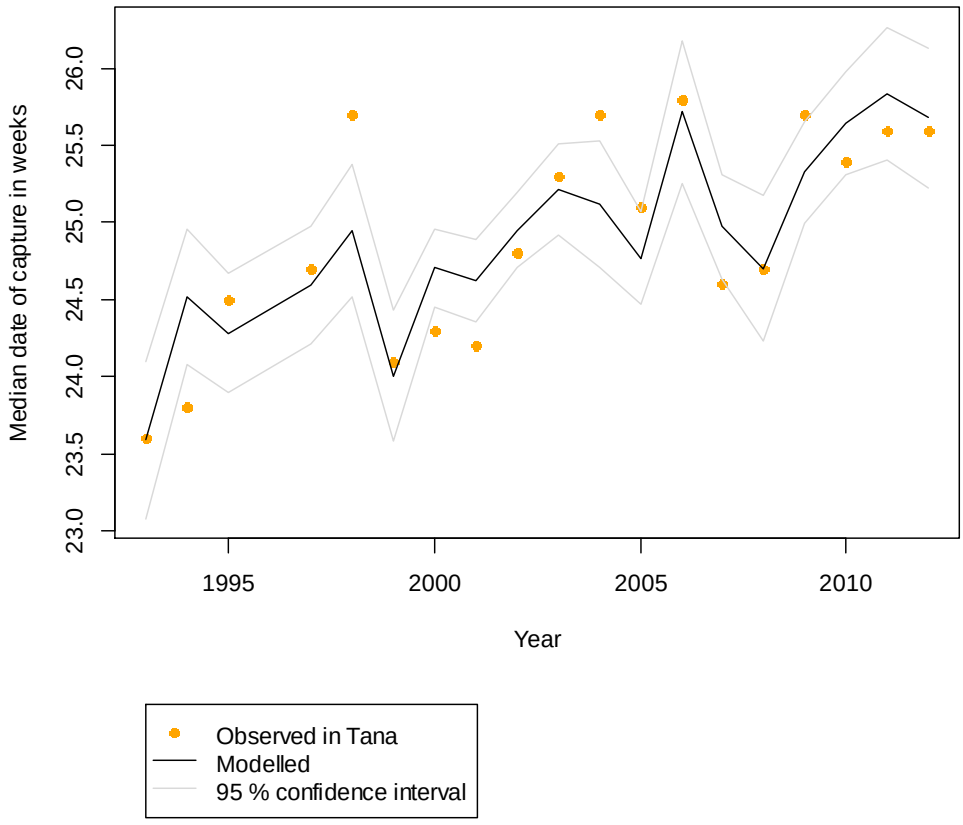
Kolarctic ENPI CBC - Kolarctic salmon project (KO197) - Report XVIII

Median dates of salmon captures affected by sea temperatures in the salmon catches in Finnmark municipalities

Eero Niemelä[1], Päivi Laukkanen-Nevala[1], Esa Hassinen[1] and Tiia Kalske[2] (ed.), Vidar Wennevik[3] and Sergey Prusov[4]

[1]*Finnish Game and Fisheries Research Institute (FGFRI), Teno River Research Station Utsjoki, Finland*
[2]*Office of the County Governor of Finnmark (FMFI), Vadsø, Norway*
[3]*Institute of Marine Research (IMR), Tromsø, Norway*
[4]*Knipovich Polar Research Institute of Marine Fisheries and Oceanography (PINRO), Murmansk, Russia*



Kolarctic ENPI CBC | CROSS-BORDER COOPERATION

KOLARCTIC SALMON 2011 - 2013

Contents

Abstract 3
1. Material and methods 4
1.1 Statistical analysis 4
2. Results 11
2.1 Results from the annual median date of captures and sea temperatures 11
2.1.1 Median dates of salmon capture in the municipalities Gamvik and Sør-Varanger 12
2.1.2 Median dates of salmon capture in the municipalities Loppa-Hasvik, Måsøy-Nordkapp and Lebesby 13
2.1.3 Median dates of salmon capture in Sør-Varanger-Nesseby- Vadsø area 14
2.2 Results of the statistical models 15
Acknowledgements 19

Cover figure: Figure 11. Observed and modeled median date of capture in Tana municipality.

This report has been produced with the assistance of the European Union, but the contents can in no way be taken to reflect the views of the European Union.

Abstract

Based on the results of the hierarchical clustering the median date of salmon capture in the municipalities of Måsøy-Nordkapp, Porsanger, Tana and Sør -Varanger were selected for detailed modeling. The mean sea temperatures were measured in the Fugløya-Bjørnøya section, Laksefjord, Varangerfjord and Kola section as described in Kolarctic salmon project Report XV. In Sør-Varanger, the difference of the sea temperatures (0-50 m) between April and March in the Kola section affected most to the estimated median date of capture, although the mean sea temperatures in January, February and March in the Fugløya-Bjørnøya section and in Laksefjord have a part in the models. In all other municipalities, in Måsøy-Nordkapp, Porsanger and Tana, the set of sea temperature variables was not enough to explain the variation in the median date of capture without including year-effect. Median dates of captures are reflecting those changes which are taken place annually in the sea temperatures. Sea temperatures are governing the time when salmon are starting their migrations from the ocean feeding grounds. Also salmon fisheries management with the time allowed for fishing is effecting into the median date of capture.

1. Material and methods

Basic data from the salmon catches was received from SSB (Statistics Norway), where daily catches are informed for salmon <3kg, 3-7 kg and >7 kg. From this catch material it was calculated the cumulative catches resulting into the data on median date of captures and lower and upper quartiles. Sea temperatures are from IMR institute in Norway and PINRO institute in Russia.

1.1 Statistical analysis

The hierarchical clustering was done for the median date of capture in the municipalities of Finnmark (Kolarctic salmon Report XVII). Based on the results of the hierarchical clustering, four municipalities in Finnmark (Måsøy-Nordkapp, Porsanger, Tana and Sør -Varanger) were selected for detailed modeling when analyzing relations between the sea temperatures and median date of capture. Values for the median date of capture includes all three size groups combined.

Sea temperatures were measured in Fugløya-Bjørnøya section, Laksefjord, Varangerfjord and Kola section. The original and modified explanatory variables are described in detail in Kolarctic salmon project Report XV. The correlation coefficients were calculated between the median date of capture in four municipalities and 92 explanatory variables including the various measurements, differences and means of sea temperatures in different sections. If the correlation coefficient was at least 0.5, the explanatory variable was included in further analysis. The calculated correlation coefficients between all selected explanatory variables and the median date of capture in Måsøy-Nordkapp are shown in figure 4 (first part) and figure 5 (second part). The calculated correlation coefficients between all selected explanatory variables and the median date of capture in Porsanger, Tana and Sør -Varanger are shown in figures 6, 7 and 8, respectively.

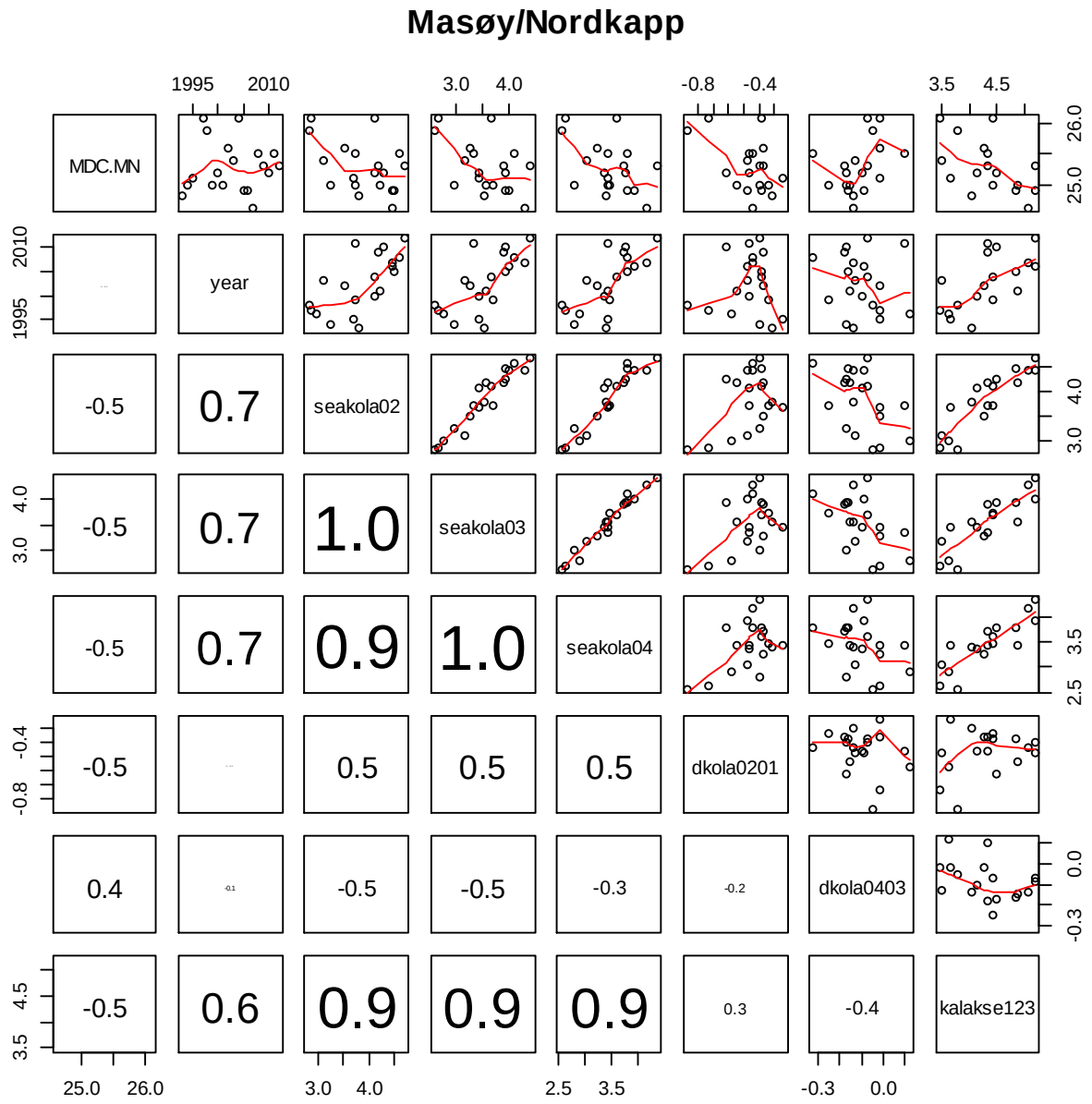


Figure 4. The pairwise correlation coefficients are shown between the first part of selected explanatory variables and the median date of capture in Måsøy-Nordkapp (variable name *MDC.MN*). The selected explanatory variables are calendar *year*; the mean sea temperature in the Kola section (0-50 m) in February (*seakola02*), in March (*seakola03*) and in April (*seakola04*); the difference of the sea temperatures between February and January (*dkola0201*) and between April and March (*dkola0403*) in the Kola section (0-50 m); and the 3-month mean sea temperature in Laksefjord during January, February and March (*kalakse123*).

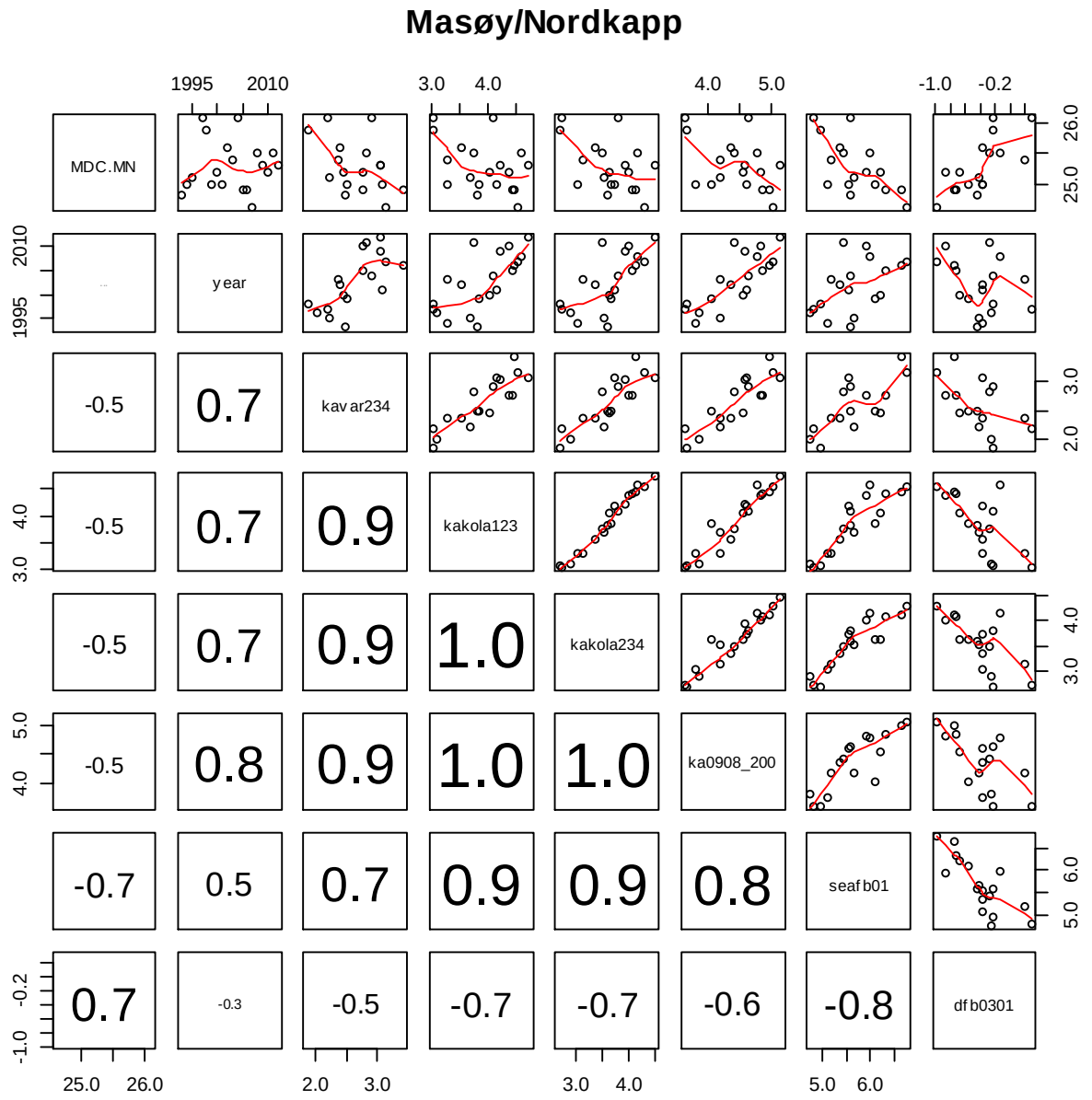


Figure 5. The pairwise correlation coefficients are shown between second part of selected explanatory variables and the median date of capture in Måsøy-Nordkapp (variable name *MDC.MN*). The selected explanatory variables are calendar *year*; the 3-month mean sea temperature in Varangerfjord during February, March and April (*kavar234*), in the Kola section (0-50 m) during January, February and March (*kakola123*), and during February, March and April (*kavar234*) respectively; the annual mean from September to August in the Kola section (0-200 m) (*ka0908_200*); the mean sea temperature in Fugløya-Bjørnøya section in January (*seafb01*); and the difference of the sea temperatures between March and January in Fugløya-Bjørnøya section (*dfb0301*).

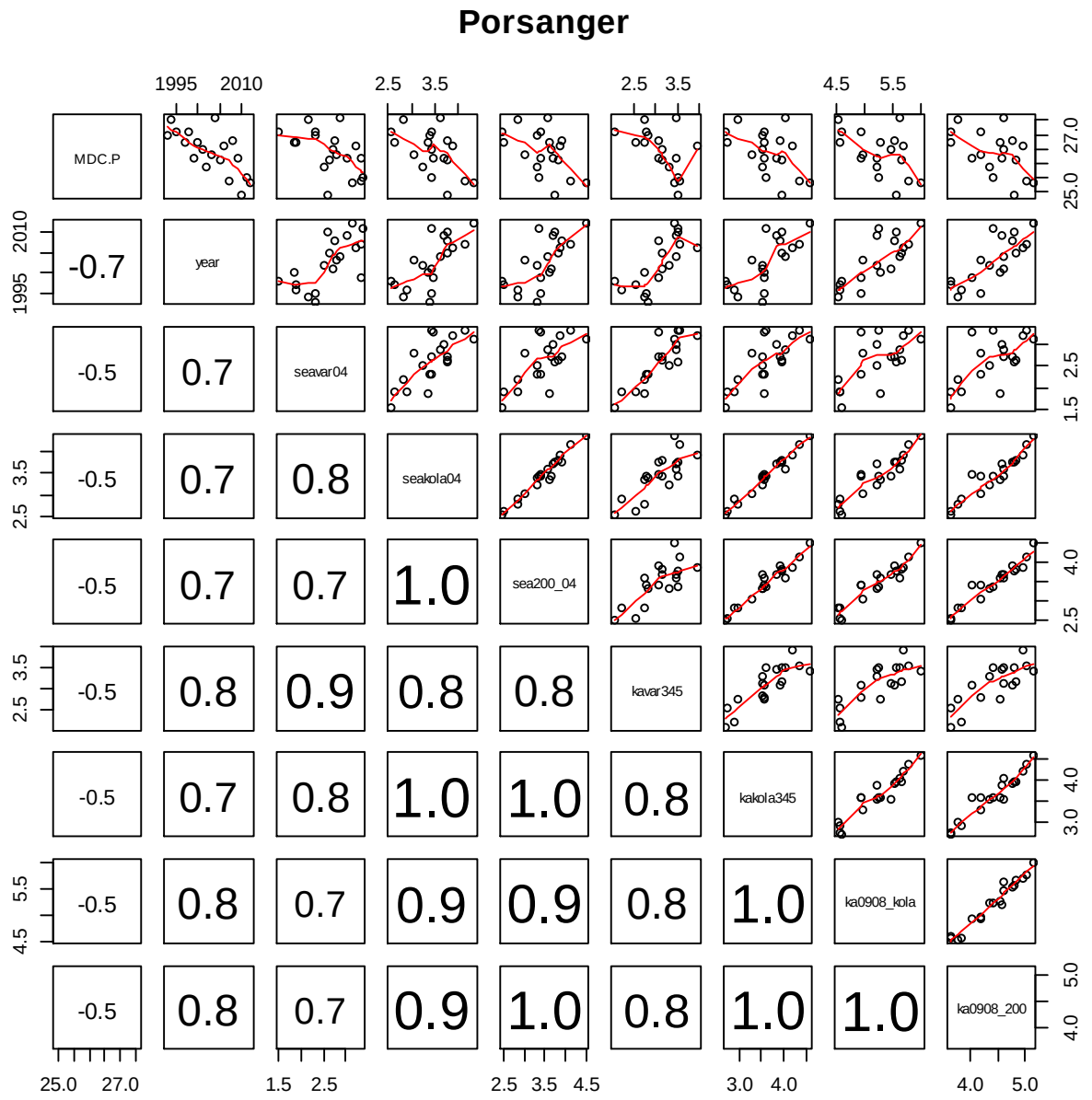


Figure 6. The pairwise correlation coefficients are shown between all selected explanatory variables and the median date of capture in Porsanger (variable name *MDC.P*). The selected explanatory variables are calendar *year*; the mean sea temperature in April in Varangerfjord (*seavar04*), in the Kola section in depths 0-50 m (*seakola04*) and 0-200m (*sea200_04*) respectively; the 3-month mean sea temperature in Varangerfjord (*kavar345*) and in Kola section (0-50 m) (*kakola345*) during March, April and May; the annual mean from September to August in the Kola section in depths 0-50 m (*ka0908_kola*) and 0-200m (*ka0908_200*).

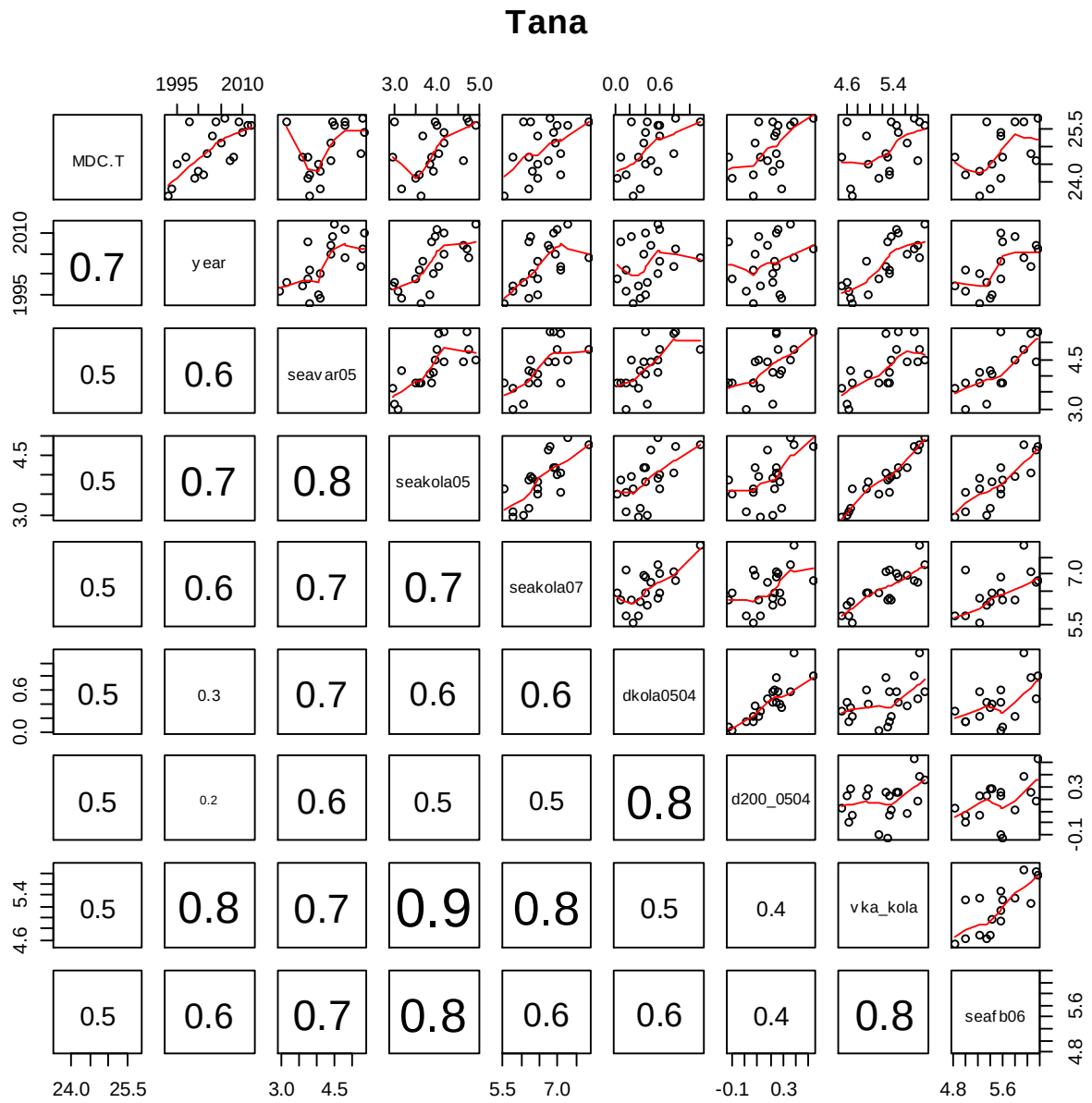


Figure 7. The pairwise correlation coefficients are shown between all selected explanatory variables and the median date of capture in Tana (variable name *MDC.T*). The selected explanatory variables are calendar *year*; the mean sea temperature in Varangerfjord in May (*seavar05*), in Kola section (0-50 m) in May (*seakola05*) and in July (*seakola07*) respectively; the difference of the sea temperatures between May and April in the Kola section in depths 0-50 m (*dkola0504*) and 0-200m (*d200_0504*) respectively; the annual mean in the Kola section (0-50 m) (*vka_kola*); and the mean sea temperature in Fugløya-Bjørnøya section in June (*seafb06*).

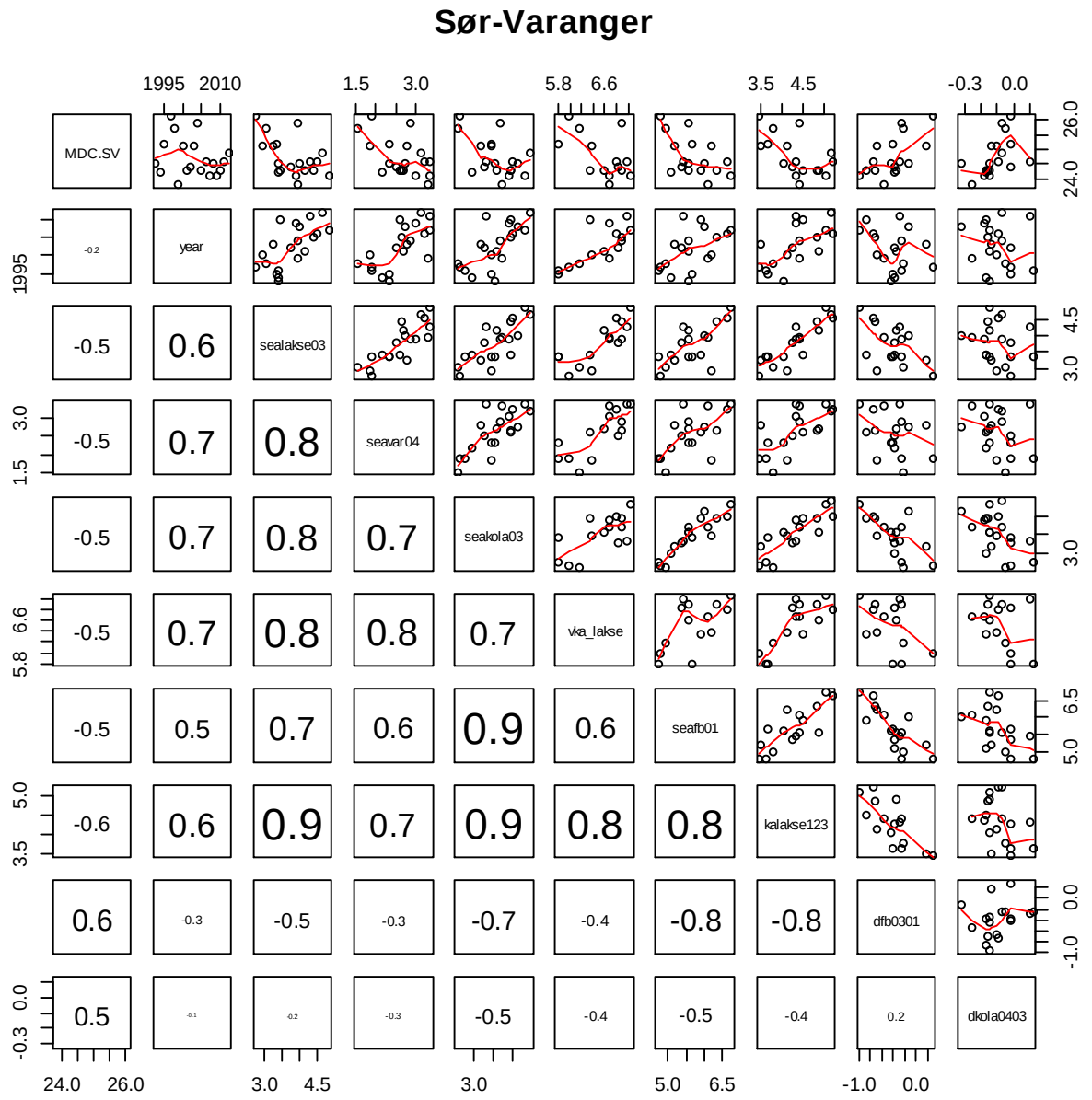


Figure 8. The pairwise correlation coefficients are shown between all selected explanatory variables and the median date of capture in Sør-Varanger (variable name *MDC.SV*). The selected explanatory variables are calendar *year*; the mean sea temperature in Laksefjord in March (*sealakse03*), in Varangerfjord in April (*seavar04*) and in Kola section (0-50 m) in March (*seakola03*) respectively; the annual mean in Laksefjord (*vka_lakse*); the mean sea temperature in Fugløya-Bjørnøya section in January (*seafb01*); the 3-month mean sea temperature in Laksefjord during January, February and March (*kalakse123*); the difference of the sea temperatures between March and January in Fugløya-Bjørnøya section (*dfb0301*); and the difference of the sea temperatures between April and March (*dkola0403*) in the Kola section (0-50 m).

By linear regression and the variance inflation factor (VIF), the sets of uncorrelated explanatory variables were selected. Mainly three sets of explanatory variables were included in generalized additive modeling (GAM) separately. The thin plate regression spline was used for smoothing. The spline smoothing was done for one explanatory variable in time for each explanatory variable in the set resulting from three to five different GAM-models. The best model candidate was selected by multi model inference using Akaike information criterion (AIC). The selected model candidate was analyzed stepwise and the reduced models were evaluated using AIC again. In the end, from all different sets of explanatory variables the best models were evaluated using multi model inference and AIC. Only one model was selected for each municipality (Table I, II).

Table I. Summary of the explanatory variables included in the final GAM-models. The median date of capture (in weeks) was explained with different uncorrelated sets of variables. For each municipality, the models with minimum AIC are shown.

Municipality	Explanatory variables (smoothed variables in paranthesis)	Deviance explained (%)	AIC
Måsøy-Nordkapp	year + seafb01 + s(dkola0403)	90.1	-2.09
Porsanger	year + s(seavar04)	71.5	32.5
Tana	seakola05 + d200_0504 + s(year)	73.2	25.4
Sør-Varanger	dkola0403 + dfb0301 + kalakse123 + s(seavar04)	99.3	-17.2

Table II. Description of the explanatory variables in Table I.

Variable name	Description of the explanatory variable
year	Calendar year
seafb01	Sea temperature in the Fugløya-Bjørnøya section in 10th of January
seakola05	Mean sea temperature in Kola section (0-50 m) in May
seavar04	Mean sea temperature in Varangerfjord in April
dfb0301	Difference of the sea temperatures between March and January in Fugløya-Bjørnøya section
dkola0403	Difference of the sea temperatures between April and March in Kola section (0-50 m)
d200_0504	Difference of the sea temperatures between May and April in the Kola section (0-200 m)
kalakse123	3-month mean sea temperature in Laksefjord during January, February and March

2. Results

2.1 Results from the annual median date of captures and sea temperatures

The reporting of salmon catches at sea was improved in Norway in the year 1993 when fishermen had to inform the daily catches for salmon smaller than 3 kilos, between 3 and 7 kilos and larger than 7 kilos for bag nets and bend nets separately. These reported salmon catches and especially the median dates of captures show clear annual variations for each size groups of salmon. It is also obvious that the median dates of captures show similar annual changes for all the three size groups of salmon. If the median date of capture is taking place earlier for one size group of salmon than in the previous year the change in the median date of capture is in many cases similar for other size groups of salmon, too. There have been changes in recent years in Finnmark within the time for legal salmon fishery at sea compared to 1990s' and early 2000 century. Also the sea temperatures have changed with clear annual variations and it looks that sea temperatures have increased during the last 20 years at least in Kola section in Barents Sea. Both the fisheries management and sea temperatures have changed in the last years which both are governing the time when salmon catches are accumulating in the fishery. The start of the fishing has been delayed and also the closing date of the fishing has become earlier and both of these regulations must have effects on the accumulation of the catches and thereafter into the median dates of captures.

In the figures 9, 10 and 11 it is visualized the clear annual variations in the median date of captures within six municipalities or groups of municipalities.

2.1.1 Median dates of salmon capture in the municipalities Gamvik and Sør-Varanger

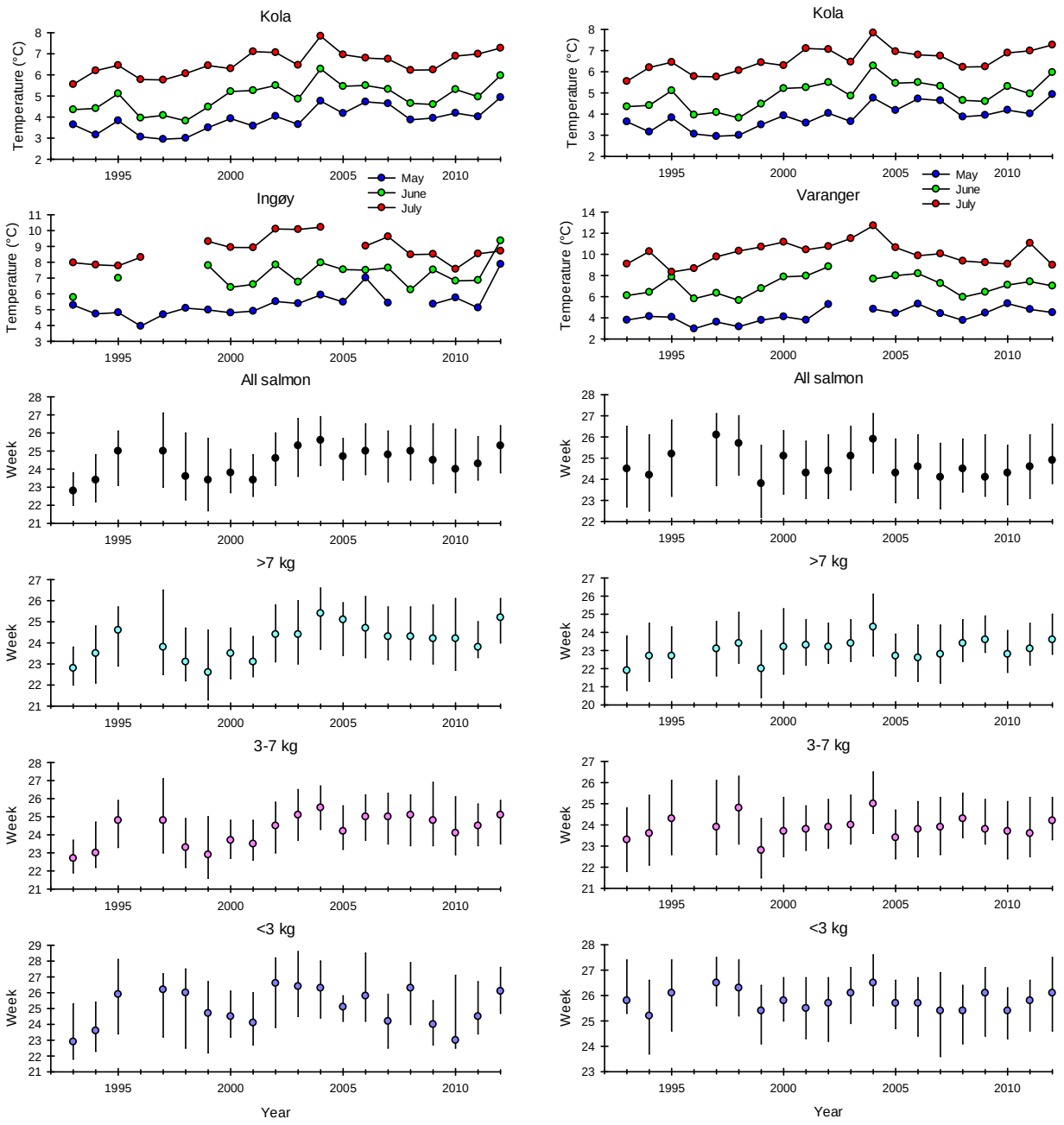


Figure 9. Median dates of the capture for salmon <3kg, 3-7 kg, >7 kg and for all salmon size groups in Gamvik (figure on the left) and in Sør-Varanger (figure on the right) municipalities. Source: SSB. The mean monthly sea temperatures for summer months are from Kola (Russia)(Source: PINRO) and from Ingøy and Varanger (Norway)(Source: IMR).

2.1.2 Median dates of salmon capture in the municipalities Loppa-Hasvik, Måsøy-Nordkapp and Lebesby

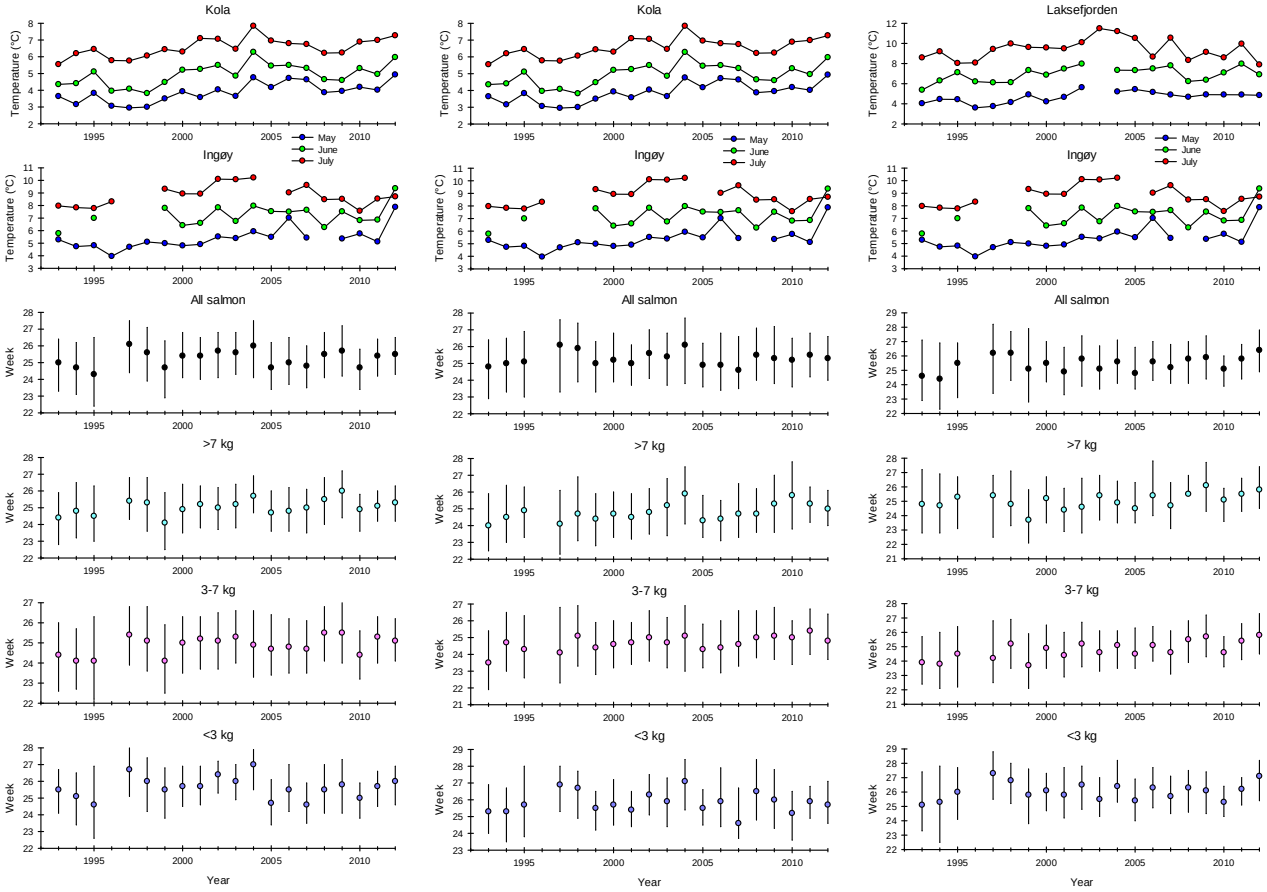


Figure 10. Median dates of the capture for salmon <3kg, 3-7 kg, >7 kg and for all salmon size groups in Loppa-Hasvik (figure on the left), in Måsøy-Nordkapp (figure in the middle) and in Lebesby (figure on the right) municipalities. Source: SSB. The mean monthly sea temperatures for summer months are from Kola (Russia)(Source: PINRO) and from Ingøy and Laksefjorden (Norway)(Source: IMR).

2.1.3 Median dates of salmon capture in Sør-Varanger-Nesseby- Vadsø area

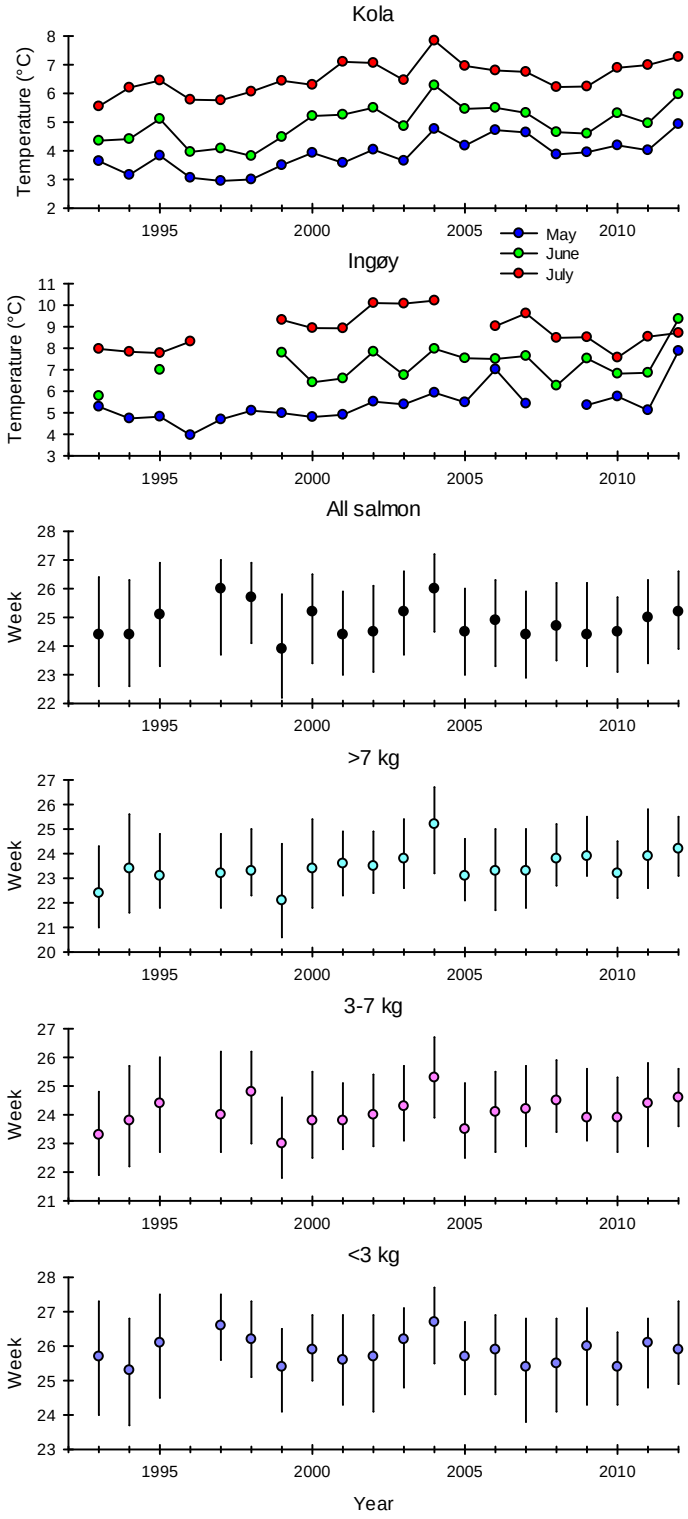


Figure 11. Median dates of the capture for salmon <3kg, 3-7 kg, >7 kg and for all salmon size groups in Sør-Varanger-Nesseby- Vadsø area. Source: SSB. The mean monthly sea temperatures for summer months are from Kola (Russia) (Source: PINRO) and from Ingøy (Norway) (Source: IMR).

2.2 Results of the statistical models

In Sør-Varanger, the deviance was highly explained by the model (Table I). In 2000, the estimated median date of capture was 26.4 weeks. The April sea temperature in Varanger was included after spline smoothing (approximate p-value 0.046). If the difference of the sea temperatures (0-50 m) between April and March in the Kola section increase by one degree, the estimated median date of capture in Sør-Varanger increase 3.3 weeks (p-value 0.030). If the difference of the sea temperatures (50-200 m) between March and January in the Fugløya-Bjørnøya section increased by one degree, the estimated median date of capture decreased 0.59 weeks (p-value 0.27). If the mean sea temperature in Laksefjord during January, February and March increase by one degree, the estimated median date of capture decreased 0.37 weeks (p-value 0.18). The fit and 95 % confidence limits of the model are shown in figure 12.

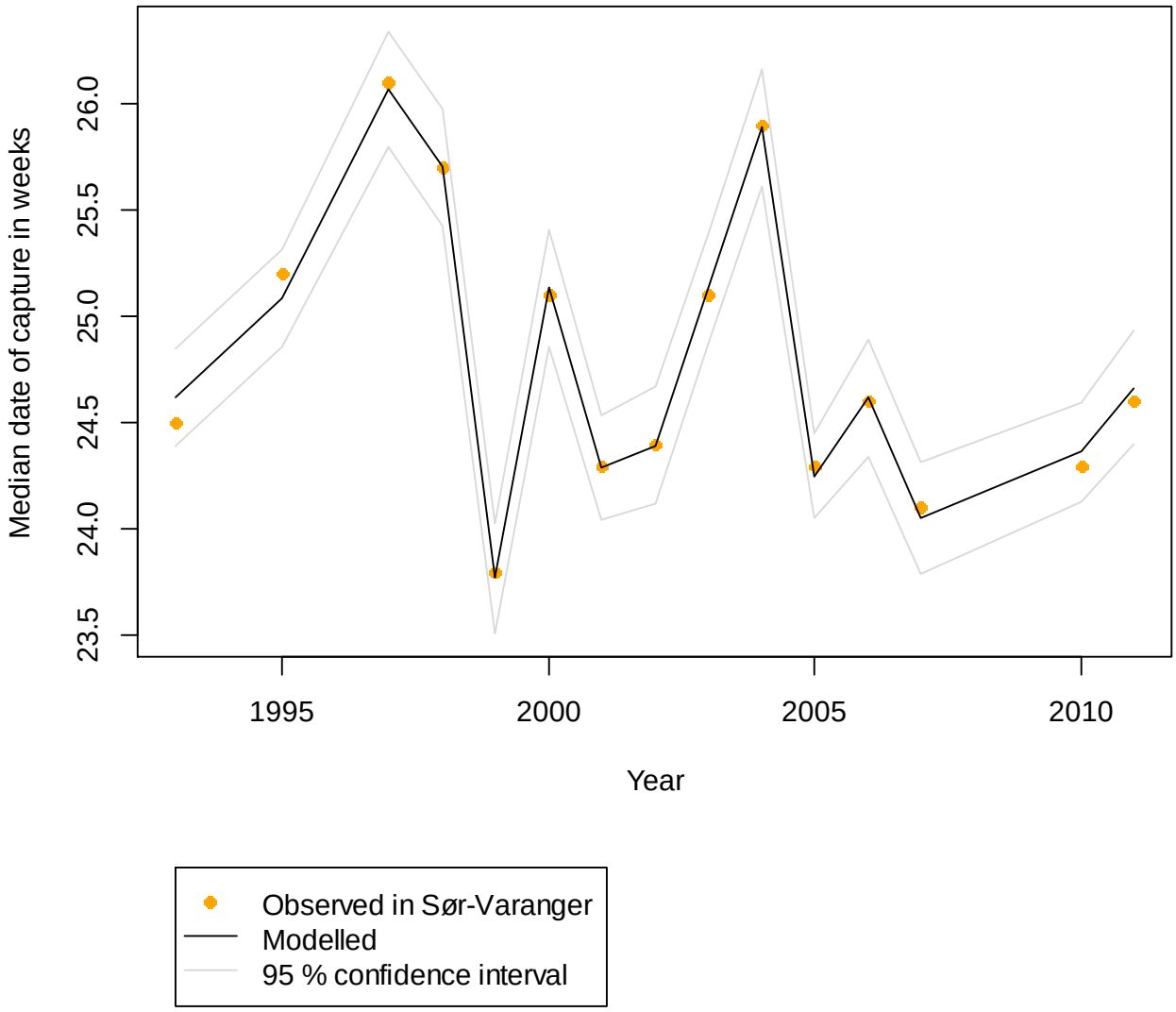


Figure 12. Observed and modeled median date of capture in Sør-Varanger.

In Måsøy-Nordkapp, the deviance was very well explained by the model (Table 1). In 2000, the estimated median date of capture was 28.9 weeks. The difference of the sea temperatures (0-50 m) between April and March in the Kola section was included after spline smoothing (approximate p-value 0.015). If the sea temperature (50-200 m) in January in the Fugløya-Bjørnøya section increase by one degree, the estimated median date of capture in Måsøy-Nordkapp decrease 0.65 weeks (p-value 0.0002). However, every year the estimated median date of capture increase 0.043 weeks (p-value 0.005), which indicates that above sea temperatures are not sufficient for explaining the variation of the median date of capture in Måsøy-Nordkapp. (Figure 13).

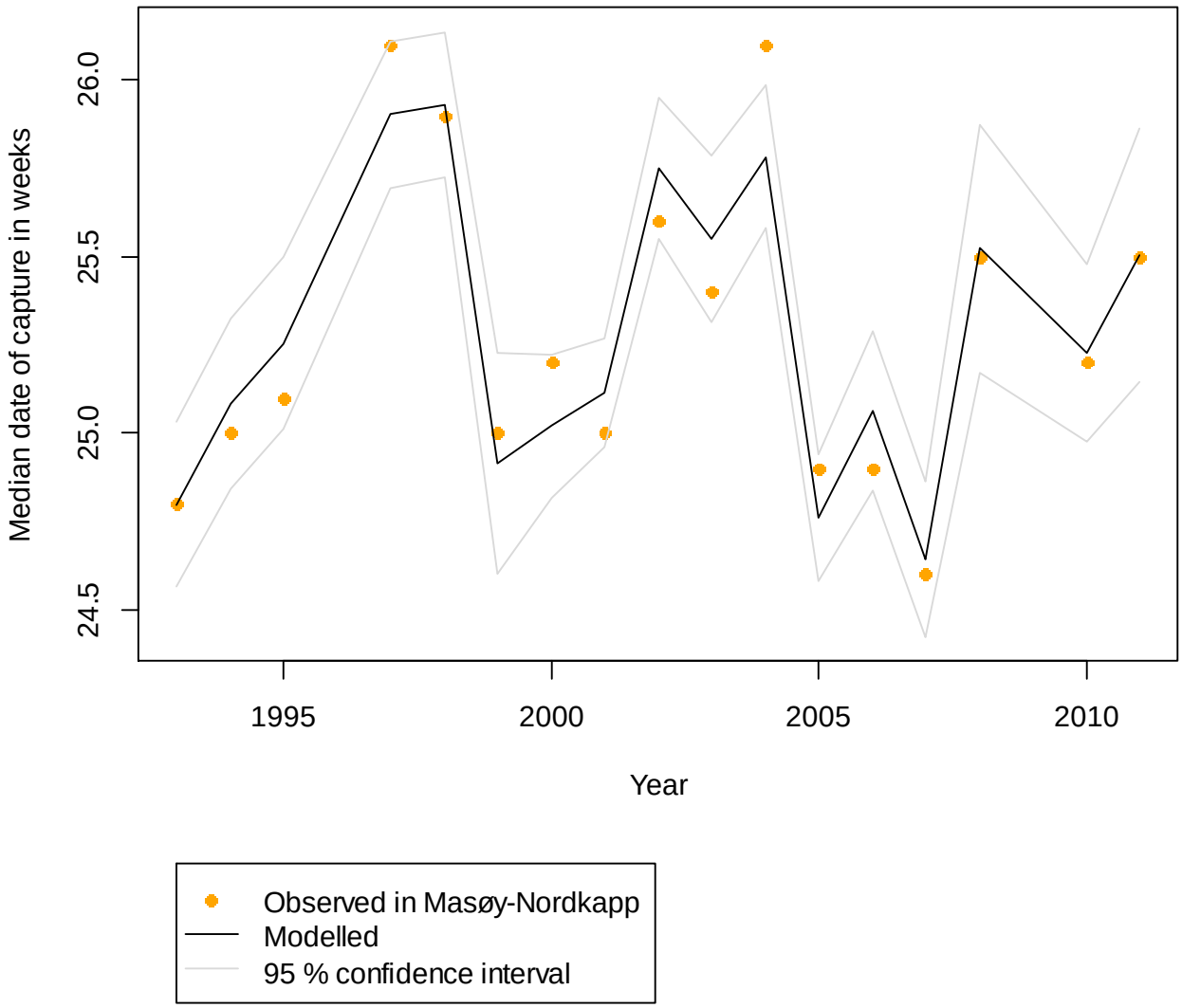


Figure 13. Observed and modeled median date of capture in Måsøy-Nordkapp.

In Tana, the deviance was well explained by the model (Table 1). In 2000, the estimated median date of capture was 26.4 weeks. If the sea temperatures (0-200 m) from April to May in the Kola section increase by one degree, the estimated median date of capture in Tana increase 2.51 weeks (p-value 0.003). If in May the sea temperature (0-50 m) in the Kola section increase by one degree, the estimated median date of capture decreased 0.51 weeks (p-value 0.07). The calendar year was need to include after spline smoothing (approximate p-value 0.0006), which indicates that above sea temperatures are not sufficient for explaining the variation of the median date of capture in Tana. (Figure 14).

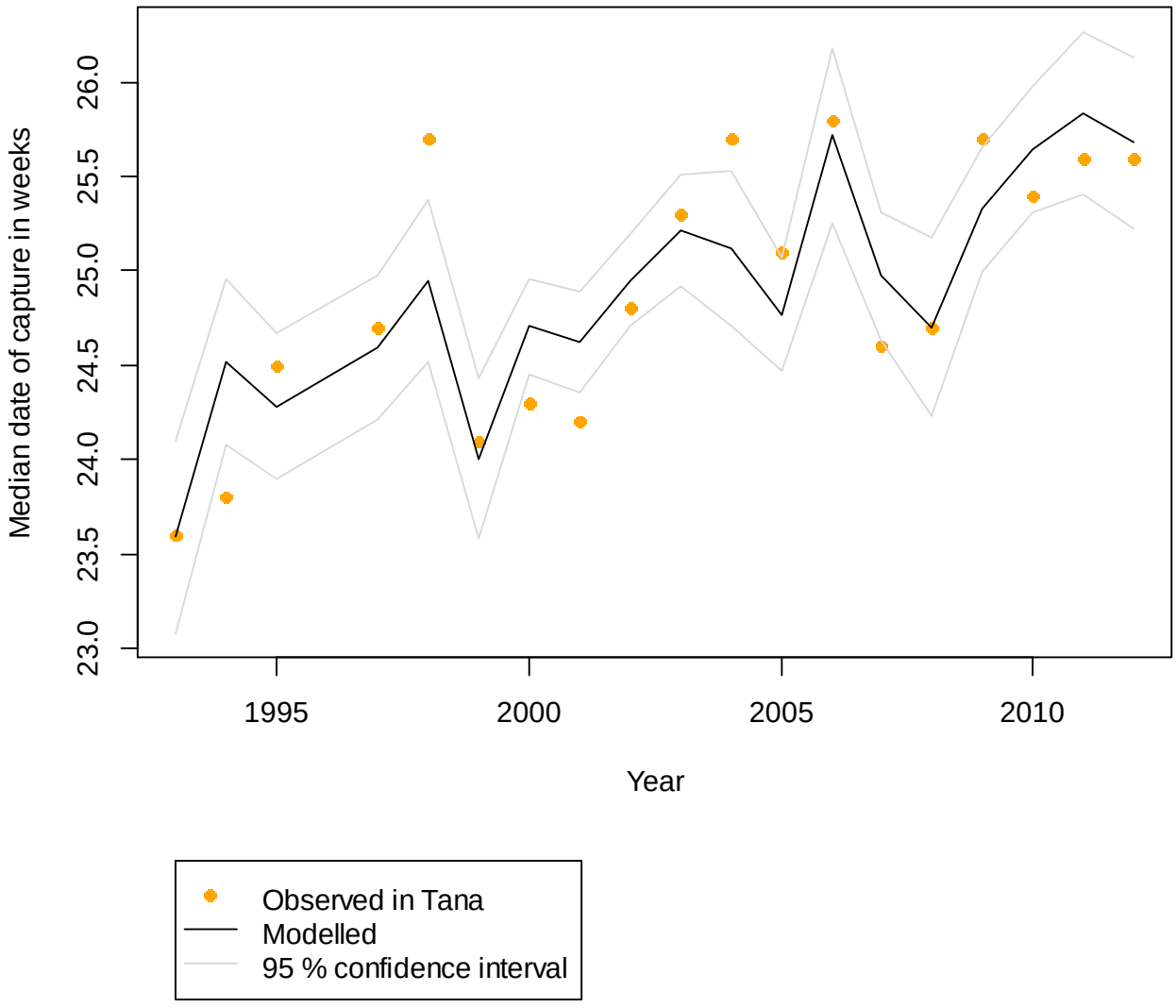


Figure 14. Observed and modeled median date of capture in Tana.

In Porsanger, the deviance was well explained by the model (Table 1). In 2000, the estimated median date of capture was 26.7 weeks. The April sea temperature in Varanger was included after spline smoothing (approximate p-value 0.37). However, every year the estimated median date of capture decreased 0.11 weeks (p-value 0.004), which indicates that above sea temperatures are not sufficient for explaining the variation of the median date of capture in Porsanger. (Figure 15).

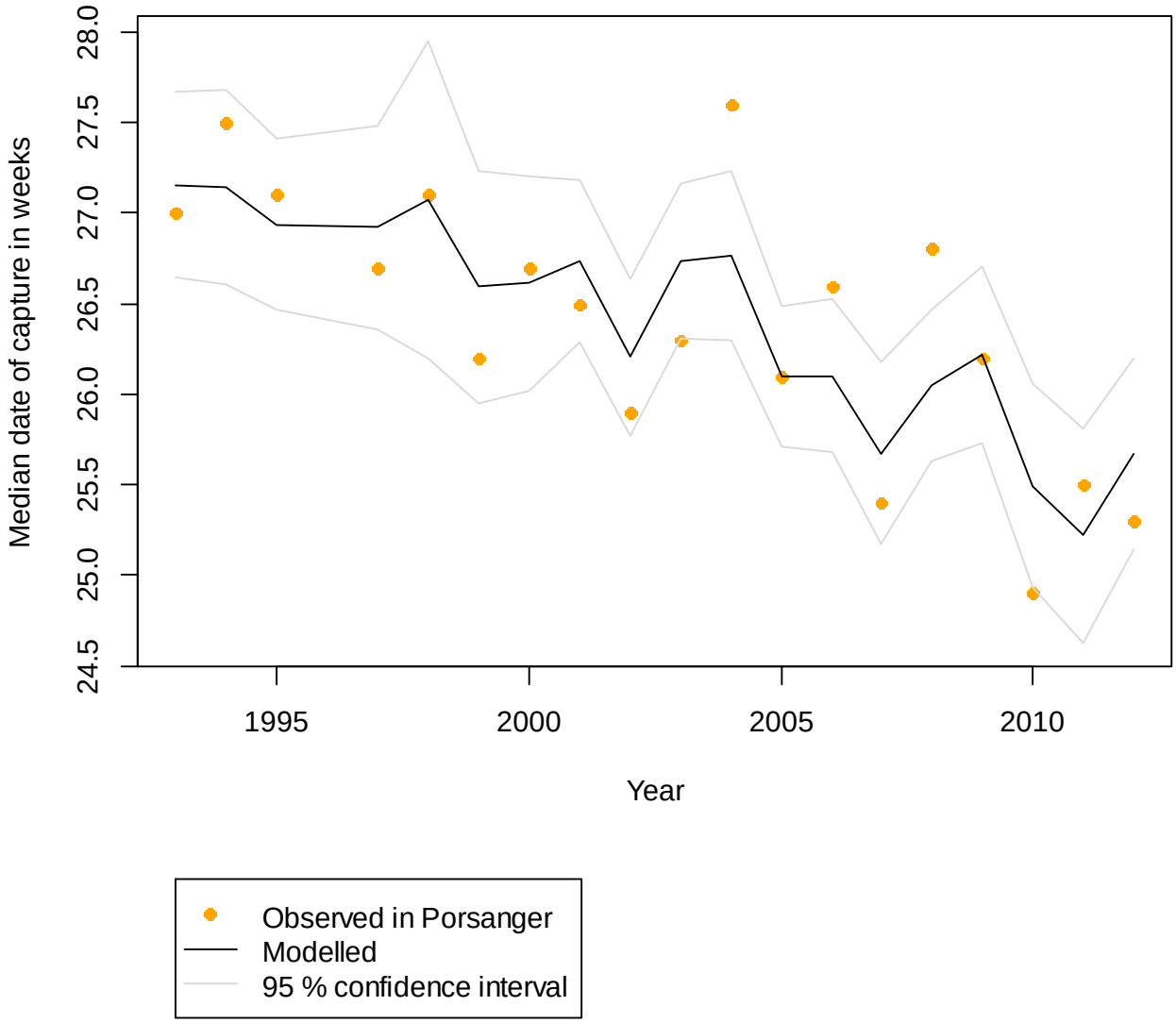


Figure 15. Observed and modeled median date of capture in Porsanger.

Acknowledgements

This study was funded by the European Union, Kolarctic ENPI CBC project – *Trilateral cooperation on our common resource; the Atlantic salmon in the Barents region* - "Kolarctic salmon" (KO197) and national sources in each participating country. The Lead partner of the project is the Office of the Finnmark County Governor (FMFI). Partners in Finland: University of Turku (UTU) and Finnish Game and Fisheries Research Institute (FGFRI). Partners in Norway: Institute of Marine Research (IMR) and Norwegian Institute of Nature Research (NINA). Partner in Russia: Knipovich Polar Research Institute of Marine Fisheries and Oceanography (PINRO).

Responsibilities in this report: FMFI organized the basic data from SSB (Statistics Norway) covering the salmon catches, FGFRI produced graphs and drafted text. IMR and PINRO delivered sea temperature values

This report has been produced with the assistance of the European Union, but the contents can in no way be taken to reflect the views of the European Union.