Assessment and interpretation of temporal or spatial differences in shellfish productivity of typical French ecosystems

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from Ifremer

and

*- providers of **qualified data** from surveys*
- managers of data banks
and designers of internet data (http://www.ifremer.fr)

« …quant aux principales circonstances
dont [la nature…] se sert encore chaque jour
*pour **varier ses productions**…,*
les principales naissent
*de l'évolution des **climats**,*
*des variations de **température** de l'atmosphère*
*et de tous les **milieux environnants**,*
*de la **diversité des lieux**…*
de celle des actions,
*enfin de celle des moyens de **vivre**,*
*de **se conserver**, de **se multiplier**, etc… »*

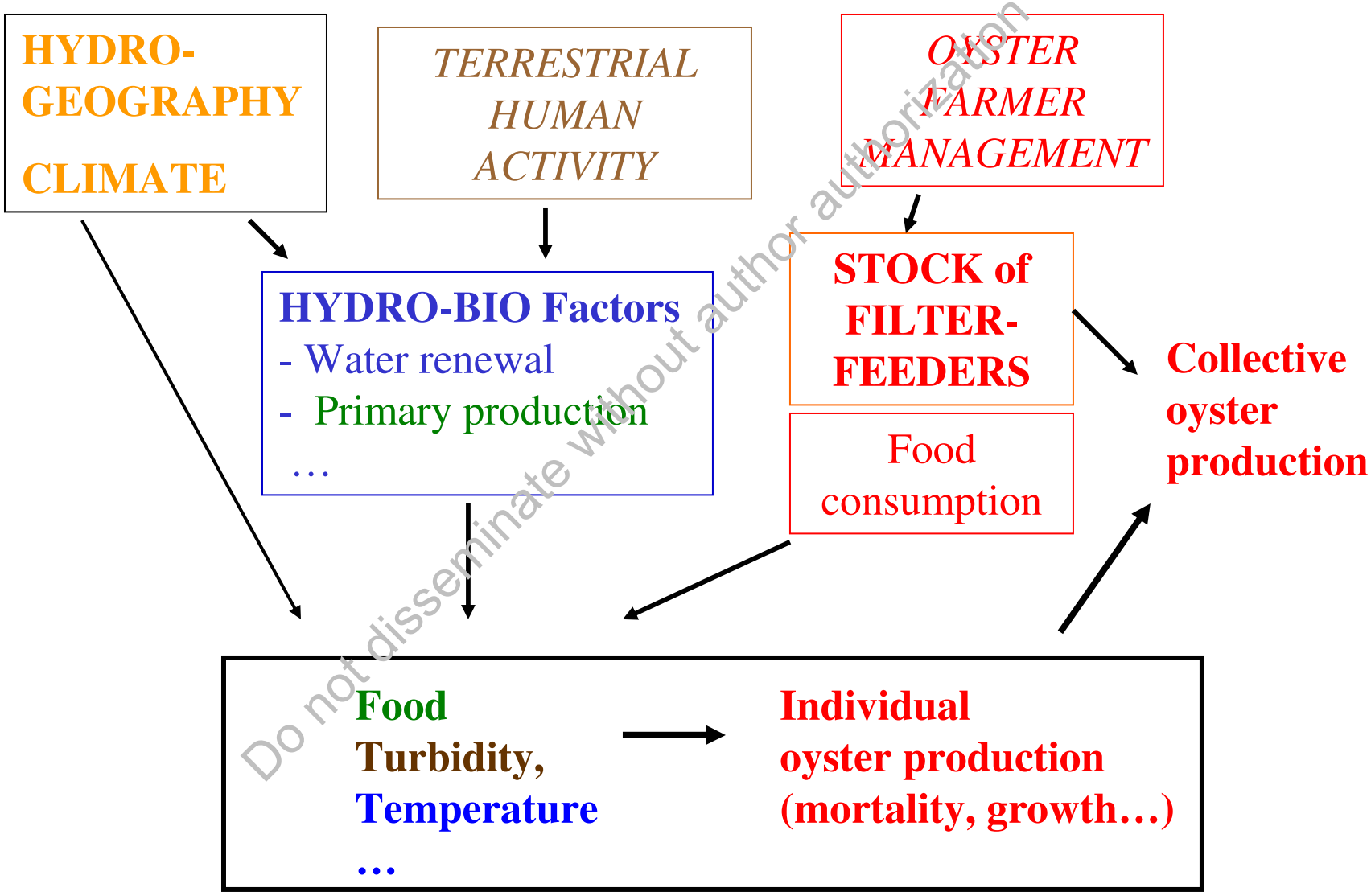
Jean LAMARCK, 1800

GENERAL FRAME OF ANALYSIS (3 levels)

Ecosystem

Farms

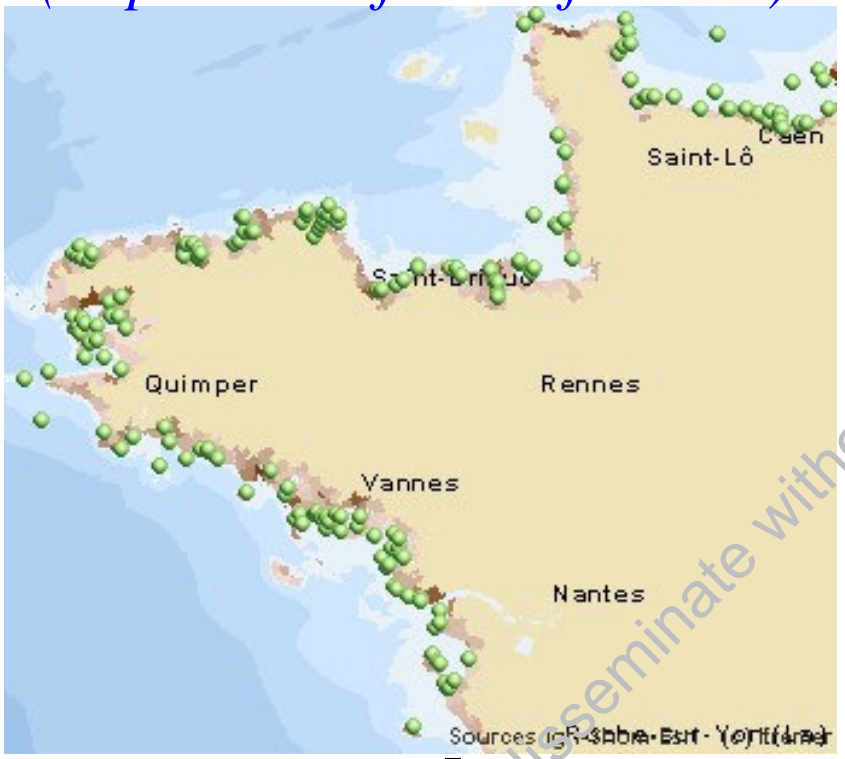
Oyster



Source of data :

« **Rephy** » network
=> surveys Phytoplankton

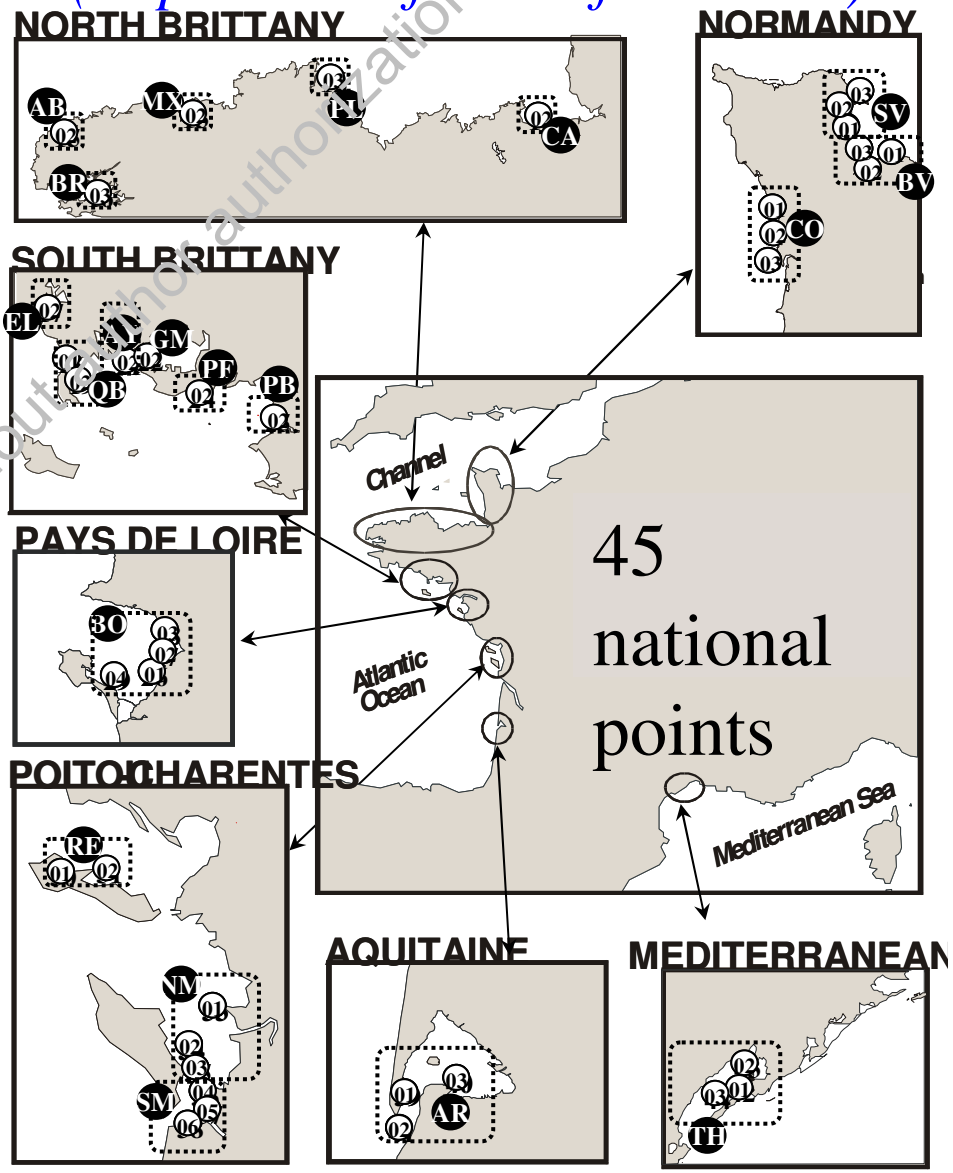
(*http://www.ifremer.fr/envlit*)



11 common stations

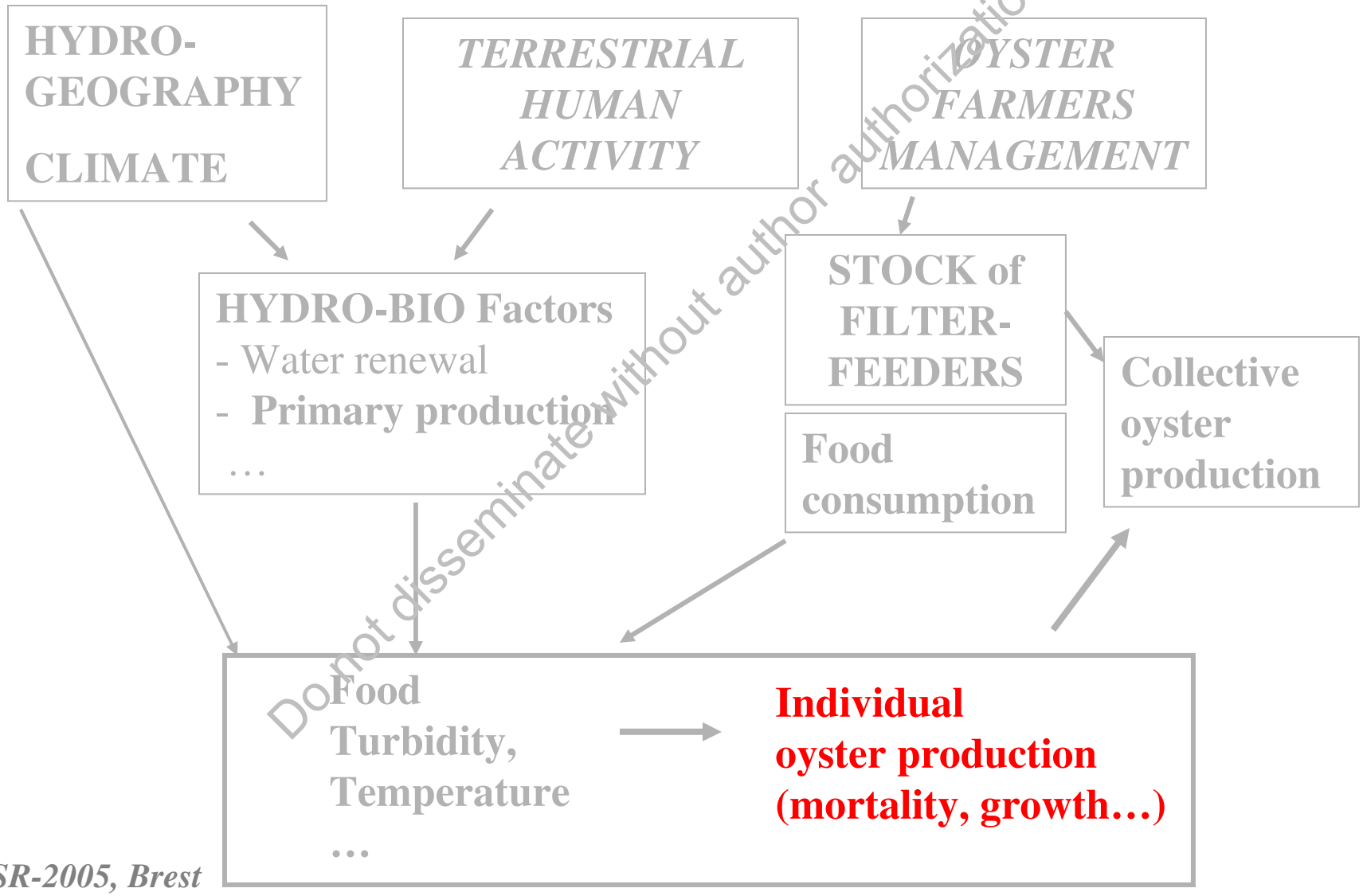
Remora network
=> monitors oyster growth

(*http://www.ifremer.fr/remora*)



Assessment and interpretation of temporal or spatial differences in shellfish productivity of typical French ecosystems

1- SHELLFISH CULTURE PERFORMANCES



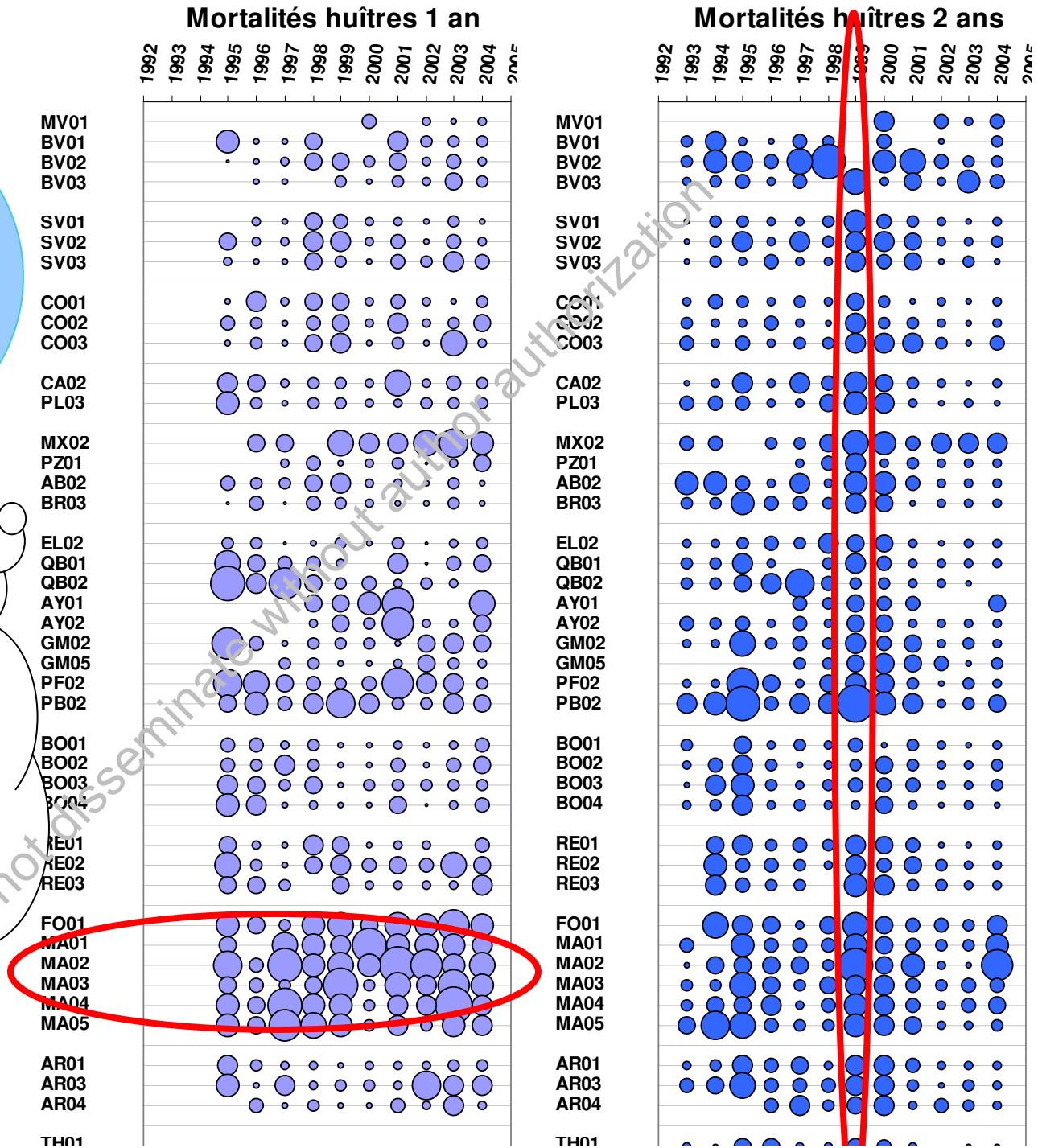
temporal

spatial

1 year-old (left)
2 years-old (right)
oysters
Mortality

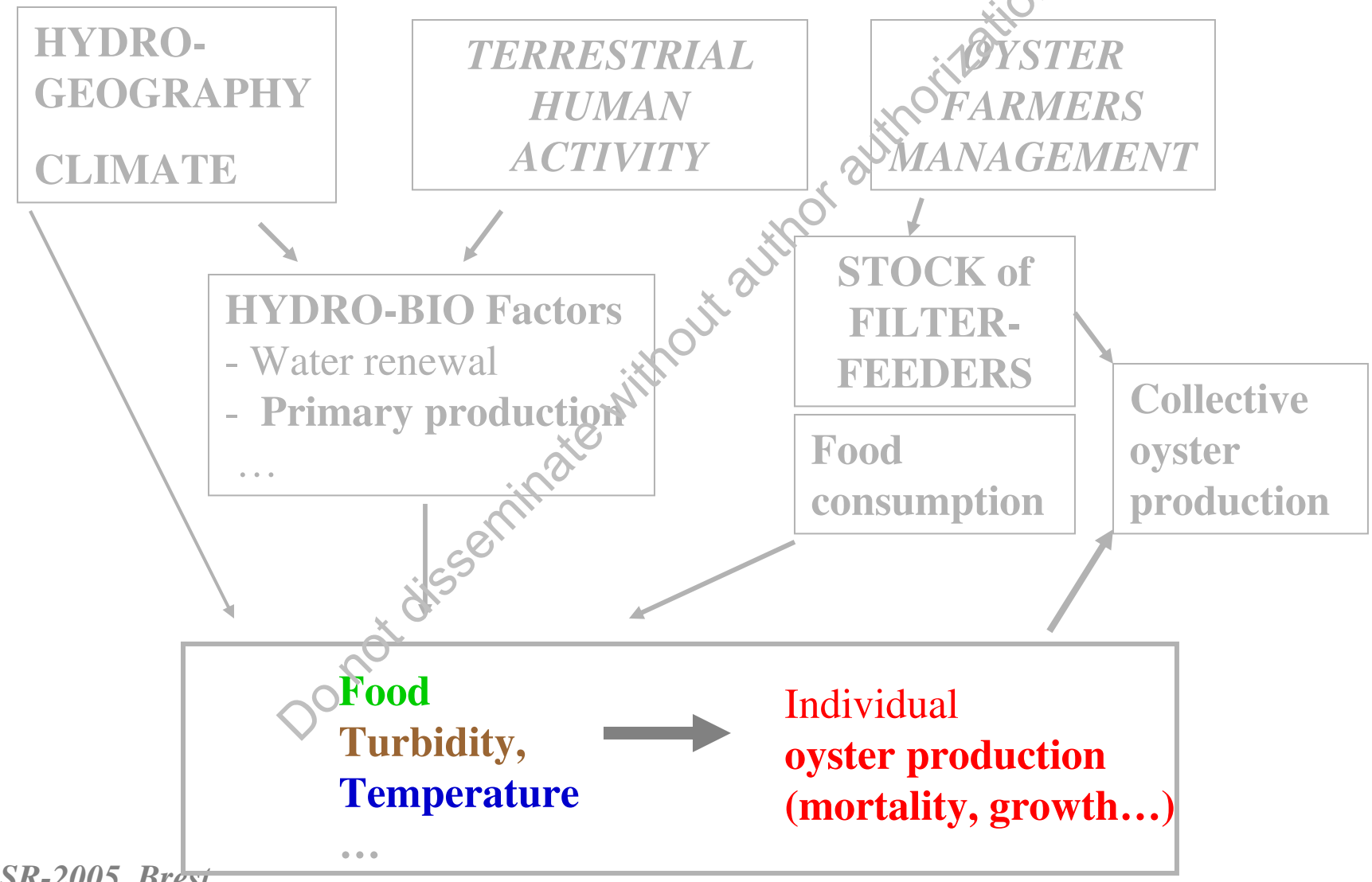
QUESTION :
what determines higher mortalities of **1yr-oysters** in some **sites**, and of 2 **yr-oysters** some **years** ?

ICSR-2005, Brest



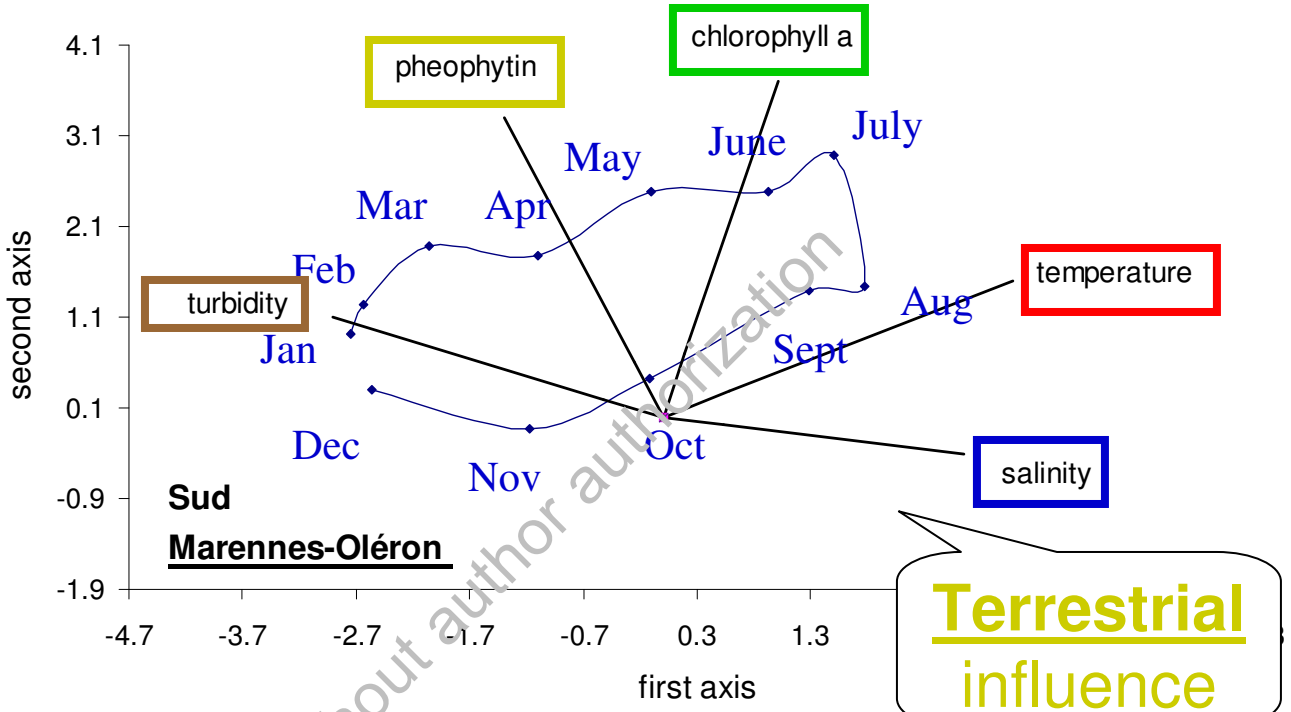
Interpretation of oysters performances, from close, surrounding medium

2- **WATER QUALITY** & SHELLFISH CULTURE



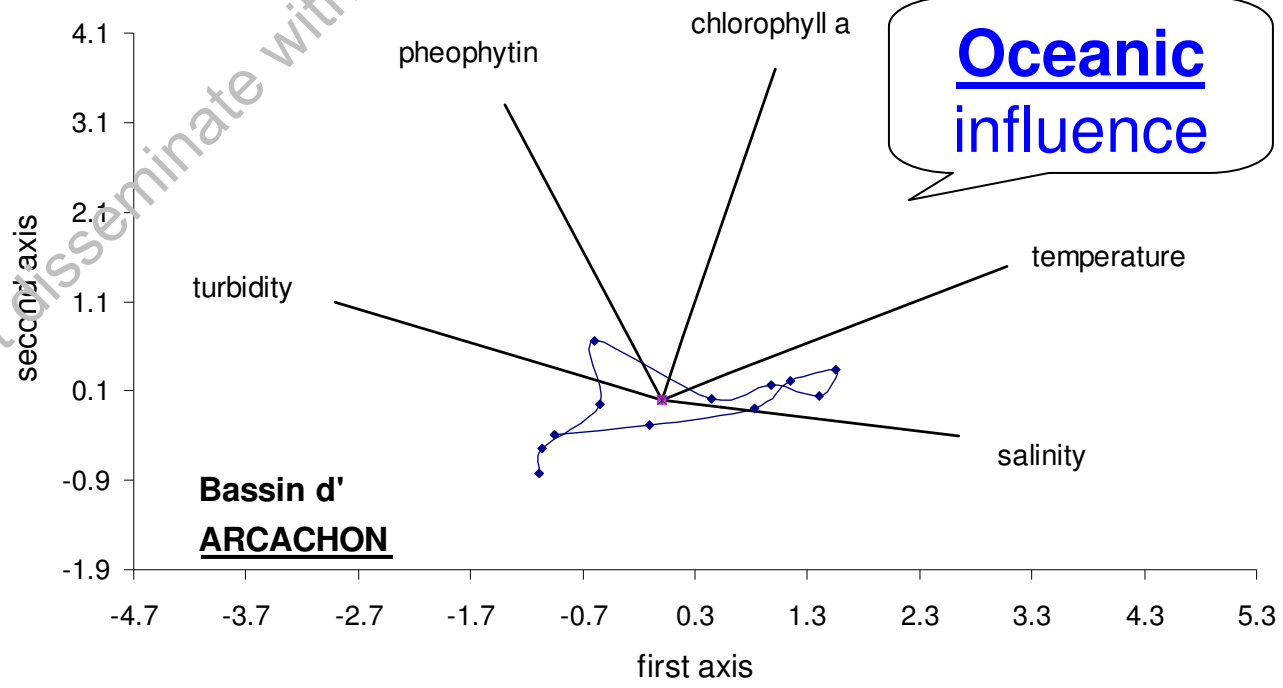
Spatial differences in water quality

: Example from 2 well-known oyster basins



Terrestrial influence

Oceanic influence



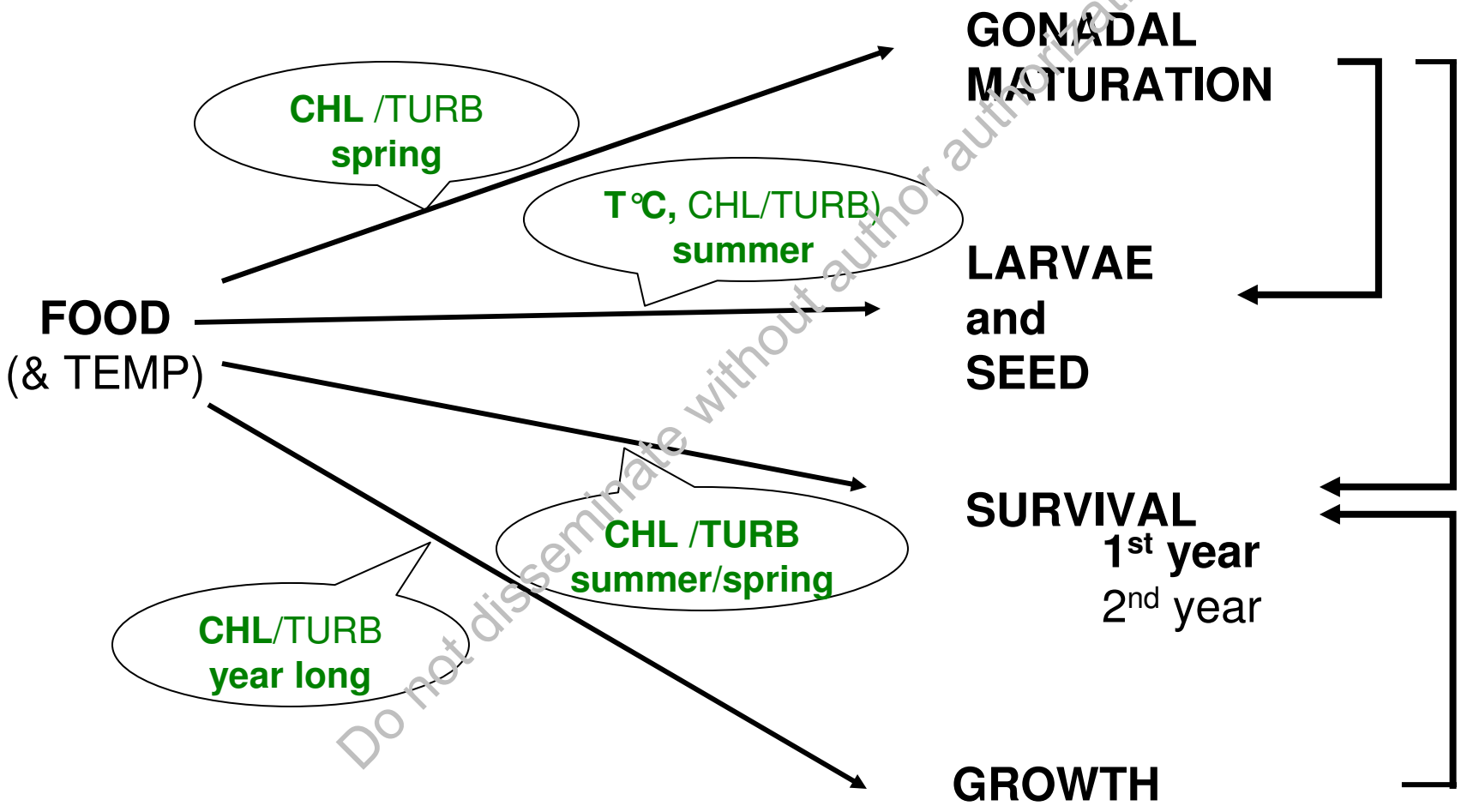
Principal Component Analysis (common to all sites) on ***monthly water parameters*** *(TEMP, SAL, CHL, PHE, TURB)* ***(means 1993-2004)***

=>

site-specific trajectories

ICSR-2005, Brest

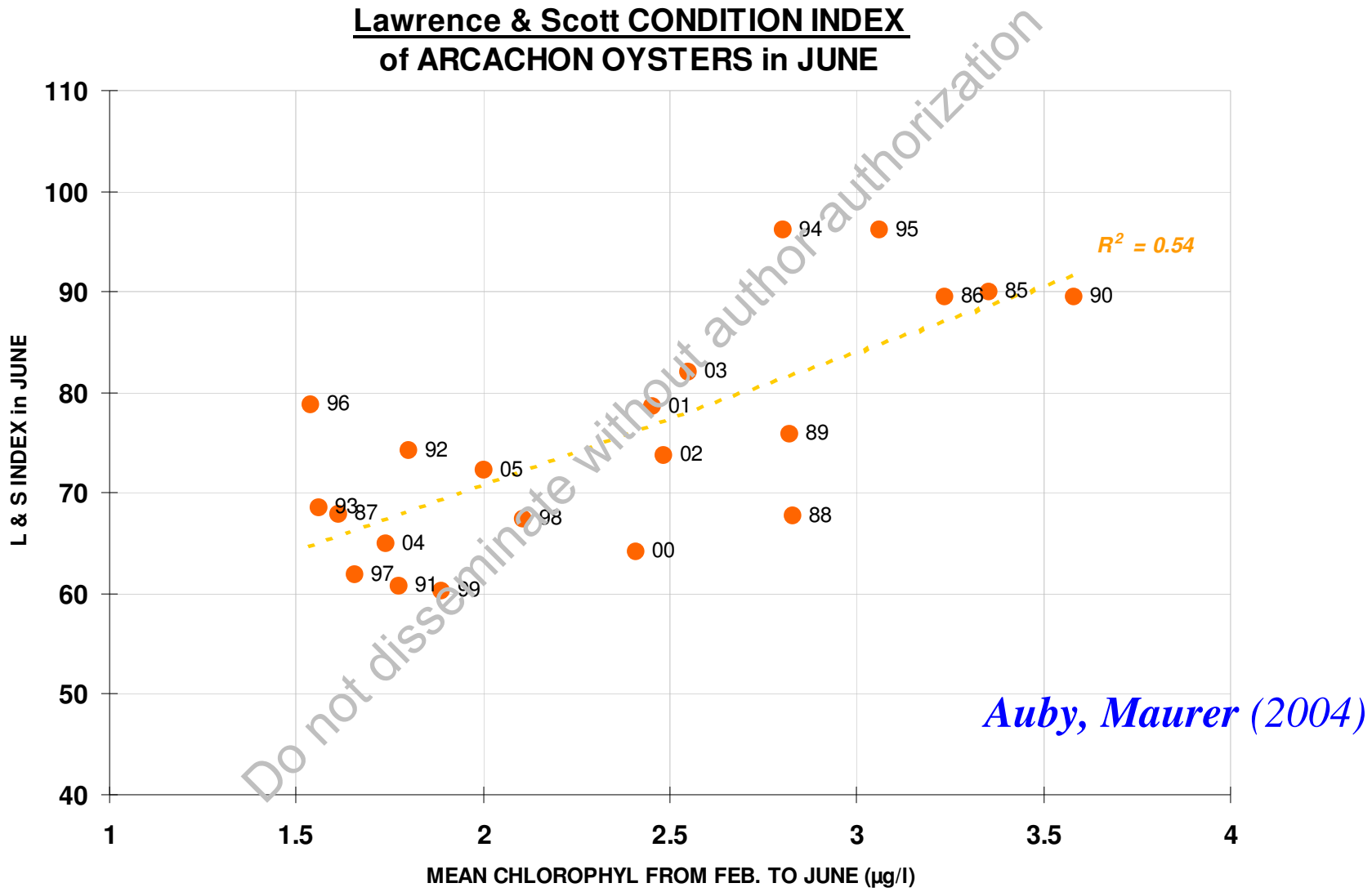
WATER QUALITY AND OYSTERS PERFORMANCES :
effective link though **food** (and temperature)



(developed next…)

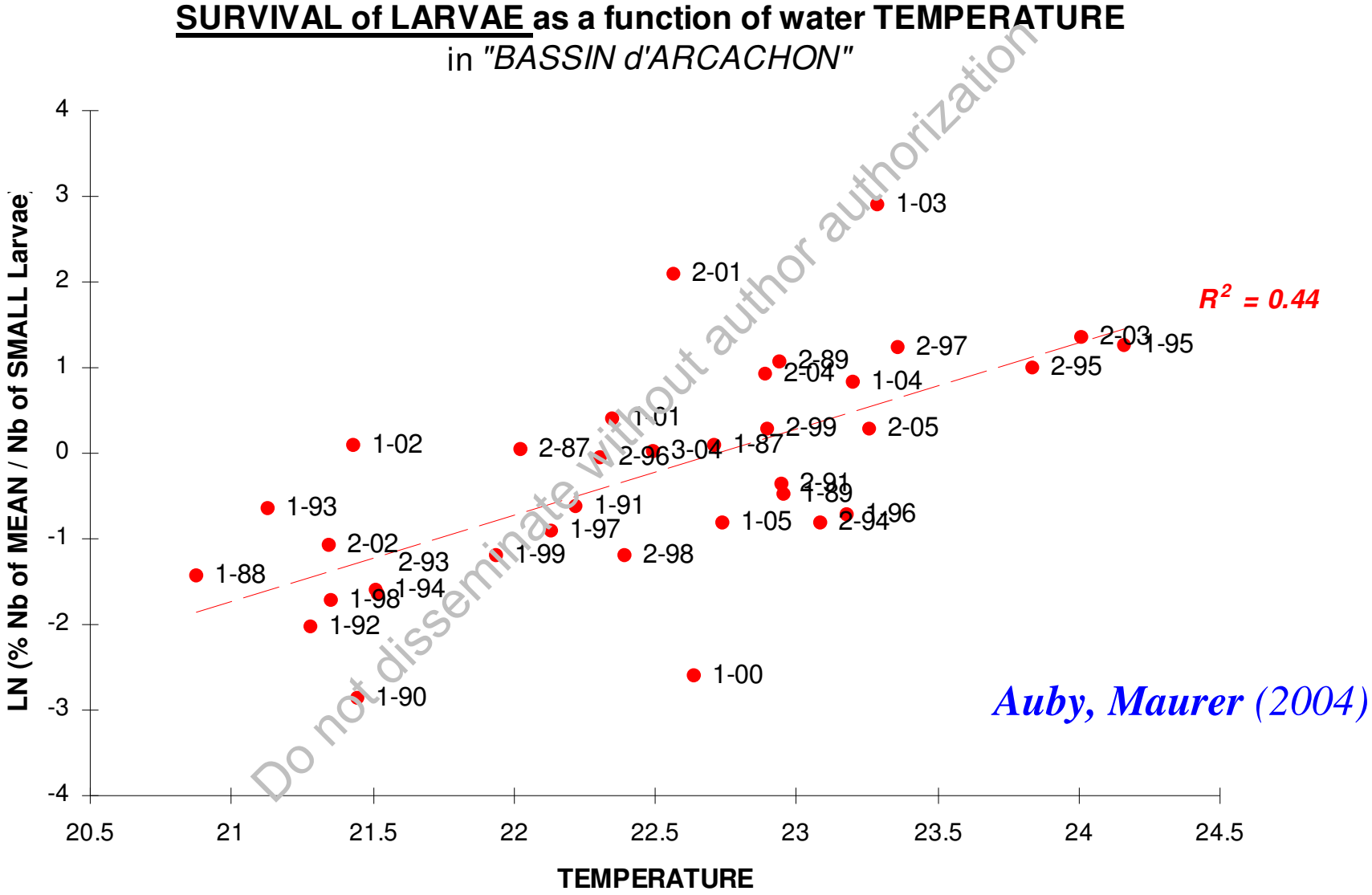
Water Quality and REPRODUCTION (1) :

REPRODUCTION « EFFORT » as (MEAT / INTERNAL WEIGHT OR VOLUME)



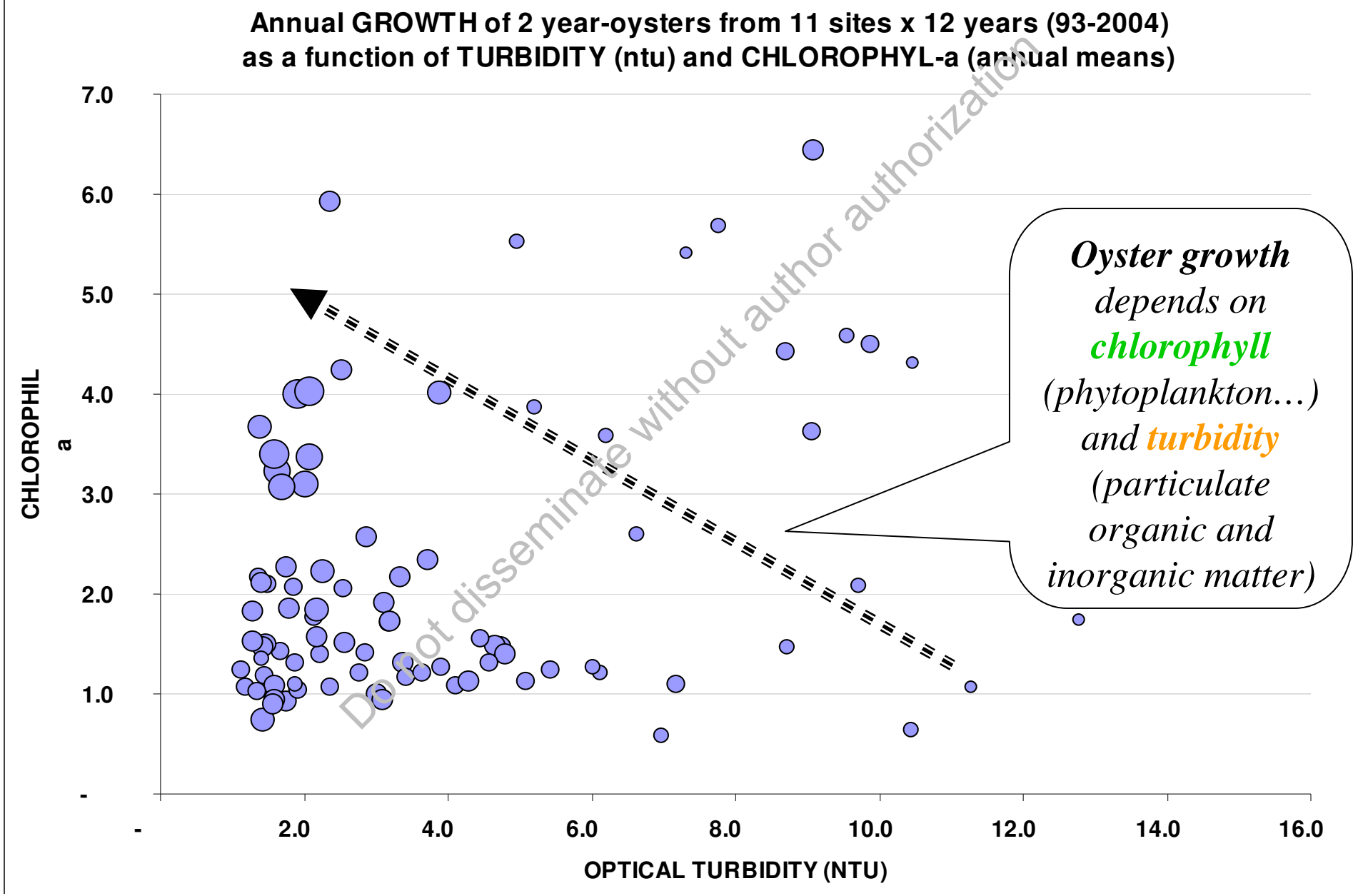
=> ***Gonade*** *size linked to spring* ***food*** *concentration*

Water Quality and REPRODUCTION (2)
Survival of larvae



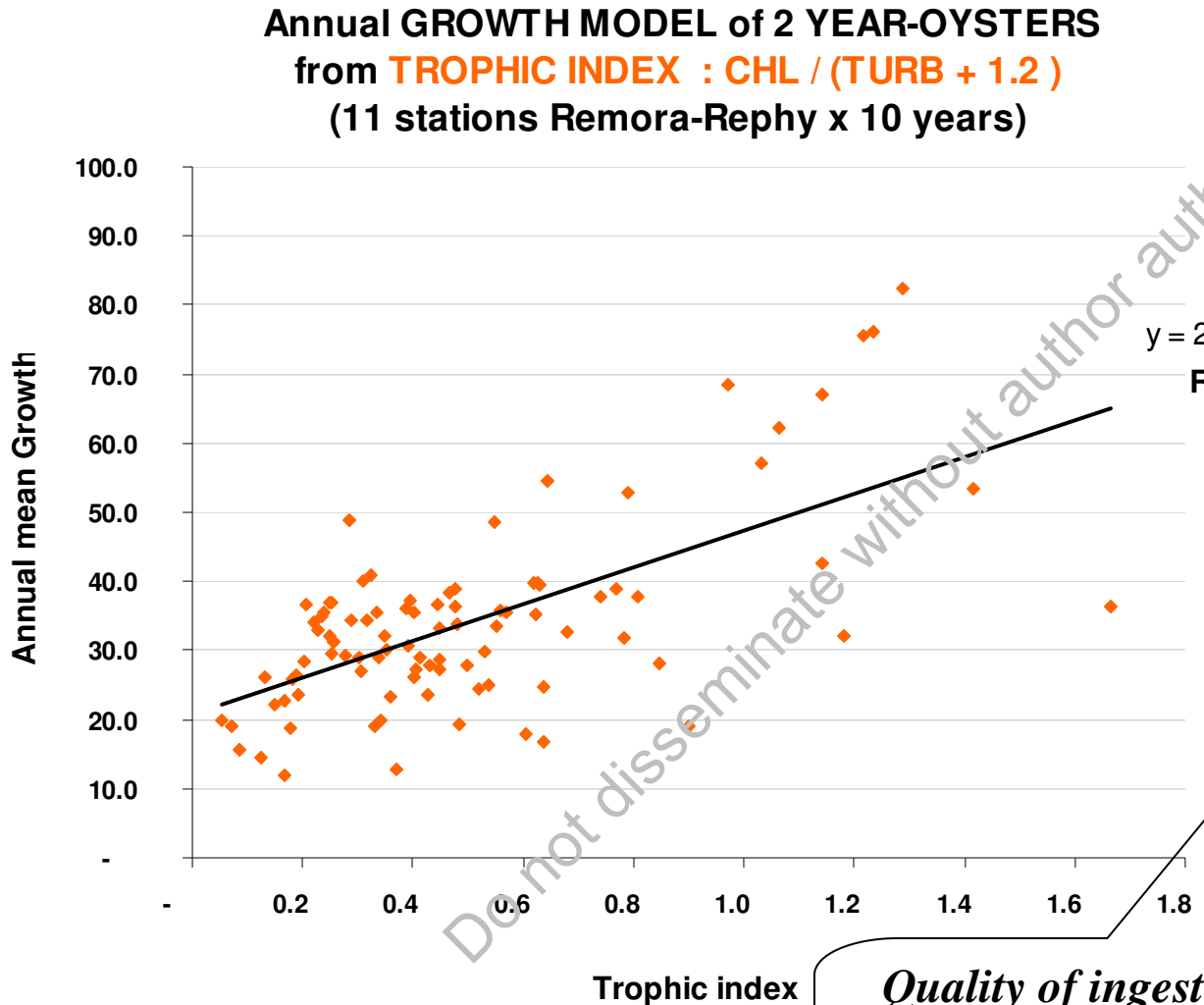
=> ***Survival of larvae*** *is linked to* ***summer water temperature***

WATER QUALITY &
2 YEAR-OLD OYSTERS GROWTH



« PHYSIOLOGICAL » GROWTH MODEL OF *C.GIGAS (1)*

2D representation



TROPHIC INDEX

$(CHL/TURB) \times f_{0-1}$ with

$f_{0-1} = TURB / (TURB + 1.2)$

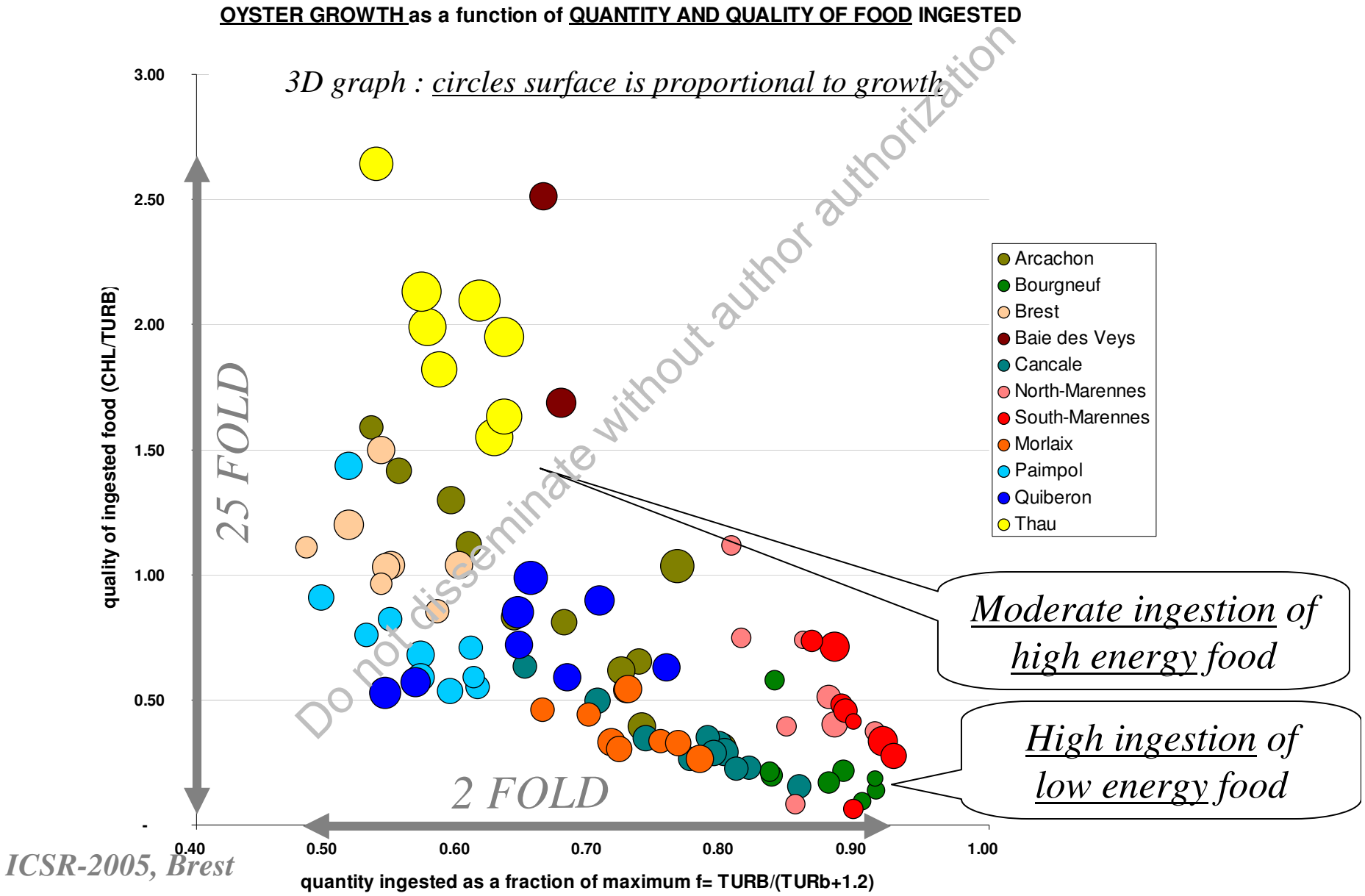
TURB : Turbidity (NTU)

Quality of ingested *food (Phytoplancton / Tot. Partic. Matter)*

Quantity ingested *(% of maximum flux) (Arrhenius fonction… in* ***Kooijman*** *DEB model)*

« PHYSIOLOGICAL » GROWTH MODEL OF *C.GIGAS (2)*

3D representation



ICSR-2005, Brest

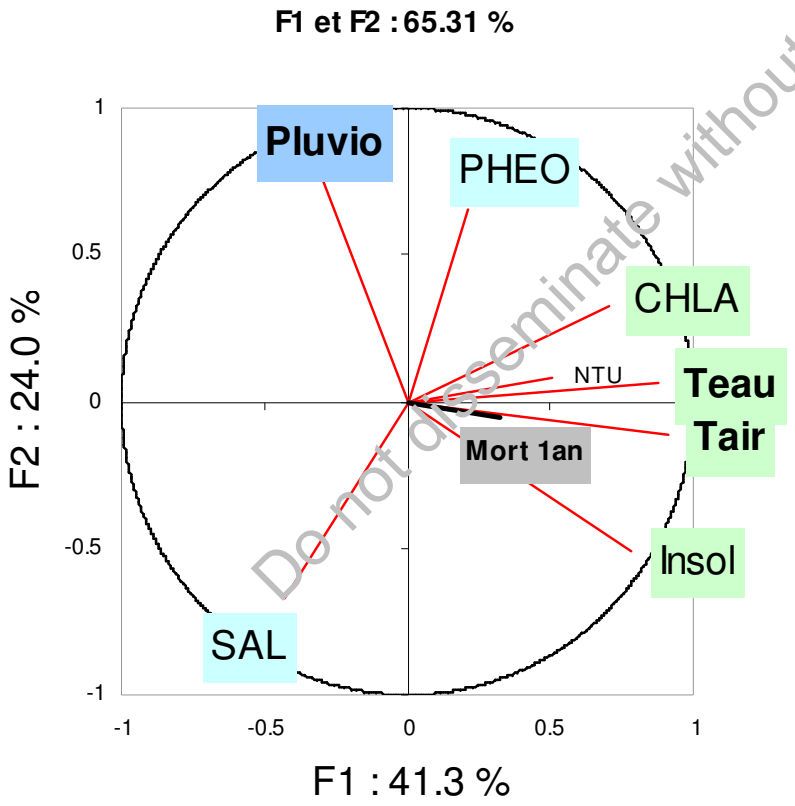
WATER QUALITY & 1-YEAR-OLD OYSTERS MORTALITIES

(mean annual data)

Matrice de corrélation :

	CHLA	PHEO	SAL	Teau	NTU	Tair	Pluvio	Insol
CHLA	1	0.221	**-0.464**	**0.523**	**0.413**	**0.504**	-0.011	**0.312**
PHEO	0.221	1	**-0.328**	0.198	0.179	0.109	**0.308**	-0.101
SAL	**-0.464**	**-0.328**	1	**-0.387**	-0.156	**-0.269**	**-0.331**	-0.042
Teau	**0.523**	0.198	**-0.387**	1	**0.248**	**0.845**	-0.114	**0.652**
NTU	**0.413**	0.179	-0.156	**0.248**	1	**0.359**	-0.183	0.219
Tair	**0.504**	0.109	**-0.269**	**0.845**	**0.359**	1	**-0.257**	**0.773**
Pluvio	-0.011	**0.308**	**-0.331**	-0.114	-0.183	**-0.257**	1	**-0.626**
Insol	**0.312**	-0.101	-0.042	**0.652**	0.219	**0.773**	**-0.626**	1

En gras, valeurs significatives (hors diagonale) au seuil alpha=0.050 (test bilatéral)



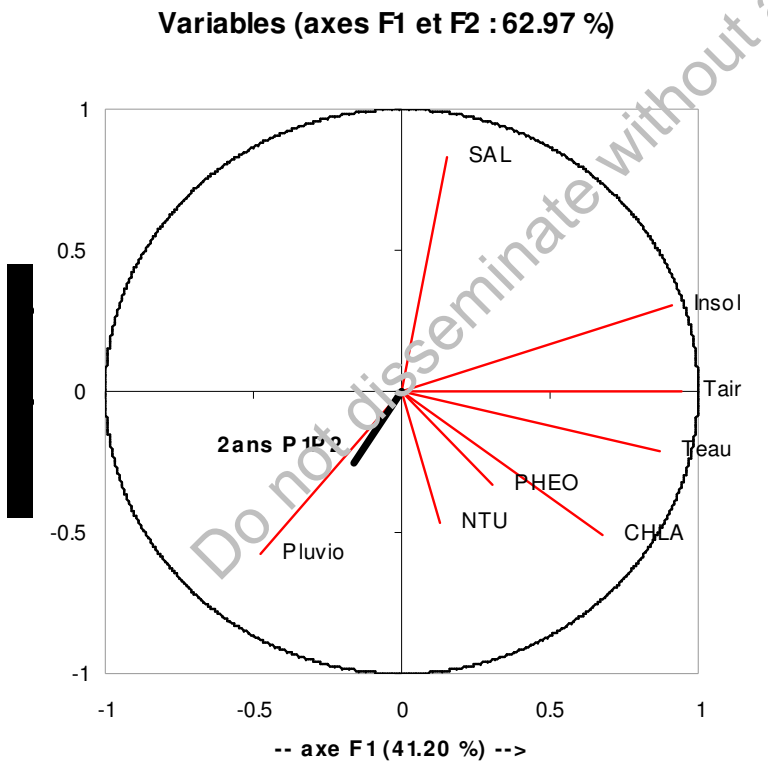
***1 year-oysters** mortality*
⇔ *TEMP, CHL, TURB*
= *factors with high*
spatial differences

WATER QUALITY & 2-YEARS-OLD OYSTERS MORTALITIES *(annual means)*

Matrice de corrélation :

	CHLA	PHEO	SAL	Teau	NTU	Tair	Pluvio	Insol
CHLA	1	**0.275**	**-0.243**	**0.600**	**0.280**	**0.561**	-0.066	**0.424**
PHEO	**0.275**	1	-0.055	**0.255**	0.037	0.210	0.065	0.146
SAL	**-0.243**	-0.055	1	-0.069	**-0.267**	0.142	**-0.402**	**0.336**
Teau	**0.600**	**0.255**	-0.069	1	0.046	**0.837**	-0.155	**0.720**
NTU	**0.280**	0.037	**-0.267**	0.046	1	0.103	-0.102	-0.051
Tair	**0.561**	0.210	0.142	**0.837**	0.103	1	**-0.346**	**0.862**
Pluvio	-0.066	0.065	**-0.402**	-0.155	-0.102	**-0.346**	1	**-0.591**
Insol	**0.424**	0.146	**0.336**	**0.720**	-0.051	**0.862**	**-0.591**	1

En gras, valeurs significatives (hors diagonale) au seuil alpha=0.050 (test bilatéral)



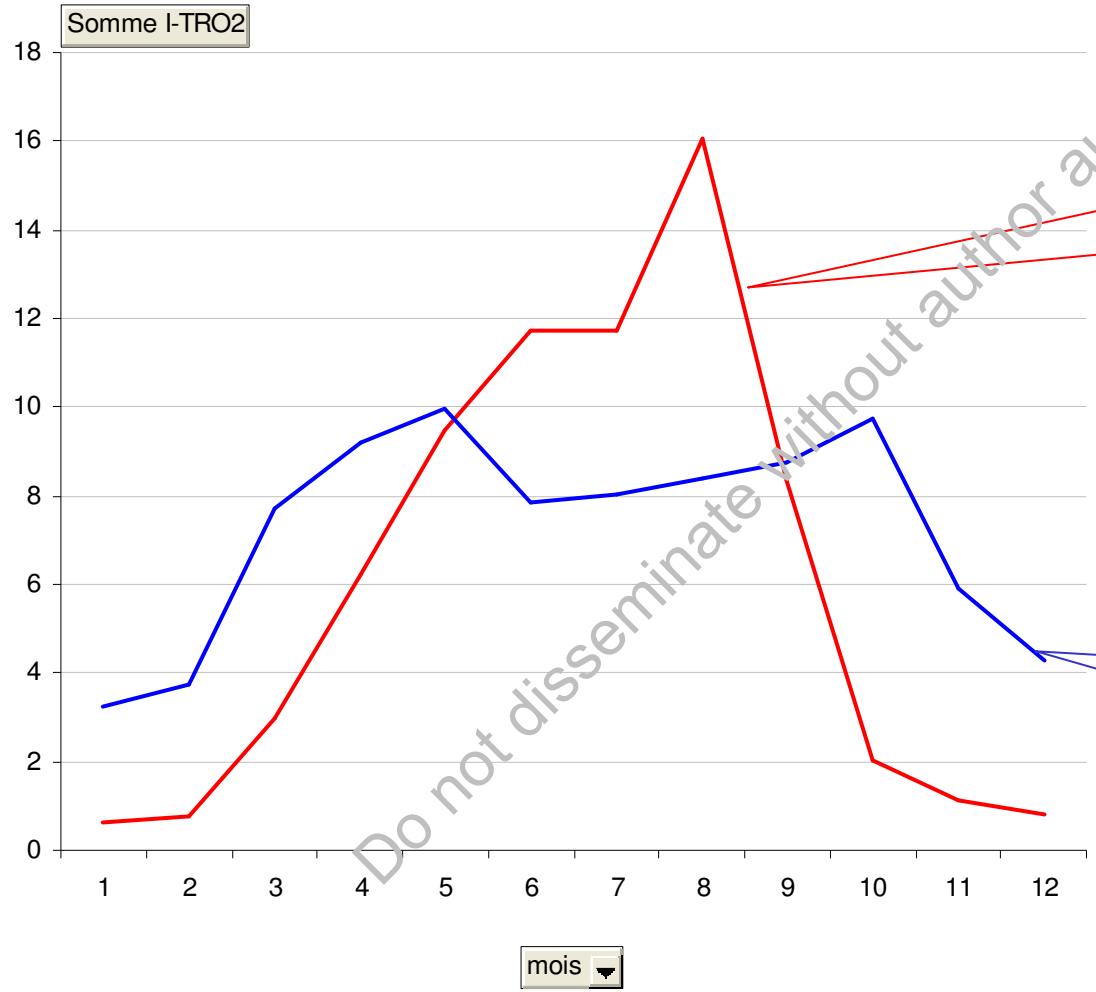
***2 year-oysters** mortality*
⇔ RAIN, SALINITY
*= factors with high **temporal (inter-annual) differences***

empirical statistical correlations however !
*=> eventual **lack of pertinent non linear combination of parameters…***

LOOKING FOR PERTINENT NON LINEAR PARAMETERS
seasonal variation of trophic index => **MORTALITY ?**

TROPHIC INDICE monthly evolution

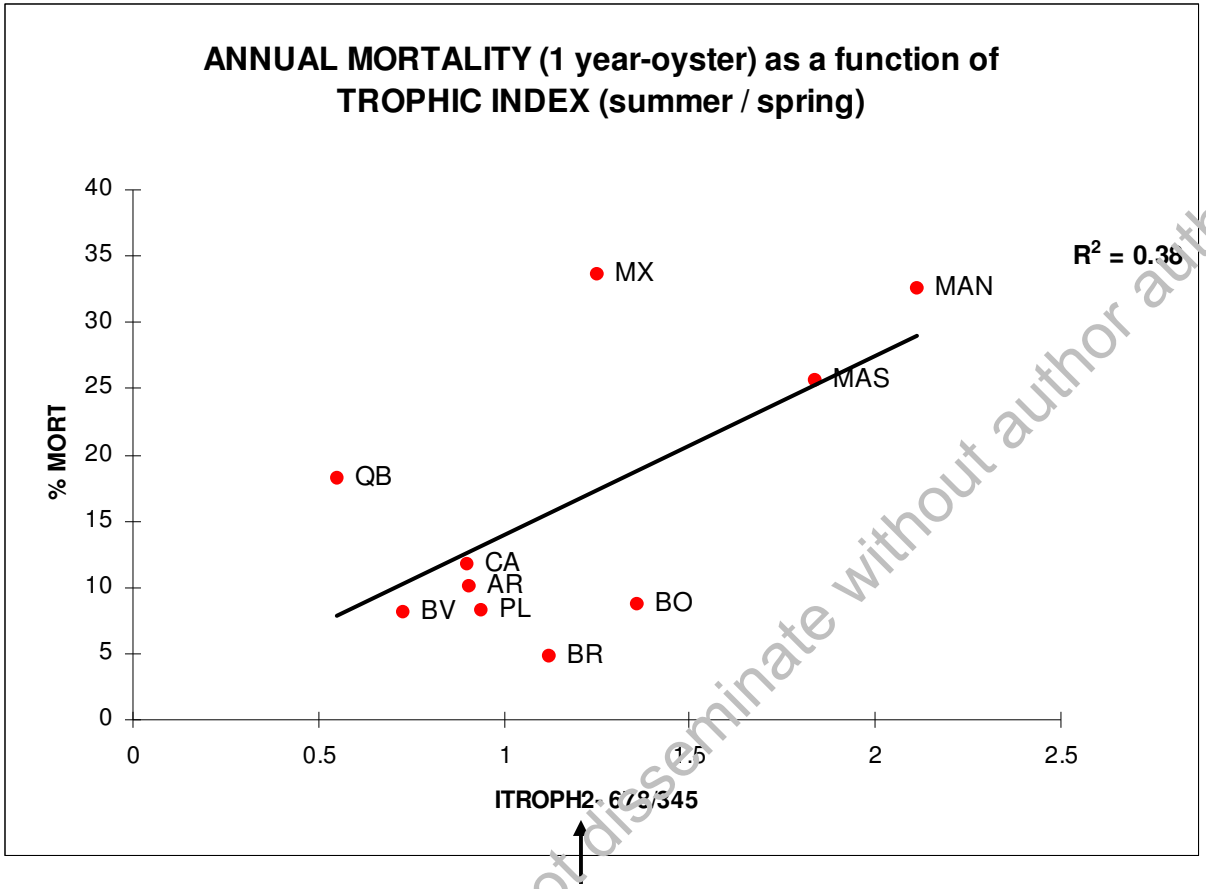
Trophic Index = **Food quality** (CHL/TURB) x Food quantity



MARENNES OLERON : **high mortality**

ARCACHON : **low mortality**

SEASONAL CHANGE IN FOOD QUALITY => 1 YEAR-OLD OYSTERS MORTALITY



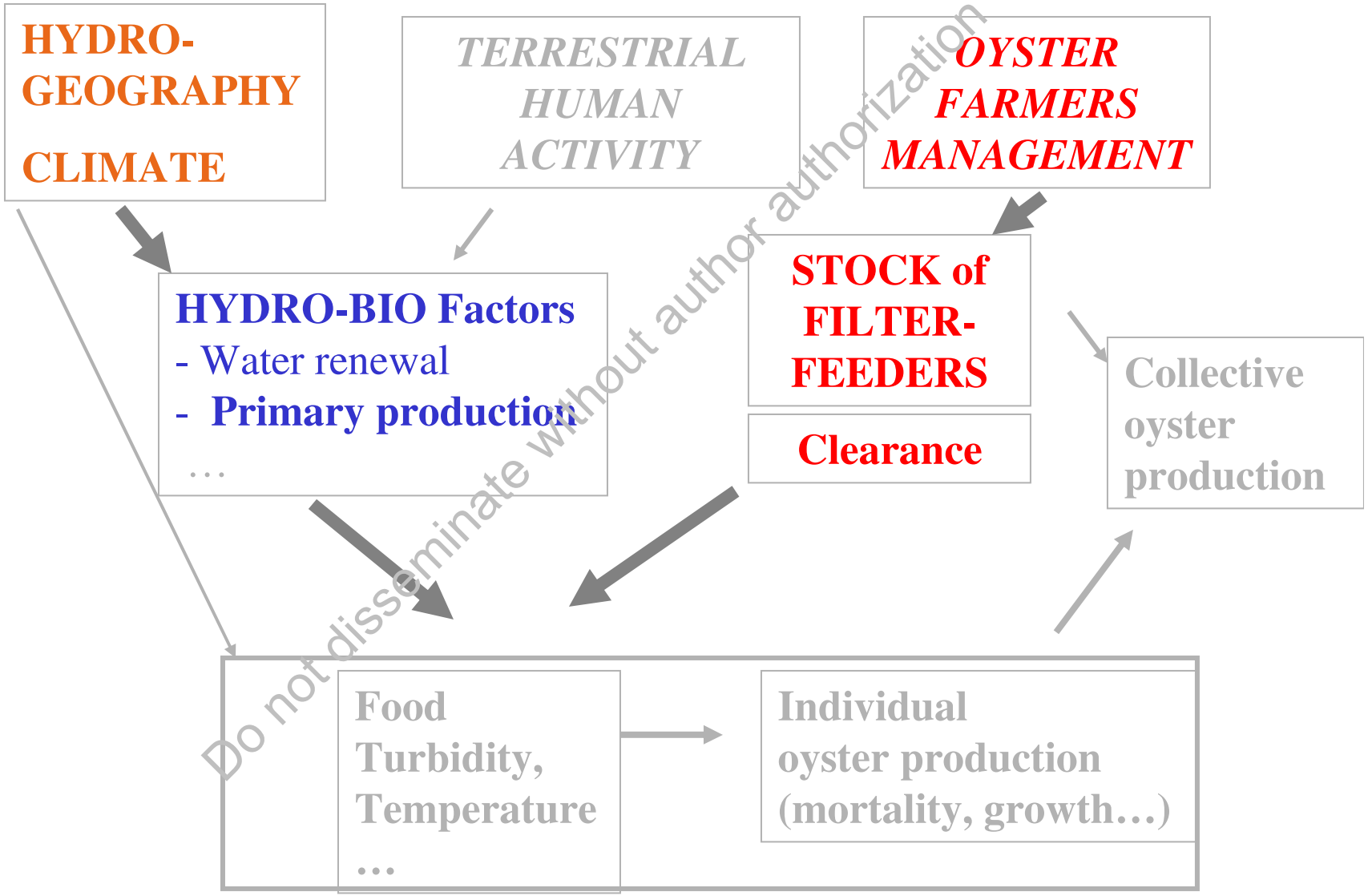
Mean Trophic Index summer (month 6-7-8) / Mean Trophic Index spring (month 3-4-5)

Trophic index = CHL/(TURB +1.2)

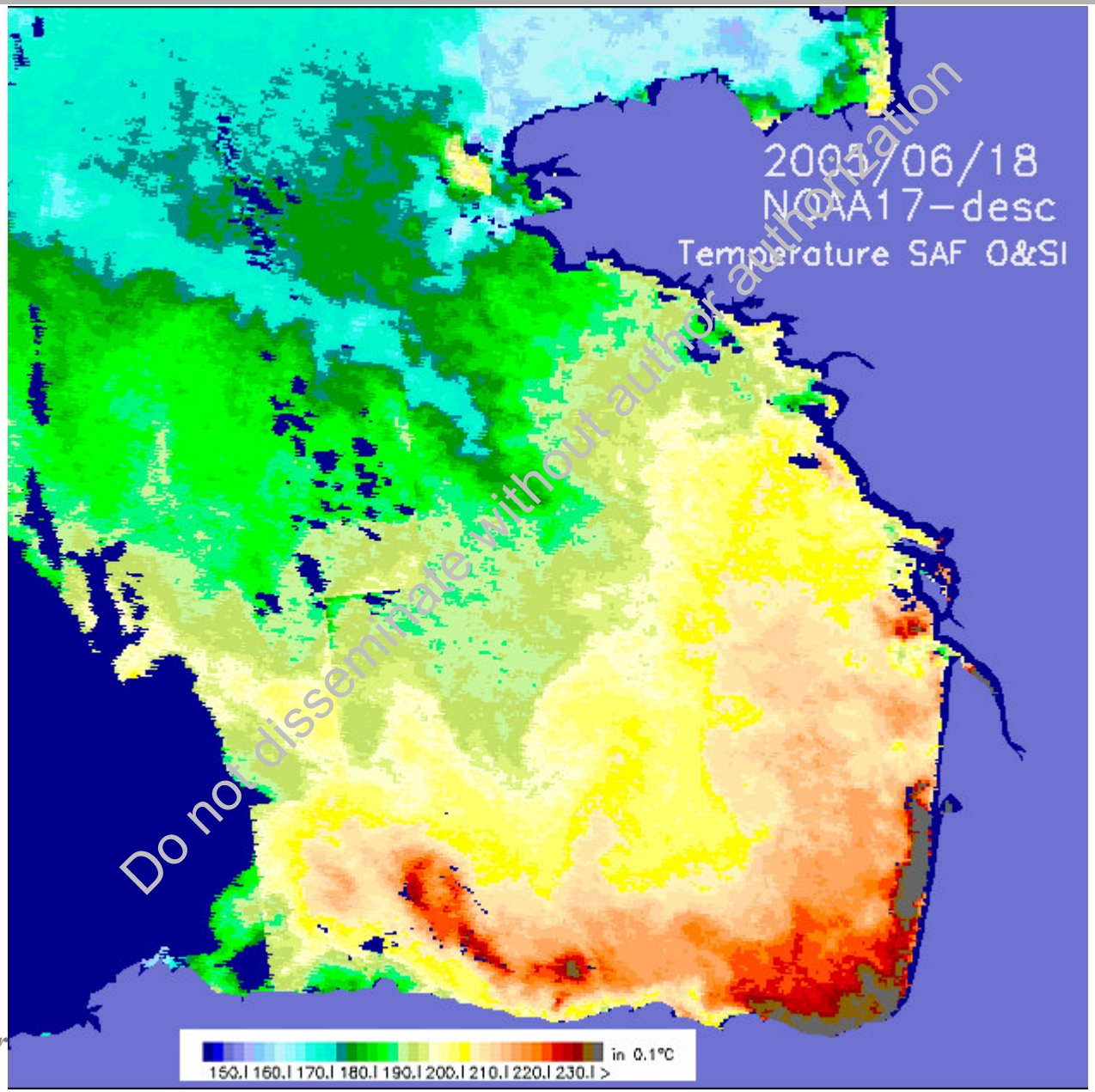
*(Seasonal change between spring and summer = **at the end of gonadal maturation**)*

II- Upper explanatory levels : Hydro-Geo & Human

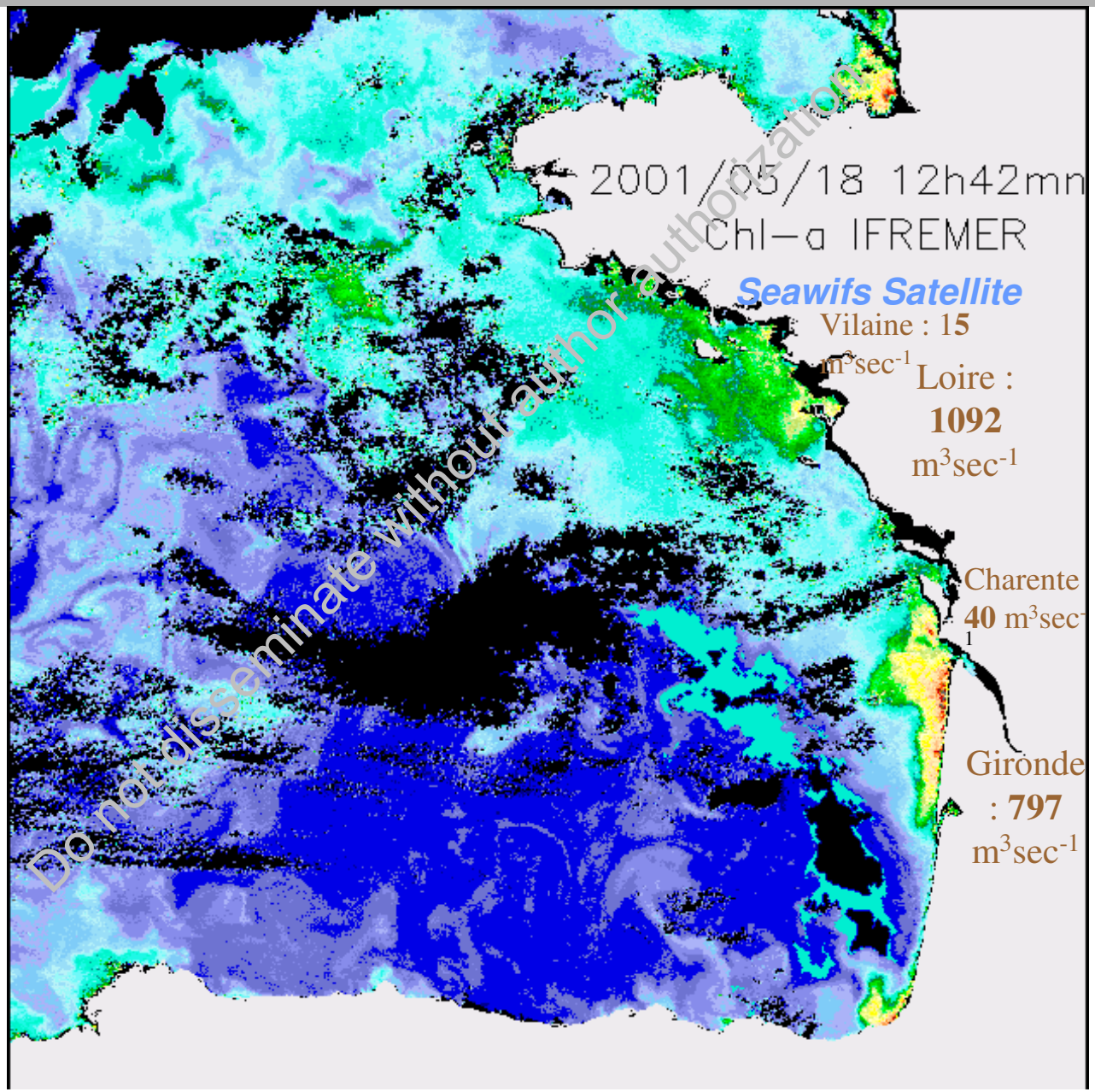
Oyster Ecosystem Environment



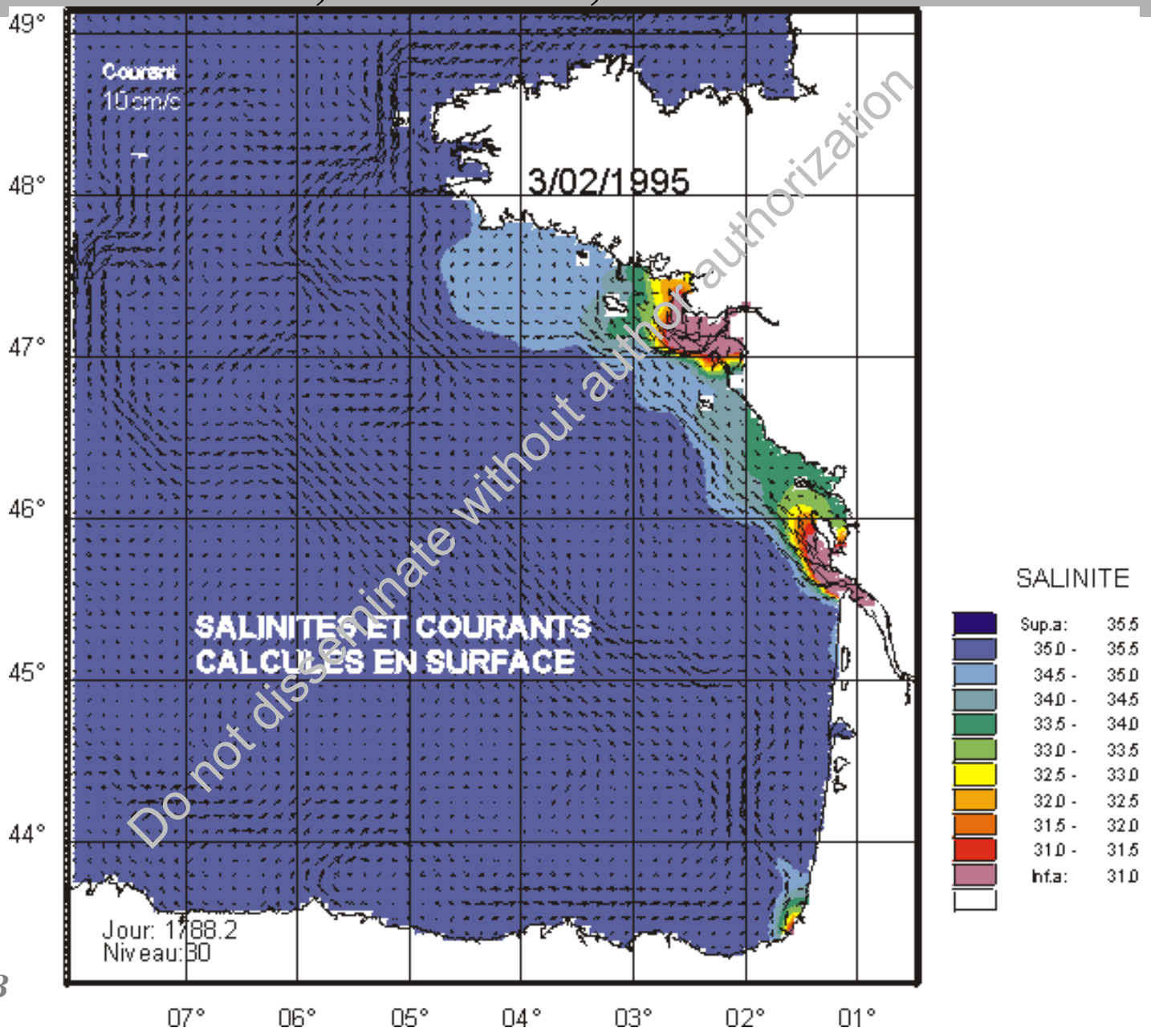
HYDRO-GEOGRAPHY & CLIMATE => TEMPERATURE, SALINITY, PHYTOPLANKTON…



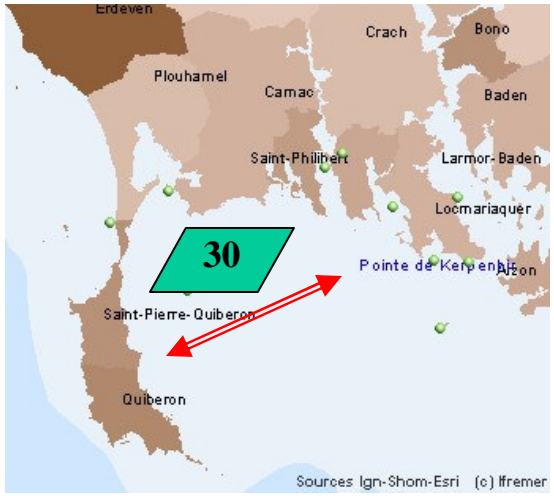
HYDRO-GEOGRAPHY & CLIMATE => TEMPERATURE, SALINITY, PHYTOPLANKTON…

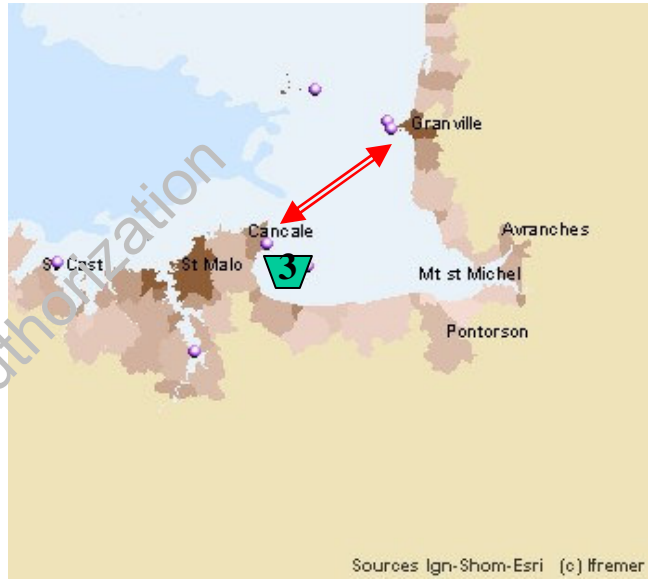


HYDRO-GEOGRAPHY & CLIMATE => TEMPERATURE, SALINITY, PHYTOPLANKTON…

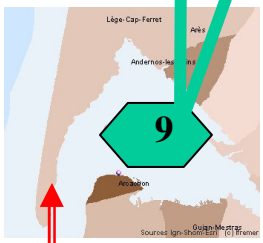


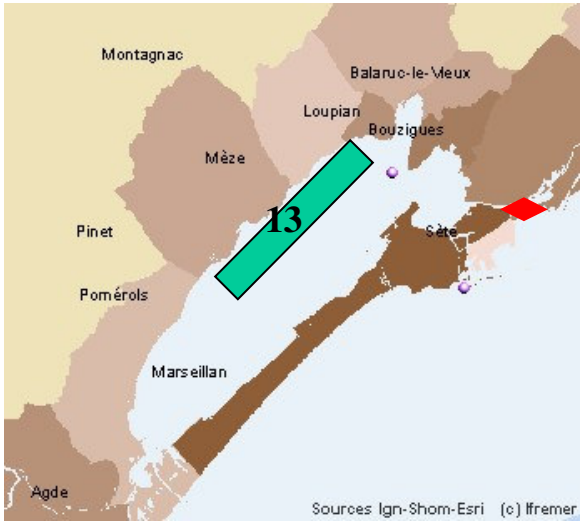
(GEO-)MORPHOLOGY AND PRODUCTIVITY (1)





Surface conceded (km²)





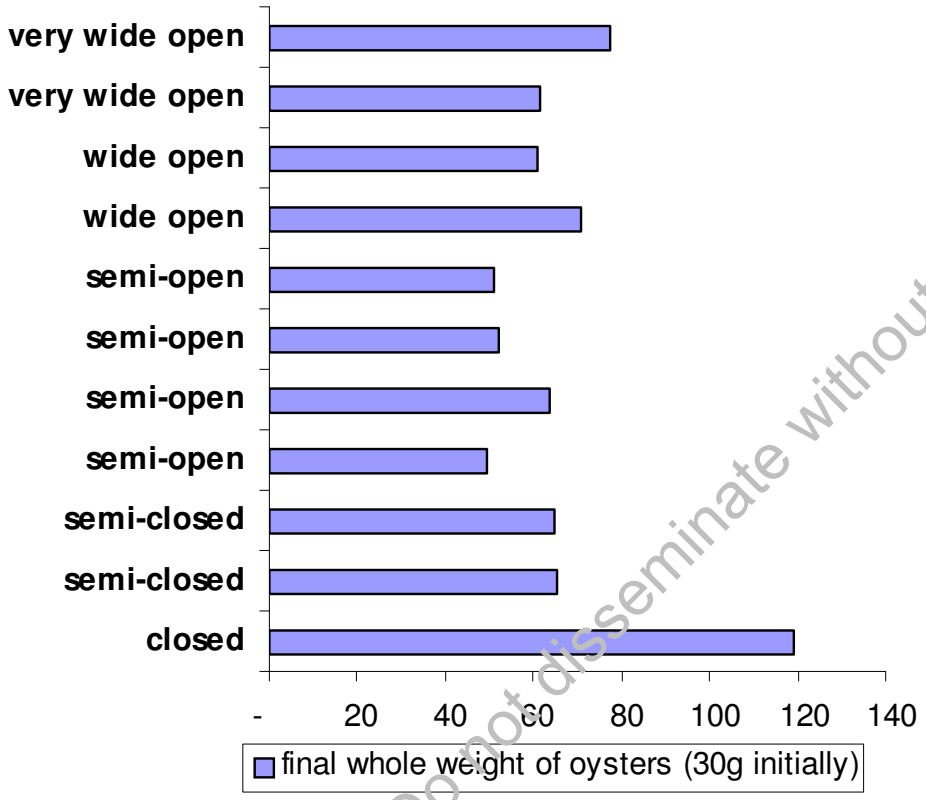
Small / large , …

Wide open, semi-open, almost closed, …

oriented north, west, south…

} ***what importance ?***

Degree of **aperture** (or surface of **exchange**) **with ocean**

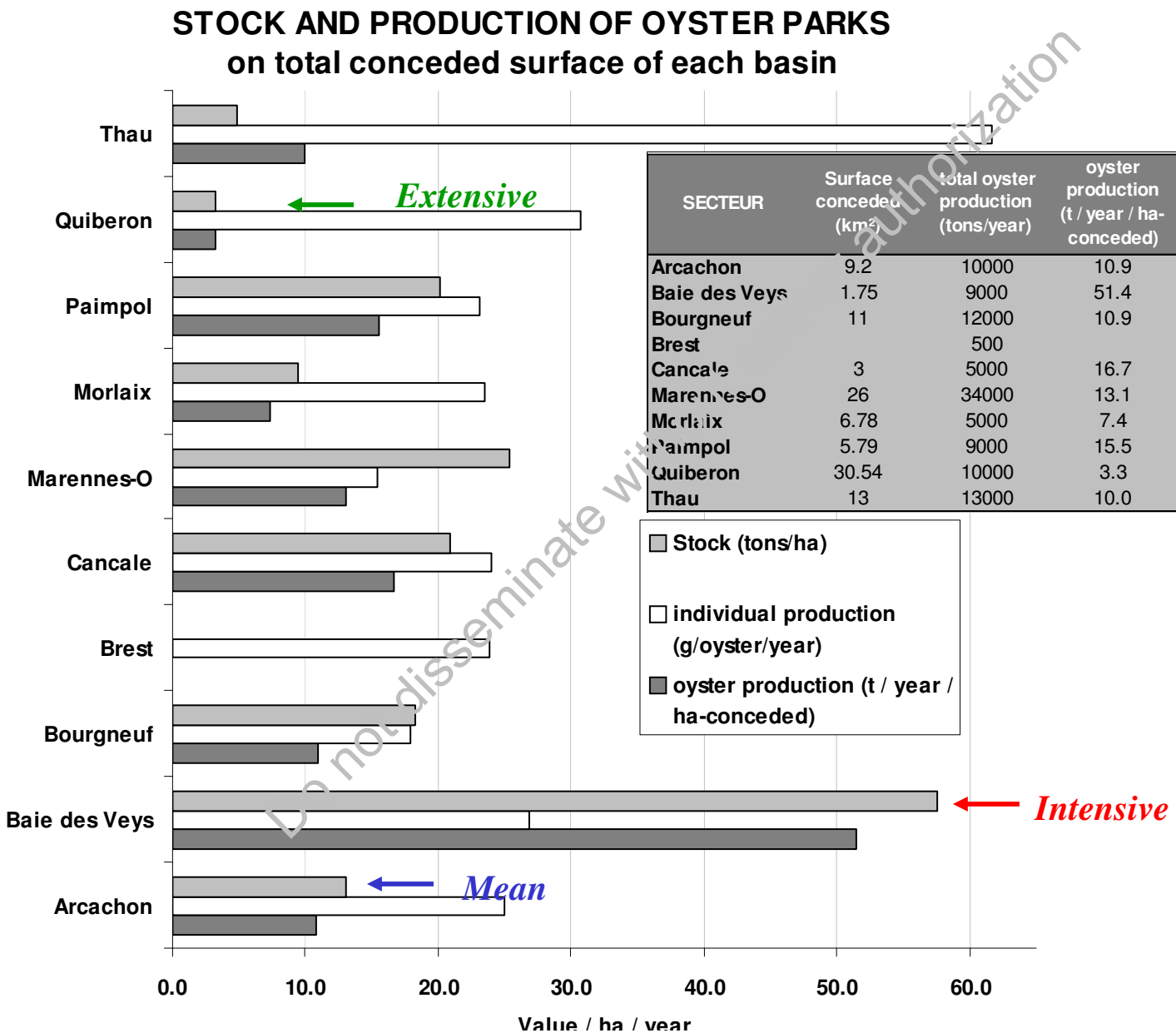


= not determinant

Evidence :
oyster growth is ***not simply linked*** *with the relative surface of exchange between farming basin and ocean*

Explanation : Geography determines the ***flux of water*** *though the farming area (in and out) : in terms of* ***food budget****, the balance may be positive (net import) or negative (net export)*

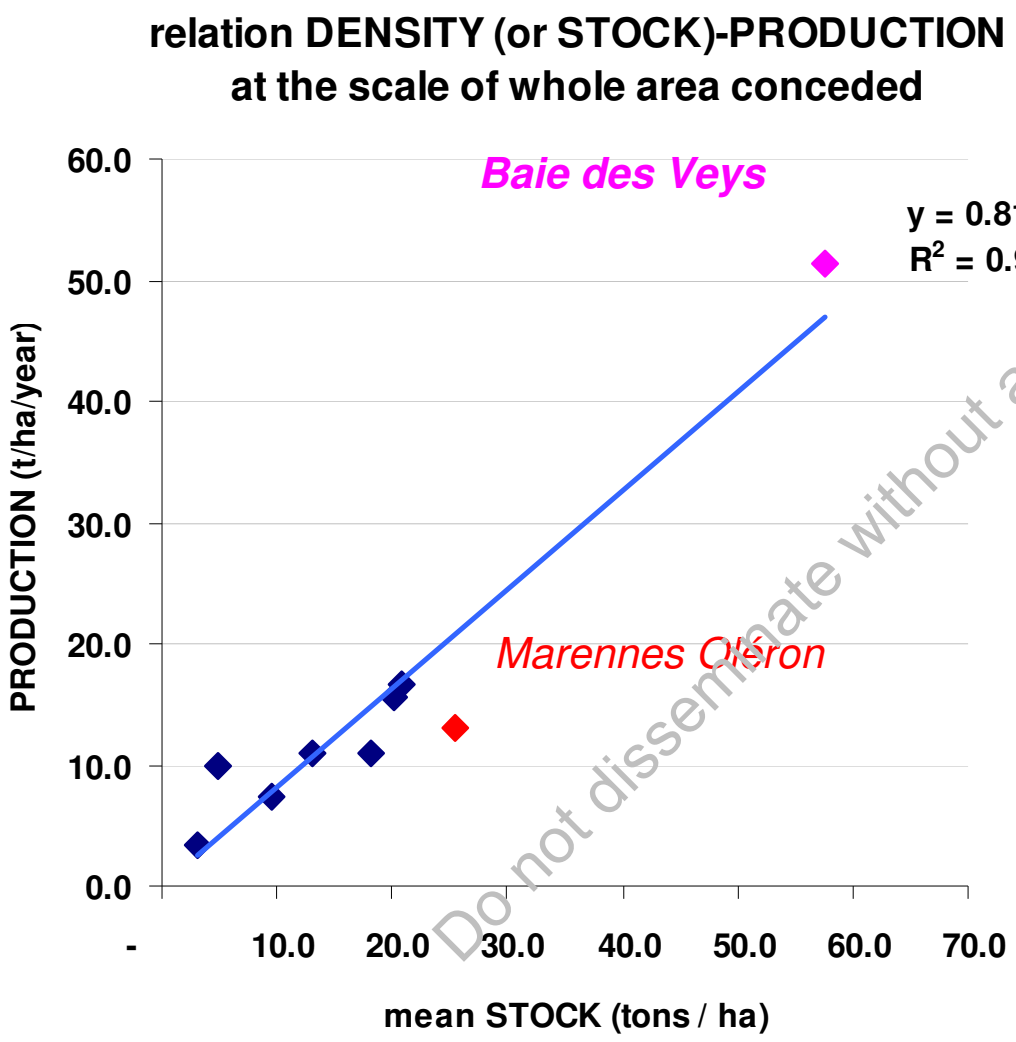
Oysters DENSITY at the scale of concessions influences production, but productivity / kg ?



SECTEUR	Surface conceded (km²)	total oyster production (tons/year)	oyster production (t / year / ha-conceded)	individual production (g/oyster/year)	Stock (tons/ha)
Arcachon	9.2	10000	10.9	25	13.06
Baie des Veys	1.75	9000	51.4	27	57.53
Bourgneuf	11	12000	10.9	18	18.25
Brest		500		24	
Cancale	3	5000	16.7	24	20.88
Marennes-O	26	34000	13.1	15	25.39
Morlaix	6.78	5000	7.4	23	9.43
Paimpol	5.79	9000	15.5	23	20.15
Quiberon	30.54	10000	3.3	31	3.21
Thau	13	13000	10.0	62	4.86

ICS

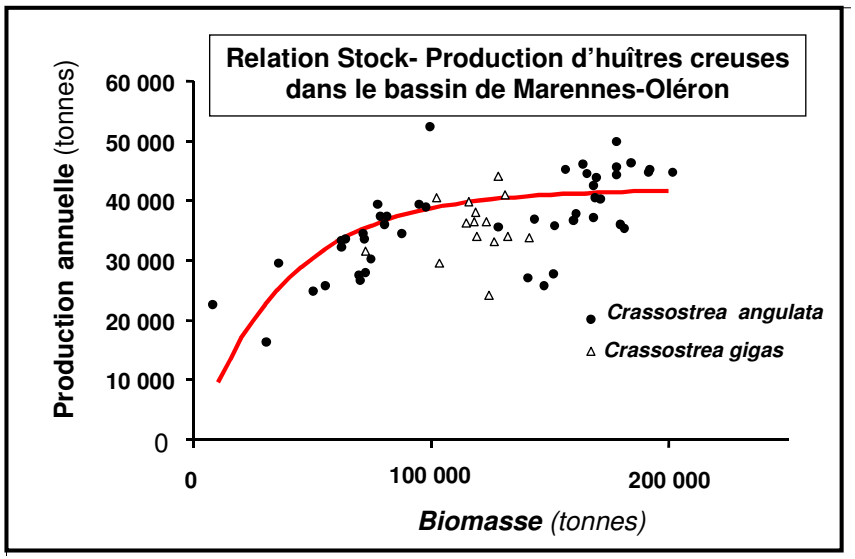
No clear effect of **stock density** on **stock productity,** *inter-sites*



Mean P/B = 0.8 year^{-1}

but clear stock effect ***intra****-Marennes-Ol*

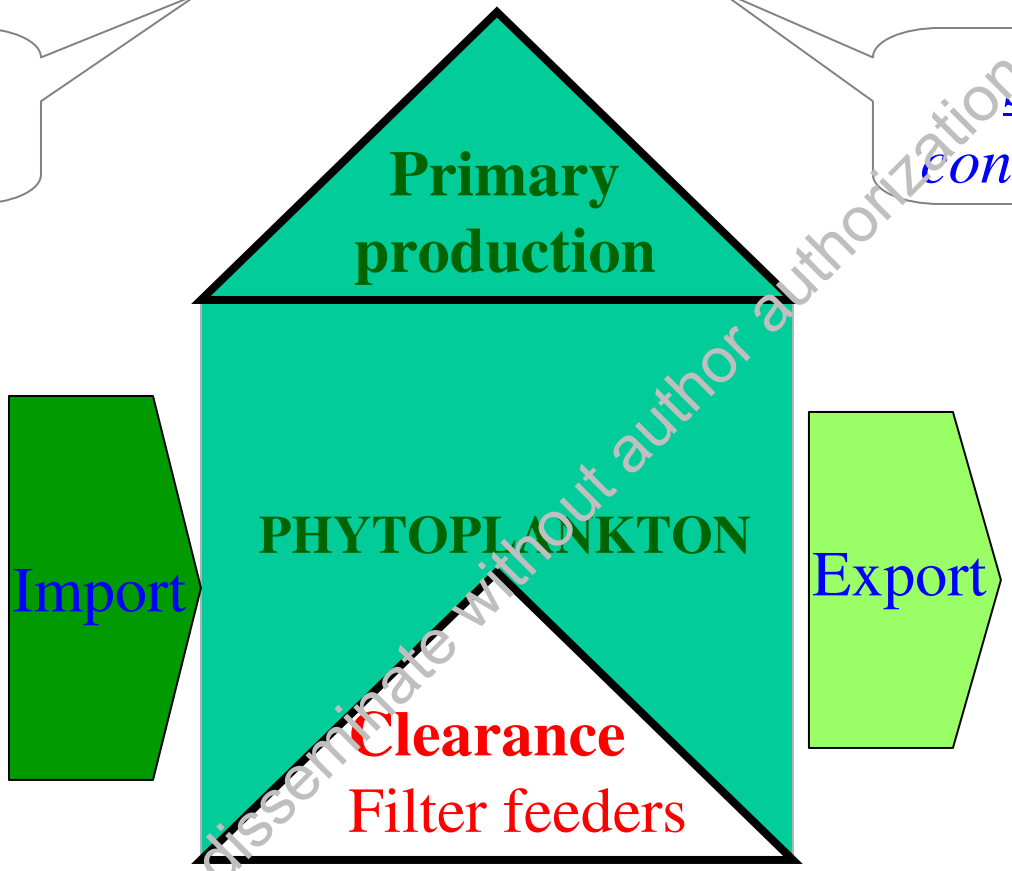
Heral et al (1986)



Confrontation DEMAND (Clearance) ⇔ OFFER (endogeneous or exogeneous Phytoplancton)

Production consumable

Stock consumable



15 t/ha of oysters (whole weight)
in a 3 m water column
clear daily 100% of Volume

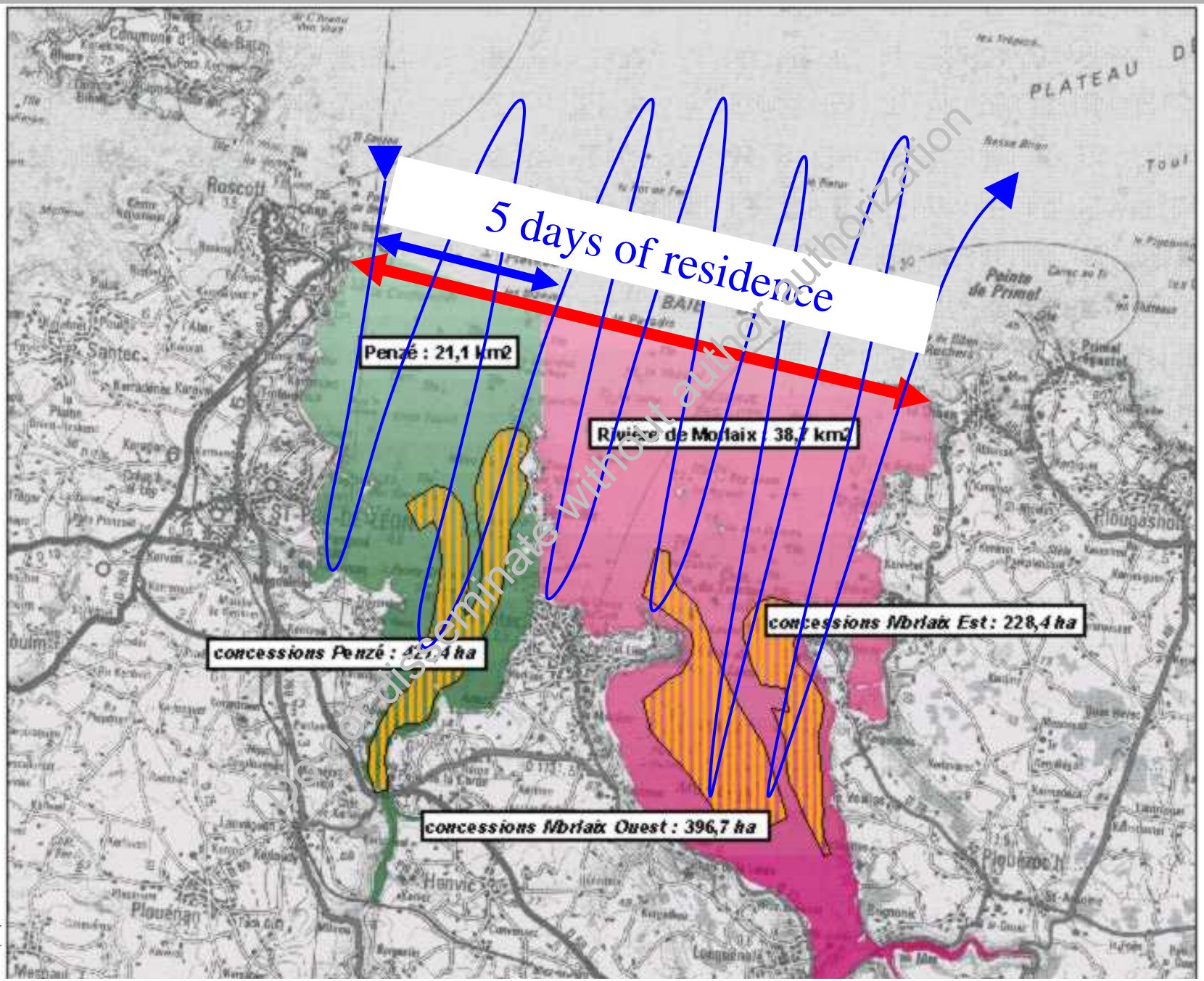
BALANCE RULE :

Clearance rate* < Renewal rate* + Primary production rate* ** expressed as (% stock or vol.)*

or **Clearance time* > Residence time* + Primary production doubling time*** ** expressed in days*

*from **Smaal, Dame, Prins**(…) and …common sense*

RENEWAL RATE / RESIDENCE TIME



FOOD UPTAKE > FOOD RENEWAL (exogenous or endogeneous) ?

Area considered = conceded area

*Data of renewal and primary production based on **rough hypothesis => to be precised***

***renewal** : 10 km² / day affected to conceded surface*

***primary production** : moderated by turbidity*

Oyster stock x individual Clearance

From size and oceanic exposure

Buffered by Turbidity

Clearance / (Renewal + Prim.Prod)

	Clearance *	Renewal *	Primary production *	Indice of over-stocking	
Arcachon	**94%**	109%	158%	**0.35**	
Baie des Veys	**414%**	857%	189%	**0.40**	
Bourgneuf	**131%**	91%	8%	**1.02**	over-stocked
Brest					
Cancale	**120%**			**0.48**	
Marennes-O	**183%**	%	42%	**2.27**	**over-stocked**
Morlaix	**68%**	221%	129%	**0.19**	
Paimpol	**145%**	259%	263%	**0.28**	
Quiberon	**13%**	33%	183%	**0.06**	understocked
Thau	**18%**	0%	260%	**0.07**	understocked

Provisional data

** expressed as % of Volume daily*

CONCLUSION

Most of the **observed differences in shellfish productivity** of French ecosystems arise from **water quality** (specially food and turbidity)…

Coastal seawater productivity is mainly dependent on
hydro-geographical traits, with **climatic modulation** :
reactive in the vicinity of fluvial discharges,
buffered by ocean elsewhere
=> profitability / risk choices

The oyster farmers make use of this productivity,
through **regulation of access** to this common resource
(how many oysters stocked where ?) :
physical and social constraints generally precede food limits

Land users influence on shellfish farming is
…another story

Thanks for your attention

Coriolis Force :
winds and currents deviated rightward in North Hemisphere