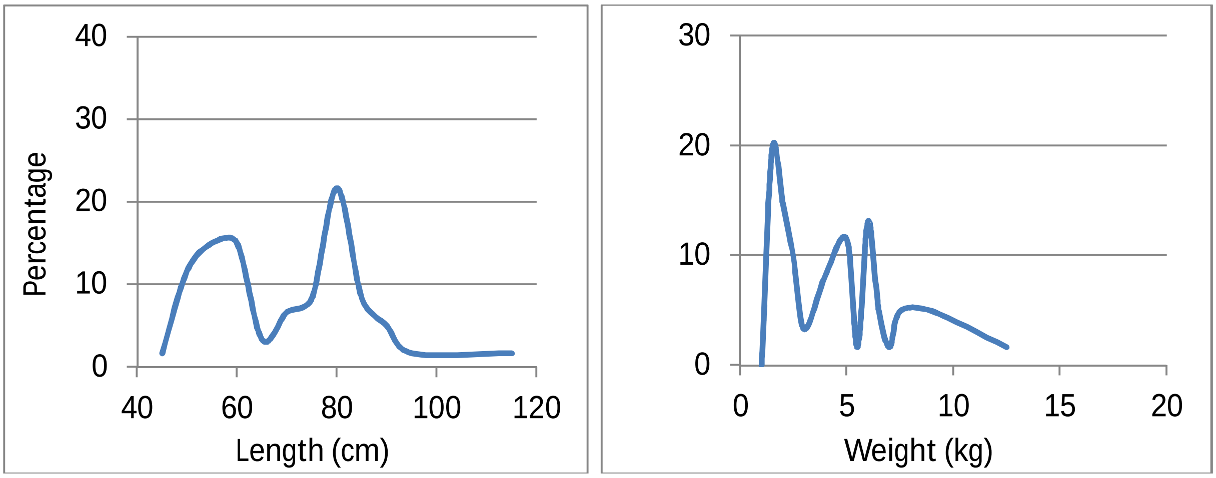


Figure 96. Length and weight distributions for Atlantic salmon sampled in Zimniy Bereg coastal, Russia in 2011-2012.

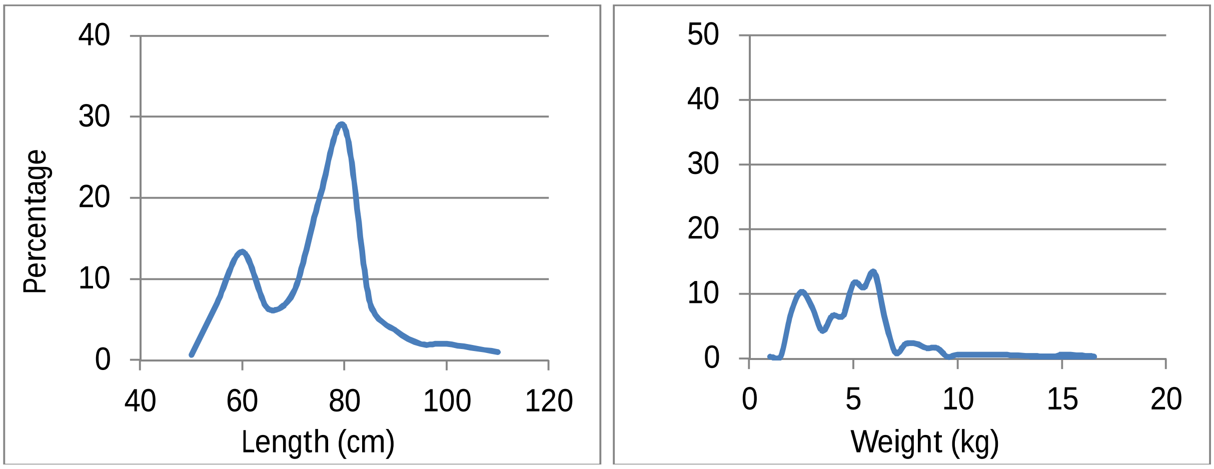


Figure 97. Length and weight distributions for Atlantic salmon sampled in Severnaya Dvina estuary, Russia in 2011-2012.

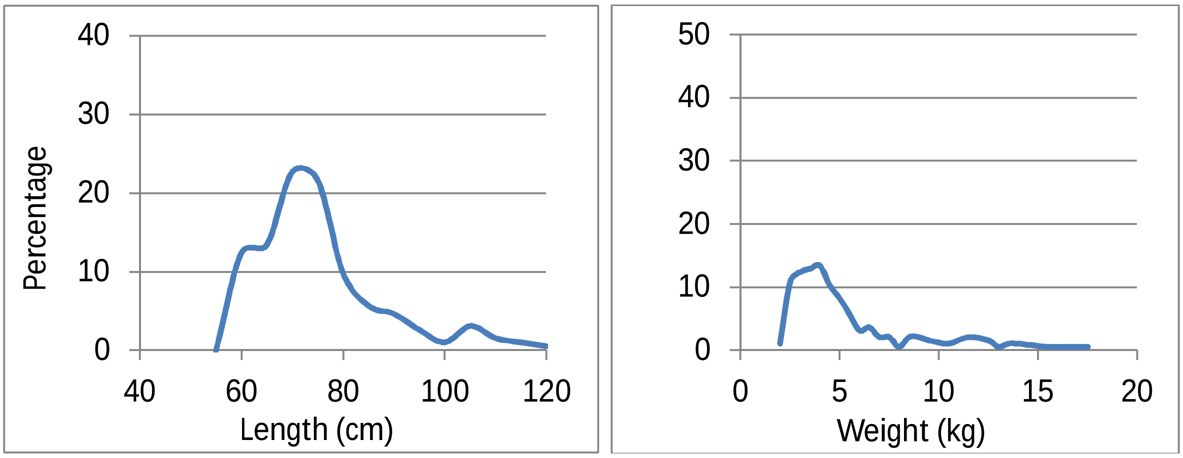


Figure 98. Length and weight distributions for Atlantic salmon sampled in Pechora, Russia in 2011-2012.

Photo 39. Pechora River is the largest river in the Kolarctic salmon project area

Photo 40. Coastal trap net fishing in the White Sea (photo: PINRO)

19. Sex ratio

Males dominated in coastal catches taken in June-July whereas females were more numerous in the catches taken in September-December on both sides of the White Sea. This sex ratio was in compliance with the structure of summer run and autumn run salmon of the White Sea salmon populations. Summer run salmon consisted mostly of 1SW males whereas the majority of autumn runners were females of different age groups. The same sex ratio also occurred in Pechora river where autumn salmon dominated in the spawning stock (Figures 99-104).

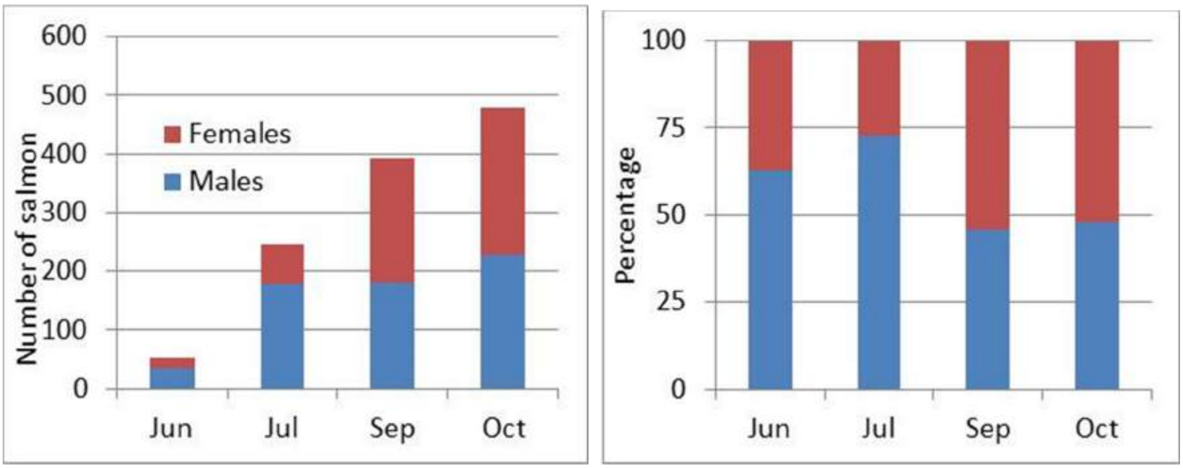


Figure 99. Sex ration for Atlantic salmon sampled in Terskiy Bereg coastal, Russia in 2011-2012

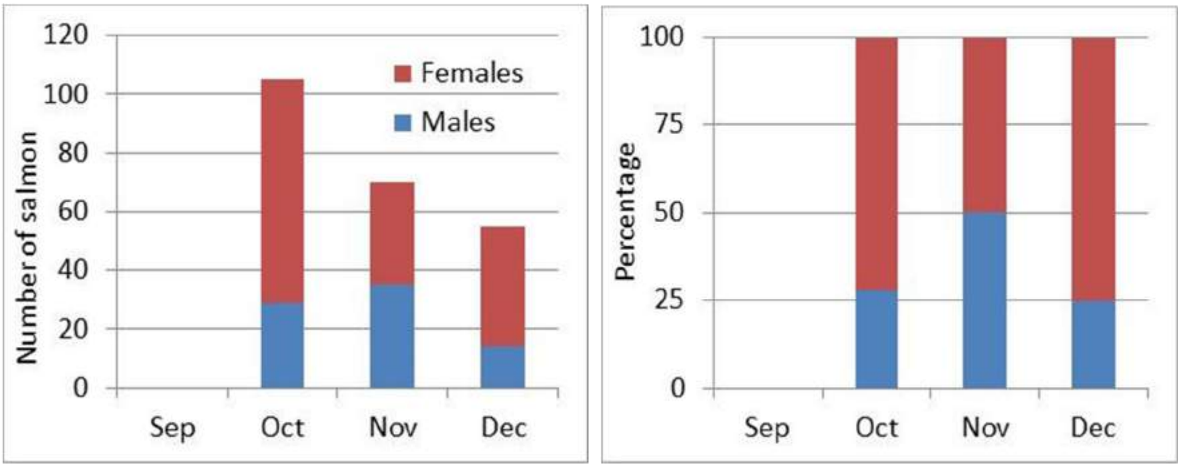


Figure 100. Sex ration for Atlantic salmon sampled in Varzuga estuary Russia in 2011-2012

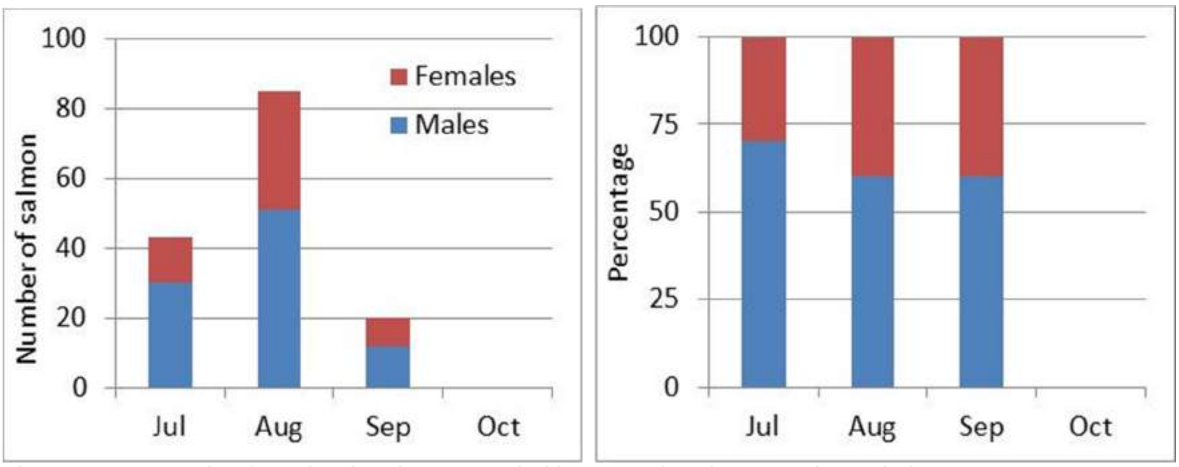


Figure 101. Sex ration for Atlantic salmon sampled in West of Umba coastal, Russia in 2011-2012

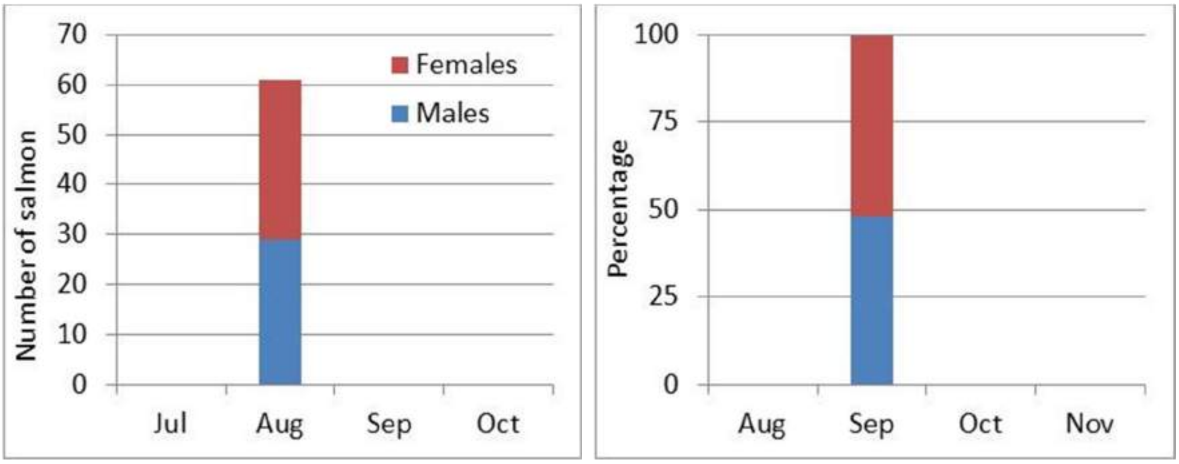


Figure 102. Sex ration for Atlantic salmon sampled in Zimniy Bereg coastal, Russia in 2011-2012

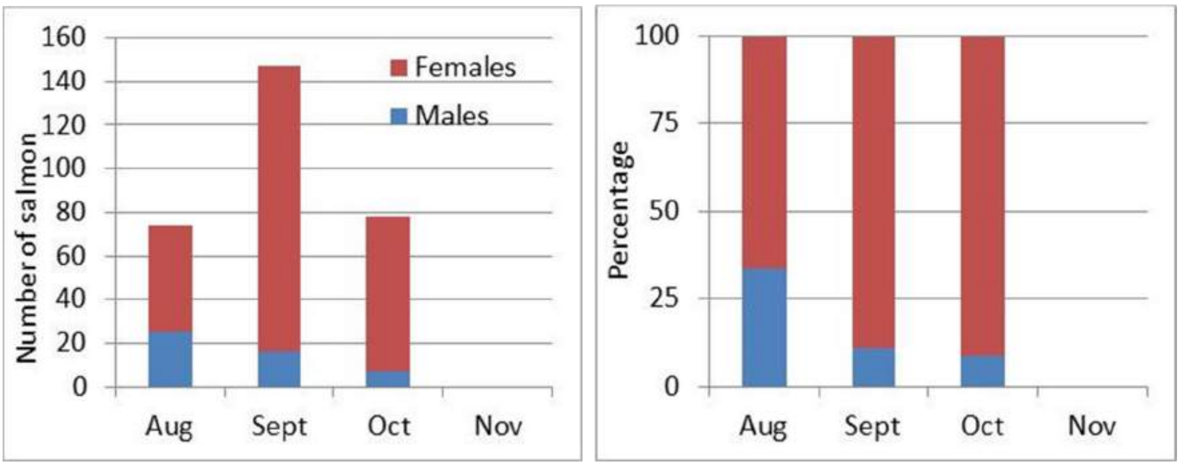


Figure 103. Sex ration for Atlantic salmon sampled in Severnaya Dvina estuary, Russia in 2011-2012

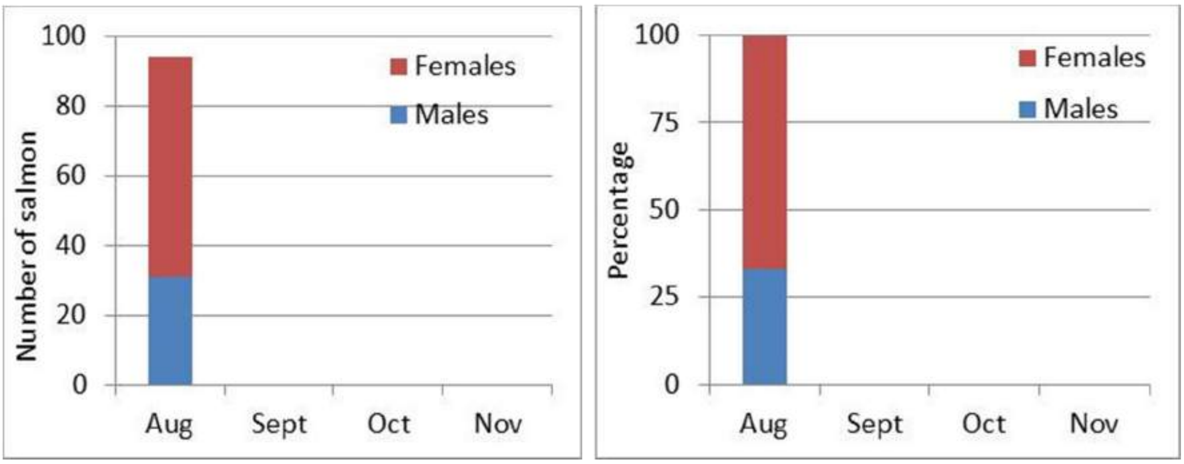


Figure 104. Sex ration for Atlantic salmon sampled in Pechora, Russia in 2011-2012

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Responsibilities in this report: FGFRI conducted the work concerning the salmon scales collected in Nordland, Troms and Finnmark: establishing the basic scale information file, making impressions from the scales, ageing salmon, designing and producing the graphs, drafting the Norwegian part of the text. FMFI organised together with FGFRI the scale collection and sampling arrangements including: information to fishermen, scale sampling manual drafting, design and purchase of scale bags, handling incoming samples and payments to fishermen. PINRO organized the coastal and estuarine salmon sampling in White Sea areas and in the Barents Sea in the Western Kola Peninsula, established the basic scale information file and produced graphs and drafted the text from the Russian material.

NINA applied for the special research permission from the Norwegian Directorate of Nature Management for fishing outside the ordinary fishing season and had contact with fishermen in Nordland and Troms.

The Sea salmon fishers associations in Finnmark and Troms gave valuable input and contacted potential fishermen, who collected the research material.

The Lead Partner and partners of the Kolarctic ENPI EU salmon project KO197 warmly thank all the fishermen for their cooperation during the sampling period. Without the help of professional fishermen we could not have collected the marvellous biological material from the salmon catches in this project area. We are thankful also to the sea salmon fishing organizations in Finnmark and Troms. We also want to say thanks to all the people who helped us process the salmon scale material.

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