Investigating the spatial distribution of European anchovy *Engraulis encrasicolus* using GAMs and GIS

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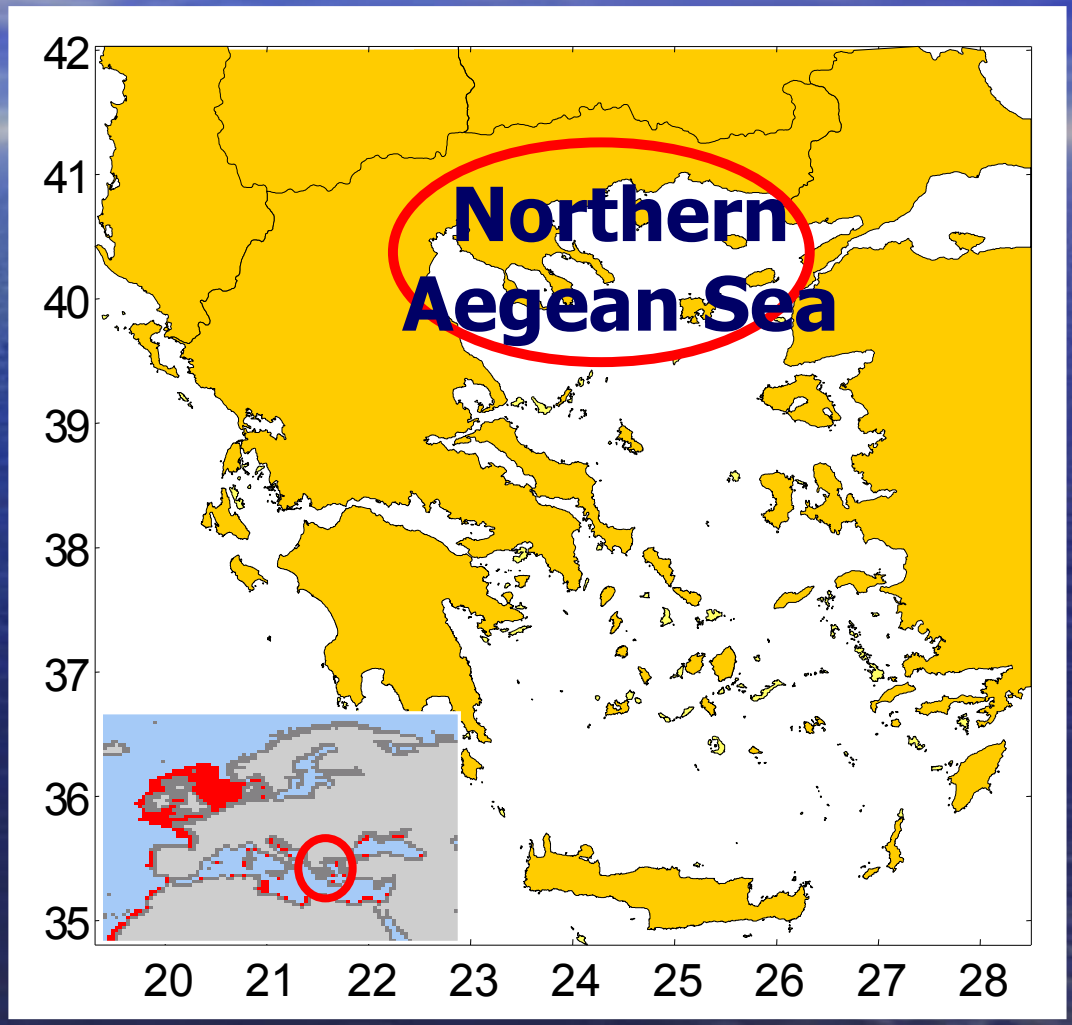
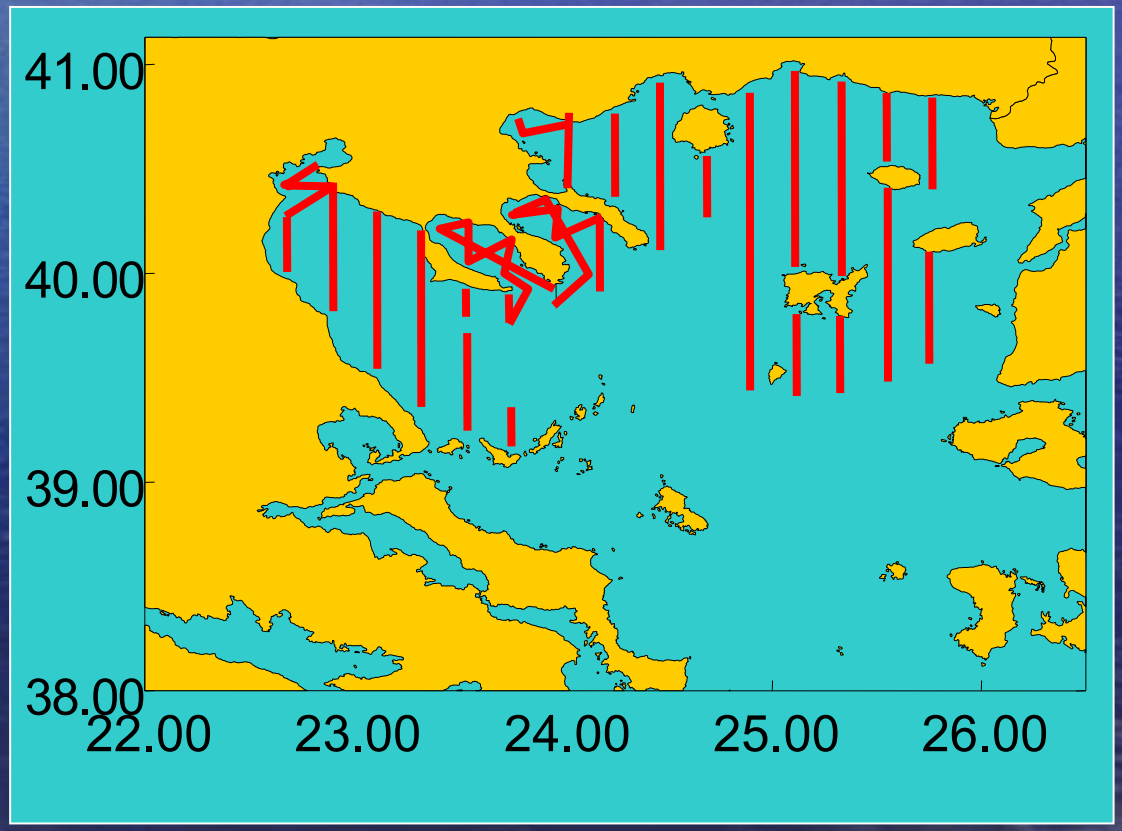
Aim:

Acoustic survey data were combined with hydrological parameters to investigate the relationships between the spatial distribution of European anchovy (*Engraulis encrasicolus*) and environmental regimes in the Northern Aegean Sea (Eastern Mediterranean basin).



Data on *Engraulis encrasicolus* abundance were collected by a Biosonic Split Beam 38 kHz echosounder

Acoustic sampling was carried out once, in June 2004, during the spawning period of anchovy, along 48 predetermined acoustic transects



Information on environmental data derived from satellite imagery, using GIS procedures

- sea surface temperature SST (°C),
- Chl-a (mg/m³) &
- minimum distance from mesoscale thermal fronts (m)

How are they computed:

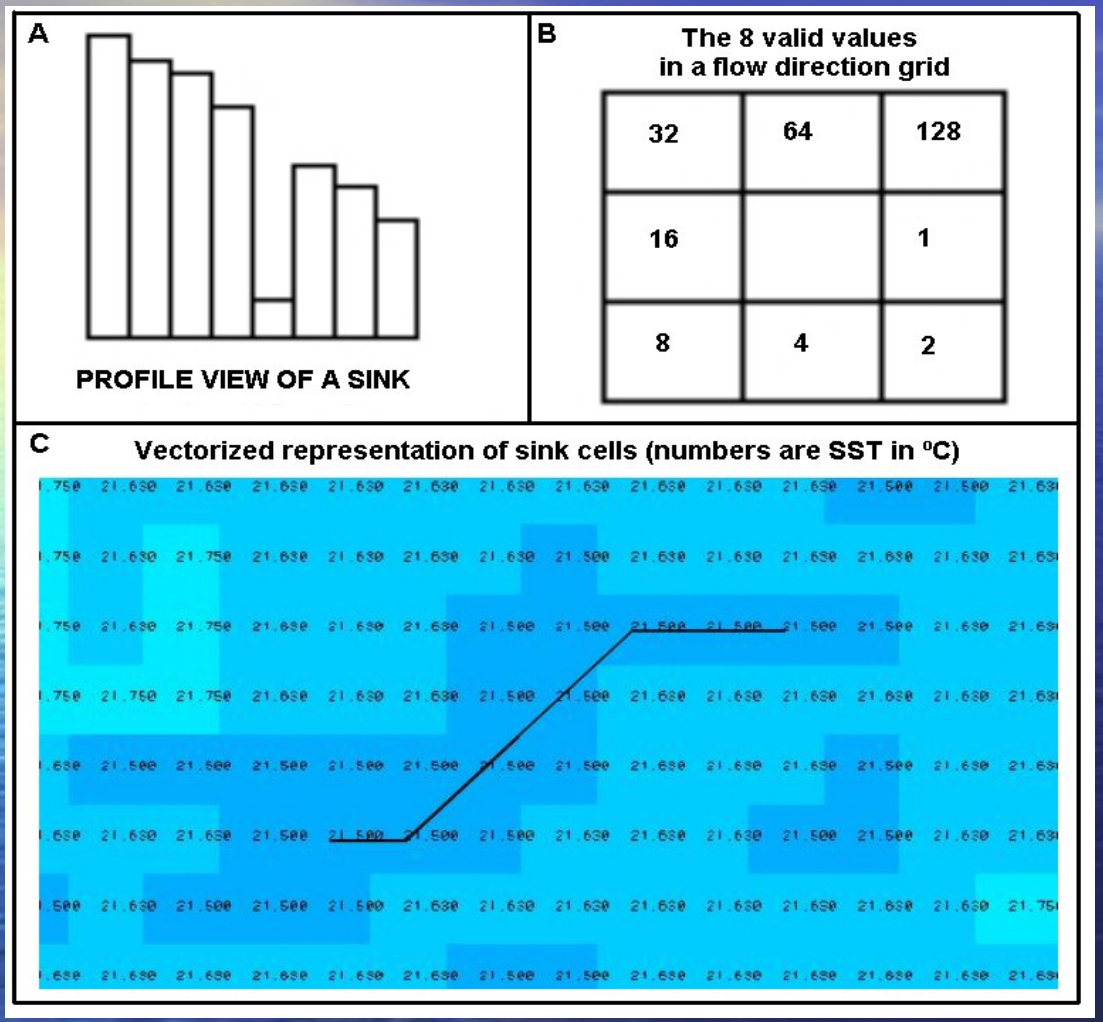
1. Initial data: AVHRR SST and SeaWiFS Chl-a imagery

2. Production of climatology for SST and Chl-a

In addition,

- bottom depth (m)

Mesoscale Thermal Fronts

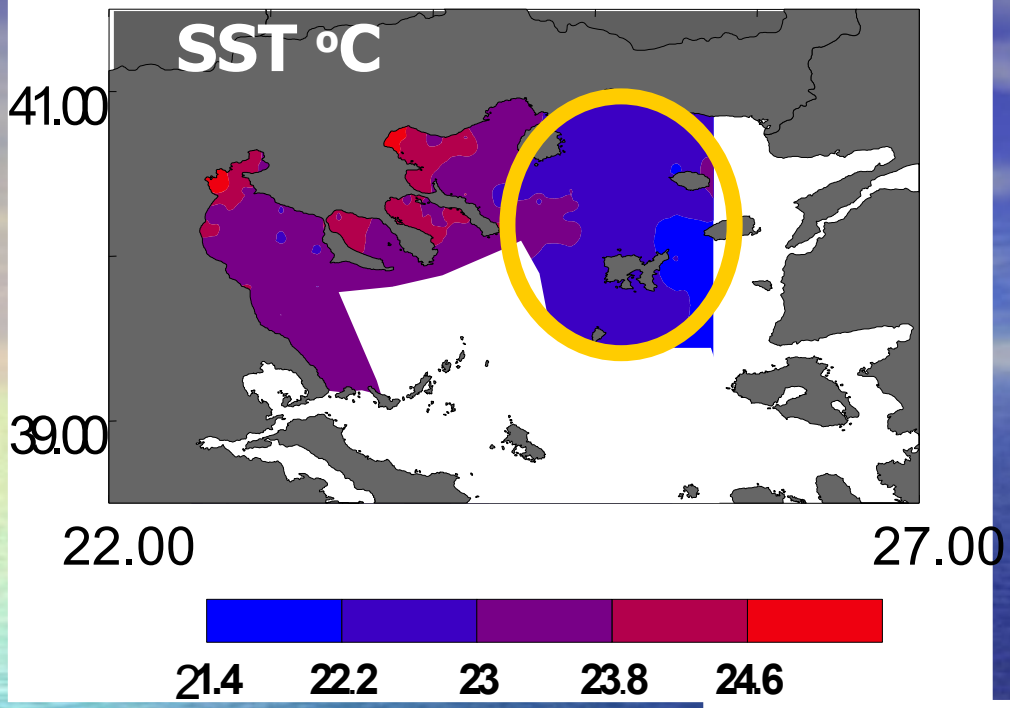


How are they computed:

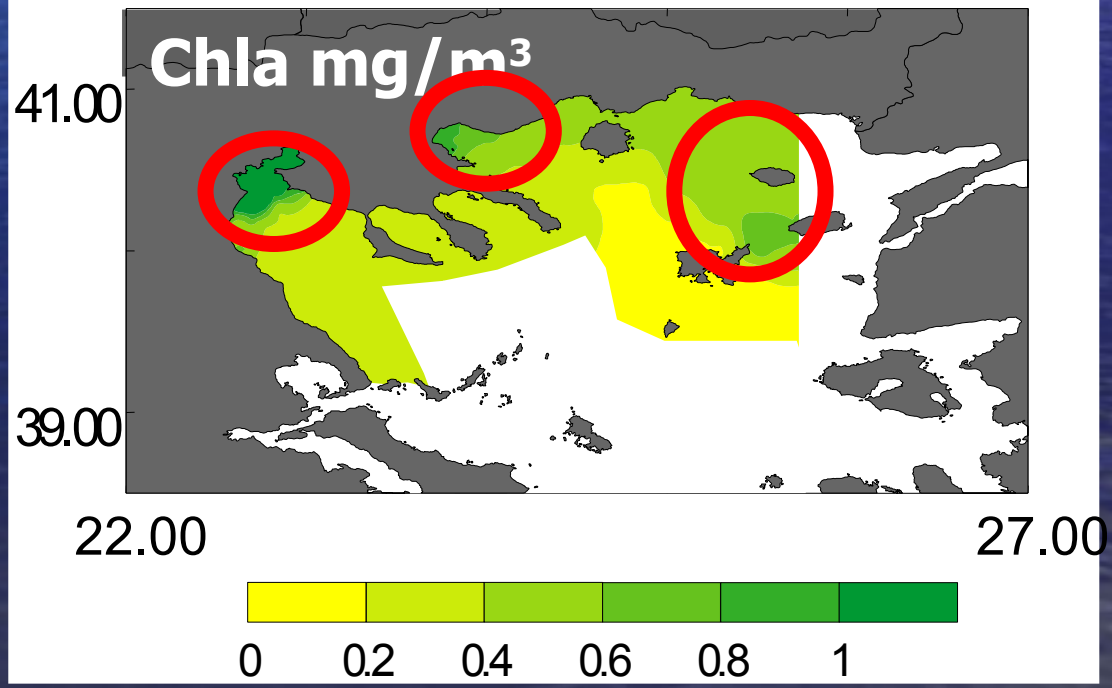
Spatially connected data sinks with simultaneous DSST < 0 and DCHL > 0 patterns are mapped as mesoscale thermal fronts

REFERENCE:

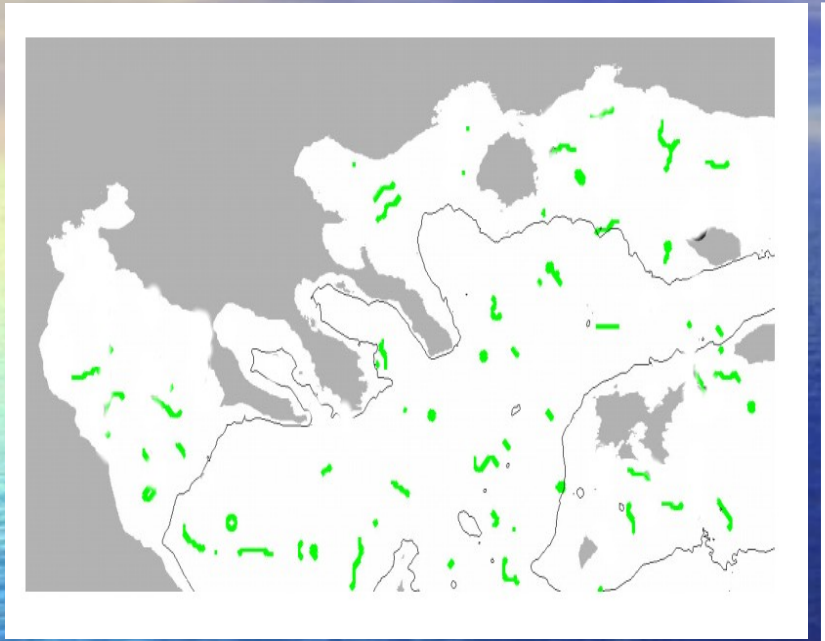
Valavanis VD, Katara I, Palialexis A (2005). Identification of mesoscale thermal fronts using satellite imagery and GIS. *International Journal of Geographical Information Science* **19(8):**in press

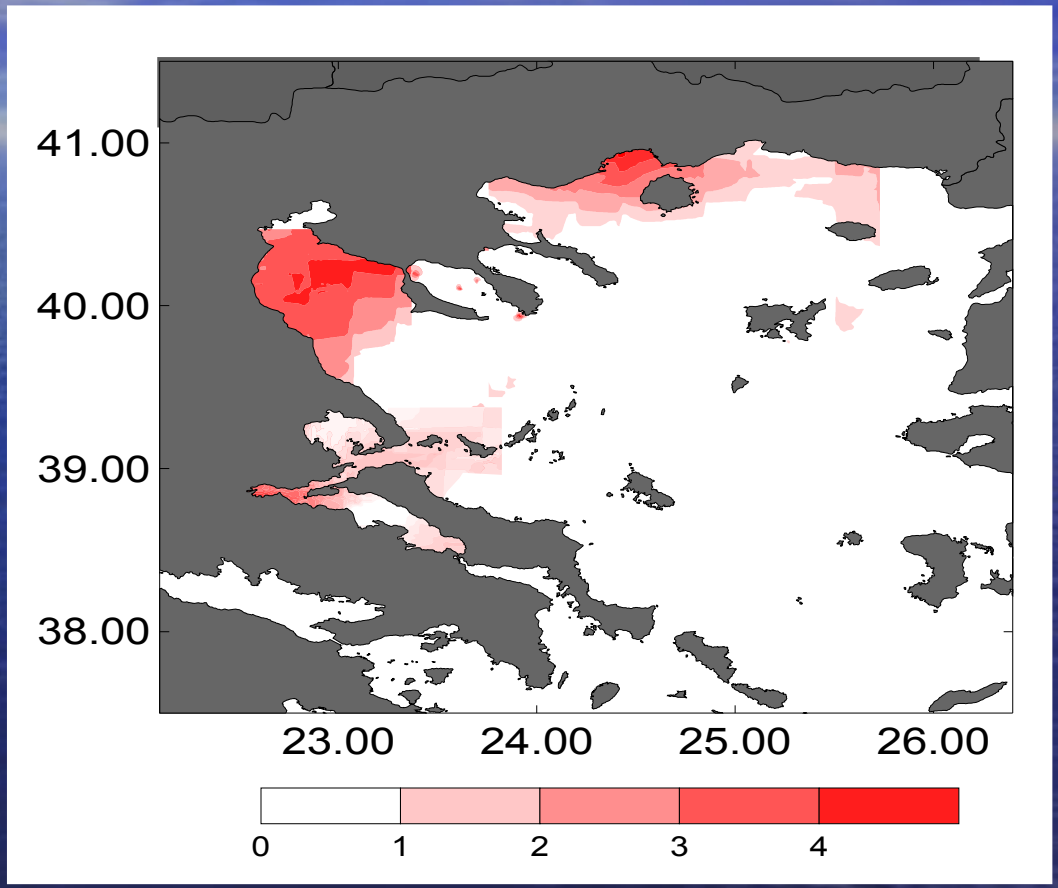


Environmental parameters distribution



Anchovy echo (NASC in $m^2/n.mi.^2$) distribution in relation to mesoscale thermal fronts





The presence of mesoscale thermal fronts is indicated with green. The isobath of -200m is also shown.

- Generalized Additive Models (GAMs) were applied in a two stage modeling approach to analyze trends in anchovy presence and its distributional abundance

GAMs were applied in two areas which are characterized by different oceanographic regimes :

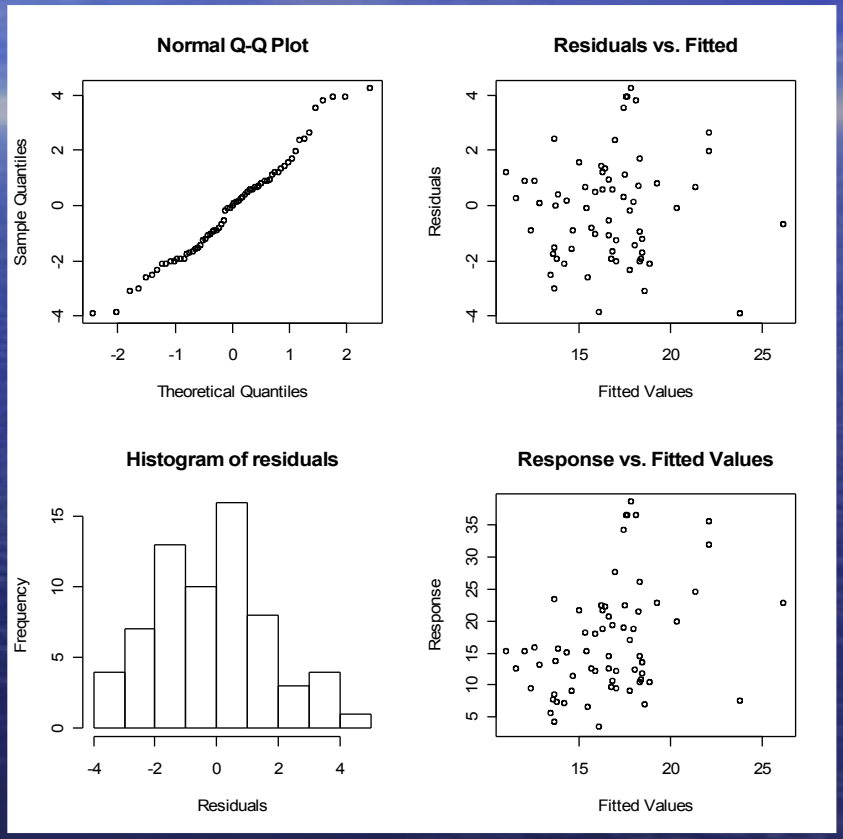
- **Thracian Sea &**
- **Thermaikos Gulf**

Two stage modeling involved:

1. Presence/absence data

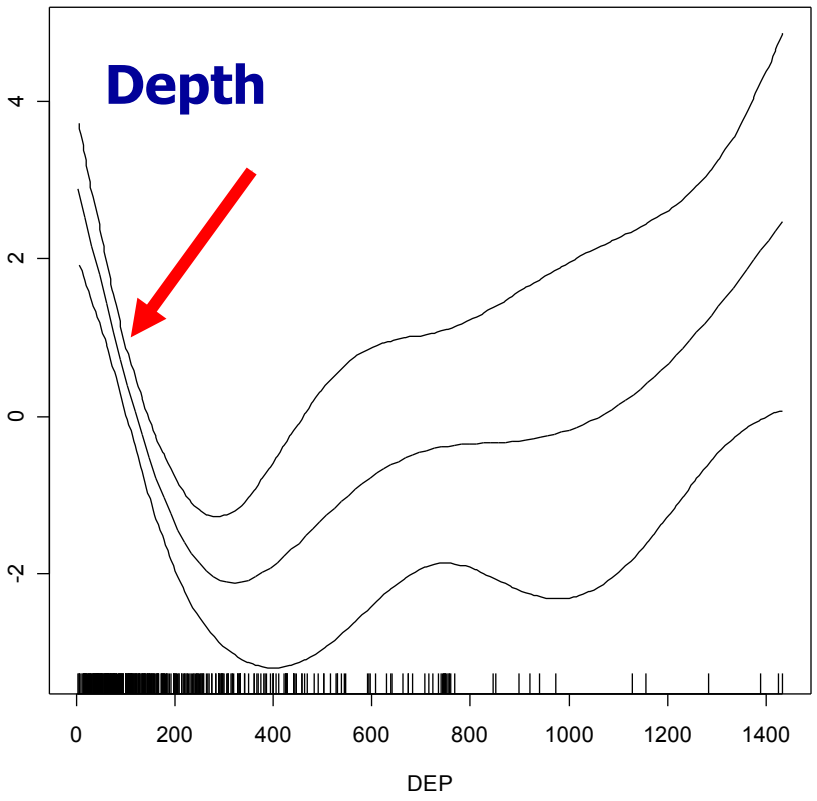
2. Given presence

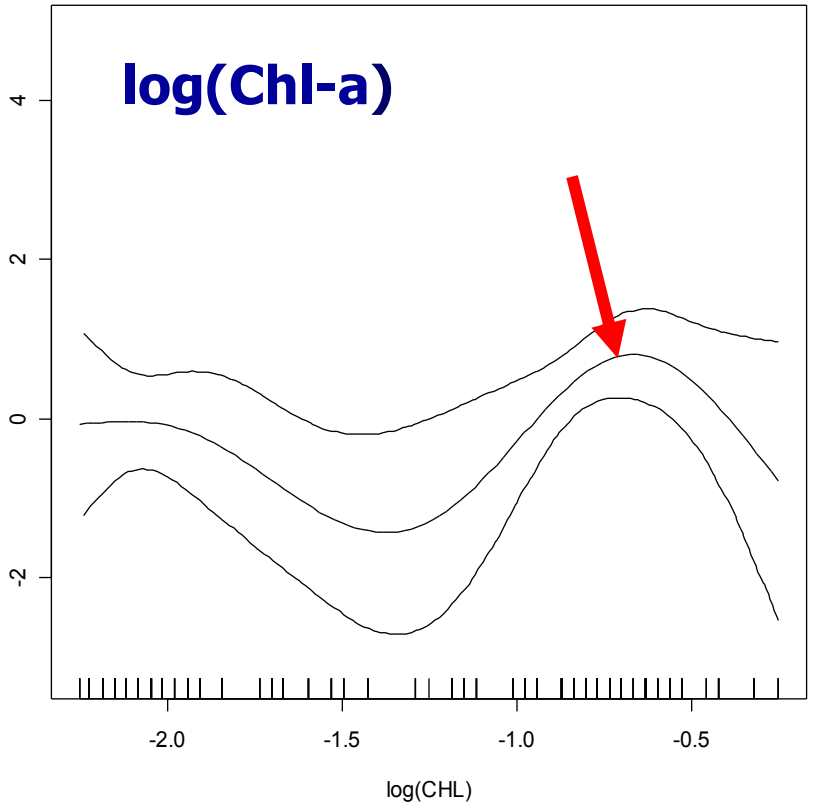
- Choice of degree of smoothness (Df) was based on Un-biased Risk Estimator (UBRE) (Wahba 1990; Wood & Augustin, 2002)
- Model selection was based on: the minimization of the UBRE criterion in the basis of a general backwards selection method (Wood & Augustin, 2002)
- A poisson error distribution was chosen as appropriate for the given presence data. Inspection of the residual plots indicated a mean variance problem that was largely eliminated by raising the data to the power of 0.4 (Wood & Augustin, 2002)
- All first order interactions were examined, but based on the model selection procedure were not selected in the final model
- Pseudo-coefficient of residual determination was estimated (Swartzman et al., 1992)



Thracian Sea (presence/absence)

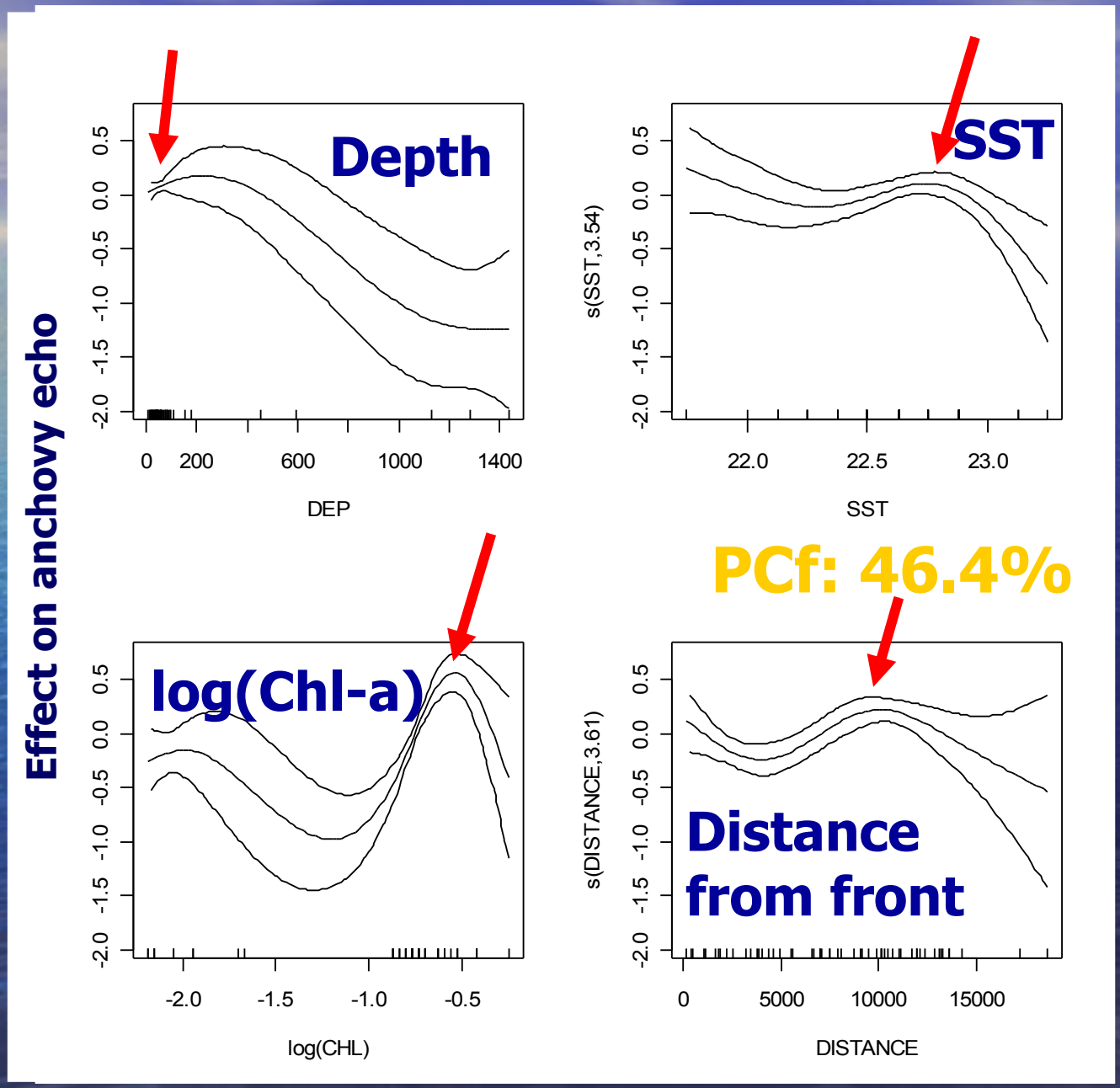
Effect on anchovy echo





PCf: 30.6%

Thracian Sea (given presence)



Results: Thracian Sea

Thracian Sea is an area dominated by permanent hydrographic features such as anticyclones and fronts.

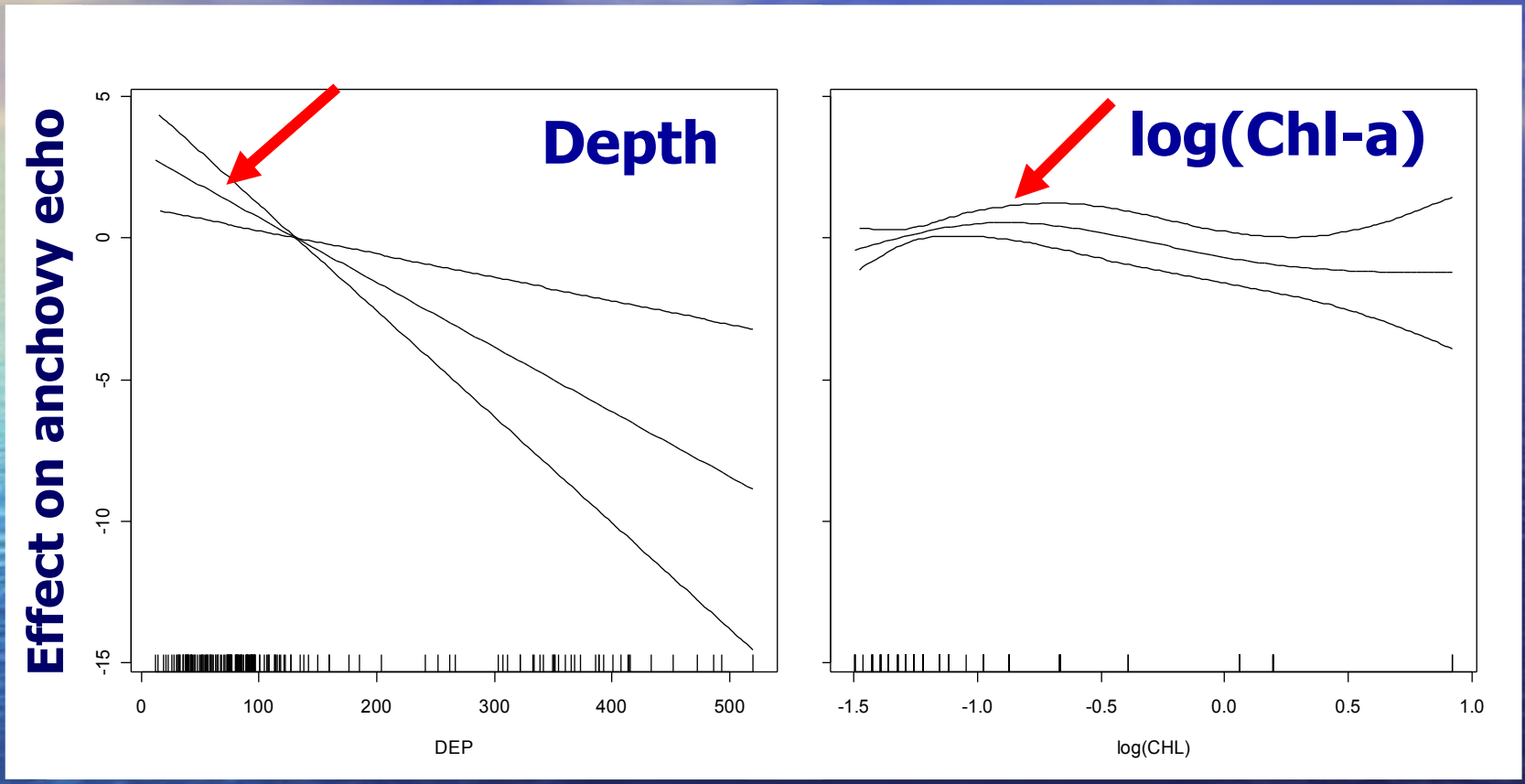
There was a higher probability of finding anchovy present:

- **within the continental shelf (depths <200m)**
- **and in areas dominated by chlorophyll-a concentrations around 0.45 mg/m^3**

Anchovy abundance was on average higher:

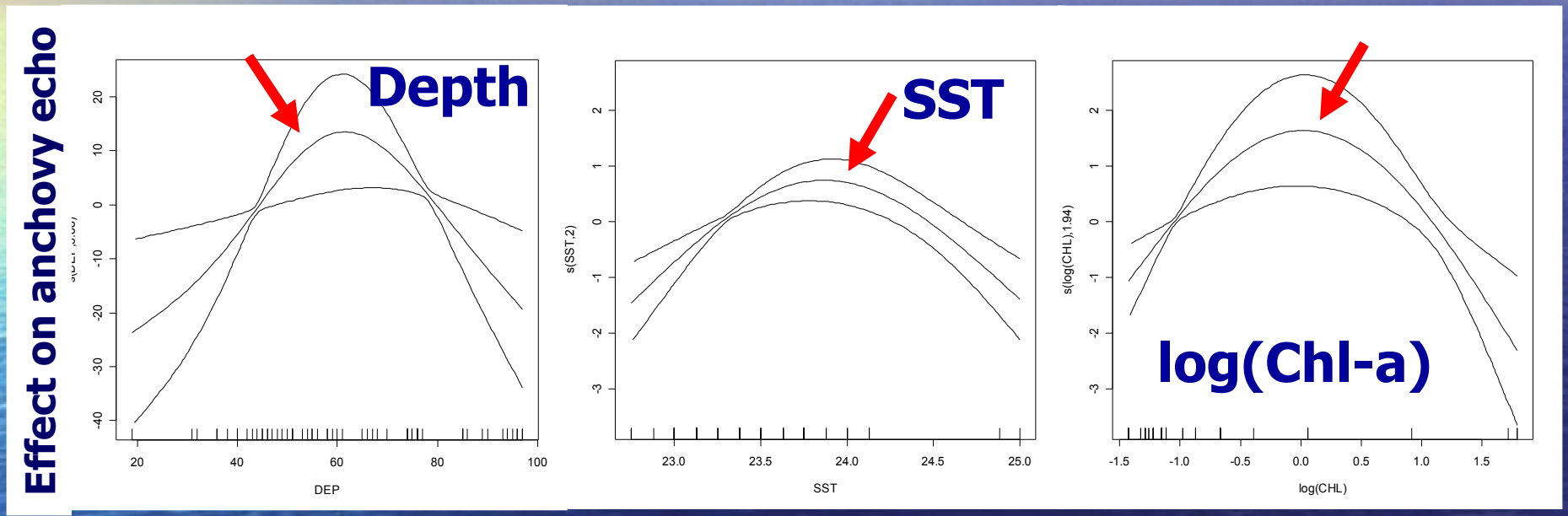
- **in water depths <200m,**
- **SST values around 22.75 ^{o}C,**
- **chlorophyll-a concentration around 0.58 mg/m^3 and**
- **around 10 km (or 5.55 nautical miles) minimum distance from existing thermal fronts**

Thermaikos gulf (presence/absence data)



PCf: 20.8%

Thermaikos gulf (given presence data)



PCf: 14.4%

Results: Thermaikos gulf

Thermaikos gulf is an area dominated by shallow waters and an extended continental shelf.

There was a higher probability of finding anchovy present in:

- shallow waters (depths <100m),
- dominated by chlorophyll-a concentration similar to Thracian Sea (around 0.45 mg/m^3)

Anchovy abundance was on average higher in:

- bottom depth around 60m and
- chlorophyll-a concentration around 1.00 mg/m^3
- SST around 23.75 ^oC

So,

It is known that

- June is the spawning period for anchovy in the study area,
- anchovy spawning grounds are generally associated with areas of high productivity and conditions favorable of anchovy feeding (e.g. riverine outflows, upwelling areas and fronts, Somarakis et al., 2004)

Generally, in both areas

- there was a high probability of anchovy to be present :
  - in shallow waters (<200m) and
  - in chlorophyll-a concentration around 0.45 mg/m^3
- Anchovy abundance was on average higher in chlorophyll-a concentration around 0.58 mg/m^3 (in Thracian Sea) & 1.00 mg/m^3 (in Thermaikos Gulf)

In addition

- The effect of the minimum distance from mesoscale thermal fronts was found significant in Thracian Sea, an area dominated by permanent hydrographic features such as anticyclones and fronts. Specifically, high anchovy echo abundance was estimated around 10 km (or 5.55 nautical miles) minimum distance from existing thermal fronts.

- the effect of SST seems to be related to anchovy association with fronts and more productive waters