Influence of biotic and abiotic environment on large pelagic fish distribution in American Samoa

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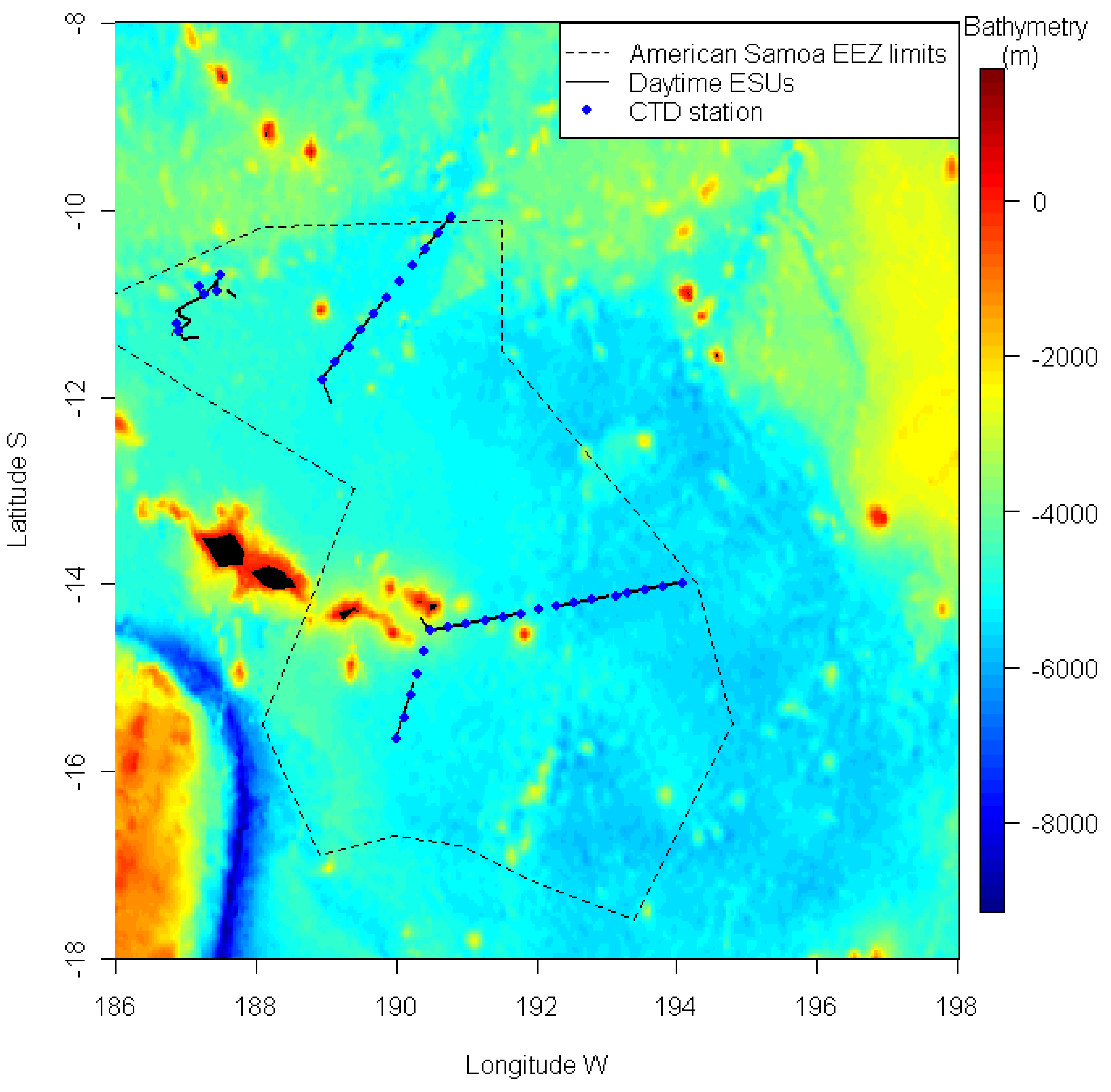
Motivations

- Influence of environment (eddy activity) on declining domestic fisheries CPUEs
- Fishery independent survey
  - → *Acoustic monitoring of large pelagic fish distribution*
  - → *Abiotic and biotic environment monitoring*
- GAM model to test influence of available *in-situ* and remote sensing environment descriptors on distribution of large pelagic fish acoustic targets

Materials and Methods



Methods: sound scattering layers characterisation

- Sound scattering layers (SSLs) acoustic data pre-processing
  - → *38 kHz, echo-integration min. thr. = -90 dB, 0-700 m*
  - → *2 NM x 50 m integration cells*
    - no spatial correlation between elementary sampling units (ESUs)
    - reduce vertical variance
  - → *Number of shoals per ESU*
- SSL structure synthetic descriptors:
  - → *PCA/clustering on ESUs acoustic density profiles*
  - → *Number of shoals and SSLs principal components (SSL.PCn) as synthetic descriptors*

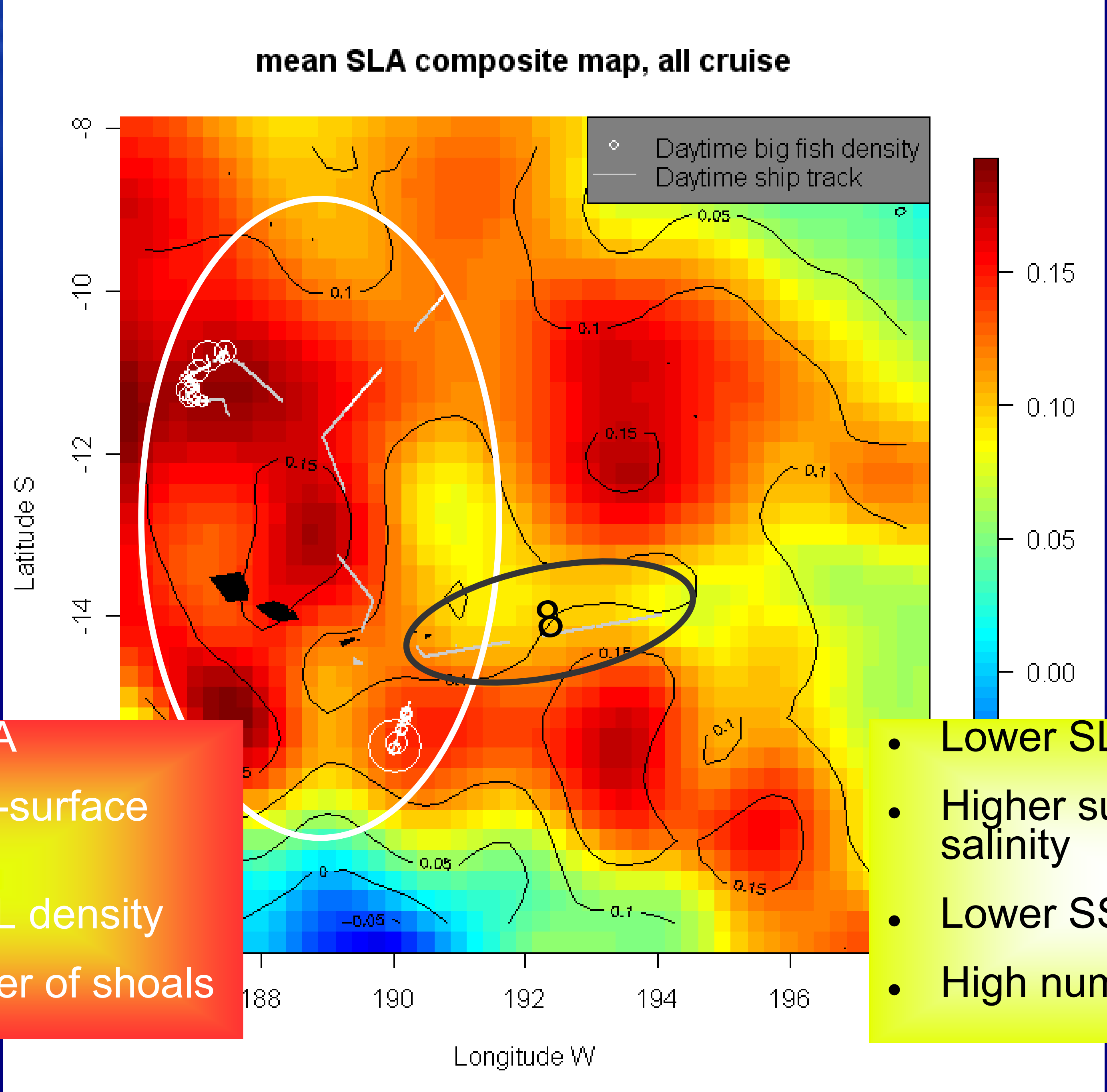
Methods: hydrological environment characterisation

- *In-situ* data
  - → *Spatial merging of acoustic and CTD data*
  - → *Synthetic descriptors of CTD profiles*
    - PCA/clustering on vertical profiles of CTD variables (resolution: 50 m, range = 0-700 m)
    - PCs as synthetic descriptors (CTD.PCn)
- Remote sensing data
  - → *Sea level anomaly (SLA): weekly, gradient, eddy kinetic energy (EKE), cruise average and standard deviation (SD)*
  - → *Sea surface temperature (SST): cruise average, gradient and SD*

Methods: large pelagic fish target selection

- Acoustic target selection
  - → *Targets tracked over 3 pings*
  - → *Minimum Target Strength threshold (Bertrand and Josse, 2000)*
  - → *Manual validation of all targets*
  - → *Detections only in daytime*
- Target counts
  - → *Target abundance biased in presence of aggregative structures*
  - → *Presence/absence in 60 m ESUs*
  - → *NBF = Number of presence in 2 NM ESUs*

Results: big fish detections and environmental patterns



- Higher SLA
- Lower sub-surface salinity
- Higher SSL density
- Low number of shoals

- Lower SLA
- Higher sub-surface salinity
- Lower SSL density
- High number of shoals

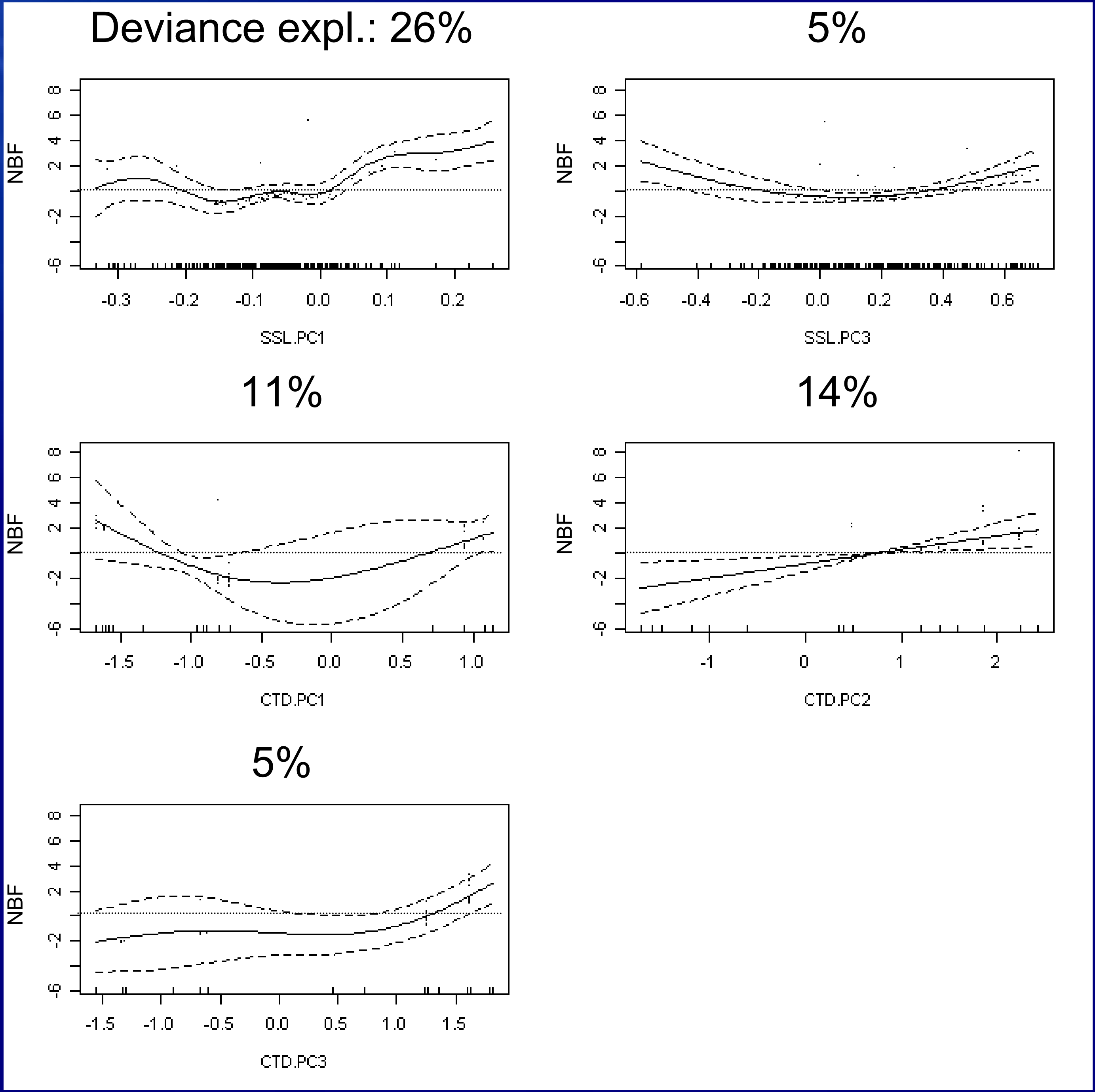
Results: GAMs with *in-situ* variables

- No spatial correlation between ESUs
- Family: negative binomial
- Model checking
  - *GCV criterion for optimal smoothing (Wood, 06)*
  - *AIC for model comparison*
  - *Randomized quantile residuals (Dunn & Smyth, 96)*

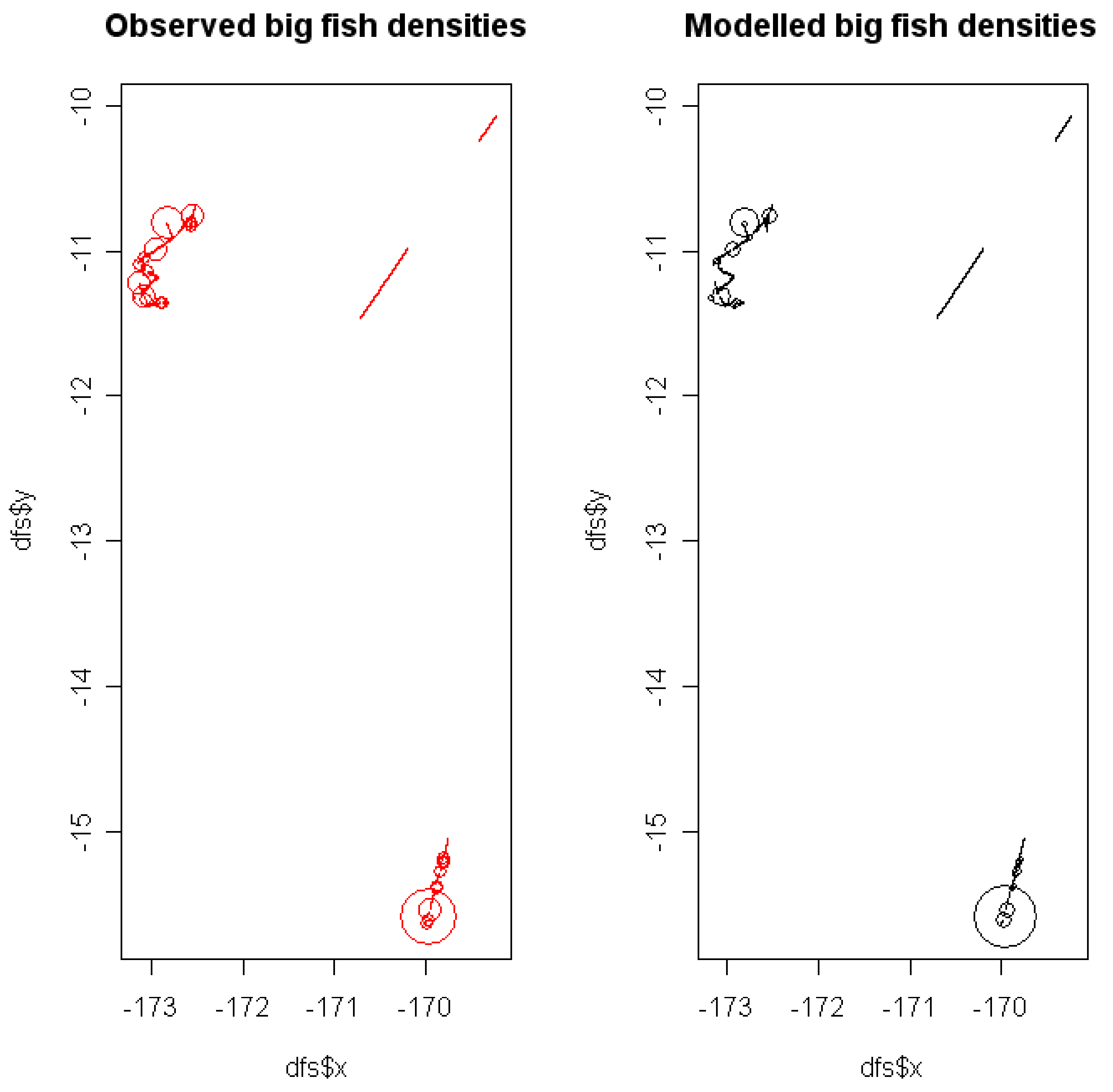
Model	***df***	***% deviance expl.***	***AIC***	***GCV.UBRE***
NBF ~ s(SSL.PC1)	4.59	26%	175.06	1.02
NBF ~ s(SSL.PC1) + s(CTD.PC1)	5.3	31%	170.22	1.03
NBF ~ s(SSL.PC1) + s(SSL.PC3) + s(CTD.PC1)	8.01	42%	161.12	1.04
NBF ~ s(SSL.PC1) + s(SSL.PC3) + s(CTD.PC1) + CTD.PC2	9.69	47%	156.96	1.01
NBF ~ s(SSL.PC1) + s(SSL.PC2) + s(SSL.PC3) + s(SSL.PC4) + s(CTD.PC1) + s(CTD.PC2) + s(CTD.PC3) + s(CTD.PC4)	19.84	64%	150.31	0.71
NBF ~ s(SSL.PC1) + s(SSL.PC2) + s(SSL.PC3) + s(SSL.PC4) + s(CTD.PC1) + s(CTD.PC2) + s(CTD.PC3)	19.41	63%	150.21	0.71
NBF ~ s(SSL.PC1) + s(SSL.PC2) + s(SSL.PC3) + s(CTD.PC1) + s(CTD.PC2) + s(CTD.PC3)	17.97	62%	149.09	0.74
NBF ~ s(SSL.PC1) + s(SSL.PC3) + s(CTD.PC1) + s(CTD.PC2) + s(CTD.PC3)	**16.33**	**61%**	**148.23**	**0.72**

Term	*df*	*% deviance explained*
s(SSL.PC3)	0.71	5%
CTD.PC2	1.68	5%
s(CTD.PC1)	2.71	11%
s(CTD.PC3)	6.64	14%
s(SSL.PC1)	4.59	26%

Results: GAMs with *in-situ* variables



Results: GAMs with *in-situ* variables

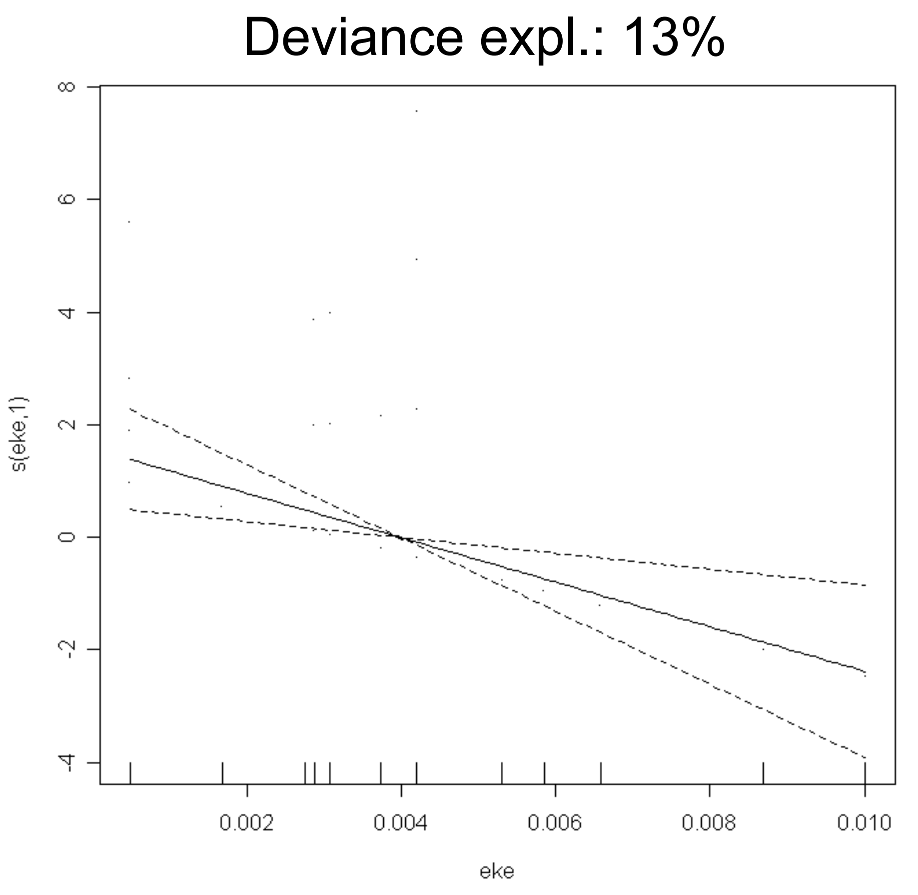


Results: GAMs with remote sensing variables

Model	*df*	*% deviance expl.*	*AIC*	*GCV.UBRE*
NBF ~ s(gmSLA)	2	8.97E-008	193.07	1.01
NBF ~ s(SLA, k = 10)	2	0	193.06	1.02
NBF ~ s(sdSST)	2.01	0	193.03	1.01
NBF ~ s(gsdSST)	2	0	192.79	1.02
NBF ~ s(gradSLA)	2	0.04	189.83	1.01
NBF ~ te(SLA, gradSLA)	7.74	0.22	188.53	1.04
NBF ~ te(mSLA, gsdSLA, k = 10)	4.67	0.13	188.06	1.04
NBF ~ s(sdSLA)	3.34	0.11	187.57	1.02
NBF ~ s(mSST)	2	0.08	187.24	1.01
NBF ~ s(mSST)	2	0.08	187.24	1.01
NBF ~ s(gmSST)	2	0.07	187.22	1.01
NBF ~ te(mSLA, gmSLA)	4.39	0.13	186.93	1.04
NBF ~ te(mSLA, mgSLA)	6.09	0.18	186.91	1.03
NBF ~ s(mgSLA)	3.81	0.13	186.55	1.03
NBF ~ te(mSLA, sdSLA, k = 10)	4.77	0.16	186.18	1.04
NBF ~ te(SLA, eke)	4	0.15	185.23	1.02
NBF ~ s(gsdSLA)	2	0.1	185.08	1.01
NBF ~ s(SLA) + s(mSLA) + s(gradSLA) + s(sdSLA) + s(mgSLA) + s(mSST) + s(sdSST) + s(gmSST)	11.9	0.32	185.08	1.02
NBF ~ s(mSLA)	3.07	0.13	184.44	1.03
NBF ~ s(SLA) + s(mSLA) + s(gradSLA) + s(sdSLA) + s(mgSLA) + s(eke) + s(mSST) + s(gmSST) + te(SLA, gradSLA)	11.45	0.33	182.85	0.99
NBF ~ s(eke)	**2**	**0.13**	**182.73**	**1.02**
NBF ~ s(mSLA) + s(gmSST) + te(SLA, gradSLA)	10.8	0.33	181.3	0.91
NBF ~ s(SLA) + s(mSLA) + s(gradSLA) + s(sdSLA) + s(mgSLA) + s(mSST) + s(gmSST) + te(SLA, gradSLA)	10.08	0.33	181.03	0.99
NBF ~ s(SLA) + s(mSLA) + s(gradSLA) + s(sdSLA) + s(gmSST) + te(SLA, gradSLA)	12.25	0.36	179.34	0.85
NBF ~ s(SLA) + s(mSLA) + s(gradSLA) + s(sdSLA) + s(mSST) + s(gmSST) + te(SLA, gradSLA)	9.14	0.33	179.2	0.98
NBF ~ s(SLA) + s(mSLA) + s(gmSST) + te(SLA, gradSLA)	11.53	0.36	177.88	0.87
NBF ~ s(SLA) + s(mSLA) + s(gradSLA) + s(gmSST) + te(SLA, gradSLA)	6.39	0.29	177.47	1.03

Results: GAMs with remote sensing variables

- Under anticyclonic conditions, large pelagics density higher in weak geostrophic currents areas (convergence)
- Remote-sensing variables non significant when added into GAM with in-situ variables



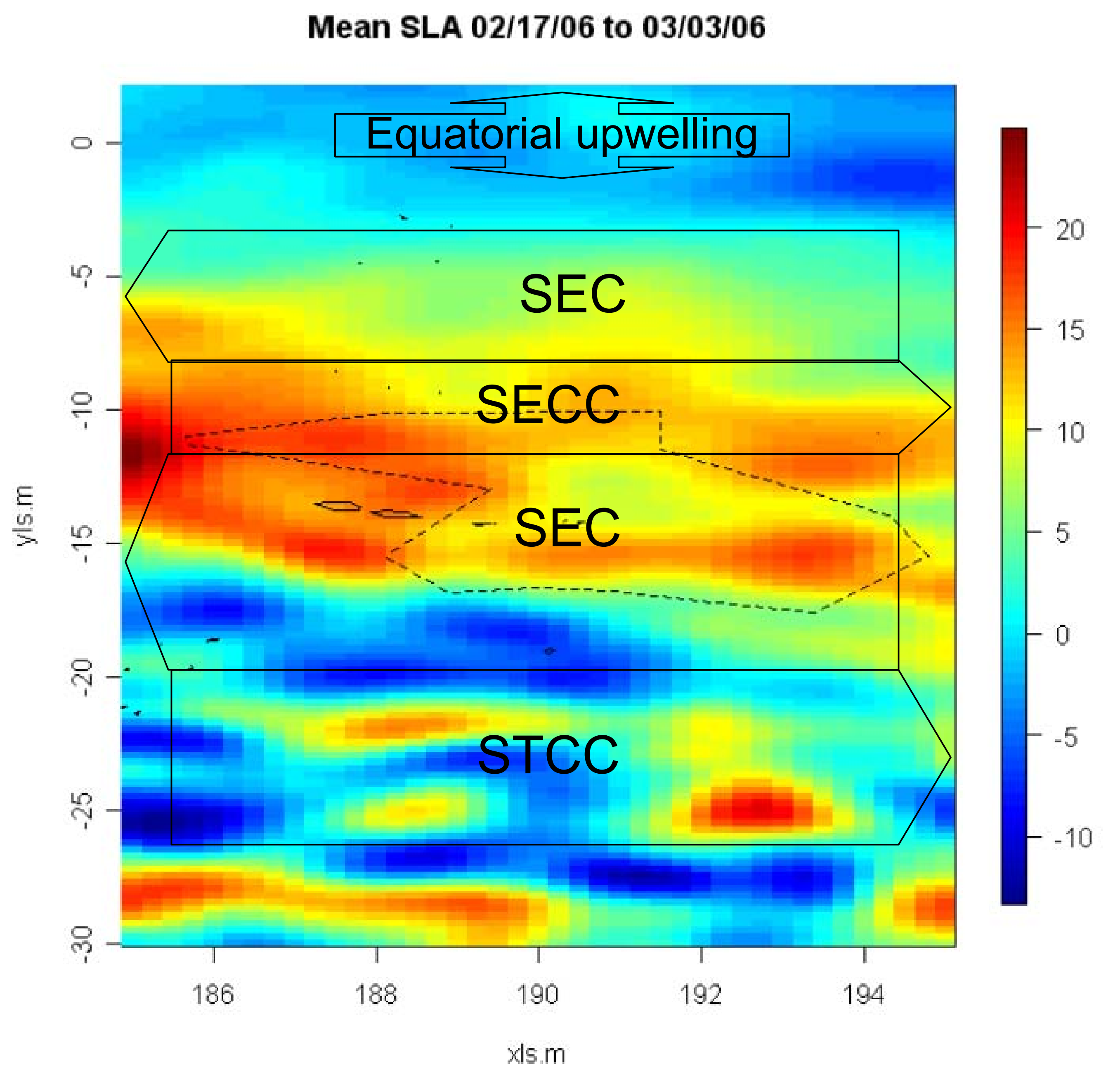
Discussion and Conclusions (1)

- Acoustic sampling
  - → *Acoustics allows for the study of deep scattered large pelagics and their preys*
  - → *Target identification?*
- Data processing
  - → *PCs useful to represent environment vertical structure*
  - → *GAM convenient tool to quantitatively explore and compare influences of environmental covariates*
- Best in-situ model explain 2 times more variance than best remote-sensing model (61% vs 29%) and are more significant
  - → *Remote sensing data limited to surface layer and lower trophic levels*
  - → *Valuable data to describe the SLA landscape in which biological production occurs*

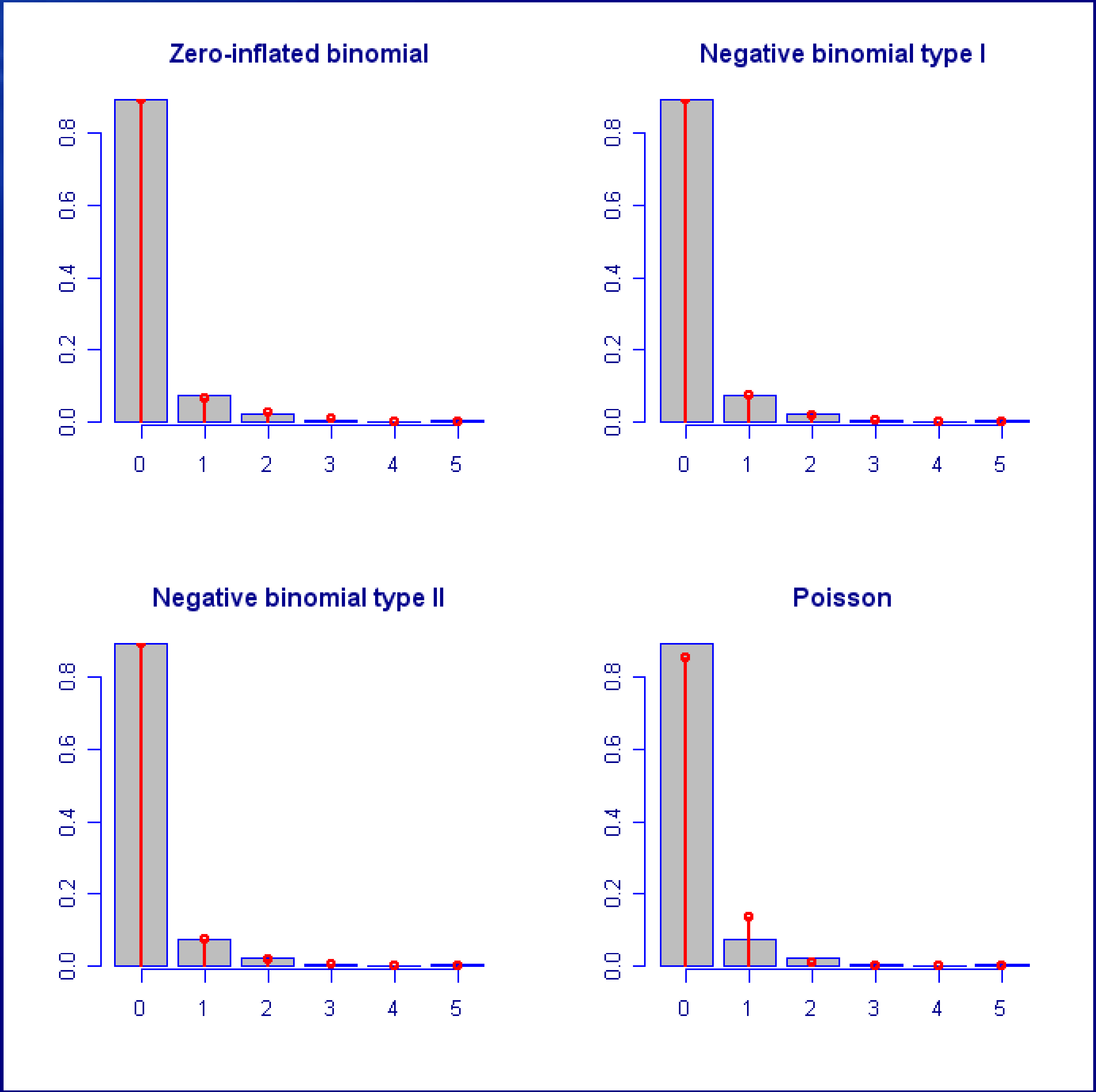
Discussion and Conclusions (2)

- Micronekton density
  - → *Explains highest amount of variability*
  - → *Proven positive correlation with big fish abundance at mesoscale*
  - → *Need for a network of instrumented buoys for continuous SSLs sampling*
- Hydrology
  - → *Explains as much variance as SSL density*
  - → *Hydrological conditions not limitant for tuna -> water masses of different origins?*
- SLA
  - → *Highest tuna and micronekton densities in weak geostrophic current areas -> convergence?*

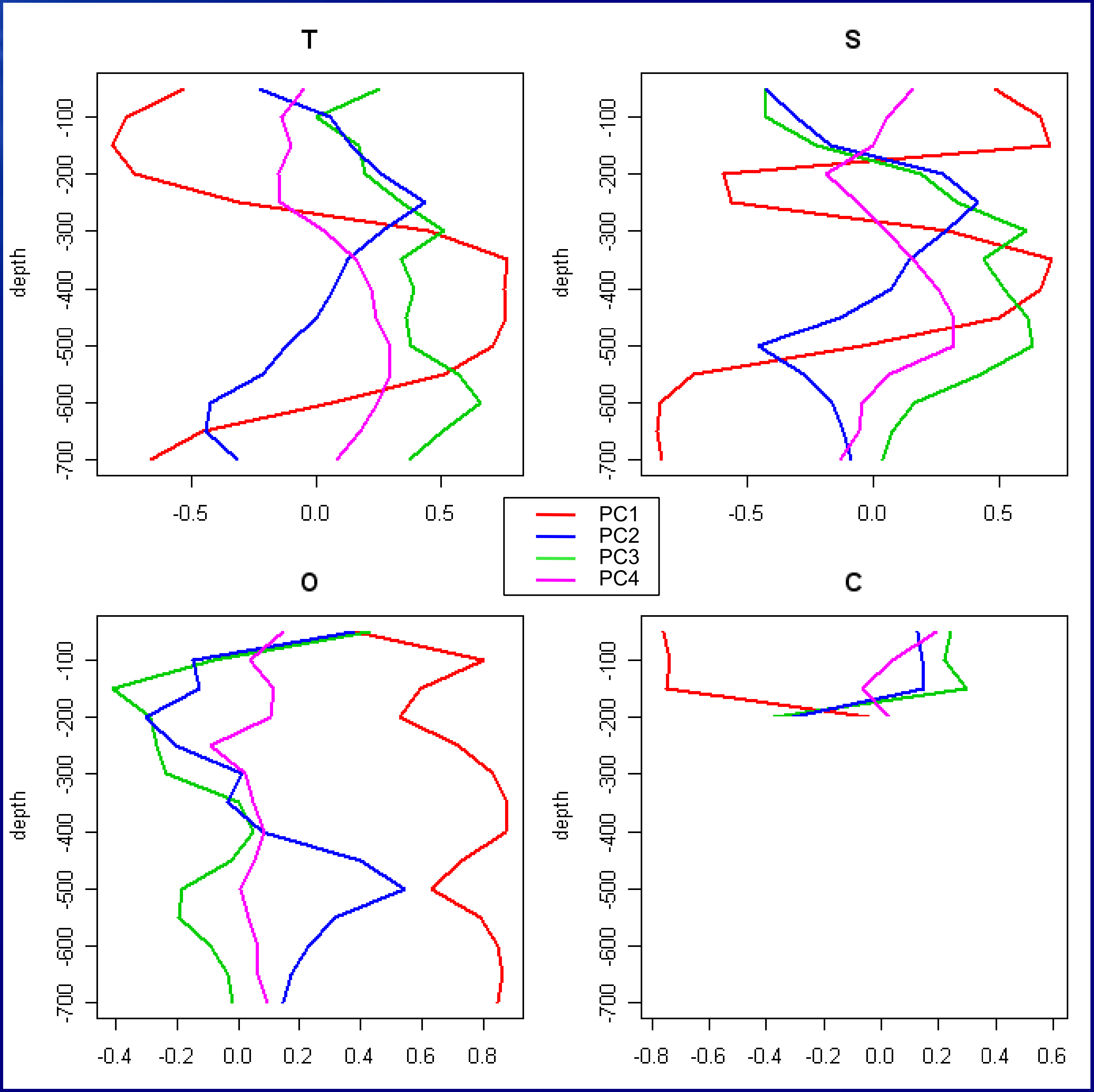
Regional oceanography



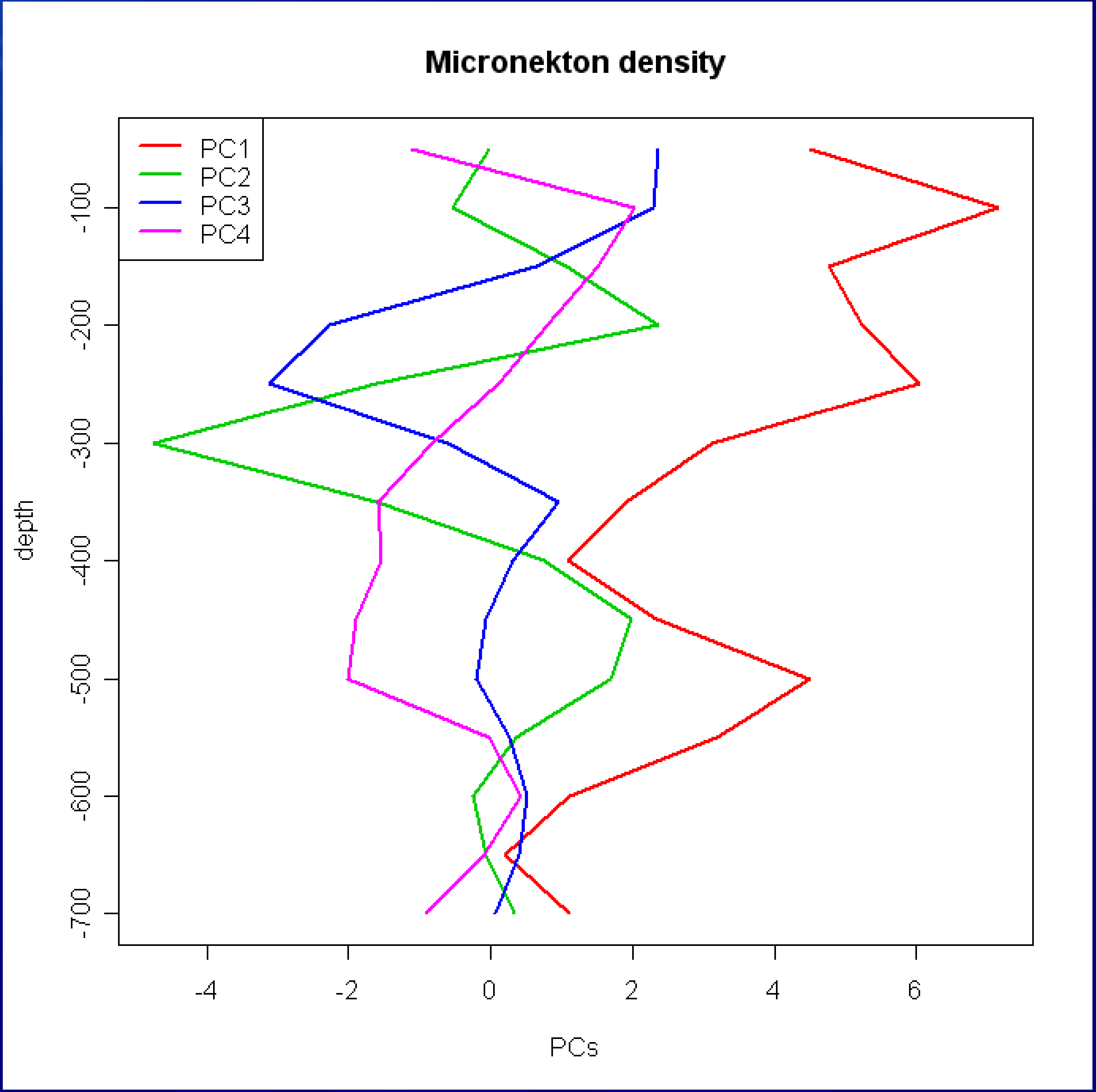
Family selection



Results: PCA on CTD



Results: PCA on SSLs



Results: big fish targets distribution