Multiplicative effect of SST variation during spawning period and 1 year after on the catches of walleye pollock 5 years later in the waters off the northeastern part of Sakhalin Island

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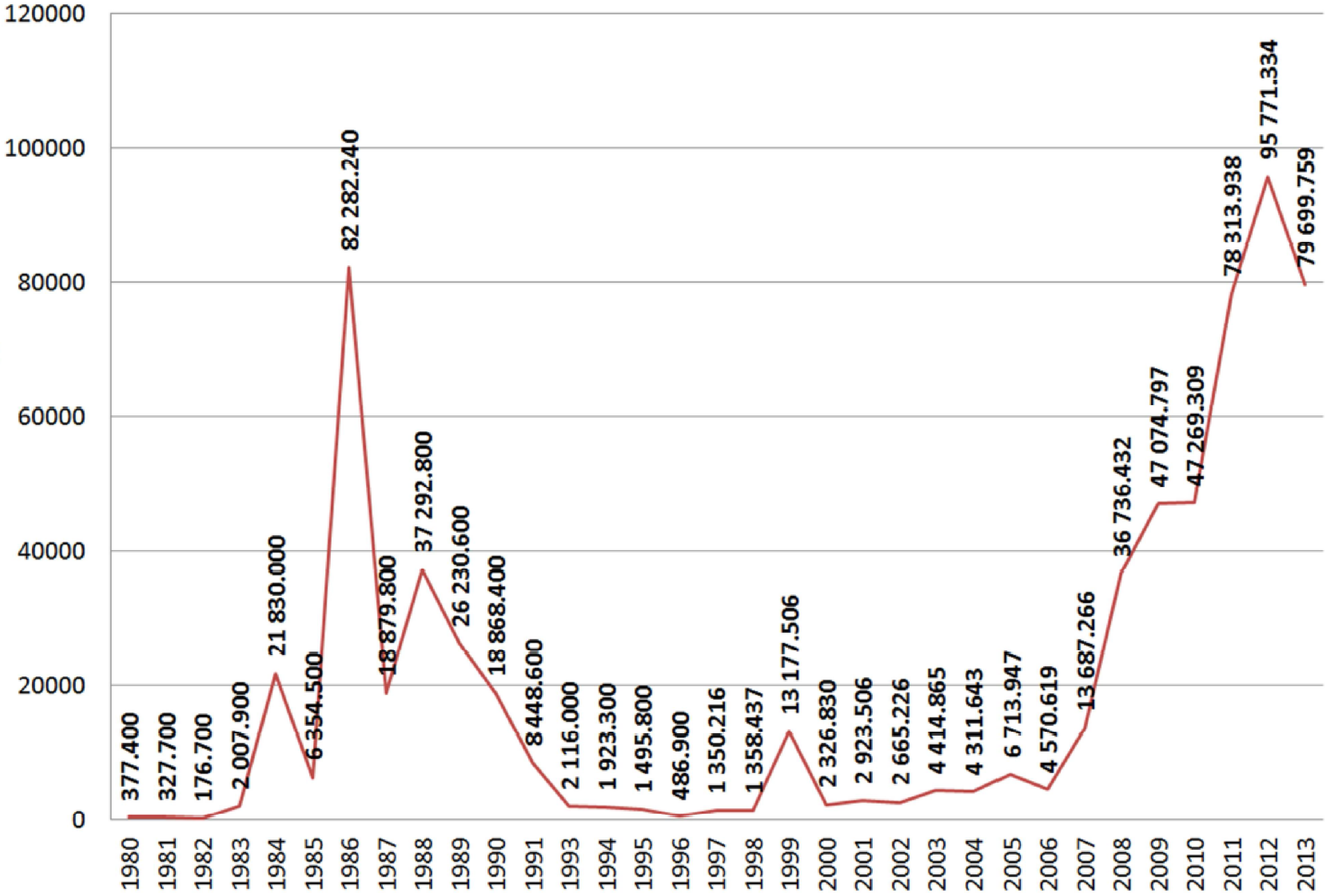
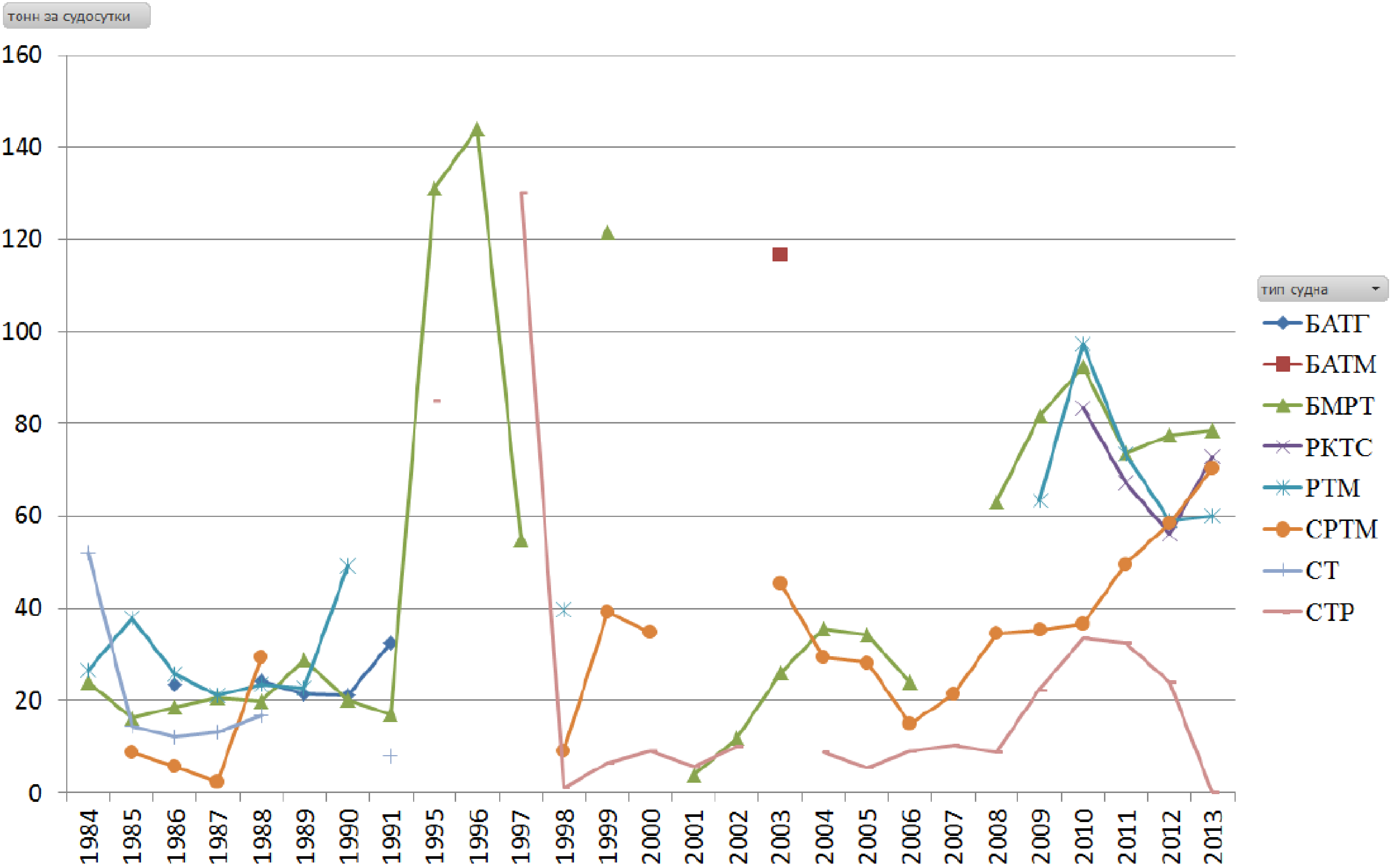
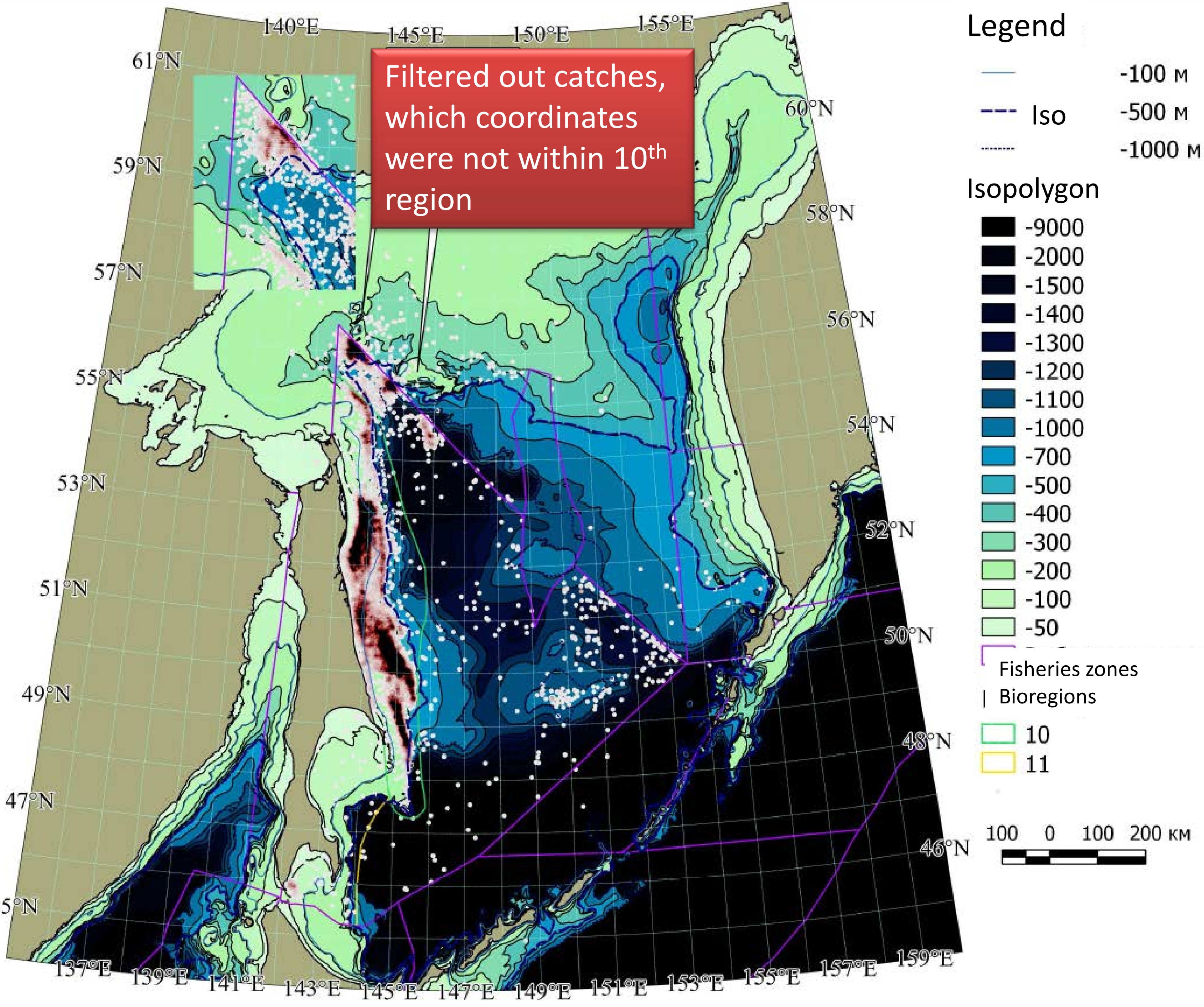


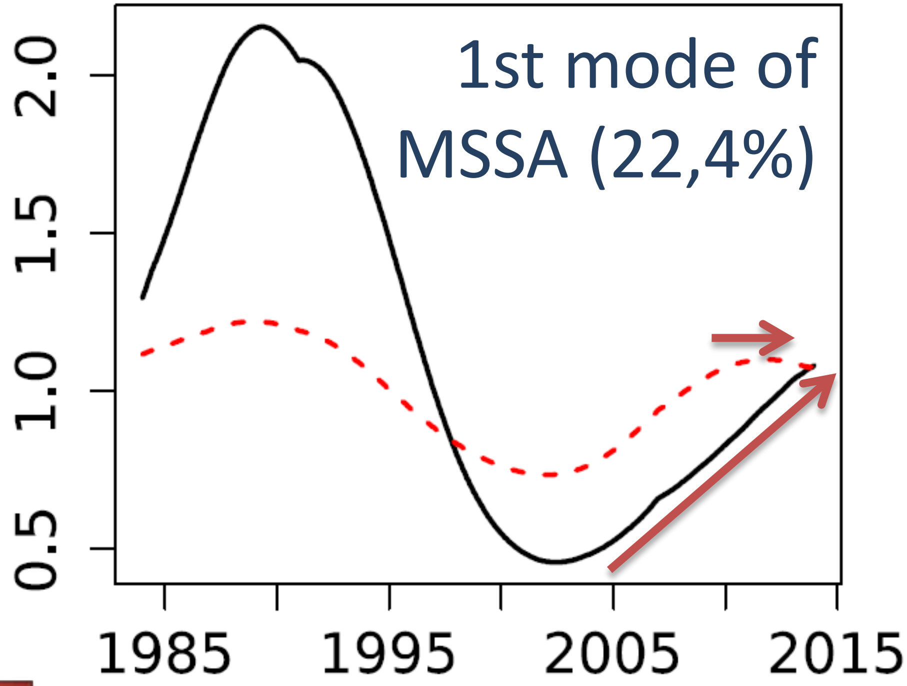
Annual catches of walleye Pollock in the eastern Sakhalin fisheries zone

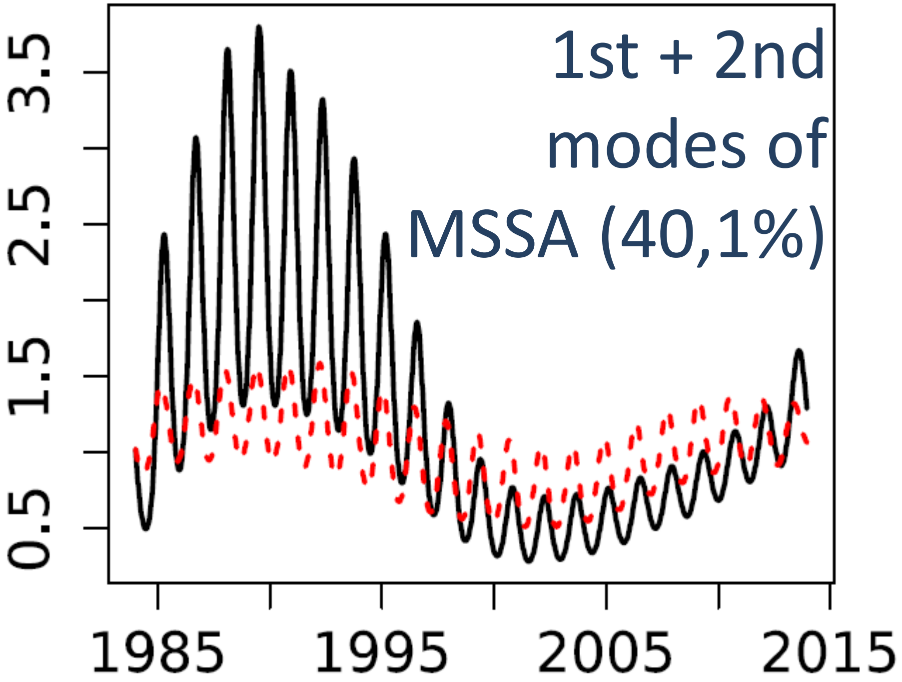


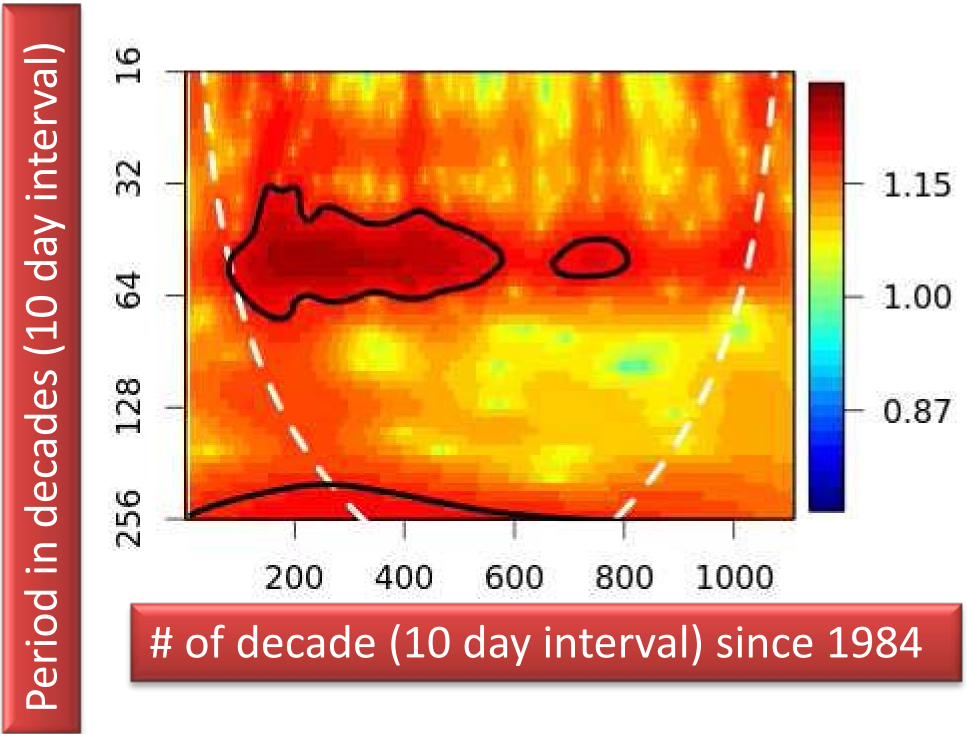
Tons per day per vessel by type of vessel



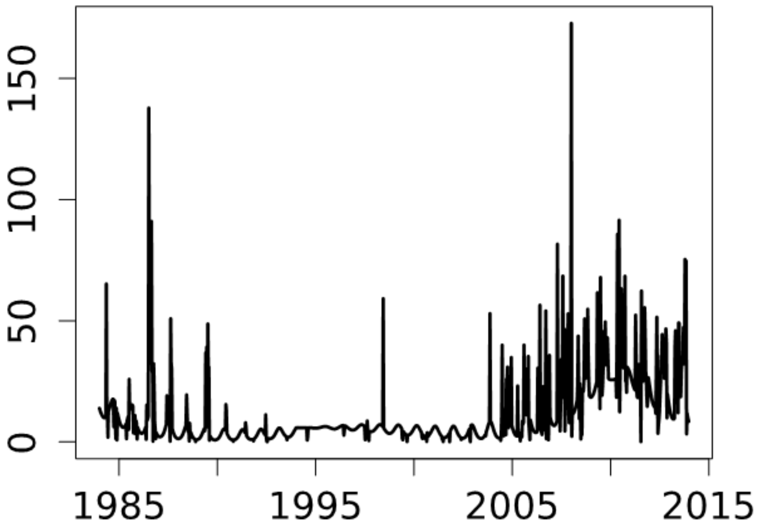
Filtered out catches, which coordinates were not within 10th region







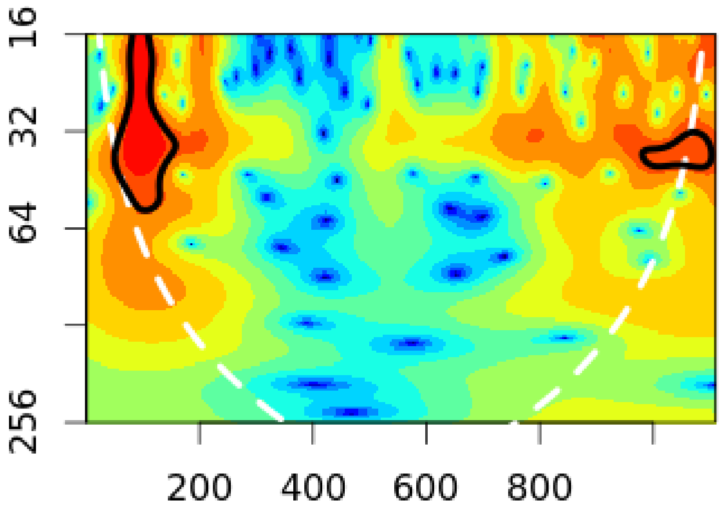
Reconstructed CPUE (tons per hour) of walleye pollock by typical grouping:
big vessels in red and **middle vessels in black** since 1984.



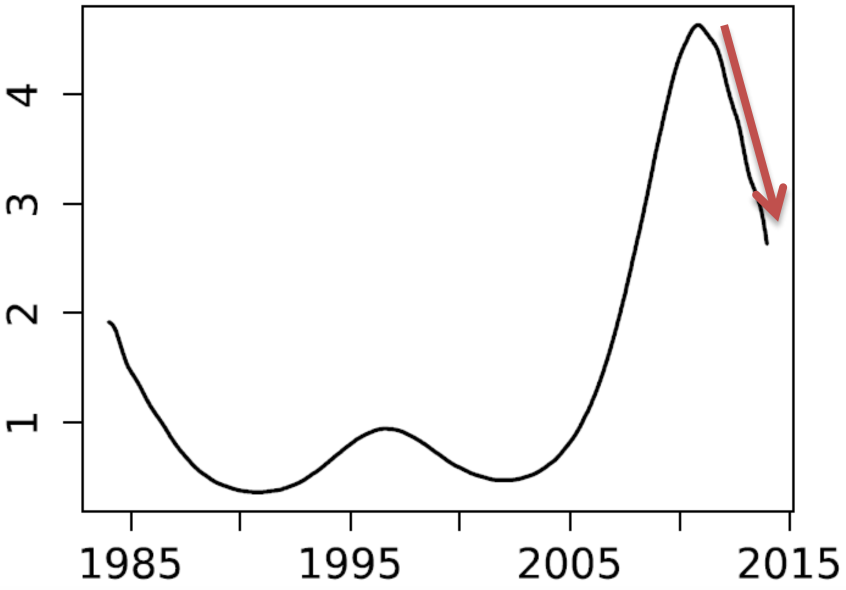
1st (34.4%) +
2nd (13.5%)
modes of SSA
= 47,9%

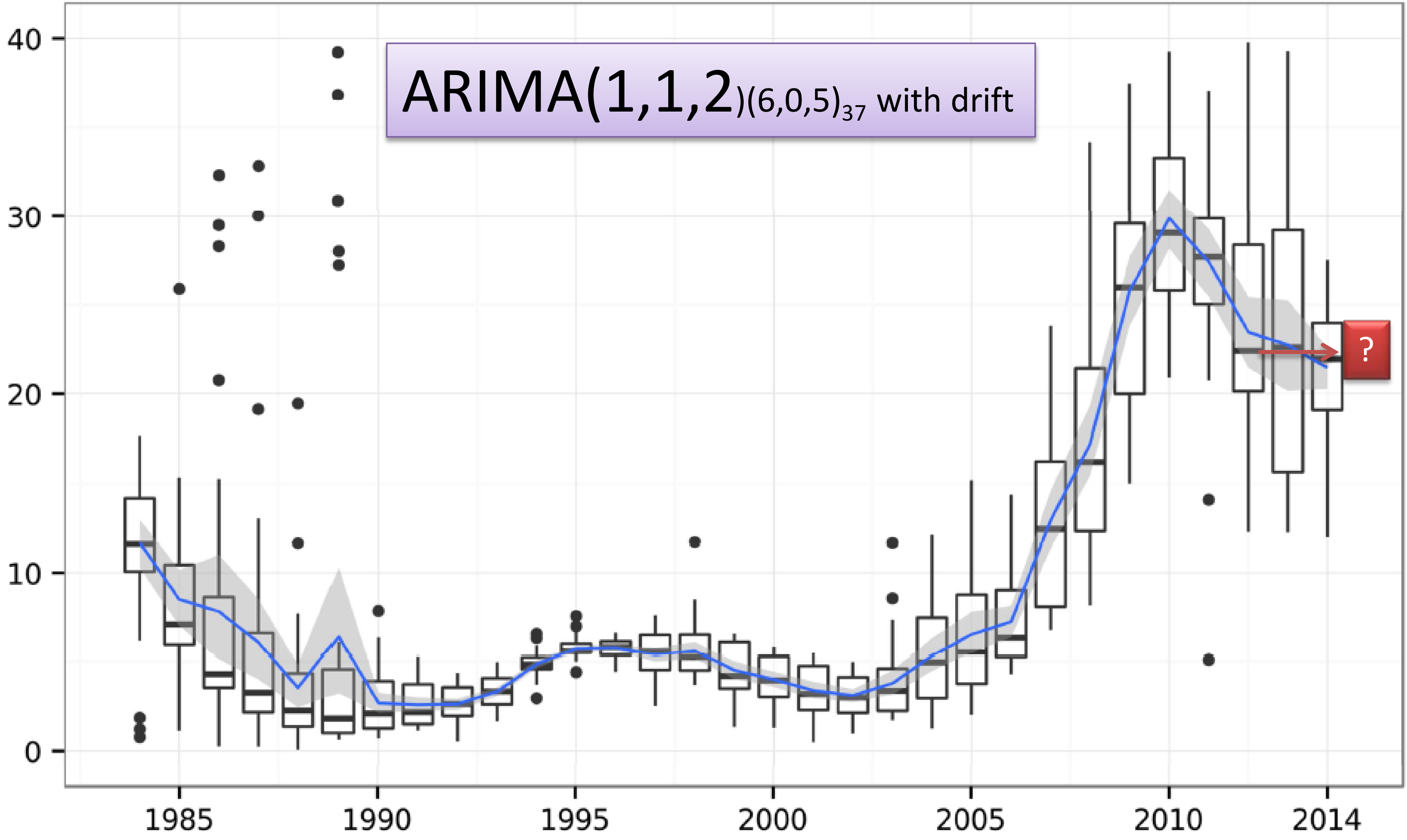
Reconstructed by SSA catch of walleye pollock in Tons per km^2

Period in decades (10 day interval)



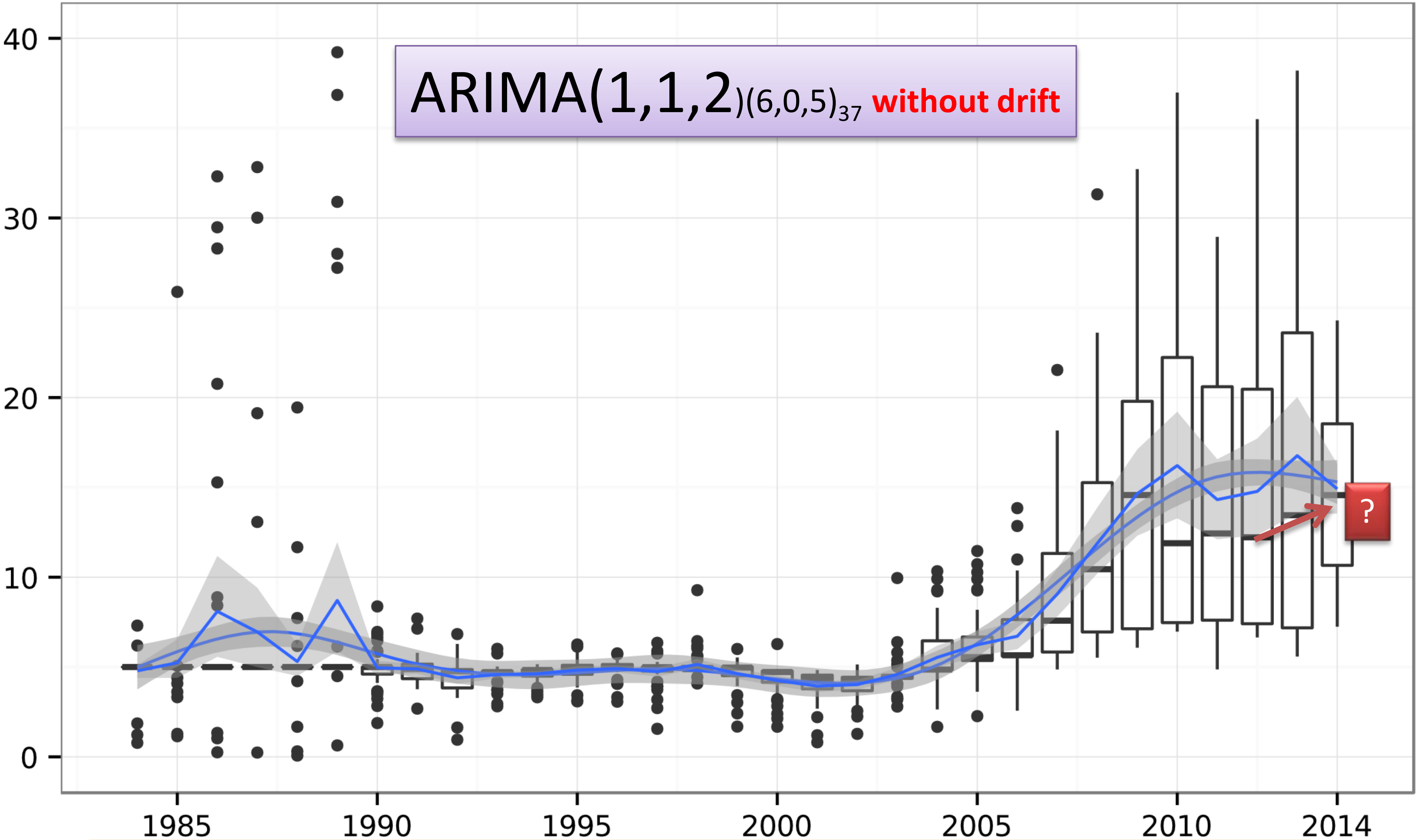
# of decade (10 day interval) since 1984





ARIMA$(1,1,2)(6,0,5)_{37}$ with drift

Annually averaged tons per square km after reconstructing time series with best SARIMA model chosen by AICc, when missing observations were filled in by SSA



ARIMA(1,1,2)(6,0,5)$_{37}$ **without drift**

Annually averaged tons per square km, when missing observations were filled in with global mean of 5 tons per square km (published estimate)

The problems:

1. catches per square km before 2004 were estimated by observers only (obviously the least part of all catches was observed),
2. since 2004 catches per square km were calculated from recognized (by ctree) parts of tracks, where vessels possibly could make trawling, therefore the process of this recognition itself had uncertainty,
3. In both parts horizontal mouth opening of the trawls was approximated by the only known parameters (speed and name of trawl)…
4. Catches per hour are known for all vessels, but individual peculiarities can influence greatly on CPUE.

Specialists during last annual workshops on stocks modeling organized by VNIRO (the main fisheries institute in Russia) recommended to use GLM to clean CPUE from effects of different vessels, trawls etc.

So this is the 1st attempt to filter out possible effects of vessels and trawls (orud) by years and months on CPUE of walleye pollock in 10th bioregion. We made the following assumptions:

$$tons_{ijkl} \sim T(\mu_{ijkl}, p);\ E(tons_{ijkl}) = \mu_{ijkl};\ var(tons_{ijkl}) = \mu_{ijkl}{}^{p};$$

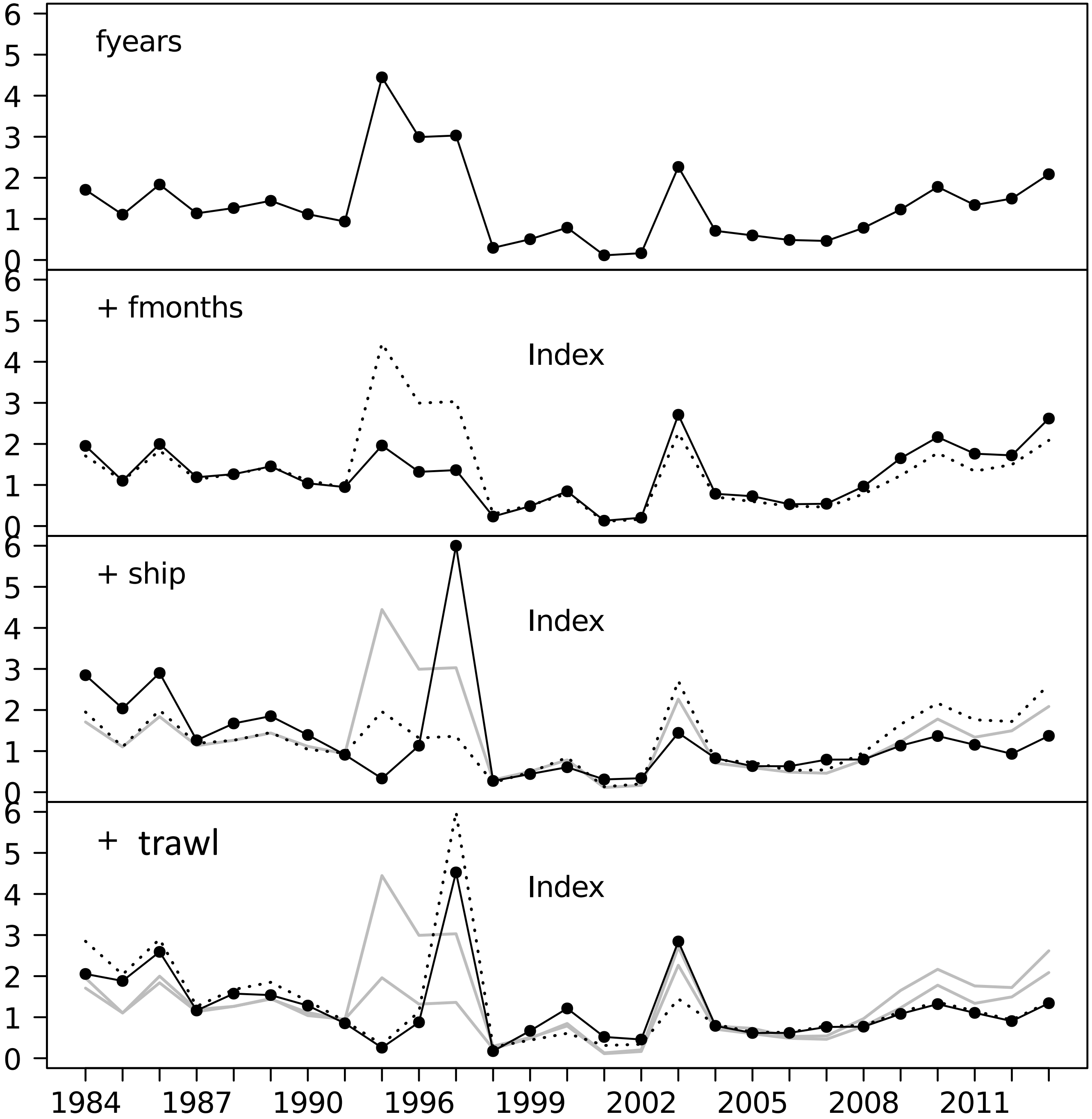
$$\eta_{ijkl} = \alpha + \beta_1 \times fyears_{ijkl} + \beta_2 \times fmonths_{ijkl} + \beta_3 \times ship_{ijkl} + \beta_4 \times orud_{ijkl}$$

$$log_e(\mu_{ijkl}) = \eta_{ijkl} + log_e(hours_{ijkl})$$

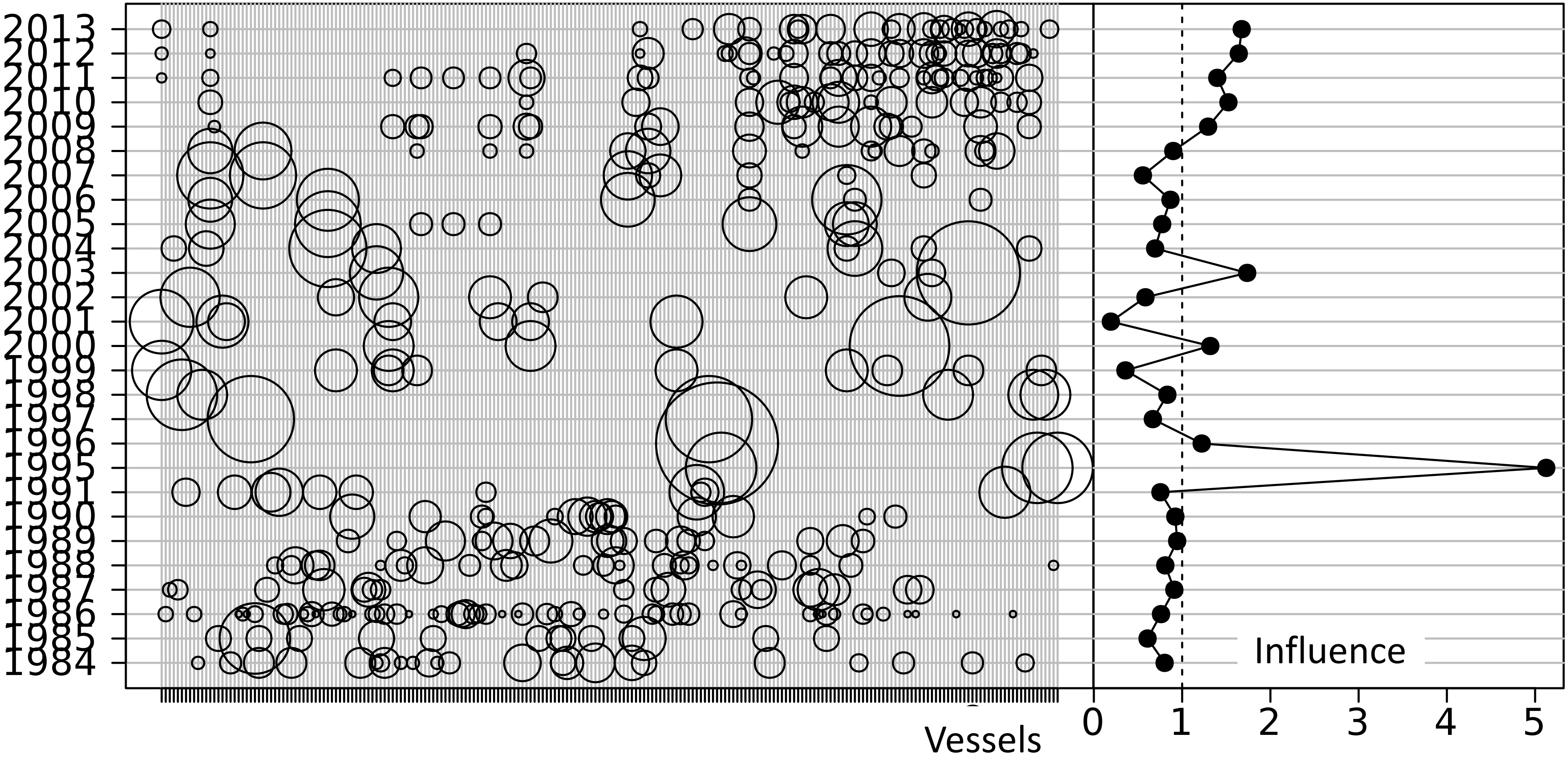
$$\mu_{ijkl} = hours_{ijkl} \times e^{\eta_{ijkl}}$$

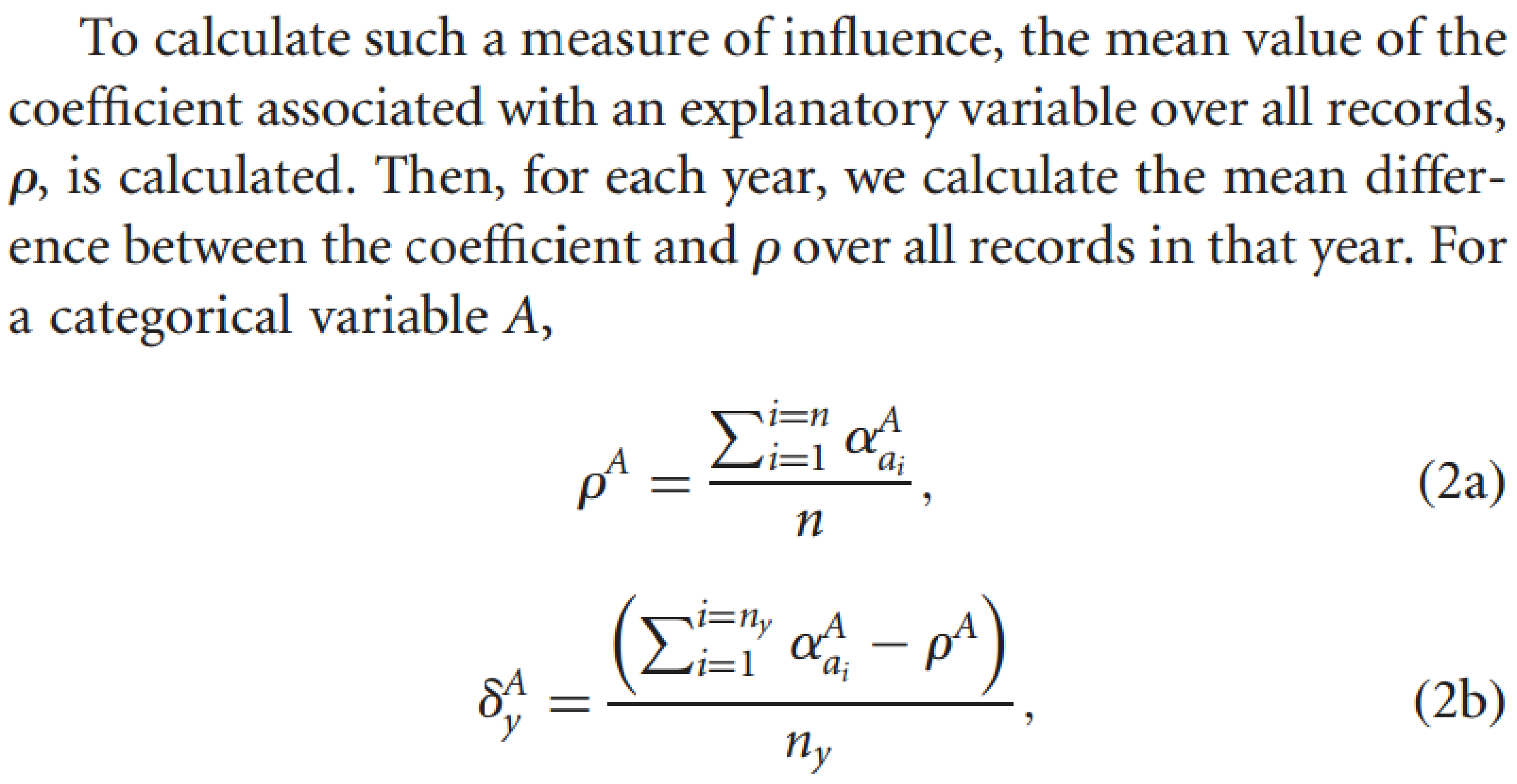
Step	DF	deviance	Share in total of deviance	AIC
fyears	26	3952	3.27%	23414
fmonths	10	763	5.69%-16%	23284
ship (name)	217	5280	32%-53.32%	**22390**
orud (trawl)	54	304	2-17%	22397*

*Not significant


fyears
+ fmonths
+ ship
+ trawl
Index
Index
Index
0
1
2
3
4
5
6
1984
1987
1990
1996
1999
2002
2005
2008
2011

“Influence” of vessels with focus on years





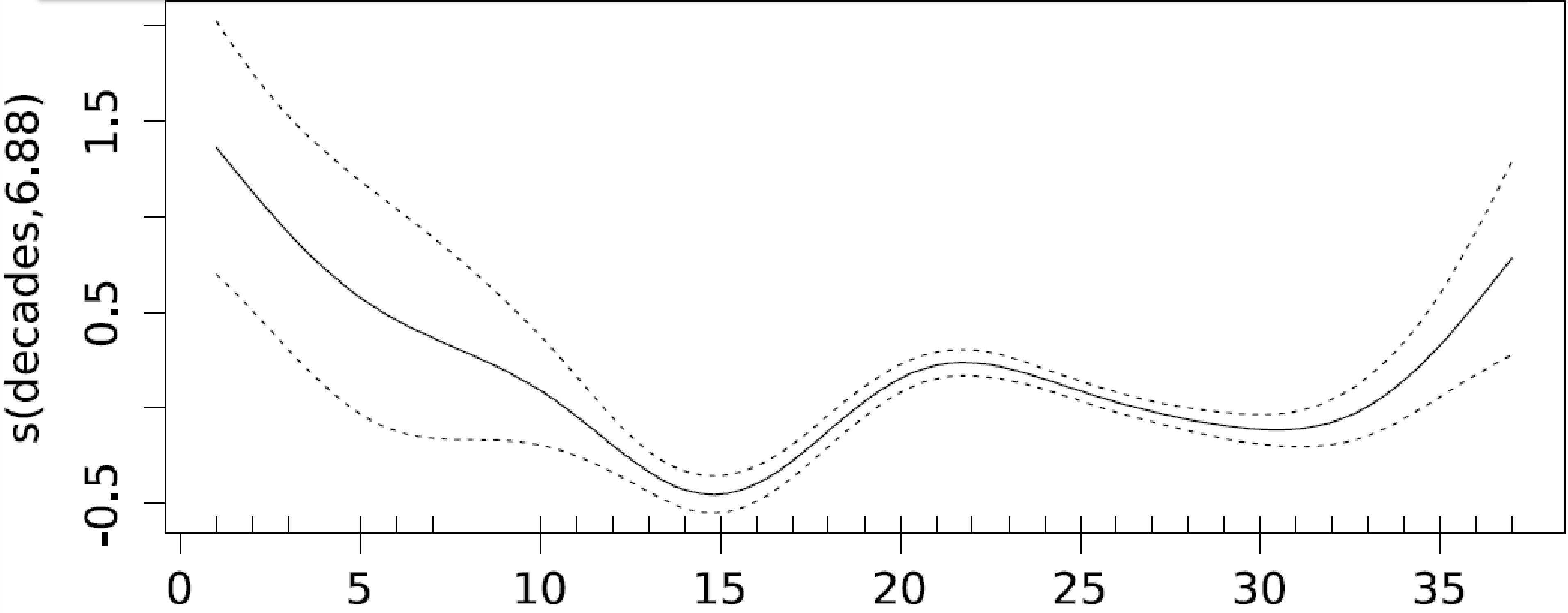
To calculate such a measure of influence, the mean value of the coefficient associated with an explanatory variable over all records, ρ, is calculated. Then, for each year, we calculate the mean difference between the coefficient and ρ over all records in that year. For a categorical variable A,

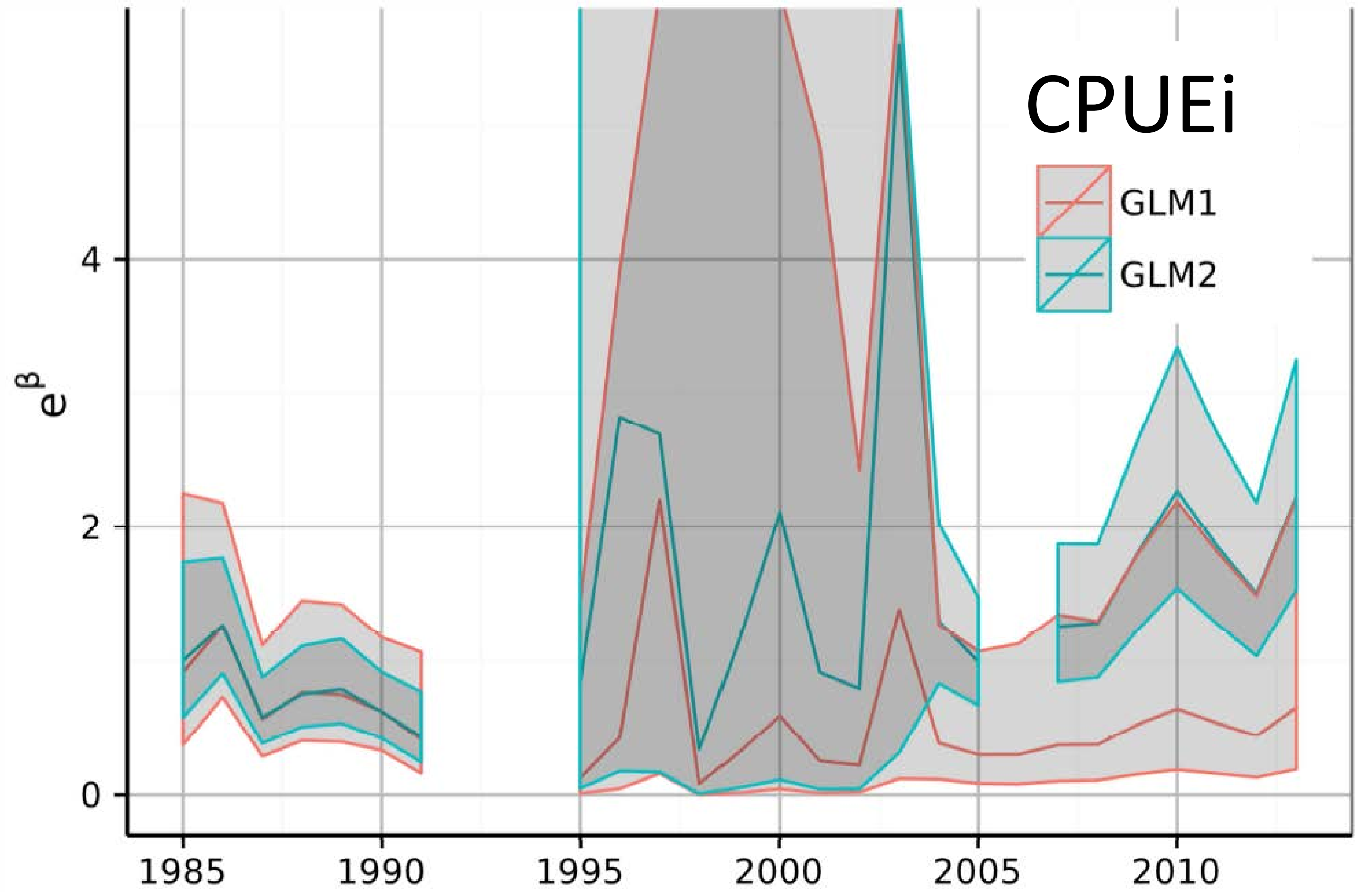
$$\rho^A = \frac{\sum_{i=1}^{i=n} \alpha_{a_i}^A}{n}, \tag{2a}$$

$$\delta_y^A = \frac{\left(\sum_{i=1}^{i=n_y} \alpha_{a_i}^A - \rho^A\right)}{n_y}, \tag{2b}$$

Bentley N. et al. **Influence plots** and metrics: tools for better understanding fisheries catch-per-unit-effort standardizations // ICES J. Mar. Sci. 2011. Vol. 69, № 1. P. 84–88.

Decreasing the number of DF by smoothing decadal (10 days) variability with spline (knots selected by GCV) instead of monthly aggregation

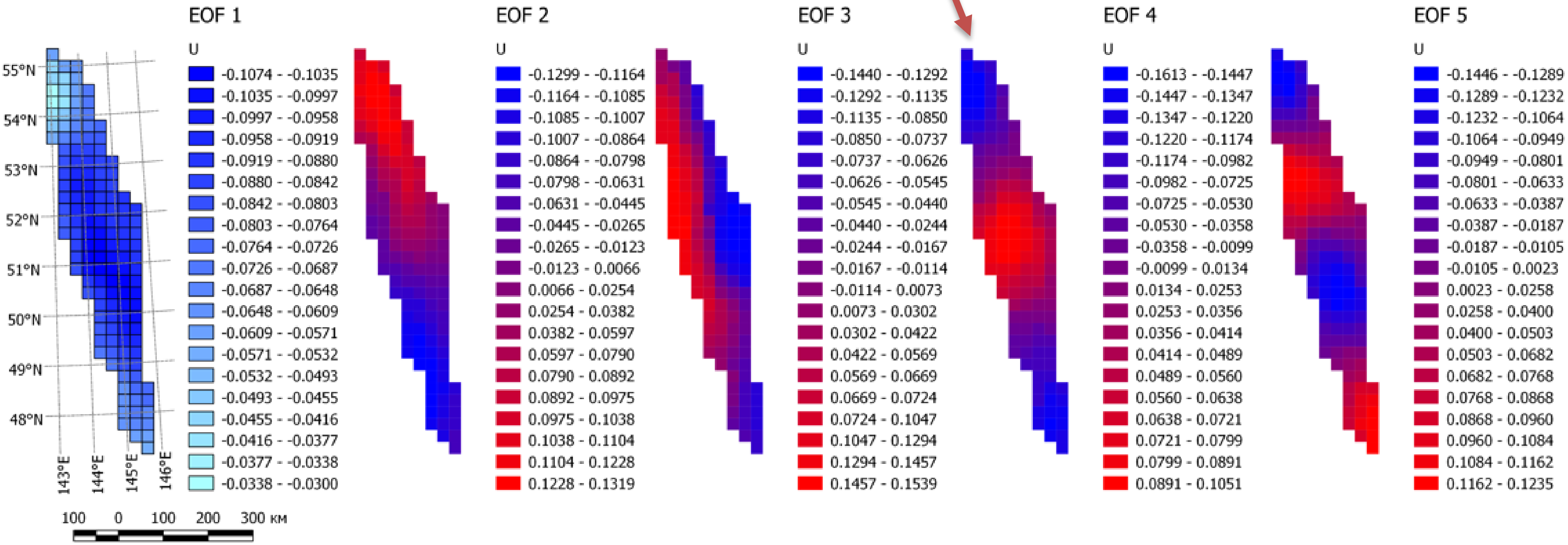




In GLM1 monthly aggregation with independent estimation of coef.
GLM2 has smoothed by spline decadal (10 days) aggregation

Optimal clustering of years in GLM2 cross-correlated best with time clusters of EOF 4

Significant modes of EOF from daily SST* anomalies in the 10th bioregion



Time Clusters of EOF 4 were split in 1989,1994,1997,2000,2006 and 2009

SST from
Reynolds R.W. et al. Daily High-Resolution-Blended Analyses for Sea Surface Temperature // J. Clim. 2007. Vol. 20, № 22. P. 5473–5496.

GLM3

$$\eta_{kl} = \alpha + f(decades) + \beta_2 \times ship_{kl} + \beta_3 \times orud_{kl} + \boxed{\beta_4 \times tup\_sd\_lag\_5}$$

$$+ \boxed{f(tlow\_sd\_lag\_4) + f(tlow\_kurtosis\_lag\_4)}$$

0,66

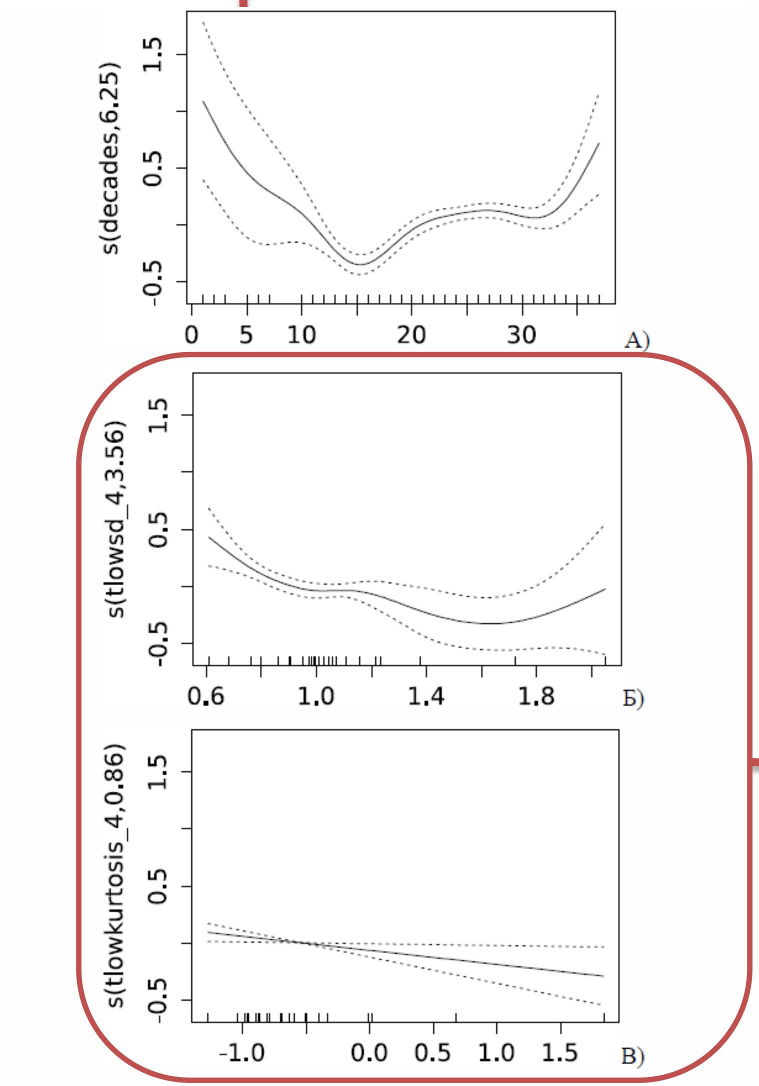
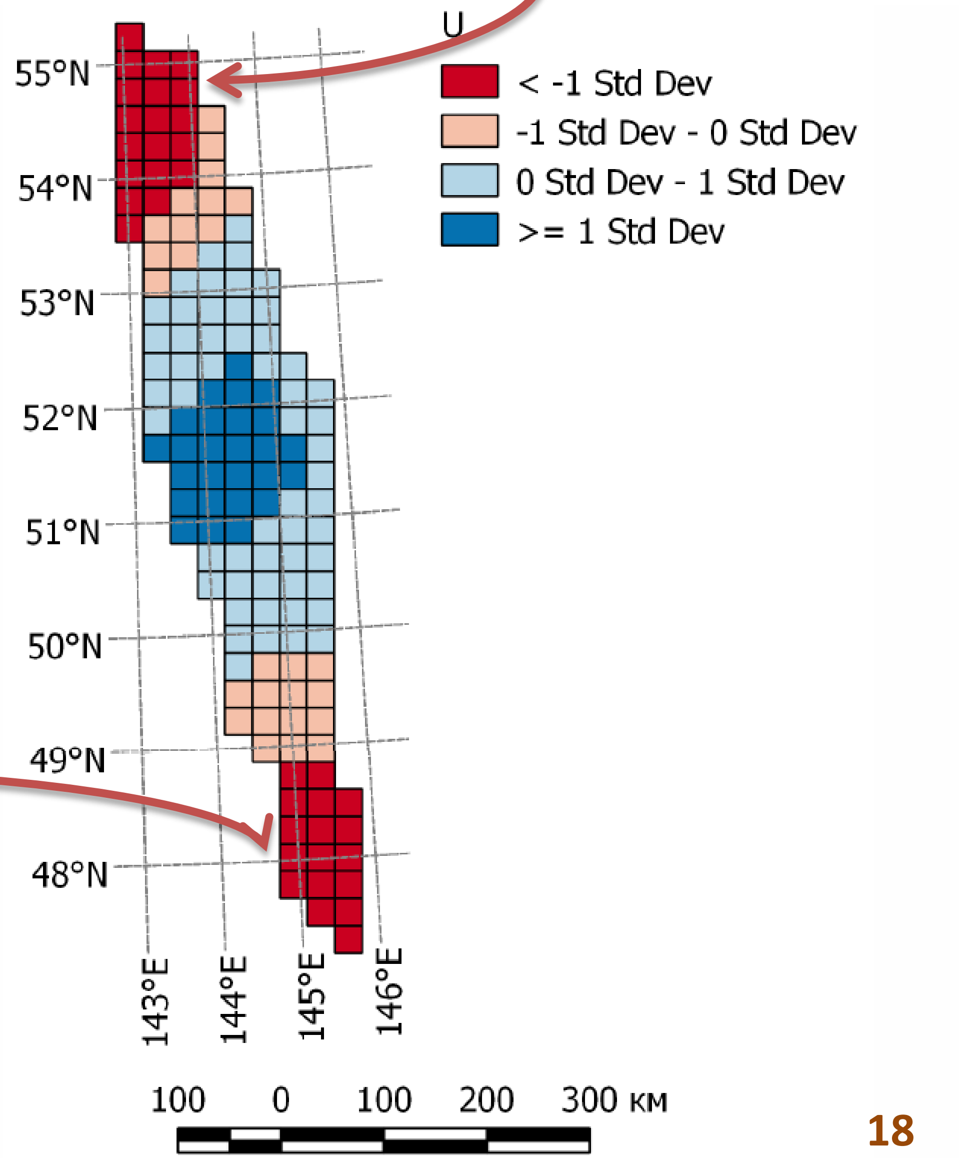


Рисунок 52 – Значения коэффициентов декад (А), *tlow_sd_lag_4* (Б) и *tlow_kurtosis_lag_4* (В)

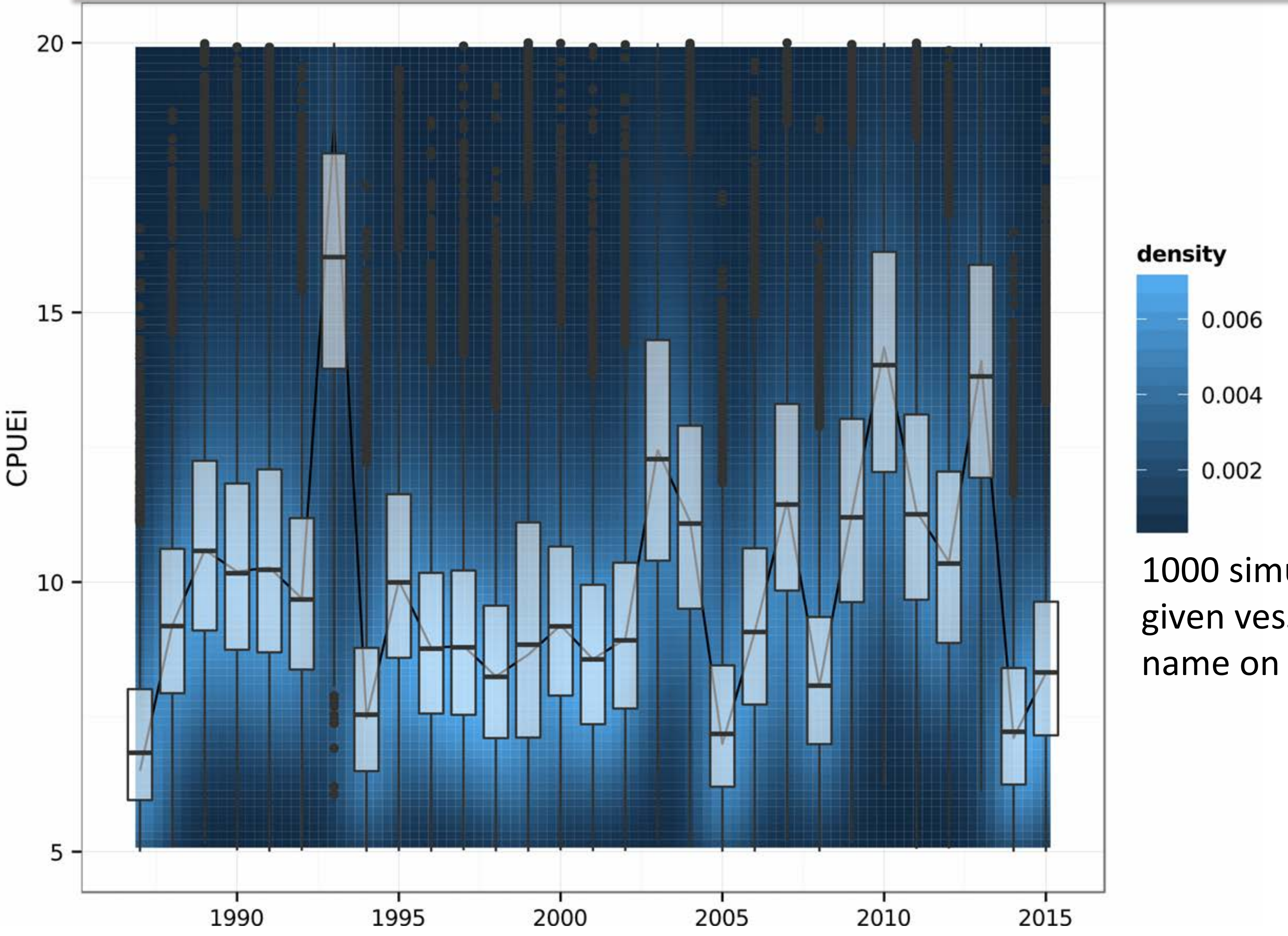


GLM3 didn’t include years as independent factors, but it could capture interannual variability from lagged SD and kurtosis of SST

	DF	AIC	BIC	REML	Adj R^2	Deviance explained
GLM1*	220	16668	17832	8206	0,746	64,1%
GLM2*	218	**16636**	17788	**8199**	0,756	64,7%
GLM3*	202	16669	**17738**	8222	0,759	63,6%

*since 1987

A huge uncertainty after taking into account CI of all parameters



1000 simulations with given vessel & trawl name on 25 decade

GLM3

Results

1. Up to 53% of deviance can be explained by vessel name and only 6% and 3% of it is explained by month and years as independent factors of GLM for CPUE of walleye pollock in the 10th region of the Okhotsk Sea.
2. We found that the exponent of the sum of the standard deviation of the sea surface temperature during May in the northern part of the 10th region with -5 years lag (when the most part of the walleye pollock was spawning) and in the southern part of the 10th region with -4 years lag could explain 1.97% of deviance in the GLM without years as factors.

Thank you for attention!