Marine Copernicus' satellite derived data as a useful tool to establish the relationships between larval fish distribution and density and the oceanography of the Gulf of Mexico's deep-water region

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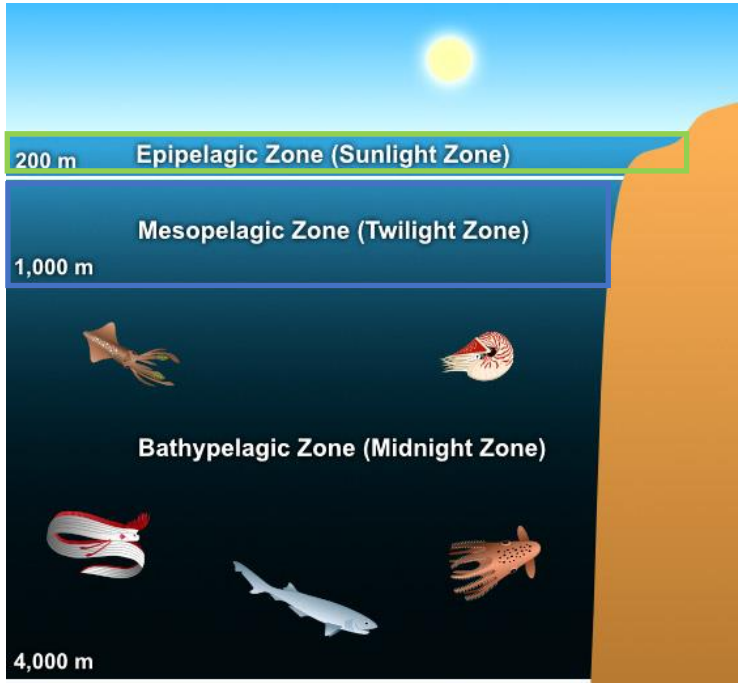
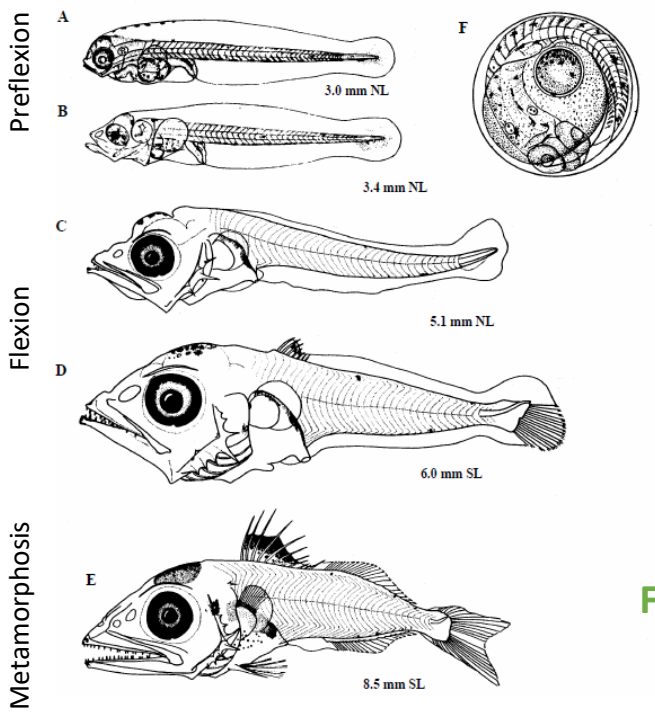
Marine fishes have complex life cycles in which each developmental stage may occupy habitat types with distinct environmental conditions

Epipelagic larvae (0-200 m) from coastal and neritic adults (within the continental shelf)
Oceanic epipelagic (0-200 m) or **mesopelagic (200 -1000 m)** from oceanic adults (beyond de continental shelf)



http://www.seasky.org/deep-sea/ocean-layers.html

Neritic or epipelagic
(shelf or Surface oceanic waters)



Auxis rochei rochei (Bullet tuna)

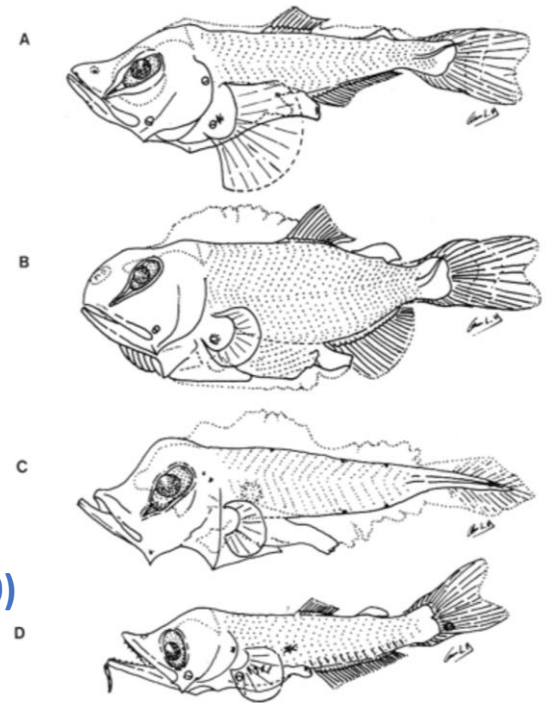
Reproduction
Seasonal Year round

Hatching
Surface At depth

Egg number
Many Few

Larval stage (days)
Fast (15-30) Slow (~50)

Mesopelagic
(oceanic Deep-waters)



Myctophum selenops (Lanternfish)

(Richards, 2006; Fahay, 2007)

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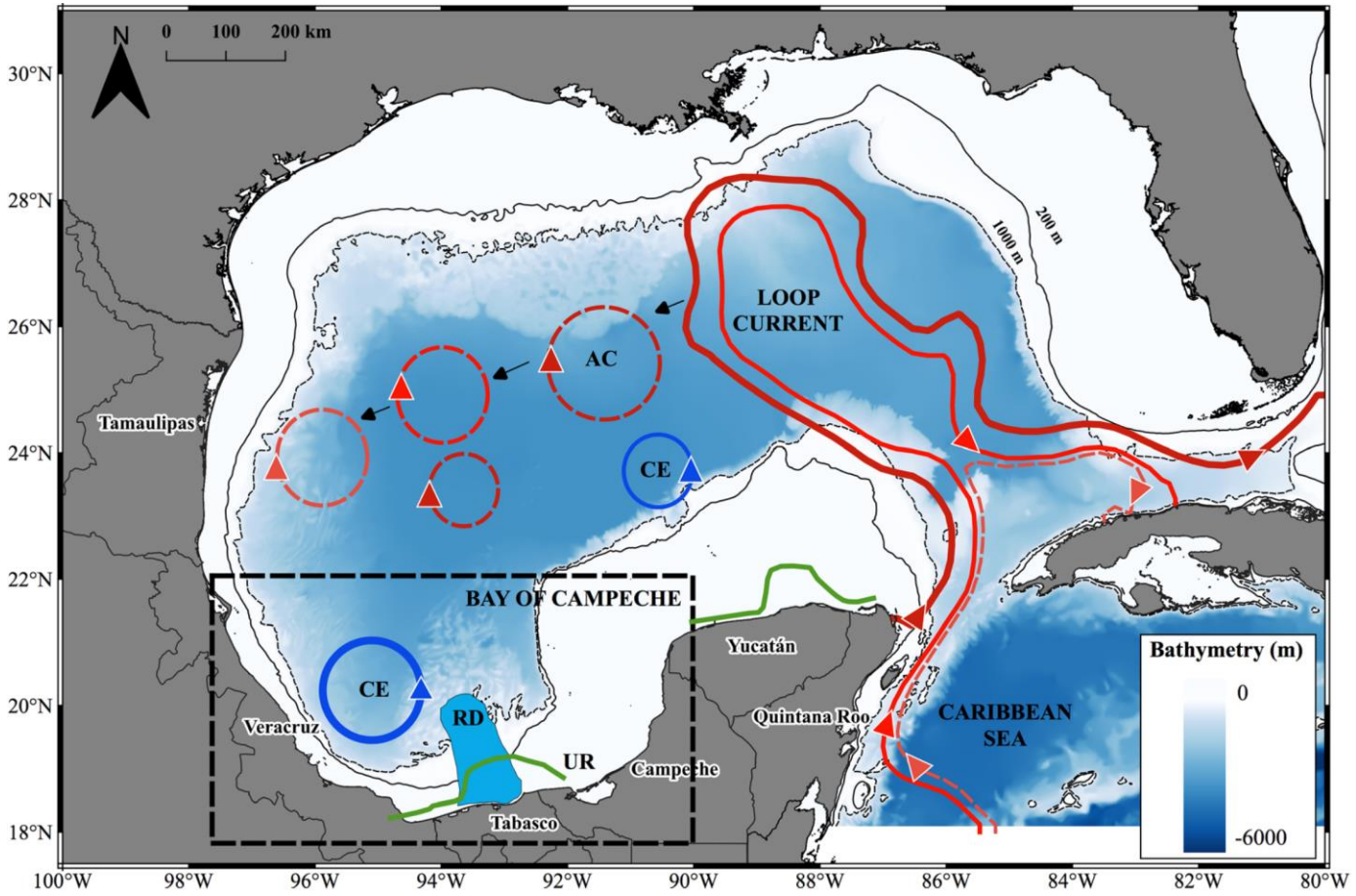
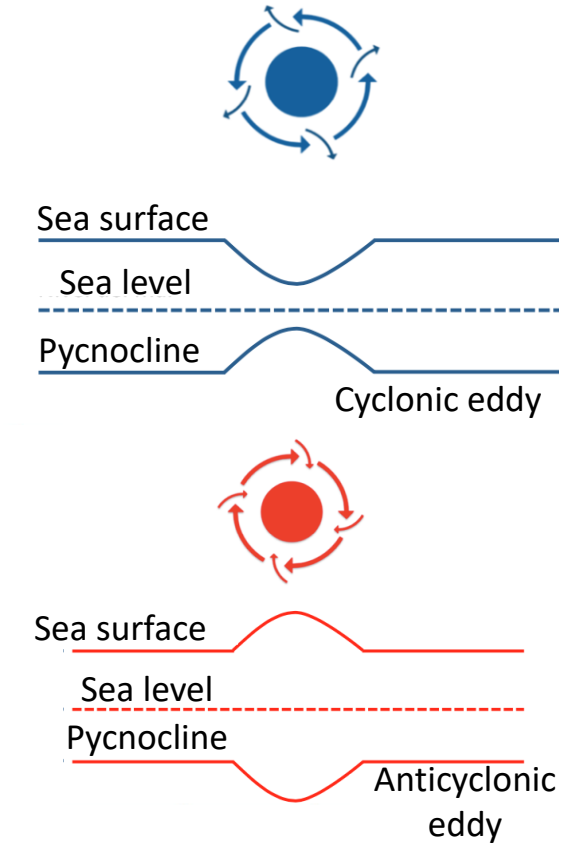
The GoM's circulation is strongly influenced by the Loop Current, mesoscale features, upwelling and offshore transport



(Echeverri-García et al., 2022)



Upwelling

Main river inflow(seasonal)

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Larval fish assemblages of myctophids in the deep water region of the southern Gulf of Mexico linked to oceanographic conditions

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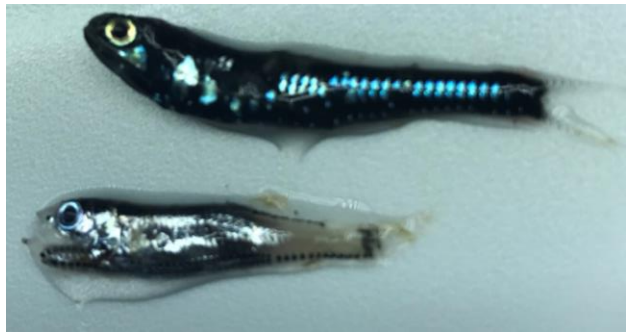

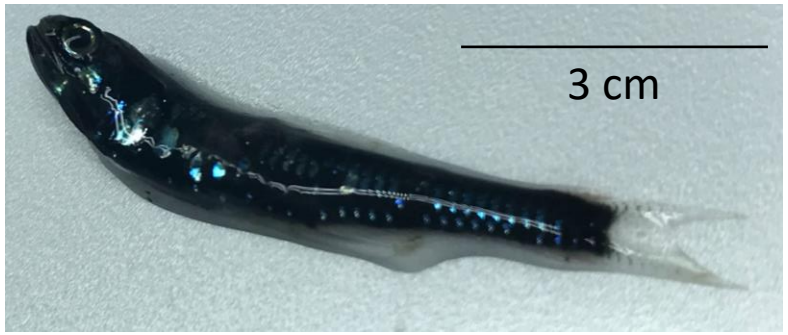

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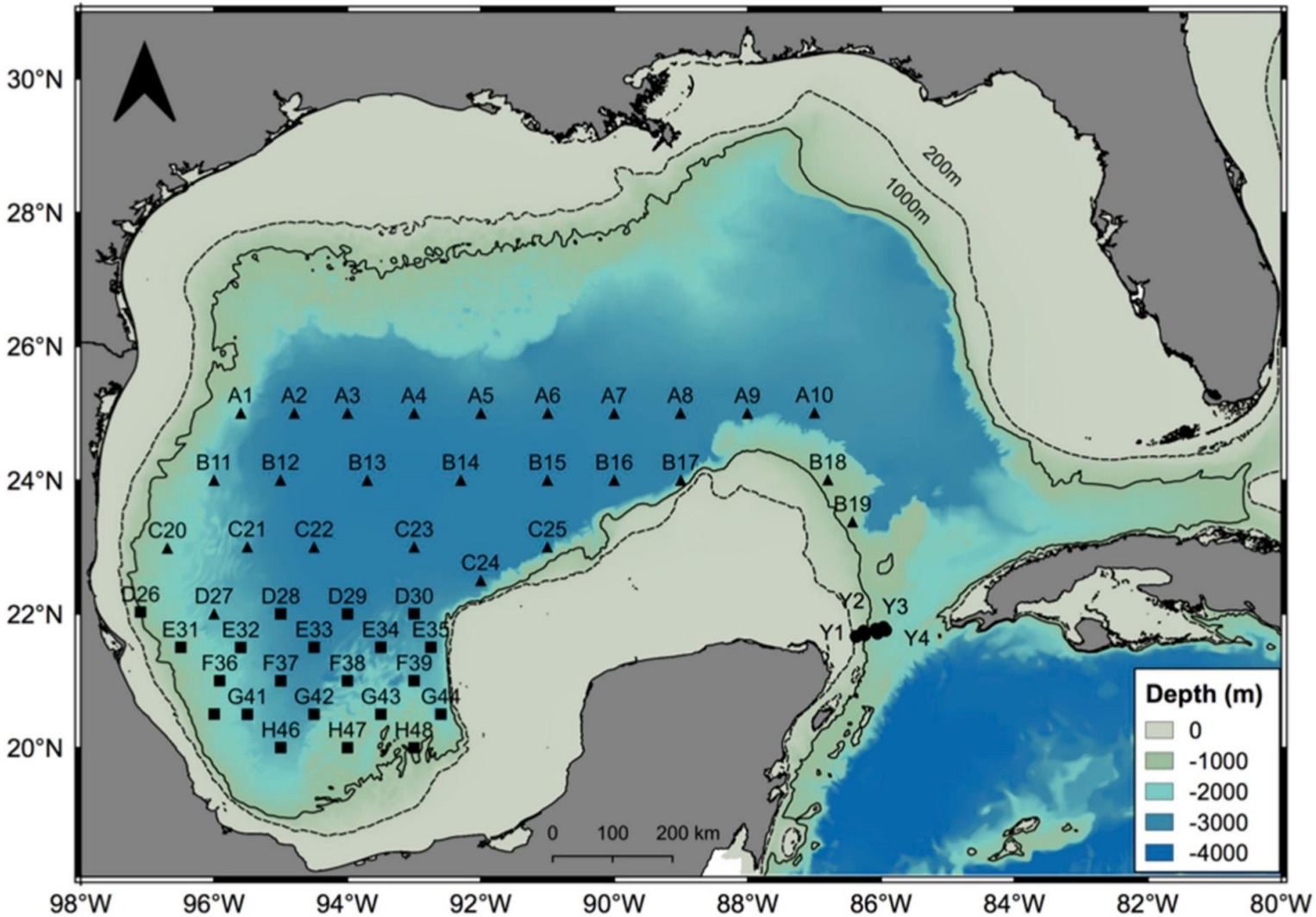
Larval fish assemblages are defined as a group of taxa present at a specific place and time
(Flores-Coto et al., 2009; Lindo-Atichati et al., 2012; Sanvicente-Añorve et al., 1998)

The aim was to characterize the structure of the Myctophidae family larval assemblages in the southern GoM relative to adult spawning and surface circulation

-**57 sampled stations** in GoM's Mexican Economic Exclusive Zone (EEZ)

-**Deep-water region** (depths > 1000 m)

-**August 27–September 16 of 2015** (XIXIMI-04)



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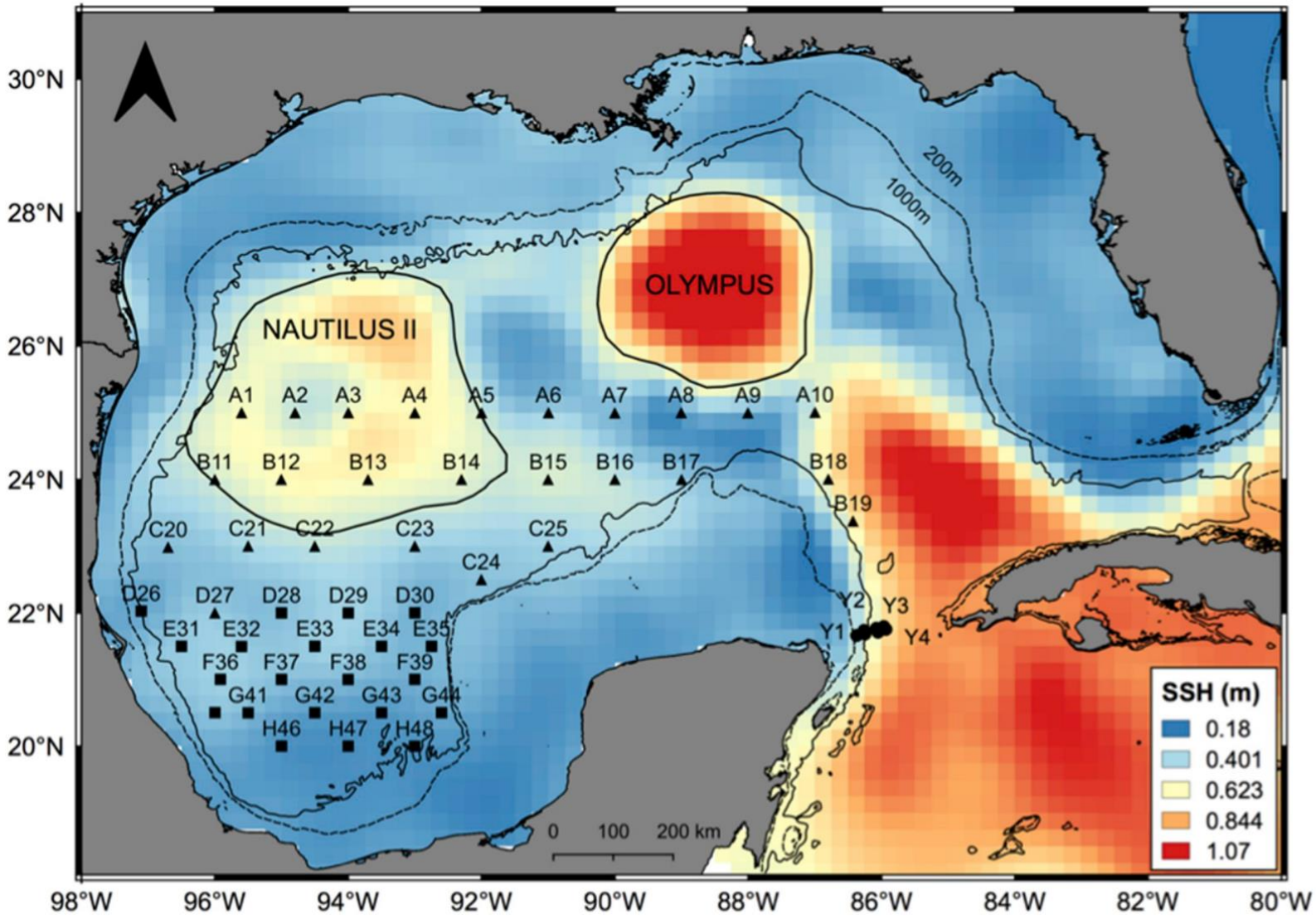
Sea Surface Height allowed to characterize mesoscale structures during the sampling period

-Olympus anticyclonic eddy recently detached from Loop Current

-Nautilus II anticyclonic eddy detached in May 2015



*also used Kinetic energy and sea Surface velocities (*u*, *v*) from HYCOM (HYbrid coordinate Ocean Model)

http://www.horizonmarine.com/loop-current-eddies.html

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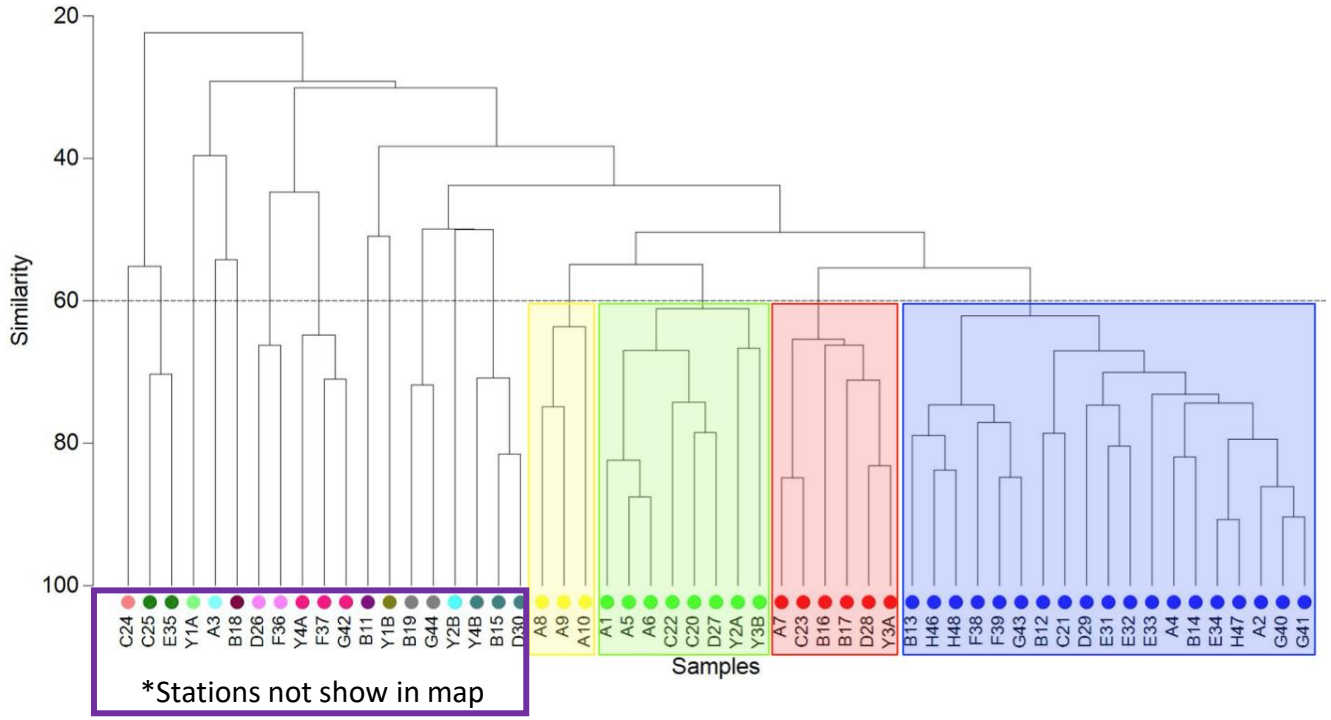
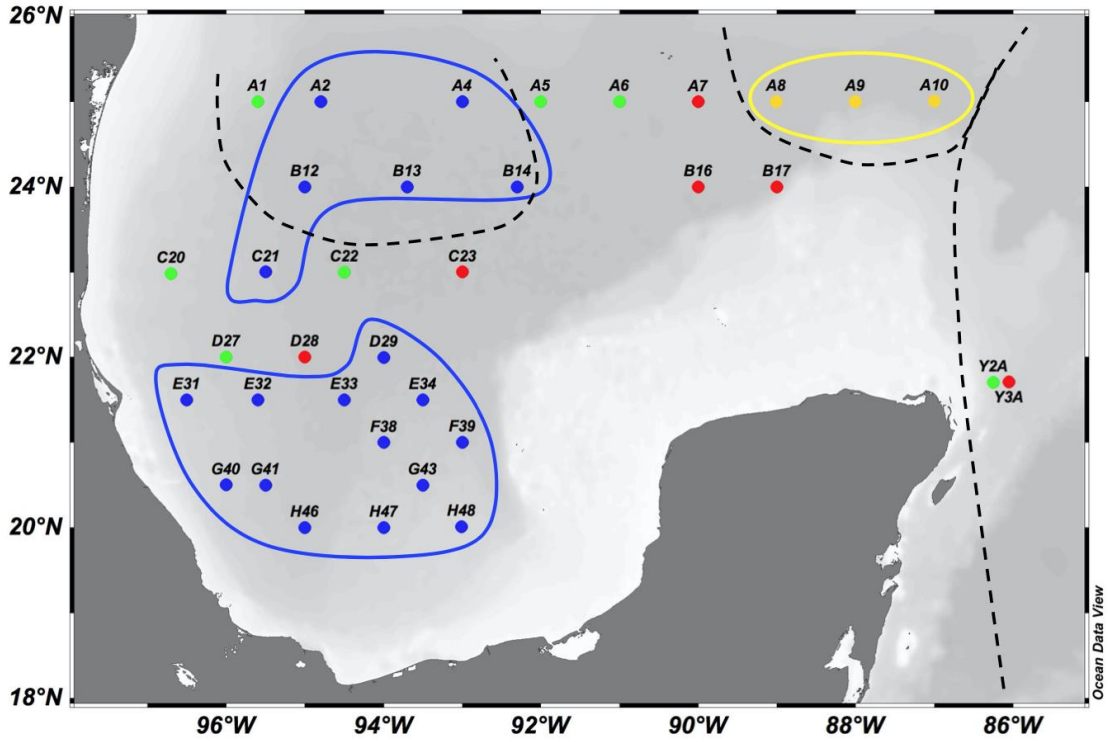
The lack of relationship with oceanographic variables (e.g. SSH) indicated that myctophid larval assemblages mainly depend on adult distribution and spawning areas

-Western gulf assemblage might indicate spawning grounds and seasonality of a similar adult community
-Loop Current assemblage due to high retention capacity of stations close to Olympus anticyclonic eddy
-Green and red assemblages dispersed along the deep water might reflect that myctophids are cosmopolitan

Clusters obtained from Bray-Curtis similarity matrix





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PLOS ONE

RESEARCH ARTICLE

Distribution and densities of fish larvae species with contrasting life histories as a function of oceanographic variables in the deep-water region of the southern Gulf of Mexico

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The aim was to describe the larval distribution and density relative to environmental conditions of species with contrasting life history strategies and adult habitats

-**12 cruises** in GoM's Mexican EEZ deep waters
-**Two seasons** according oceanographic variables:
  -Spring/Summer (April to July)
  -Late Summer/Autumn (August to October)

	Mean ± Std. Deviation	
	Season I (April-July)	Season II (August-October)
Wind speed (ms^{-1}) ($p < 0.001$)	4.70 ± 1.59	4.04 ± 1.46
Surface chl a ($mg\ m^{-3}$) ($p = 0.014$)	0.11 ± 0.04	0.09 ± 0.04
Mean salinity 0–200 m (psu) ($p = 0.002$)	36.56 ± 0.08	36.60 ± 0.08
SST (°C) ($p < 0.001$)	28.40 ± 0.95	30.03 ± 0.41
Stratification (J) ($p < 0.001$)	1537.24 ± 395.69	1784.35 ± 282.62
SSH (m) ($p < 0.001$)	0.35 ± 0.09	0.41 ± 0.11

Kruskal-Wallis test results are reported between parentheses. Variables with significant differences ($p < 0.05$) between seasons are in bold.

Selection according to ontogenic, commercial and economic importance

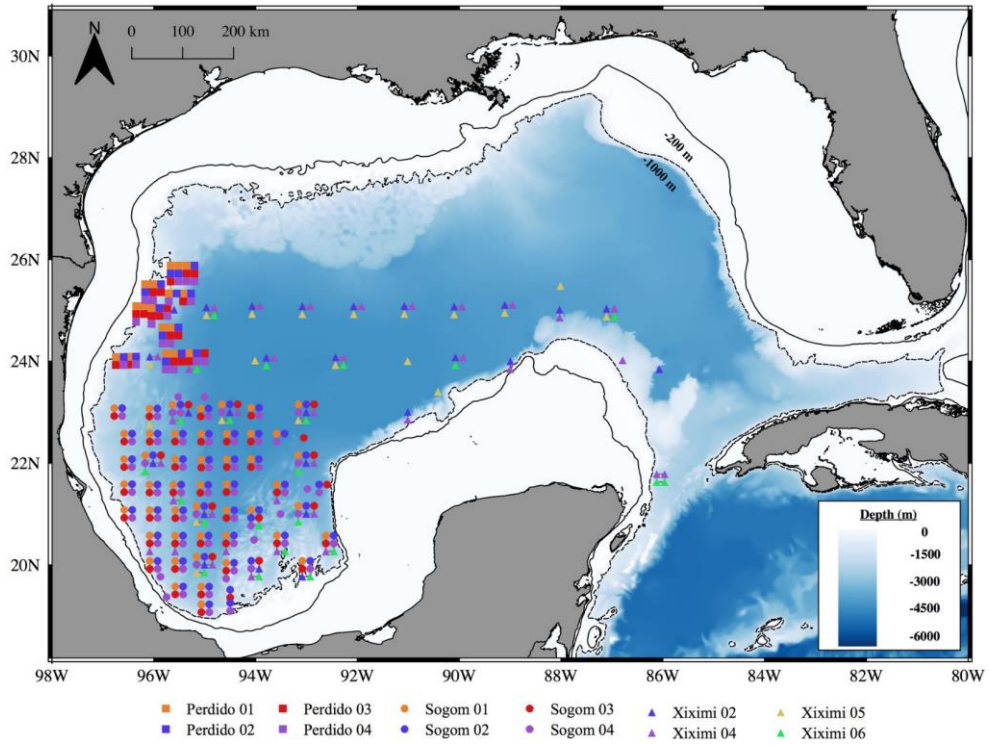
Blue runner (*Caranx crysos*)

Frigate and Bullet tuna (*Auxis* spp.)

Antenna codlets (*Bregmaceros atlanticus*)

Cigar fish (*Cubiceps pauciradiatus*)

Lantern fish (*Notolychnus valdiviae*)



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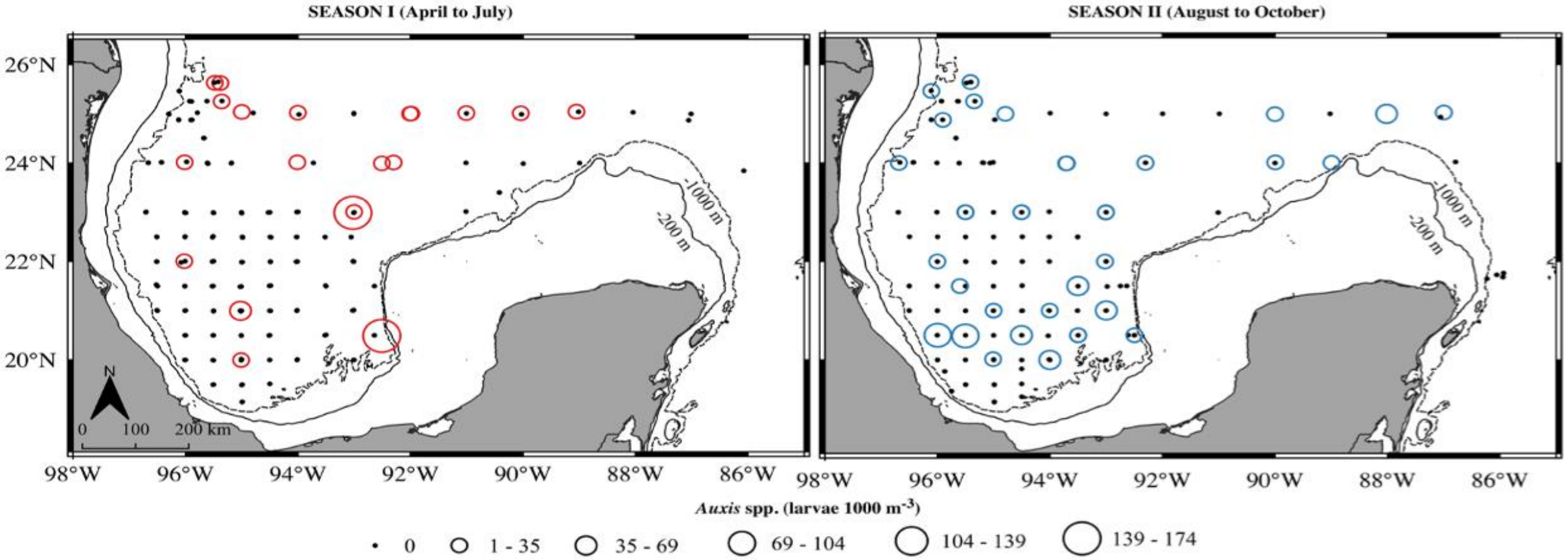
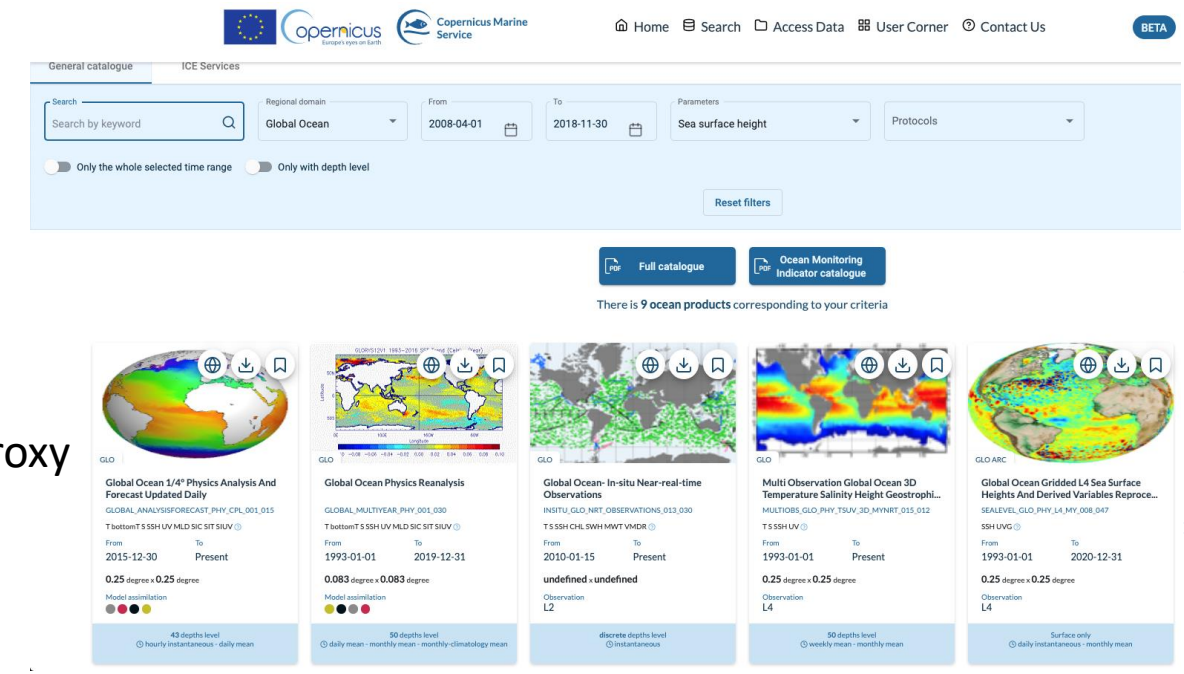
Frigate and Bullet tuna (*Auxis* spp.)



Stablish the relation between species' larval densities and oceanographic variables obtained from Copernicus Marine Service through Generalized Additive Models (GAMs)

Satellite (online)

- **Sea Surface Temperature** (^{o}C) <- Identify mesoscale structures
- **Sea Surface Height** (m) <- Identify mesoscale structures
- **Surface Chlorophyll-a concentration** (mg m^{-3}) <- Food proxy
- **Surface wind Speed** (m s^{-1}) <- Indicator of turbulence and food proxy



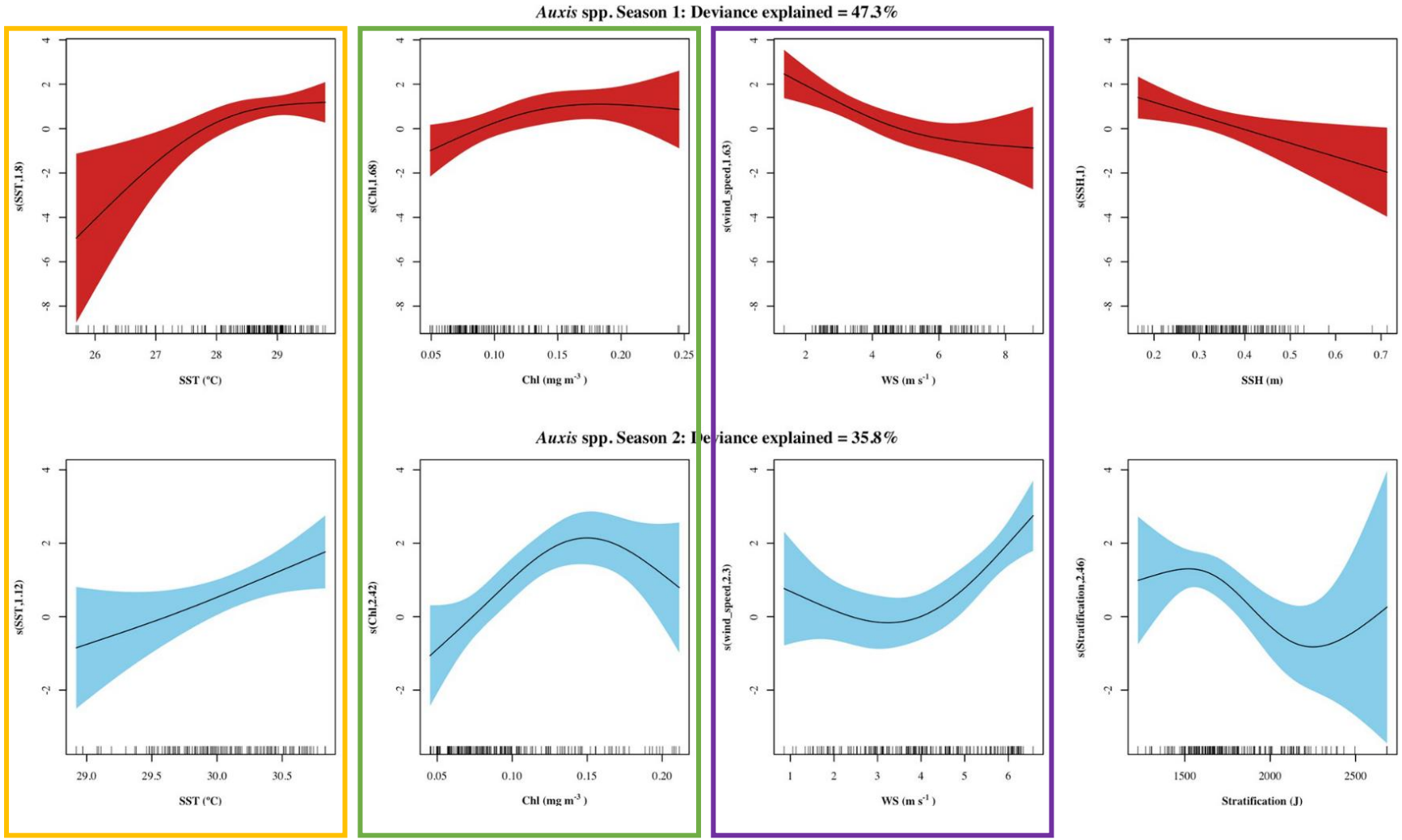
Relationships among variables analyzed with GAMS:

"GAMs are an extension of Generalized linear models, but are non parametric y non linear" (Wood, 2006)

Relationships between density and oceanic conditions suggest faster development and therefore a greater probability of survival and recruitment

Greater densities at:

- Higher temperatures
  - higher growth rate
- Higher chl-a
  - greater food availability
- Adequate wind speeds
  - feeding success



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Conclusions

- Satellite derived data (e.g. SST, SSH) allowed to identify mesoscale features in the Gulf of Mexico's deep-water region.
- Satellite data, in conjunction with other variables and analysis, allowed to define that Myctophidae larval assemblages are mainly influenced by adult distribution and spawning regions rather than by oceanography.
- Two main seasons were identified in the GoM's deep waters by comparing satellite SST, SSH, chl-a and wind speed.
- The identified variability in oceanographic conditions between seasons showed a change in the relationship between them and larval fish densities of bullet and frigate tunas.