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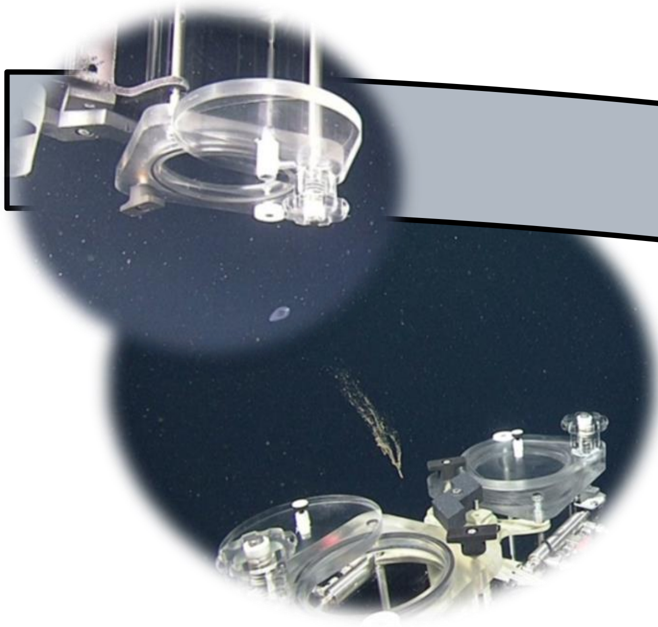
Can bioluminescence be a biological proxy *in situ* ?

The use of biological sensors on observatories, mooring lines or vehicles for long time series records

Can bioluminescence be a biological proxy *in situ* ?

- **Bioluminescence kinetics can discriminate groups of organisms**
  - Classification(K-means), pattern-recognition of bioluminescence kinetics (with Monique) from laboratory experiments with results applied to DORADO AUV dataset
- **Bioluminescence can be understood and predicted using models based on environmental variables**
  - Tree-based model (decision tree) on AUV DORADO dataset

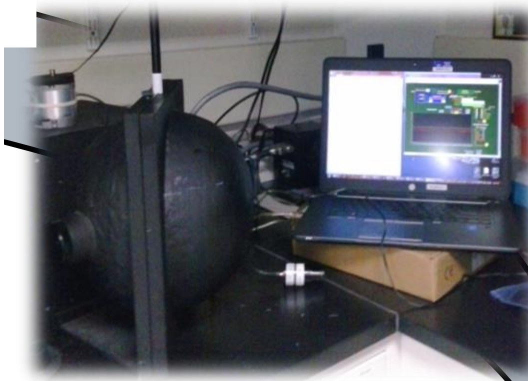
1- Bioluminescence to discriminate groups of organisms



Bioluminescent organisms:

- Copepods (metridinidae)
- Beroe sp.
- Euphausiid
- Dinoflagellates species
- Larvaceans (+/- house)
- Marine snow
- Bacteria

Haddock lab



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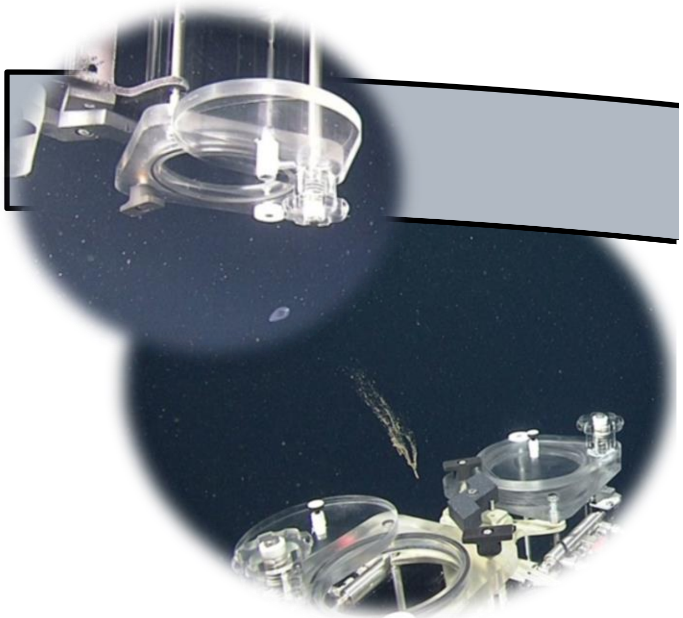

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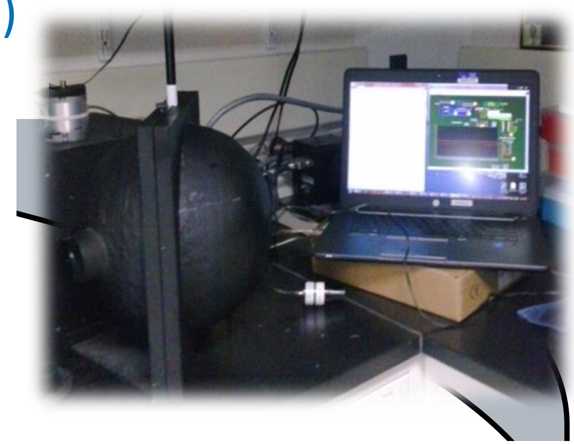
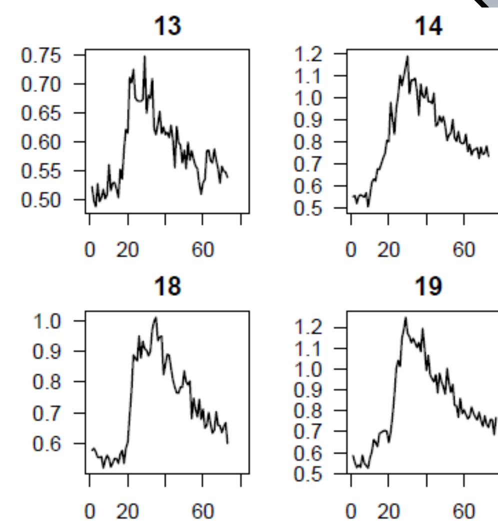
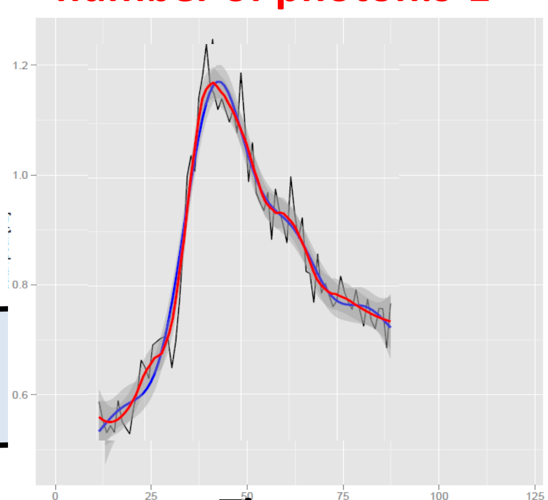


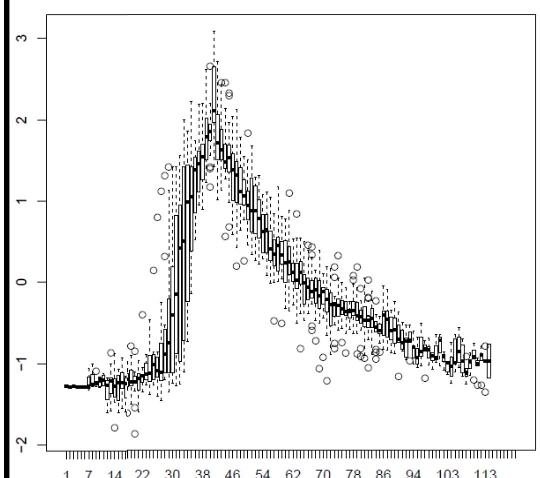


Several peaks for each individual

Bioluminescence = number of photon.s-1



intra-species variability



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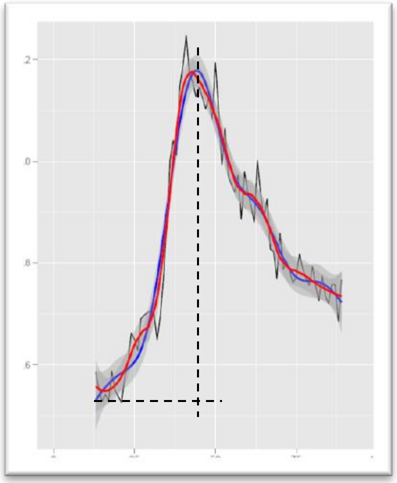
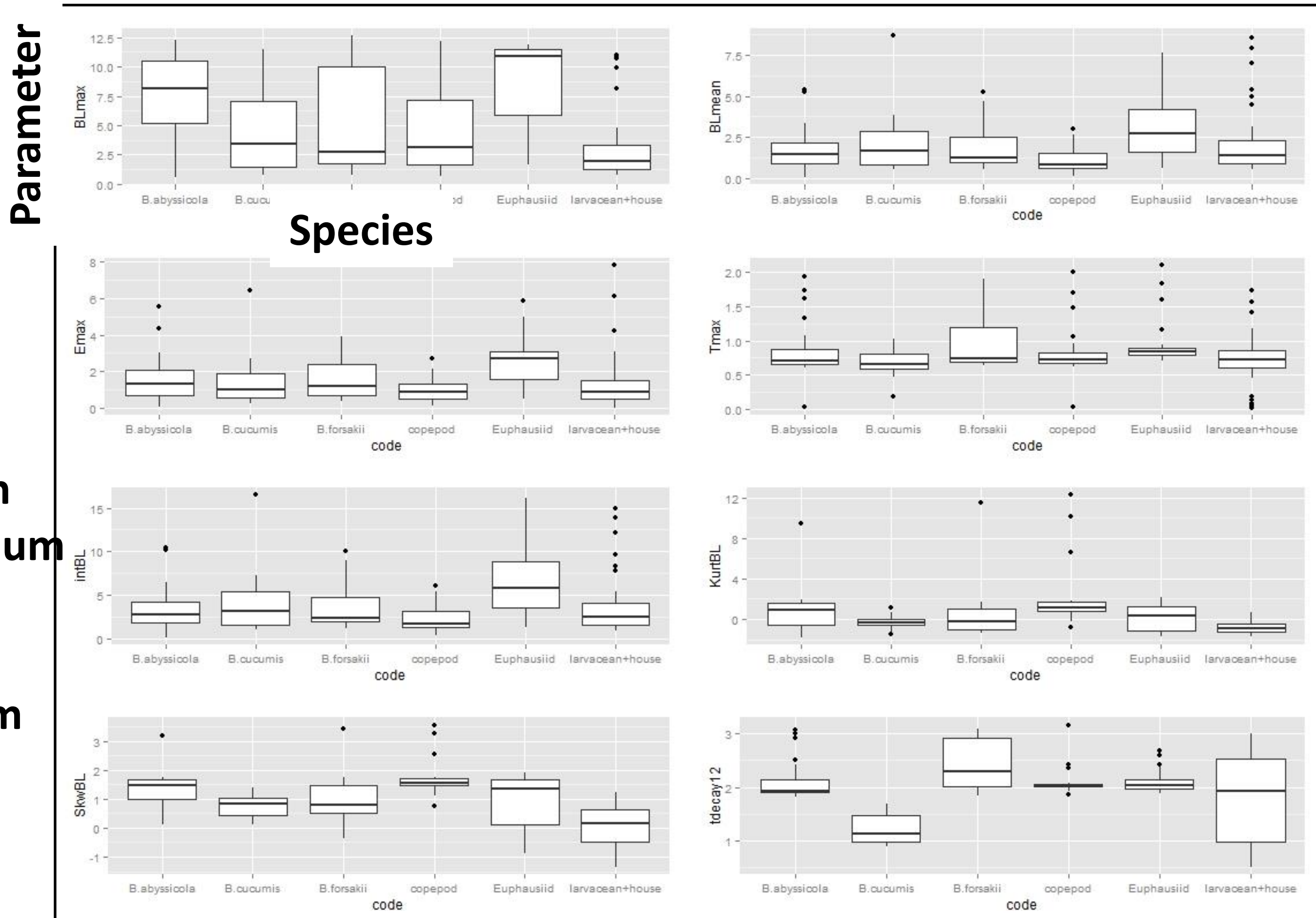


Kinetic parameters have been described for each individual and the **inter-species** variability is observed

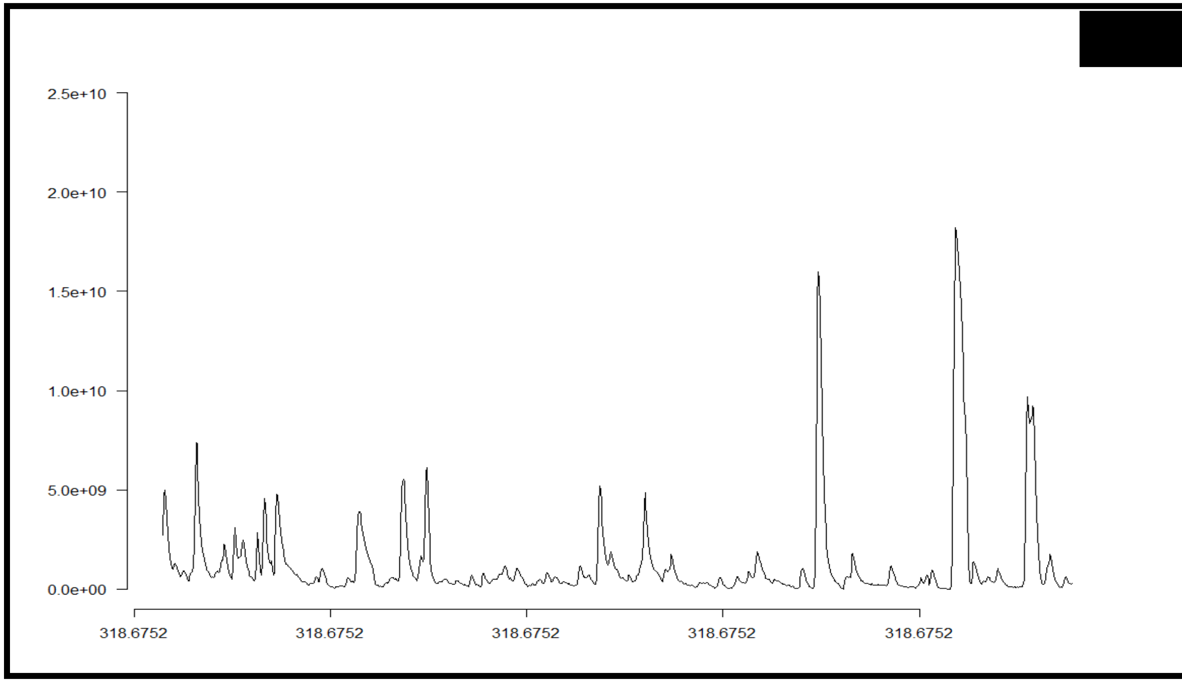


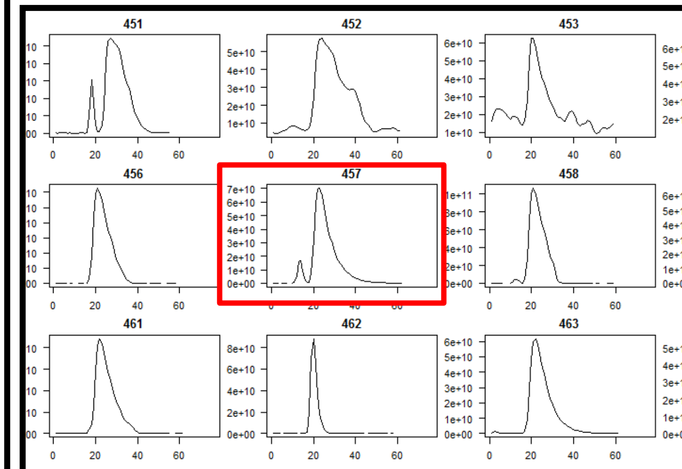
Parameters:

- Maximum intensity
- Integration of photon
- Integration to maximum
- Kurtosis
- Skewness
- Time to the maximum
- Decay time

What are the most relevant parameters to describe those species ?

2- Reverse application on DORADO-AUV dataset





KINETIC PARAMETERS

- **Bioluminescence record by bathyphotometer during the survey**
- **Peaks extraction**
- **Computation of all parameters**

2- Reverse application on DORADO-AUV dataset

- **Unsupervised classification**

- **K-means with K=3 clusters**
  based on ecological knowledges and assumptions looking at the peaks shapes

- **Minimize the variability W_{CK} within clusters C_K**

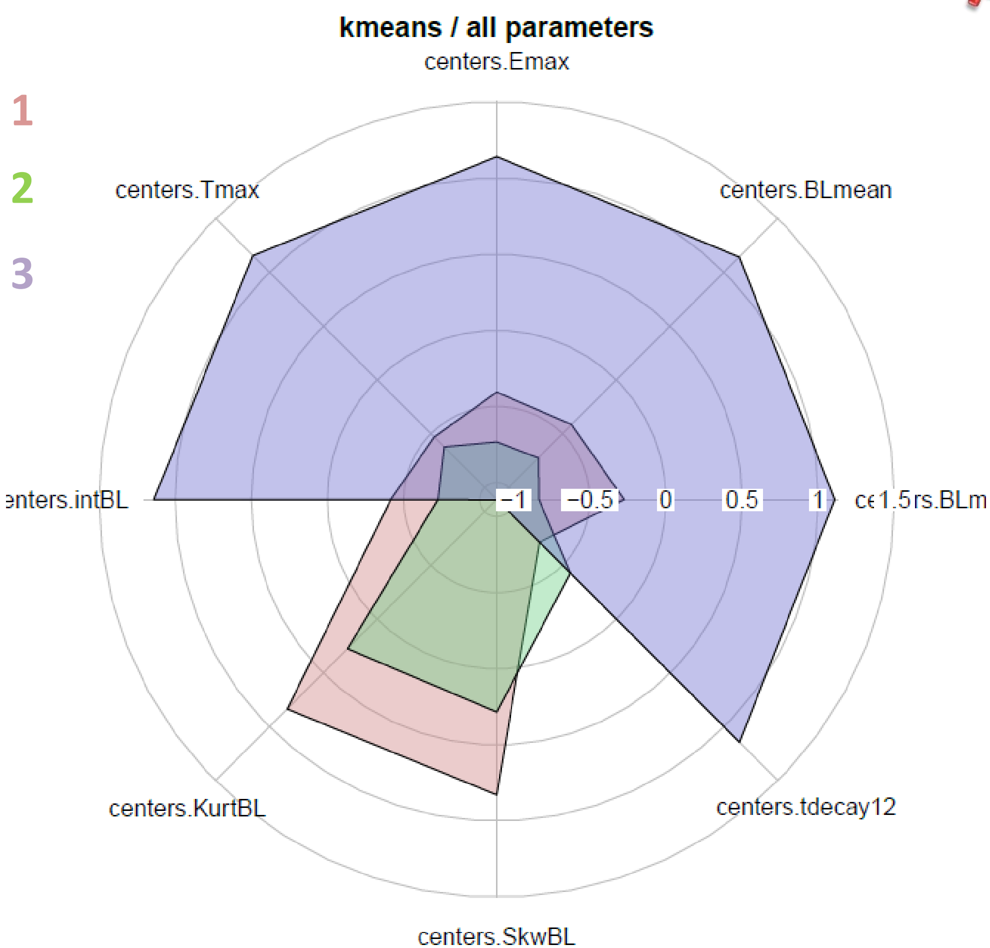
$$minimize_{C1,\dots,CK}\left\{\sum_{k=1}^{K} W(C_k)\right\}$$

2- Reverse application on DORADO-AUV dataset

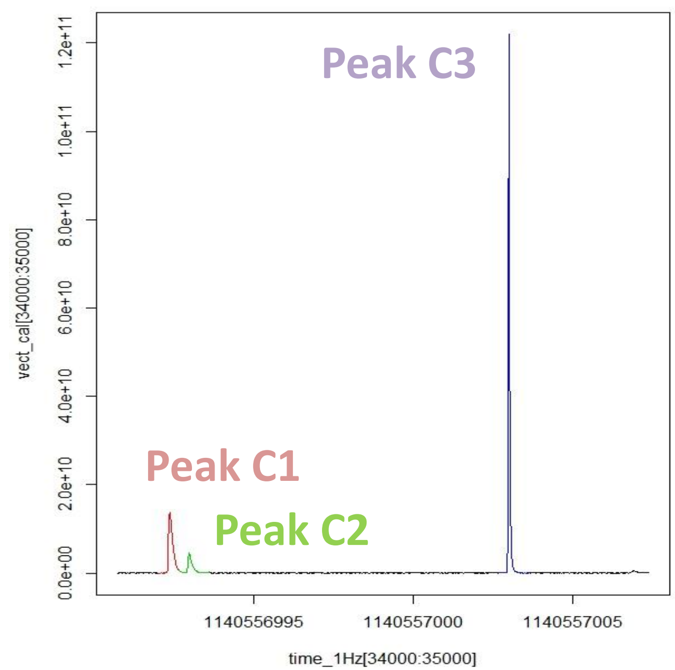
Cluster 1

Cluster 2

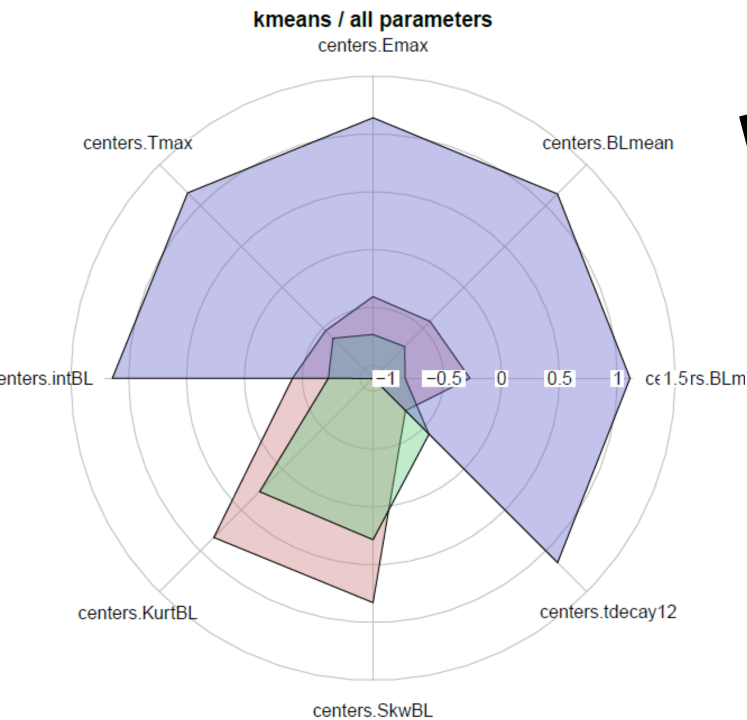
Cluster 3



PRELIMINARY RESULTS:
To be confirmed…

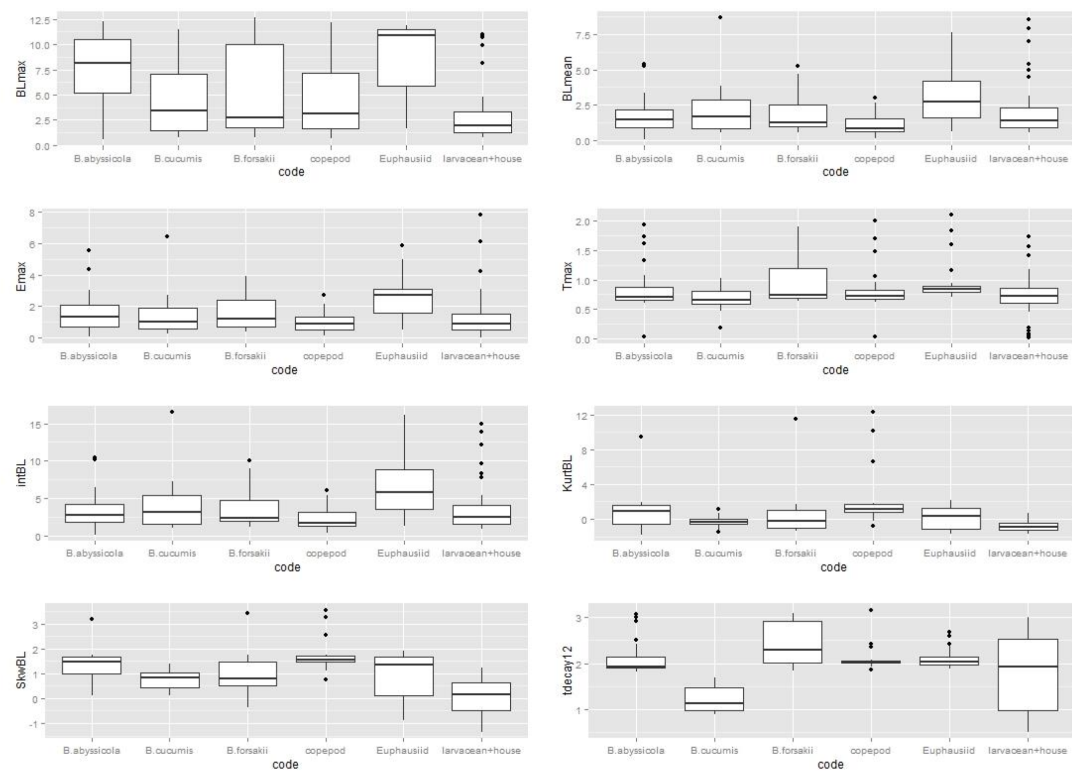


2- Reverse application on DORADO-AUV dataset



?

Which species belong to each cluster based on their kinetic parameters ?



3- Tree-based model to predict bioluminescence from environmental variables

Y(bioluminescence) = f(environmental variables)

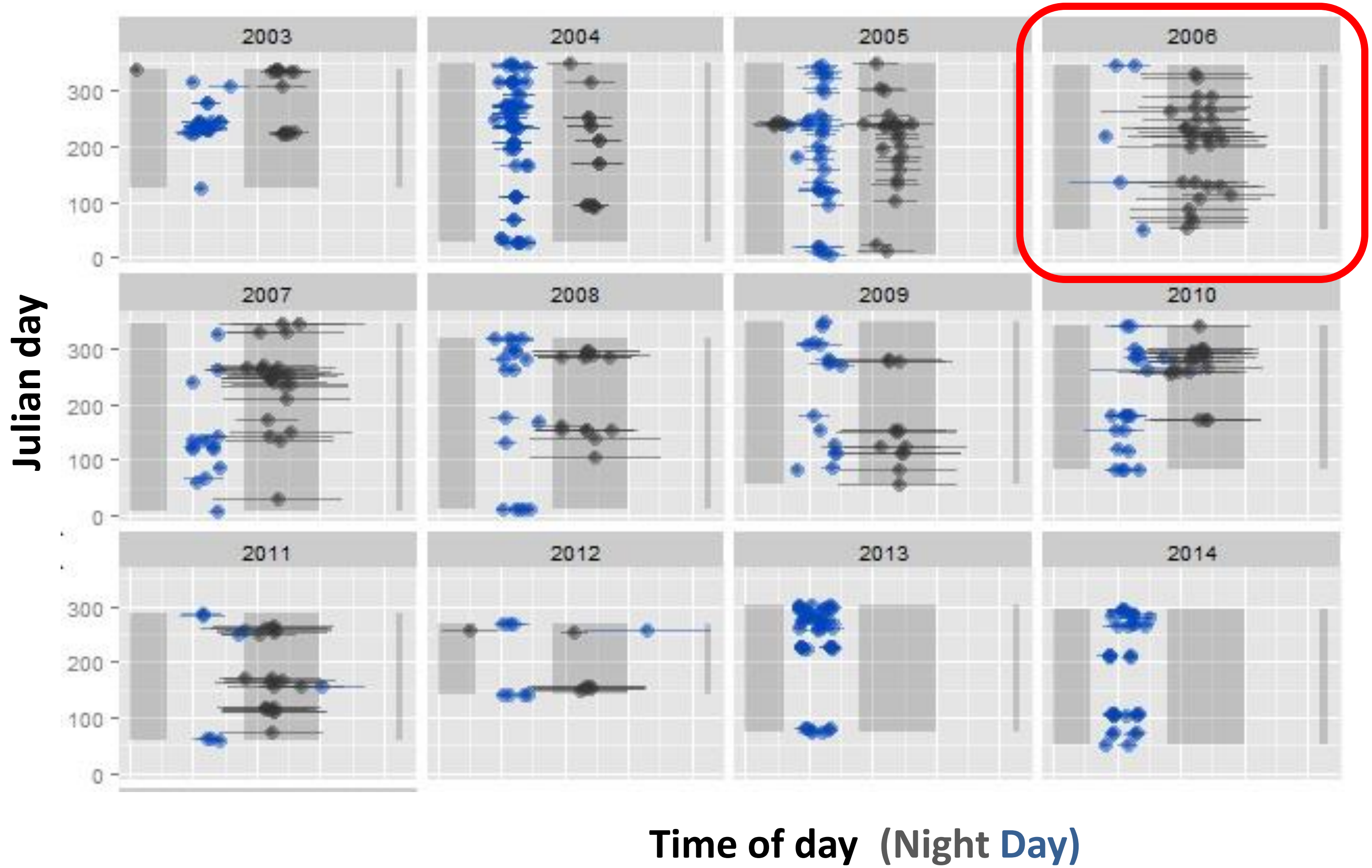
<u>Can AUV surveys be considered as time-series ?</u>

<u>For mathematical analyses:</u>

– **strong sampling variability in time, depth AND space**

+ **strong sampling variability in time, depth AND space**

3- Tree-based model to predict bioluminescence from environmental variables



- **2006 "well" sampled in time**

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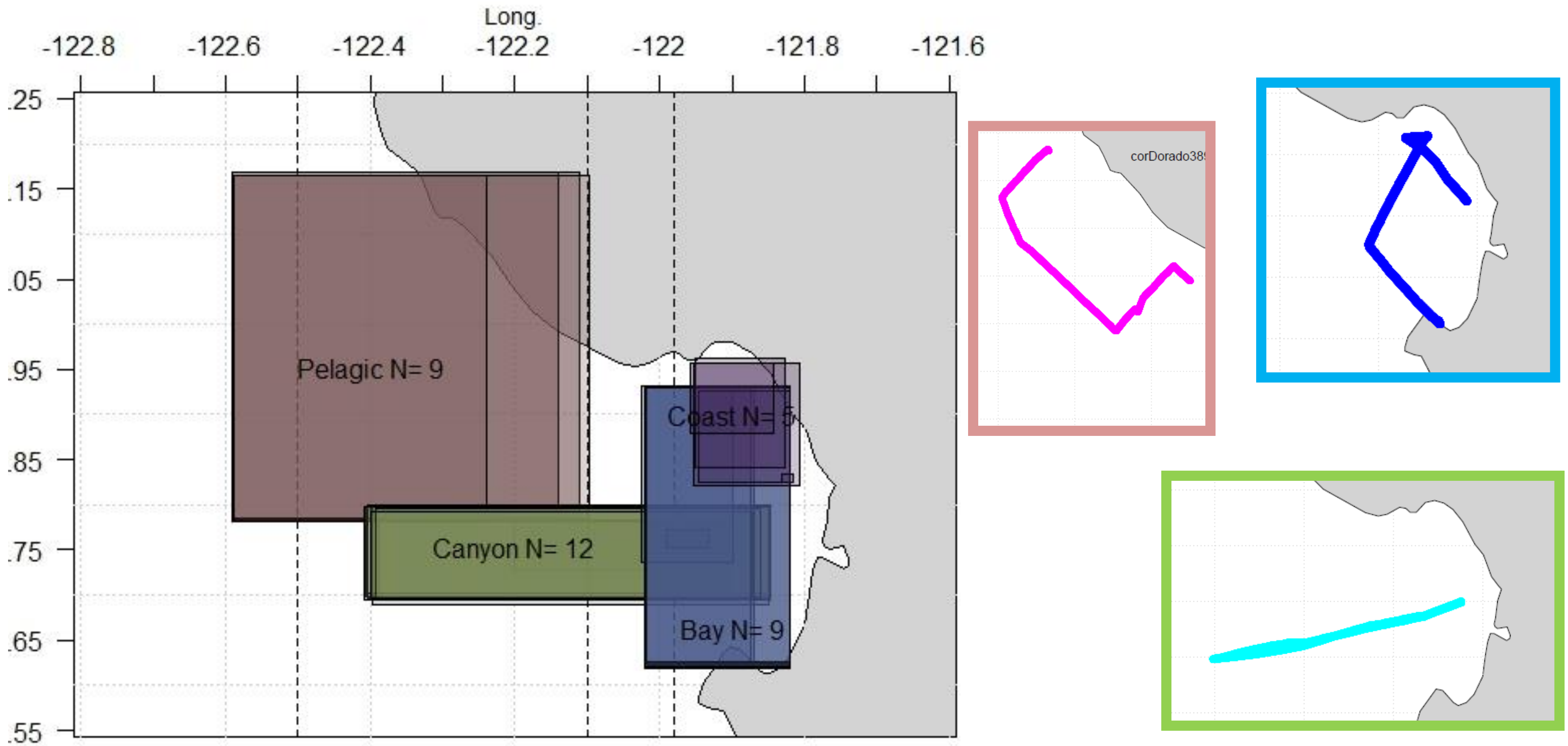
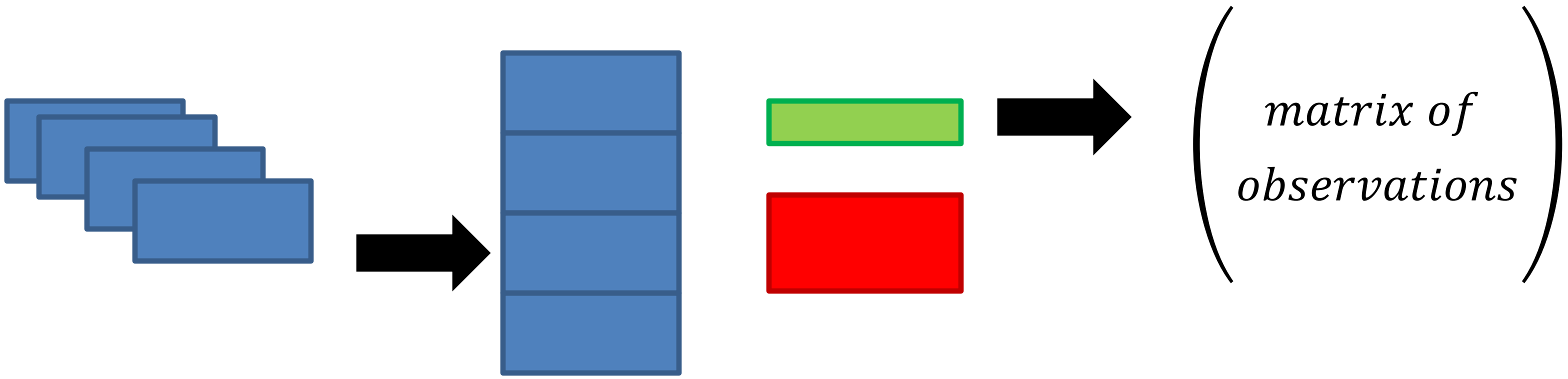
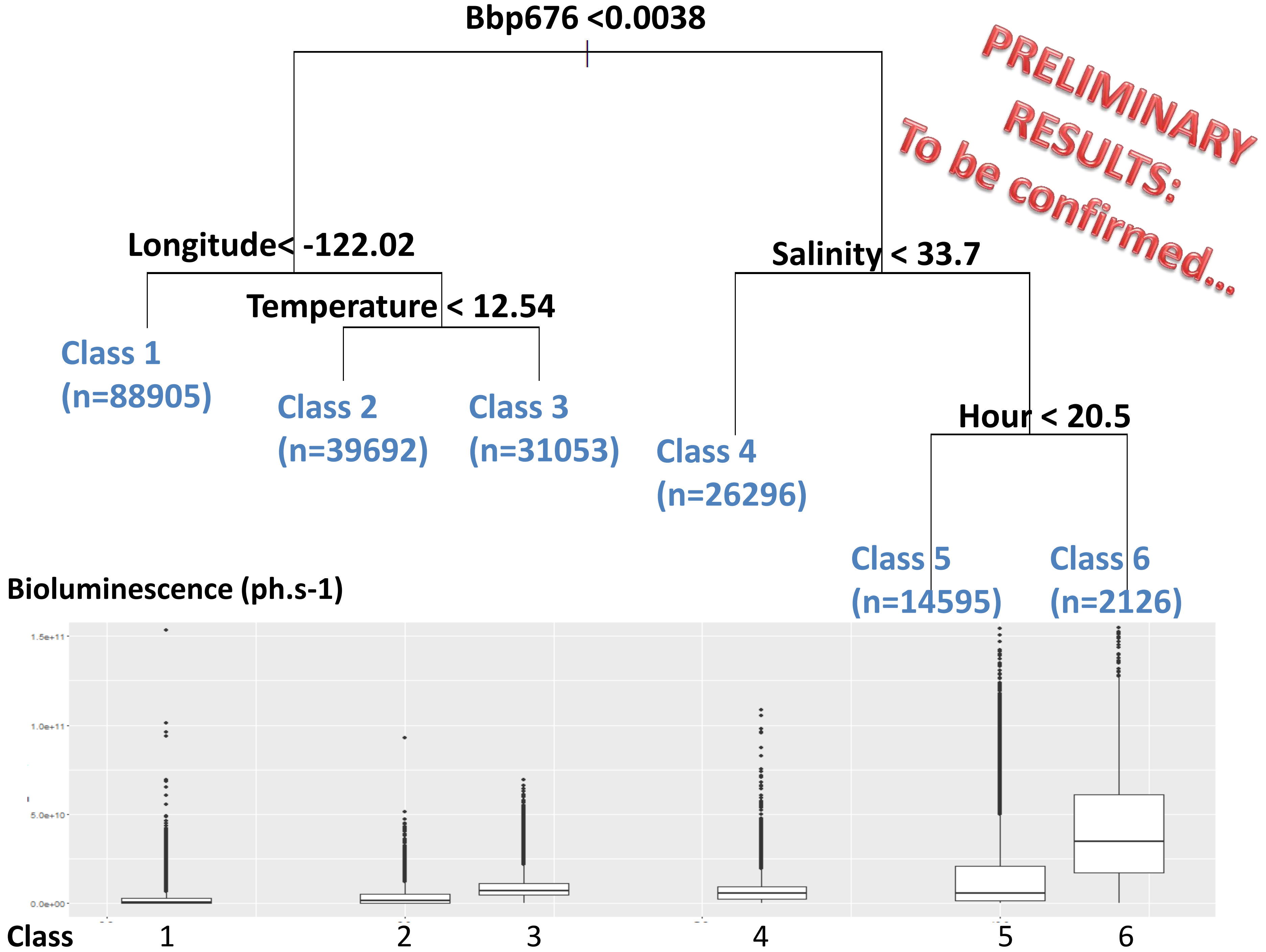


- **2006 “well” sampled in space**
- **Repetitive surveys**

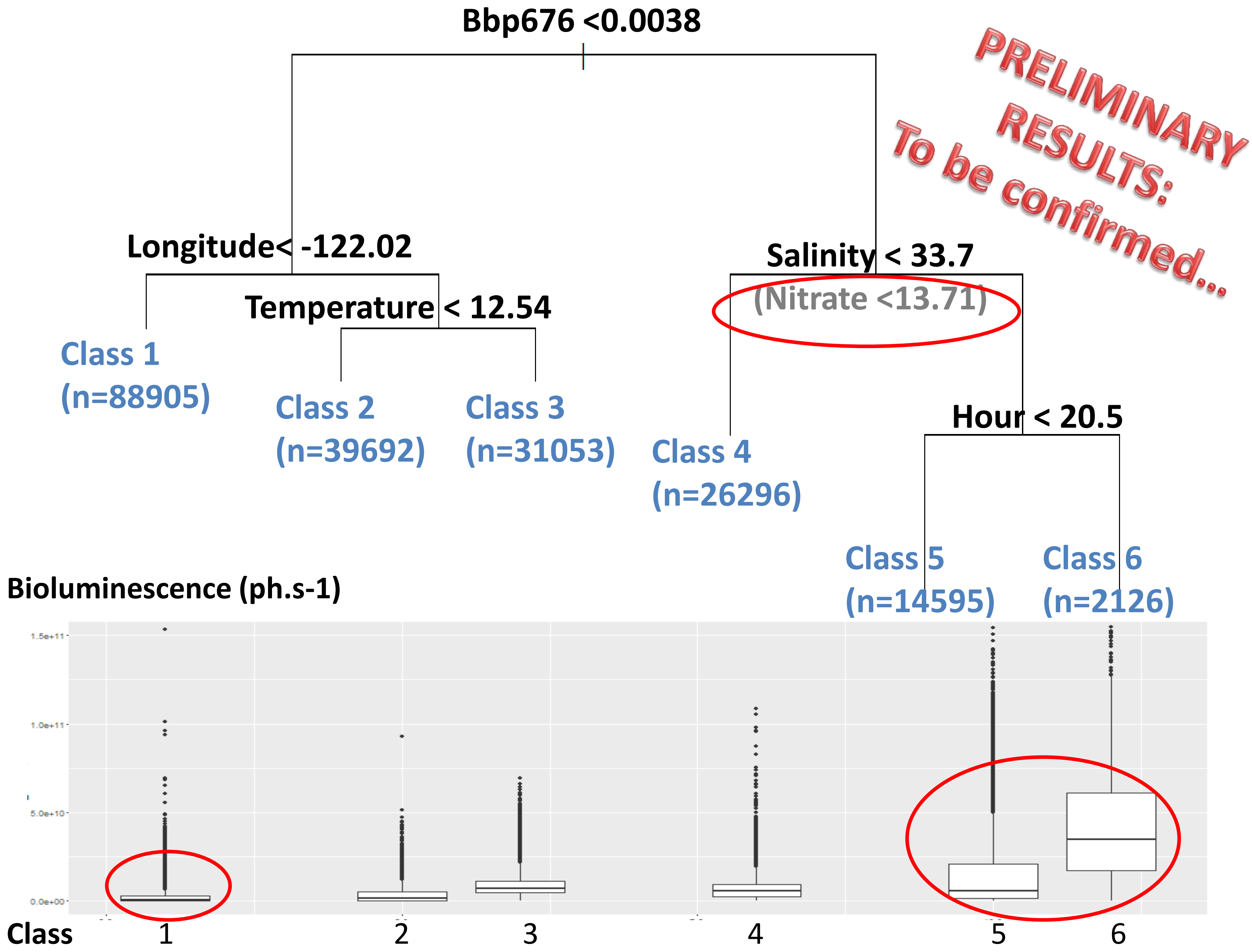
- **2006 surveys after correction of artefacts**
- **Y(bioluminescence) = f(Temperature + salinity + depth + oxygen + nitrate + bbp470 + bbp676 + latitude + longitude + hour of day)**
- **30% of data from each survey randomly = training dataset**
- **70% of data = efficiency of the model**



- **Binary recursive partitioning, maximize the variability within class, recursive process**
- **“Decision tree”**



Bbp676 <0.0038
PRELIMINARY RESULTS:
To be confirmed...
Longitude< -122.02
Temperature < 12.54
Salinity < 33.7
Hour < 20.5
Class 1
(n=88905)
Class 2
(n=39692)
Class 3
(n=31053)
Class 4
(n=26296)
Class 5
(n=14595)
Class 6
(n=2126)
Bioluminescence (ph.s-1)
1.5e+11
1.0e+11
5.0e+10
0.0e+00
Class
1
2
3
4
5
6


Bbp676 <0.0038
PRELIMINARY RESULTS:
To be confirmed...
Longitude< -122.02
Temperature < 12.54
Salinity < 33.7
(Nitrate <13.71)
Class 1
(n=88905)
Class 2
(n=39692)
Class 3
(n=31053)
Class 4
(n=26296)
Hour < 20.5
Class 5
(n=14595)
Class 6
(n=2126)
Bioluminescence (ph.s-1)
1.5e+11
1.0e+11
5.0e+10
0.0e+00
Class
1
2
3
4
5
6

Verifications :

- **Nodes are stable with recursive dataset (other 10% dataset within surveys)** **YES**

  avoid overfit as not reliable nodes

- **Percentage of good classification using the 70% of data for efficiency of the model** **~ 84%**

  classes have been defined by 1st to 3rd quartile using training distribution (boxplot without extreme values)

TO DO:

- **Improve the reliability of the model**
- **Try other mathematical methods (random forest)**
- **Ecological meaning of classes ? Relation with the knowledge of processes in the bay (front, thin layers …)**
- **Does the model work under highly variable environmental conditions ? Are we able to predict bioluminescence for different environmental conditions ? Upwelling strong/weak ?**
- **Application to detect/sample higher bioluminescence using AUV (cf thin layers)**