Stock dynamics and stock assessment of Octopus in the COPACE area

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- **ISTAM project**
- **Octopus vulgaris in the COPACE area**

Stock assessment

- **Surplus Production models**
- **Depletion models**

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Stock assessment

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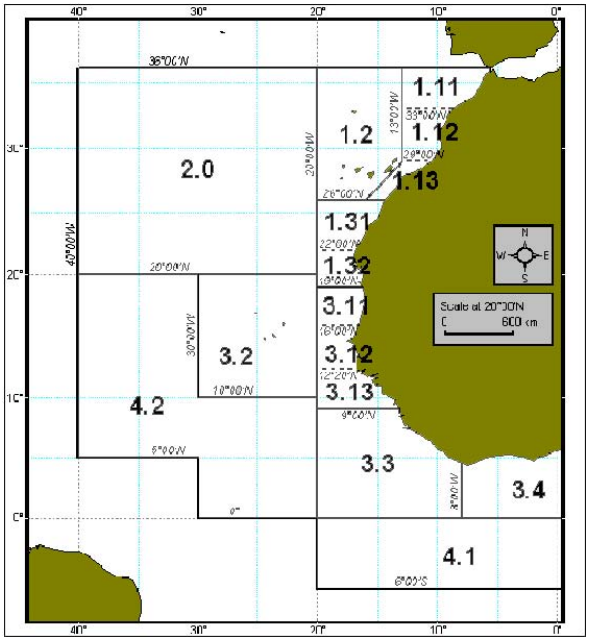
ISTAM project (istam.org)

- **Concerted Scientific Action**
  - **Financed by European Comission**
  - **2006 - 2008**
- **Objectives**
  - **Improve Scientific and technical Advices for Fisheries Management**
  - **FAO COPACE Area**
  - **Work Packages**

WP1 : Monitoring systems
WP2 : Sub-regional information systems (data base)
WP3 : Stock assessment methods
WP4 : Training activities
WP5 : Dissemination

ISTAM project (istam.org)

- **FAO COPACE Area**
  - ***« Comité des Pêches pour l'Atlantique Centre Est »***
  - **Scientific advices**
  - **Creation : 1967**



TheFAOFishing Area 34 (from Gibraltar to the Congo river, Lat. 36°00'N-6°04'36"S, Long. 12°19'48"E-5°36'W).

Map modified afterFAO(2001). Equidistant cylindrical projection.

ISTAM project (istam.org)

ISTAM Partners

Guinea	CNSHB - Centre National des Sciences Halieutiques de Boussoura
France	IRD
	Agrocampus
	IFREMER
Marocco	INRH - National Institute of Fisheries Research
Mauritania	IMROP - Institut Mauritanien de Recherches Océanographiques et de Pêches
UK	University Porthmouth - Centre for the Economics and Management of Aquatic Resources
Spain	Universidad de Las Palmas de Gran Canaria
Senegal	Institut Universitaire de Pêche et d'Aquaculture
Portugal	IPIMAR - Instituto of Investigação das Pescas e do Mar
Norway	IMR - Institute of Marine Research
Regional Organism	
	CSRP - Commission Sous Régionale des Pêches

ISTAM project (istam.org)

- **Objectives WP3 (Stock assessment methods)**
  - ***Robust methods for stocks Dynamic – Assessment in « data Poor environment »***
  - **Effect of the environment (Upwelling area)**
  - **Activities in WP3**

4. Data poor

4.2. Dynamic *vs* Equilibrium in production models

6. Environmental models

6.1. Multi-oscillatory approach system

6.2. Env. variability in production models

- ISTAM project
- **Octopus vulgaris in the COPACE area**

Stock assessment

- Surplus Production models
- Depletion models

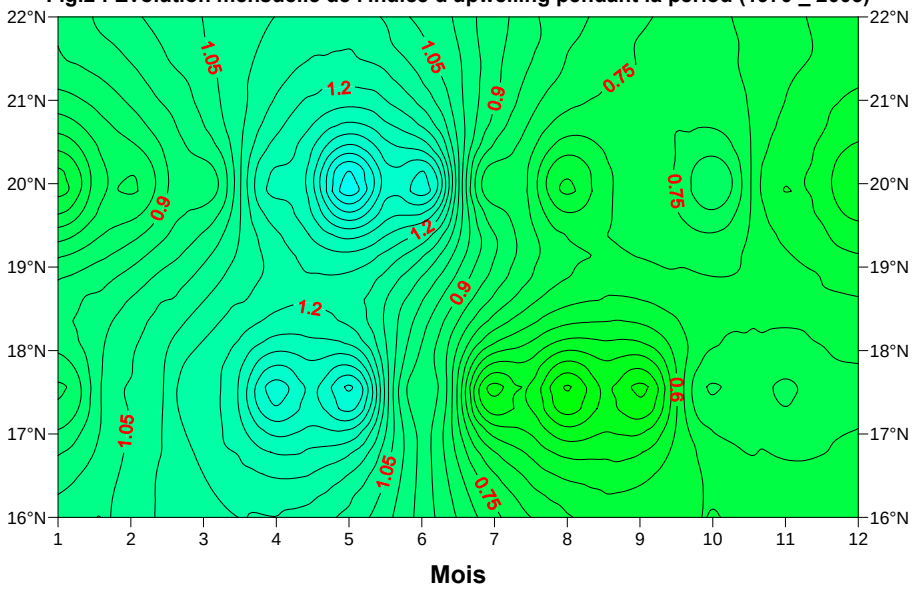
Octopus vulgaris

- **Biology**
  - **Mollusc (cephalopod)** (***Octopus vularis*, Cuvier 1797**)
  - **Benthic with variable habitat (mud, rocky)**
  - **Limited seasonal migration (spawning)**
  - **Growth :** **Very high growth rate**
    Exponetial growth
    Max weigth ~ 10 kg
  - **Semelparity**
    max age ~ 1.5 years

Upwelling area

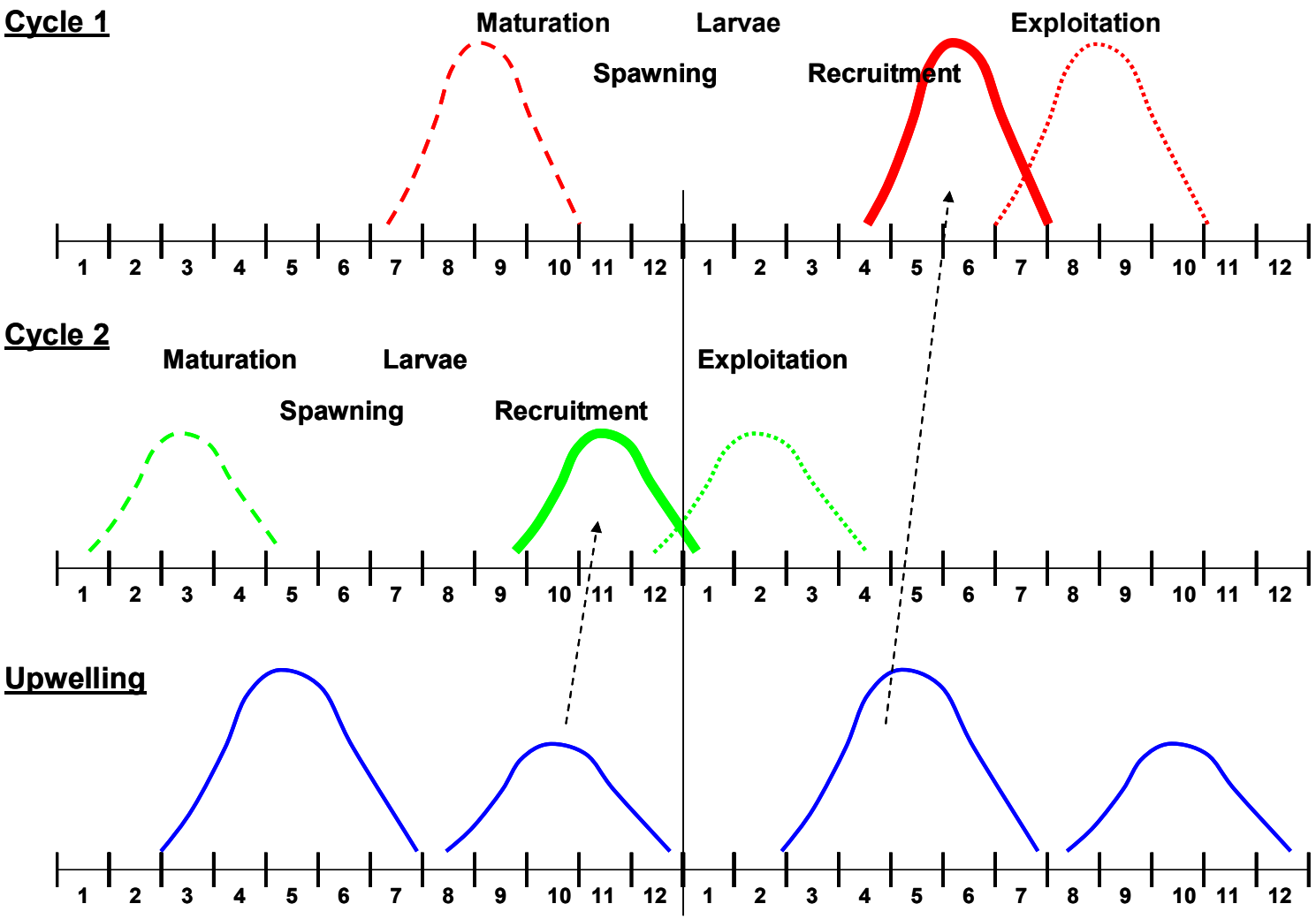
- **Example mauritania**
  - **Mean seasonnal upwelling regime (1970 – 2005)**

Fig.2 : Evolution mensuelle de l'indice d'upwelling pendant la période (1970 _ 2005)



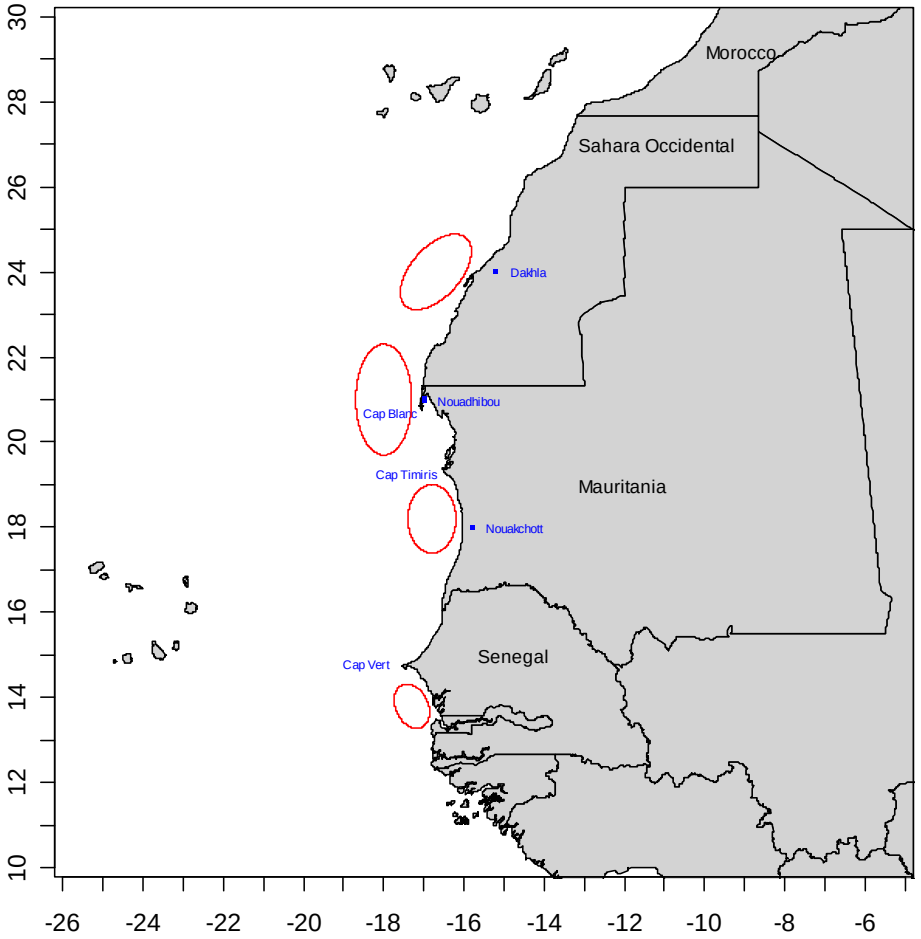
Source : Bambaye H., Mariem B. & Mariem E. - IMROP

Octopus highly depends upon the environment



Octopus vulgaris

- **4 main stocks in the COPACE area**



Octopus vulgaris

- **Fishery in the COPACE area**
  - **Rapid development in the 60’ - 70’**
  - **Now over-exploited**

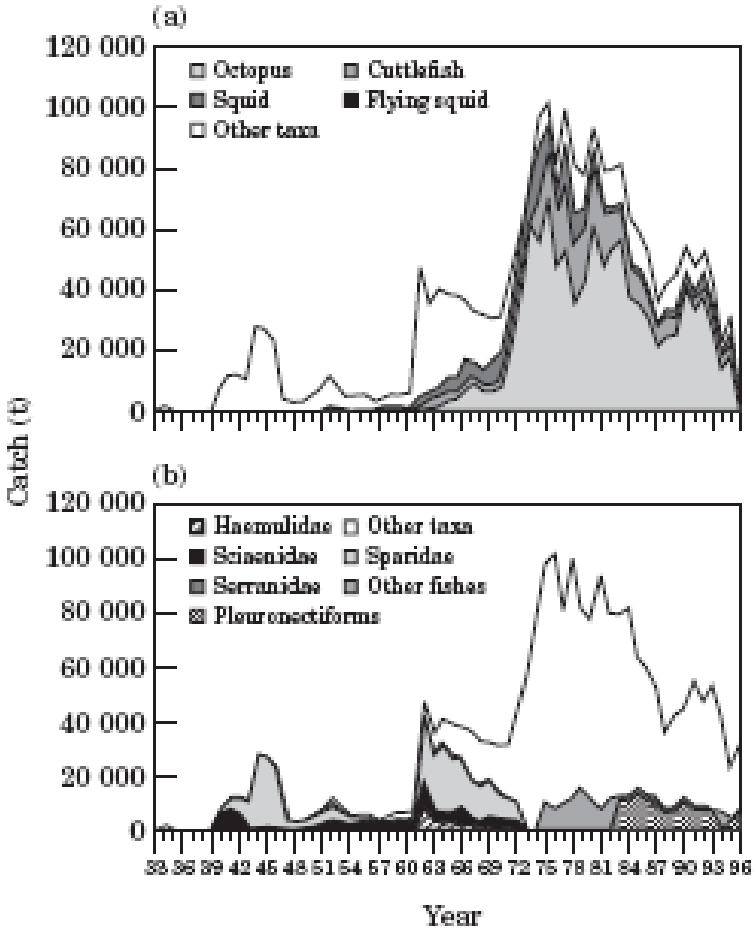
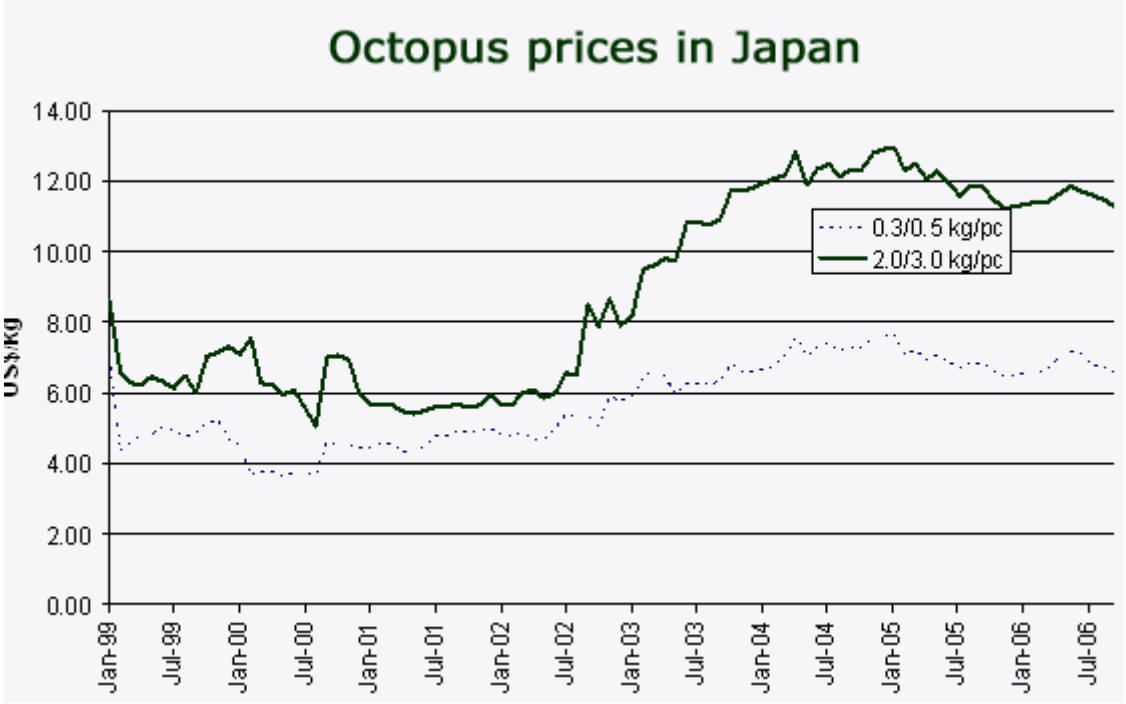


Figure 2. Composition of Spanish landings (in tons) from the Saharan Bank, 1933–1990. (a) By major cephalopod taxa, (b) by major fish taxa.

Balguerias E. et al. 2000. **The origin of the Saharan Bank cephalopod fishery.** ICES Journal of Marine Science, 57: 15–23.

Octopus vulgaris

- **Fishery**
  - **Very high value species**



Source : GlobeFish FAO

Octopus vulgaris

- **Fishery**
  - **Artisanal**

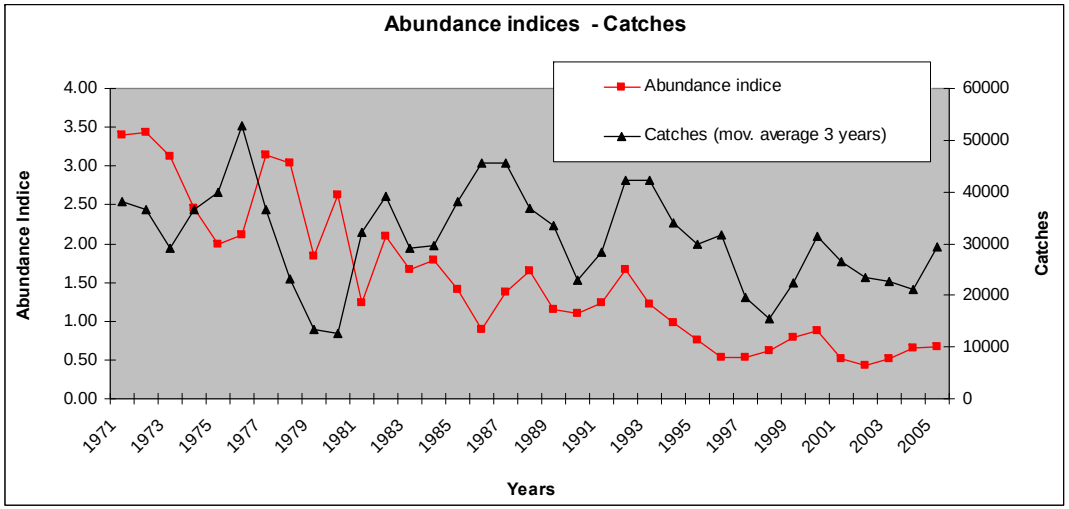
Mauritania

  - **Industrial**

Octopus vulgaris

- **Fishery - Example Mauritania**
  - **Mauritania : Octopus = 70% (value) of fishes exports**

(Artisanal = 20 % catches)



Source : IMROP WG 2006

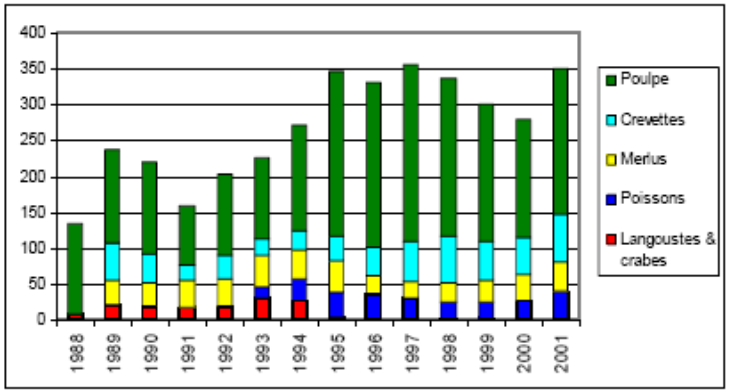


Figure 1.1: Nombre cumulé de chalutiers démersaux

Source : FAO CoPACE 2002 – Evaluation pêcherie démersale ZEE Mauritanienne – p -6

- ISTAM project
- Octopus vulgaris in the COPACE area

Stock assessment

- **Surplus Production models**
- **Depletion models**

Objectives

- **Stock dynamics – assessment**

  - **In a « Data poor context »**

    - Catches / Abundance indices

    - Time step = Year or shorter (month, week ?)

Surplus Production models

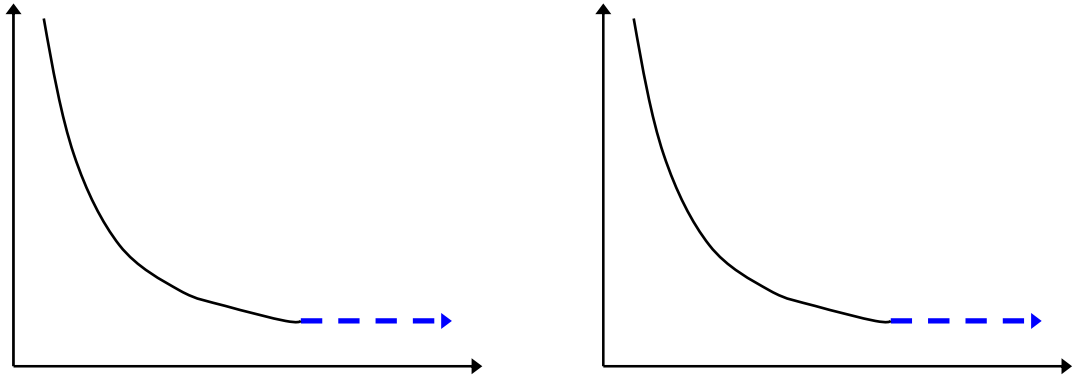
Mid / Long term - assessment
- management
Historic evolution
Estimation of reference points
Evaluation of the current status / ref points

$$\begin{cases} B(t+1) = B(t) + g(B(t)) - C(t) \\ I(t) = q \cdot B(t) \end{cases}$$

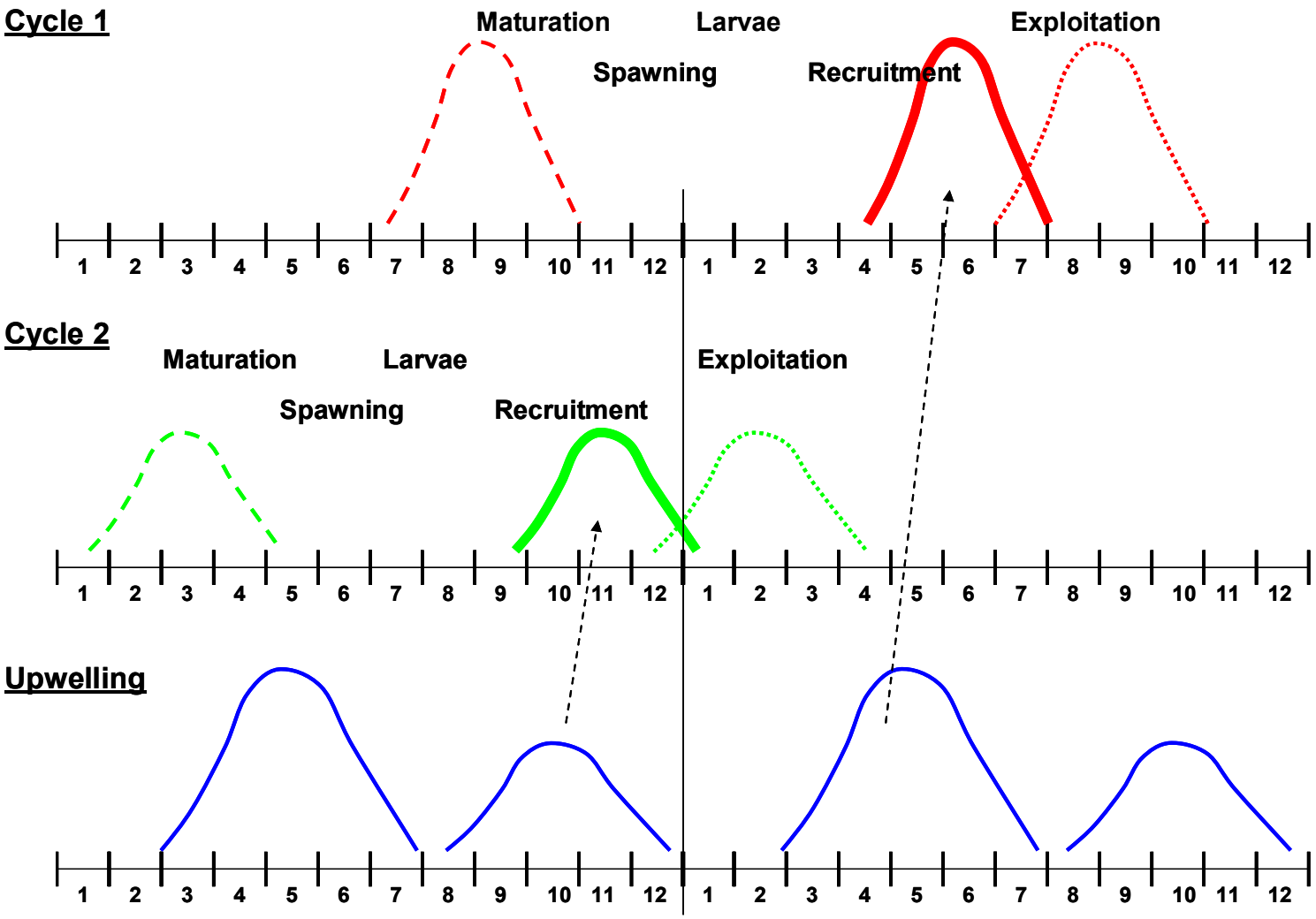
Depletion models

Short term - assessment
- management

$$\begin{cases} N(t+1) = N(t) \cdot e^{-M} + R(t) \cdot e^{-M/2} - C(t) \cdot e^{-M/2} \\ I(t) = q \cdot N(t) \end{cases}$$



Octopus highly depends upon the environment



- ISTAM project
- Octopus vulgaris in the COPACE area

Stock assessment

- **Surplus Production models**
- Depletion models

3 key issues

- **Accounting for multiple source of uncertainties**
  - **Process**
  - **Observations**
- **Dynamic / Equilibrium**
- **Environmental effects**

Surplus production model – State-Space model

State process

Dynamic

$$B(t+1) = B(t) + g(B(t)) \cdot e^{\varepsilon(t)} - c(t)$$
$$\varepsilon(t) \sim N(0, {\sigma_p}^2)$$

$$\begin{cases} \frac{1}{B(t)} \cdot \frac{\partial B(t)}{\partial t} = r \cdot (1 - \frac{\ln(B(t))}{\ln(K)}) \\ Fox: g(B(t)) = r \cdot B(t) \cdot (1 - \frac{\ln(B(t))}{\ln(K)}) = \underbrace{\frac{r}{\ln(K)}}_{h} \cdot (\ln(K) - \ln(B(t)) \end{cases}$$

Equilibrium

Catches (t) = Surplus Prod (t)

$$c(t) = g(B(t)) \cdot e^{\varepsilon(t)}$$
$$\varepsilon(t) \sim N(0, {\sigma_p}^2)$$

Observation process

$$i(t) = q \cdot B(t) \cdot e^{\omega(t)}$$
$$\omega(t) \sim N(0, {\sigma_o}^2)$$

$$\lambda = \frac{{\sigma_p}^2}{{\sigma_o}^2}$$

Why Bayesian framework ?

Pro's

- More complex for simple models, but easier for more complex models
  FLEXIBILITY
  - Multiple source of uncertainty
  - Dynamic
  - Environmental effect K(t)
- Informative priors
- Risk analysis
- We don't like « ready-to-use press-button approach »
- Softwares (MCMC)

Con's

- Sensitivity analysis to priors
- We like « ready-to-use press-button approach »
  (MCMC can be long and tedious)

  - Excel sheet for « equilibrium fit »
  - Dyn Obs error model (e.g. BioDyn)

1. **Does the method works ?**

   « Simulation / estimation »

2. **Application**

   Mauritania

1. **Does the method works ?**

   « Simulation / estimation »

2. **Application**

   Mauritania

Modélisation statistique Bayesienne d'un modèle de production de biomasse. Application à la pêcherie de poulpe (*Octopus vulgaris*) de Mauritanie

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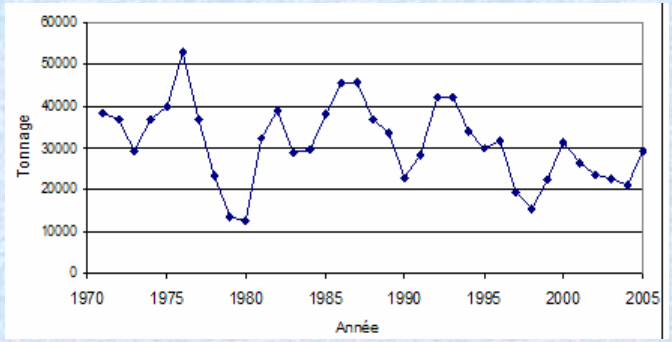
Septembre 2007

Laboratoire d'Ecologie Halieutique
AGROCAMPUS

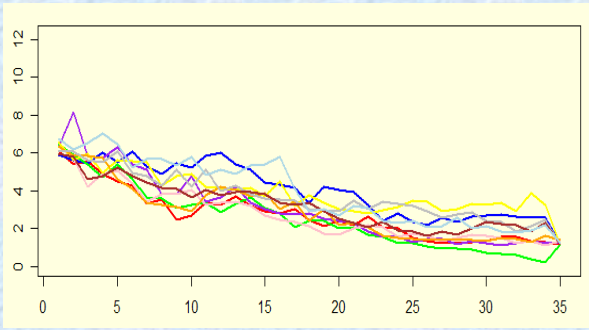
Objectives / Methods

- **Assess the accuracy / precision of estimates derived from Bayesian analysis of production models (SSM)**
- **Questions**
  - **Sensitivity to the prior**
  - **Influence of the level of information in the data**
    - **History of I (depletion rate)**
    - **Variability in the process and noise in the data**
  - **Influence of the « equilibrium assumption »**

Simulations / estimations



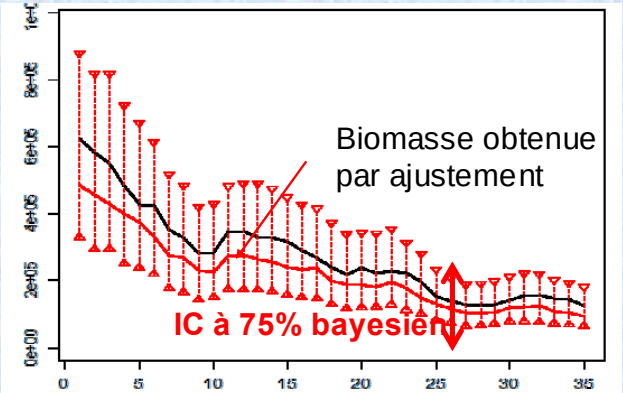
Captures totales de poulpes

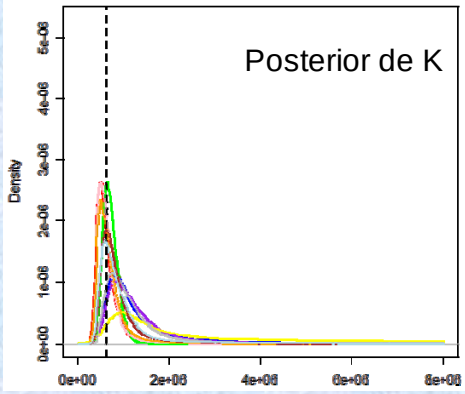


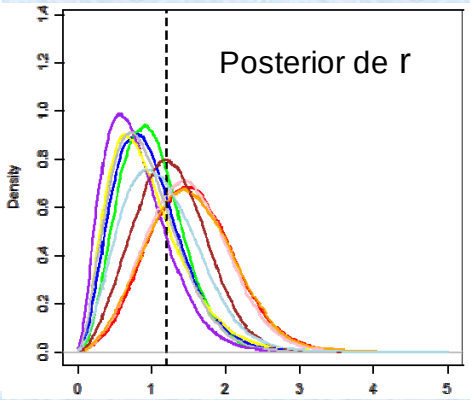
Séries d'IA générés

ajustement

Evolution de la Biomasse sur 35 ans







Simulations / estimations

1. Simulation à paramètres fixes (13 scénarii)

Numéro de scénario	B_{35}/K	r	K	q	λ	σ^2_p
1	0,2	1,20	624959	10^{-5}	1	0.0049
2	0,5		816503	10^{-5}	1	0.0049
3	0,8		1775133	10^{-5}	1	0.0049
4	0,2	3,00	323623	10^{-5}	1	0.0049
5	0,5		351177	10^{-5}	1	0.0049
6	0,8		639299	10^{-5}	1	0.0049
7	0,2	0,60	870489	10^{-5}	1	0.0049
8	0,5		1252907	10^{-5}	1	0.0049
9	0,8		2936590	10^{-5}	1	0.0049

Numéro de scénario	B_{35}/K	r	K	q	λ	σ^2_p	σ^2_{IA}
10	0,2	1,20	624959	10^{-5}	1	0.0004	0.0004
11					1	0.04	0.04
12					0.1	0.00049	0.0049
13					10	0.0049	0.00049

Outlines of results

- **Informative priors are needed**
  - **At least for one of the key parameters in (r,K)**
- **Prior information on the relative part of the variability process / obs. is needed**
  - **Default hypothesis : $\lambda = \sigma^2_p / \sigma^2_o$**
- **« One-way trip » trajectory are poorly informative**
- **The more stochastic the process**
  The more noisy the data
  } **The more biaised and imprecise the results**
- **Equilibrium assumption lead to (more or less) biased results**
  - **Dynamic should be prefered (if inf. prior available)**

1. Does the method works ?

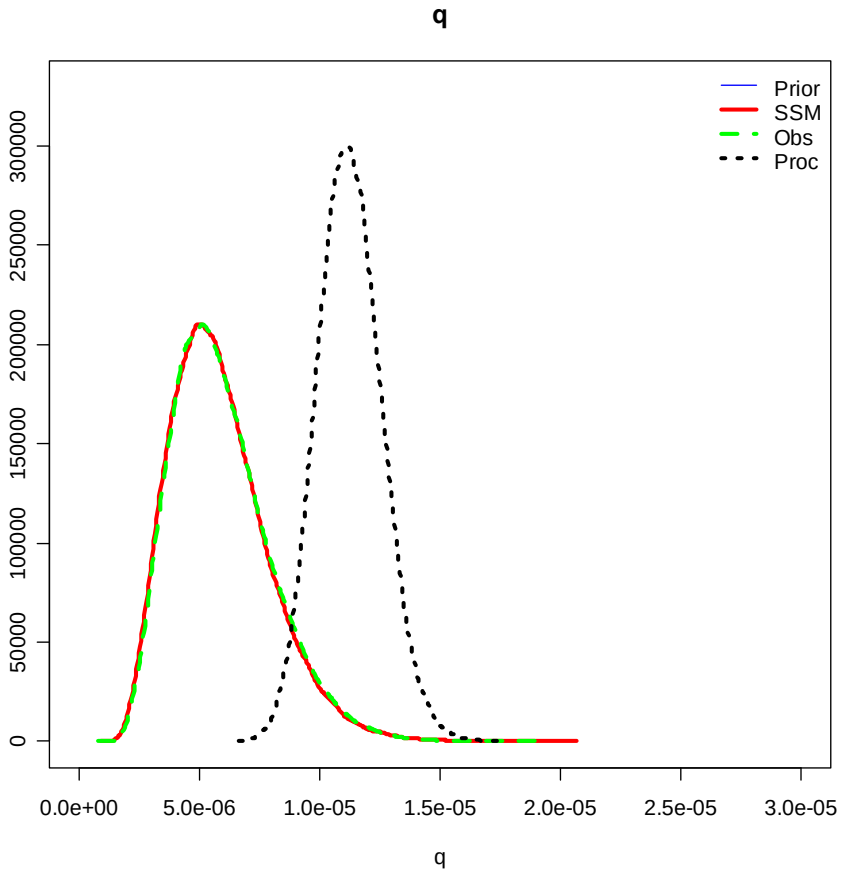
   « Simulation / estimation »

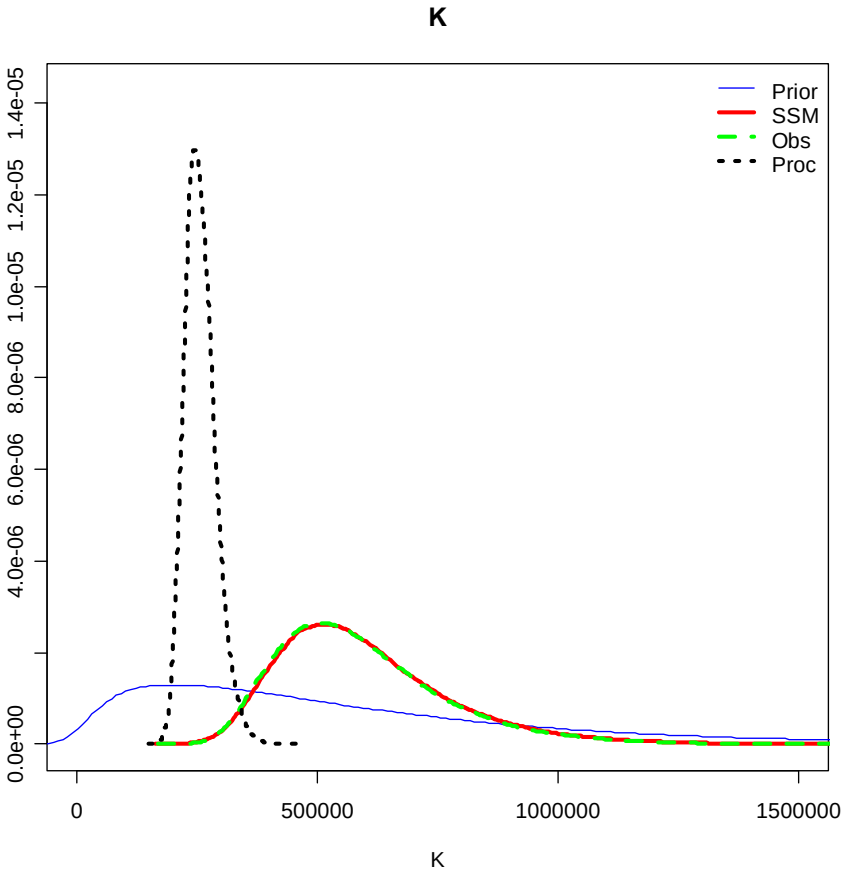
2. **Application**

   Mauritania

Comparative analysis - error structure

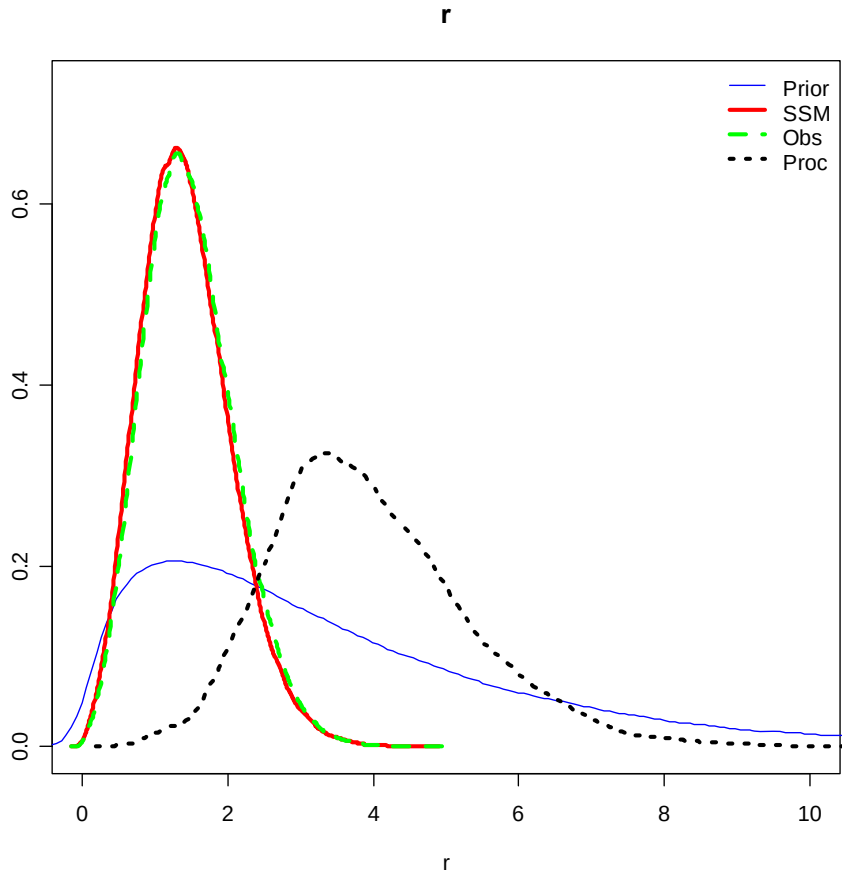
- **Parameters**





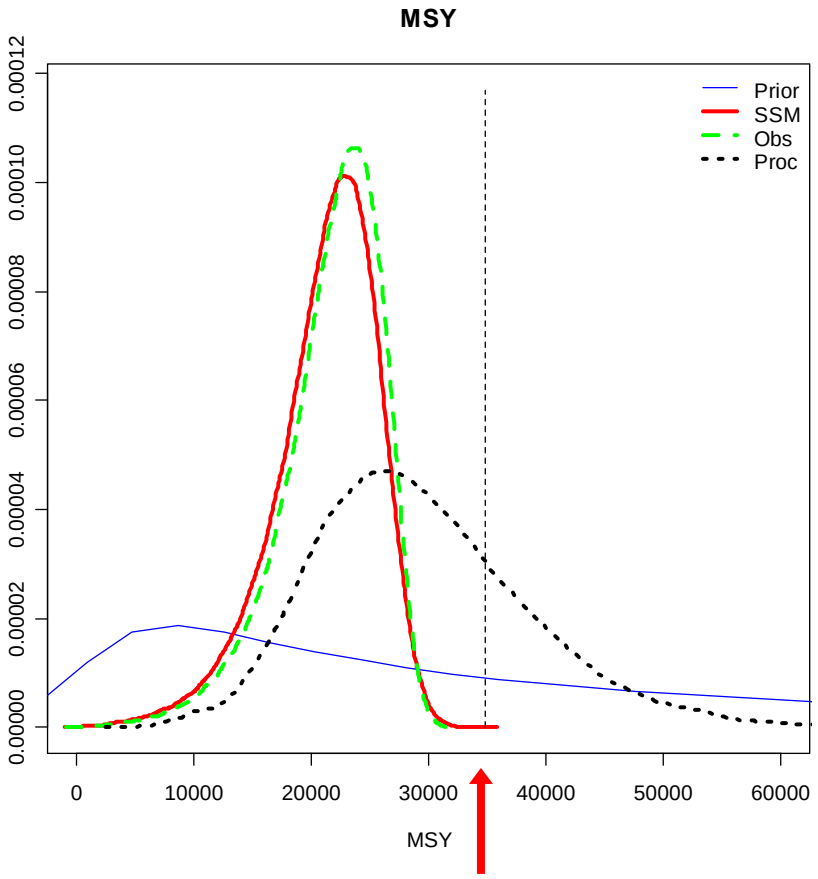
Comparative analysis - error structure

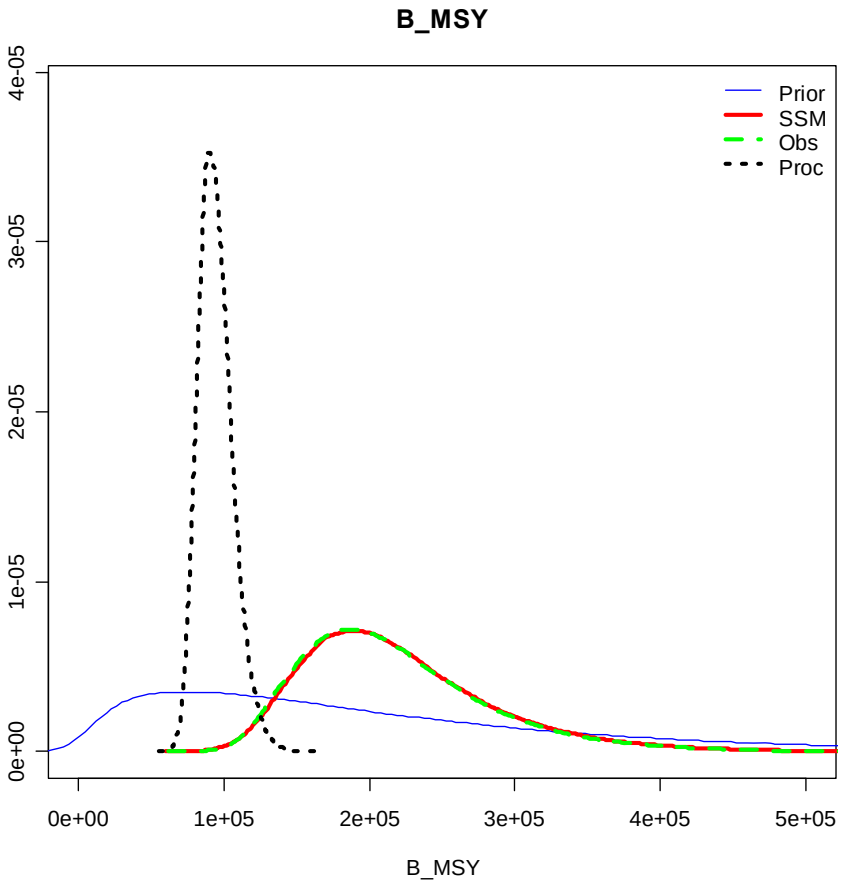
- **Parameters**



Comparative analysis - error structure

- **Management reference points**

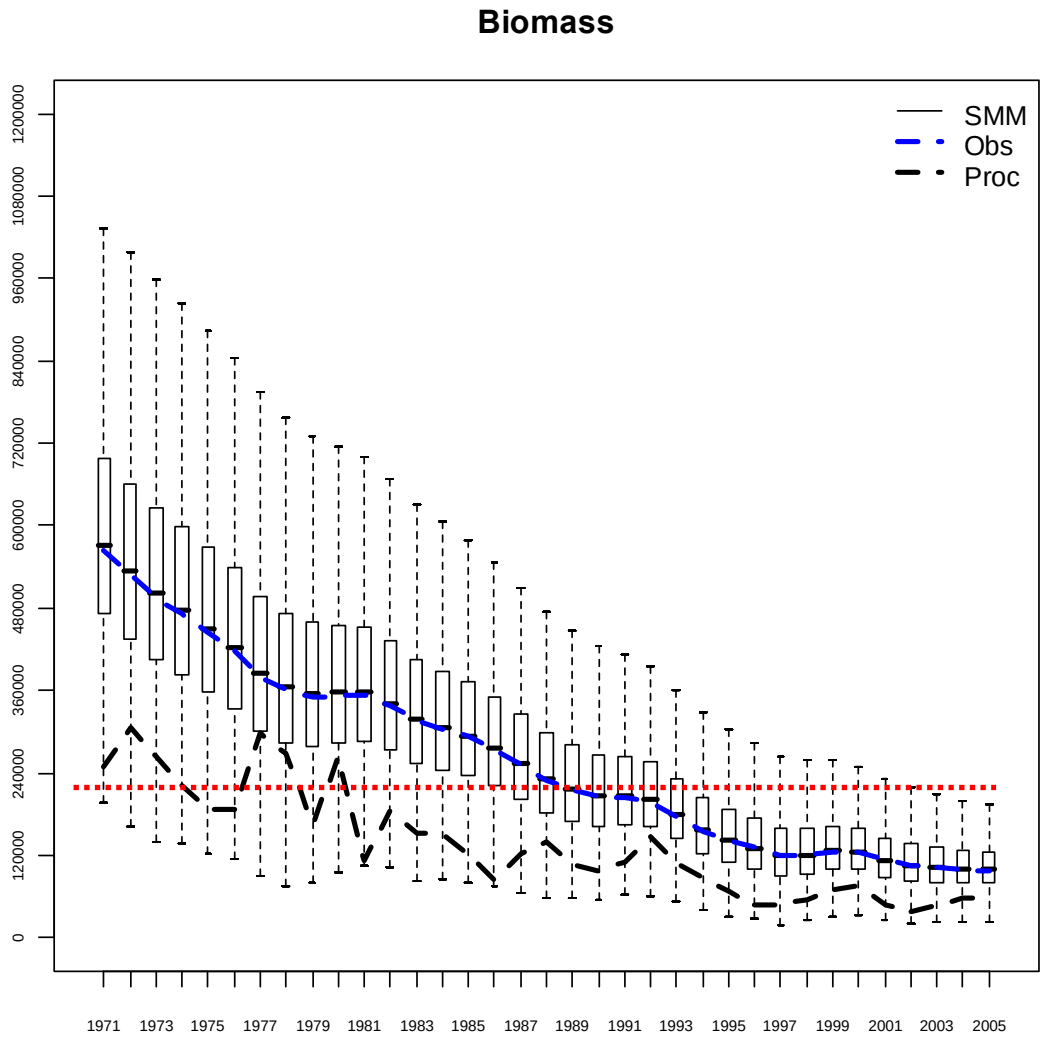




Point estimates WG IMROP 2006

Comparative analysis - error structure

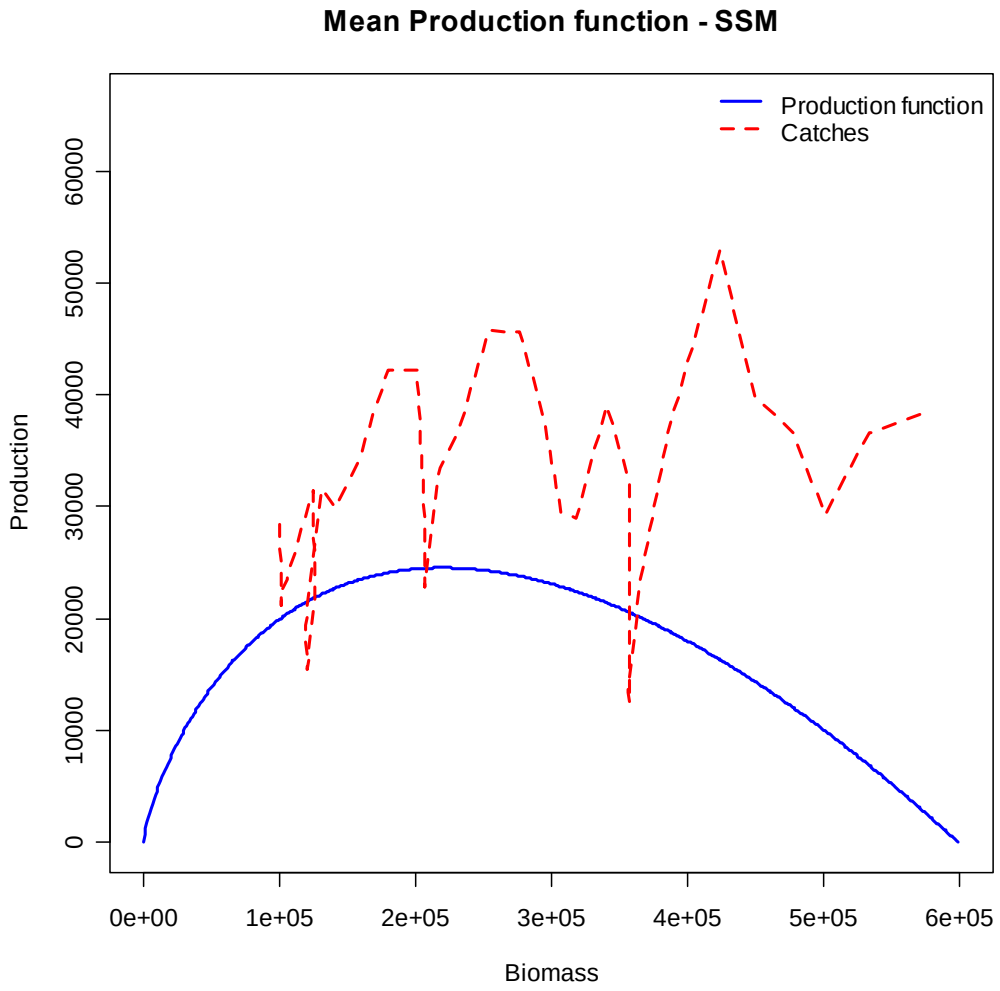
- **Biomass**



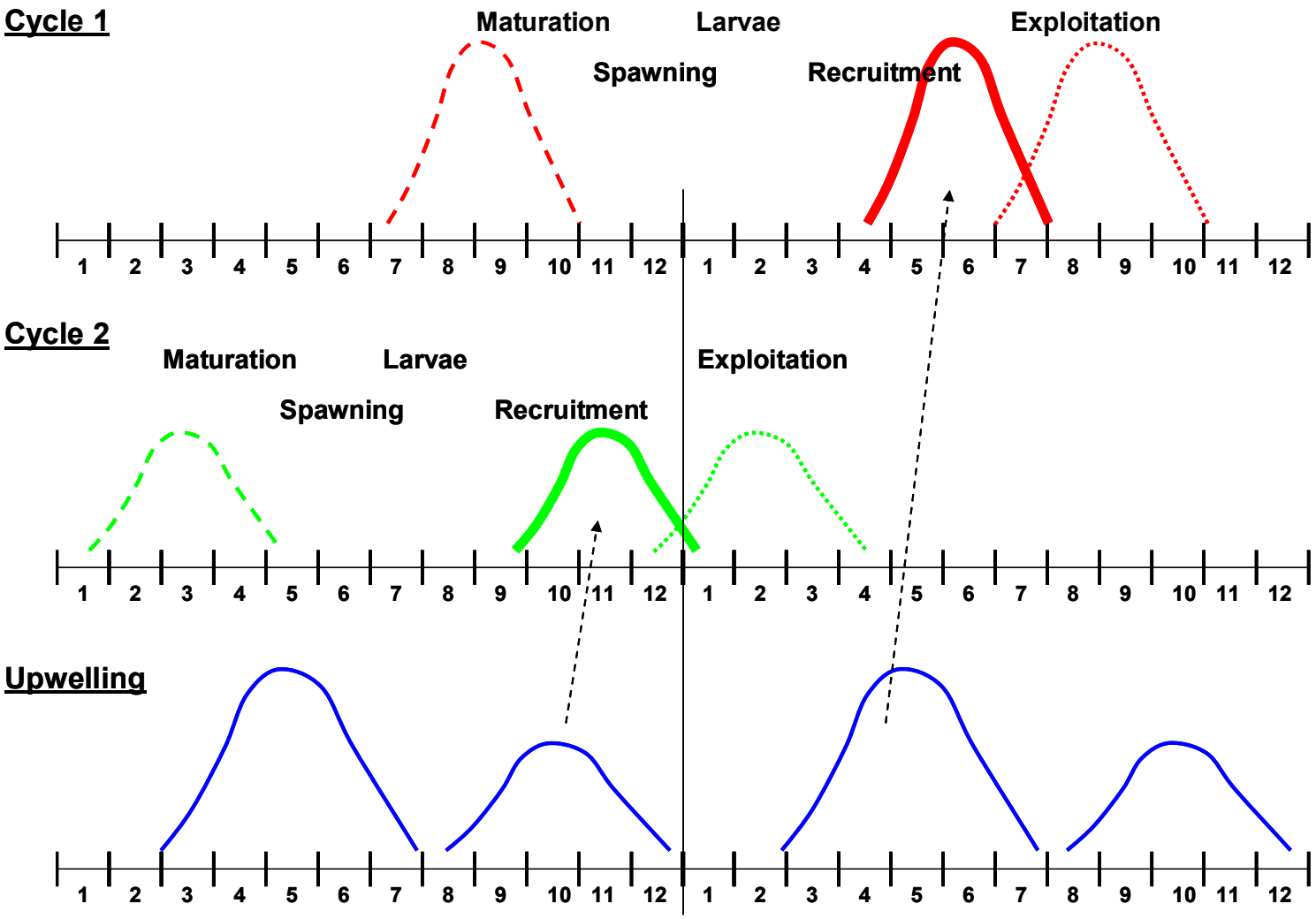
Depletion = 0.15

Dynamic (SSM) - λ = 1

- **Theoretical production**

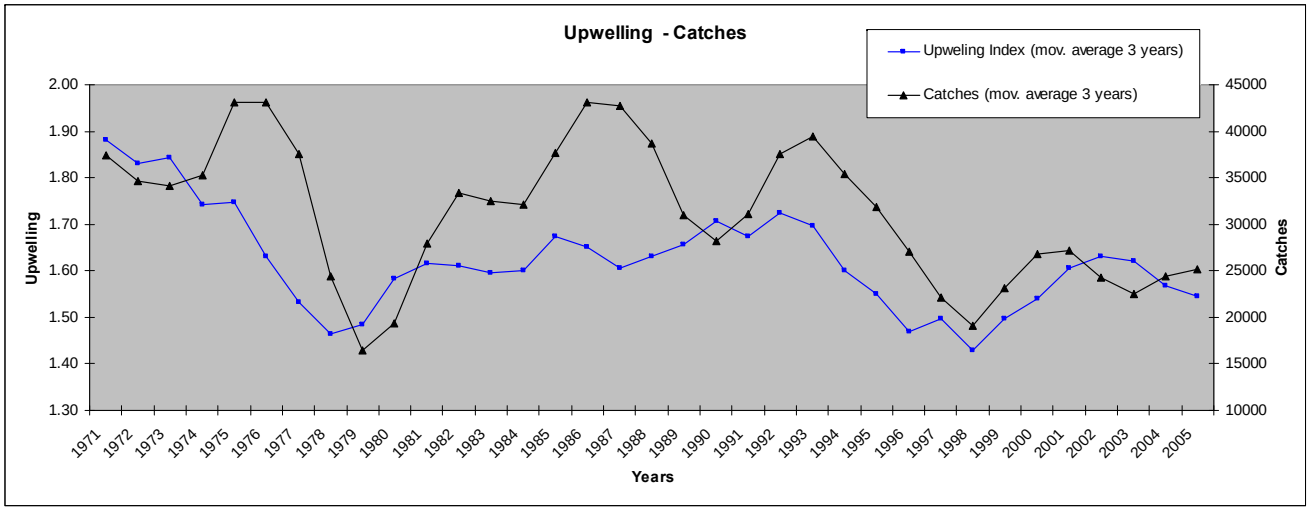


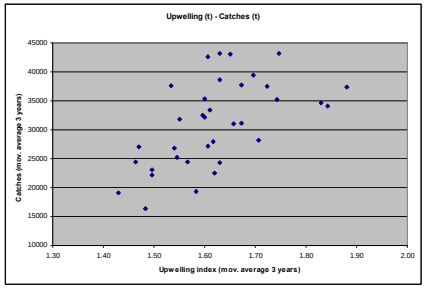
Octopus highly depends upon the environment

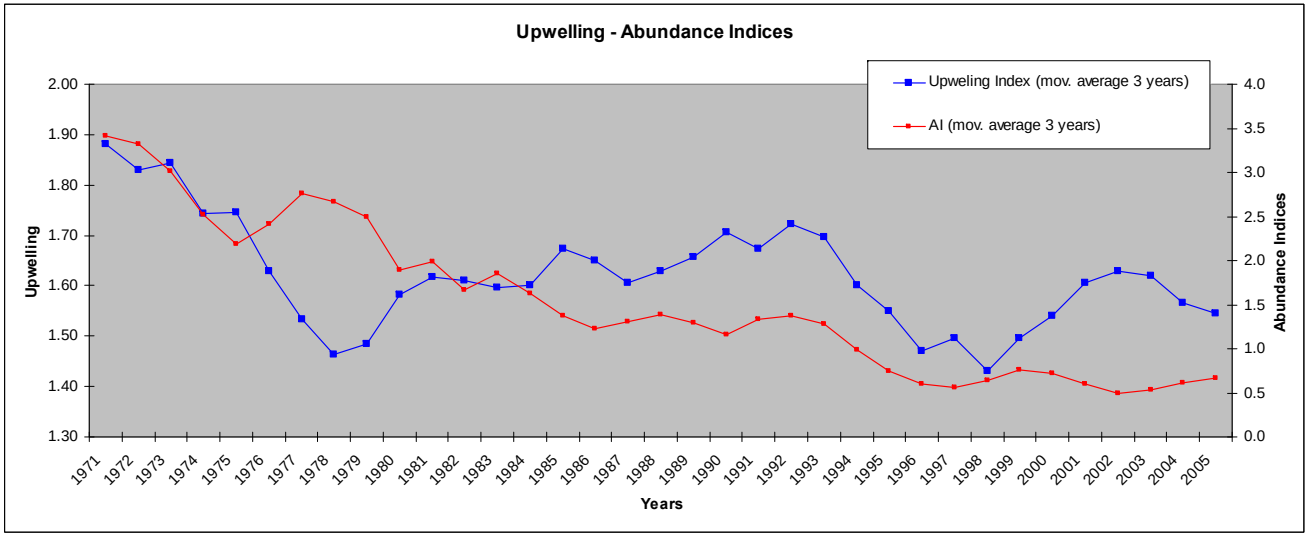


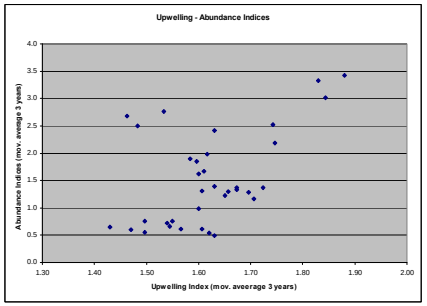
Environnemental effect

- **Data**



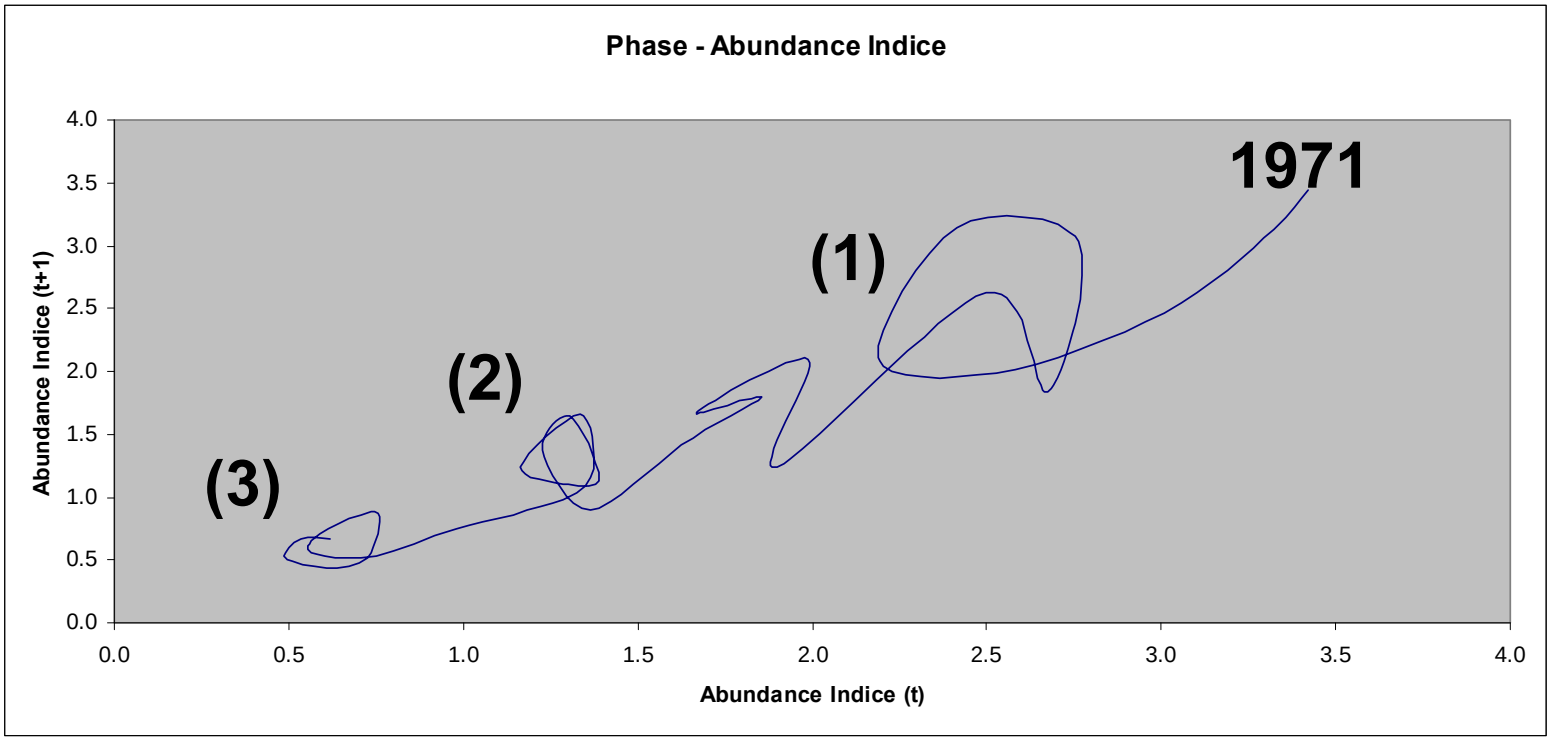






Environnemental effect

- **Time series analysis – Abundance Indice (Mauritania)**

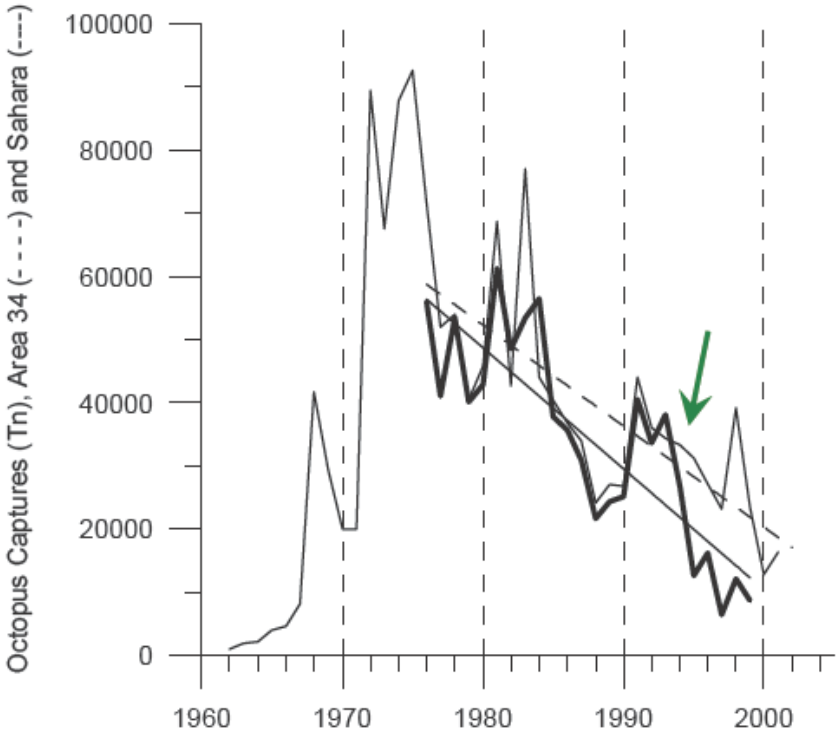


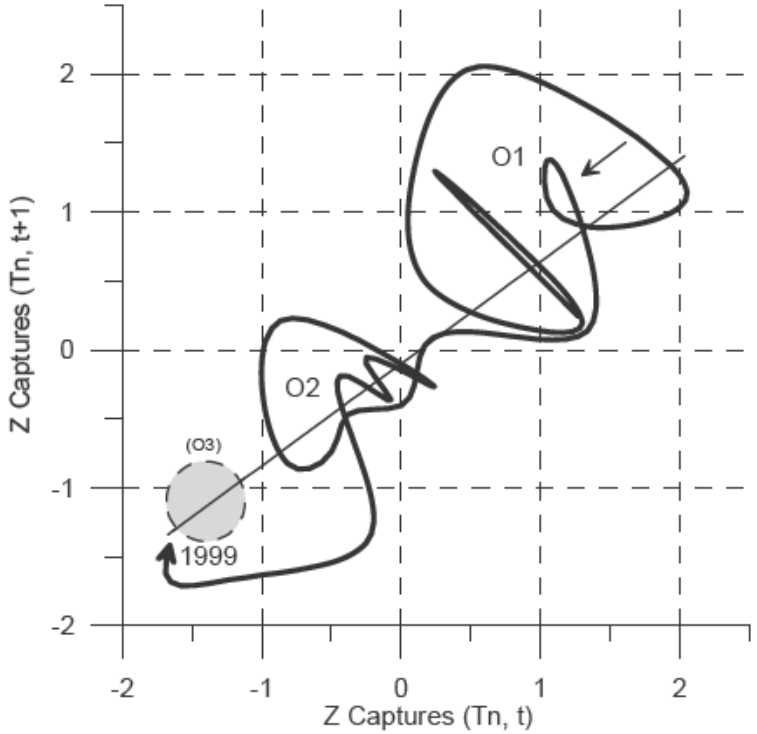
(Adapted from Solari et al. ISTAM report)

Environnemental effect

- **Spain fishery (from Solari et al. ISTAM report)**

IEO and catch (Tn) series on the common *Octopus* in the Saharian Upwelling zone



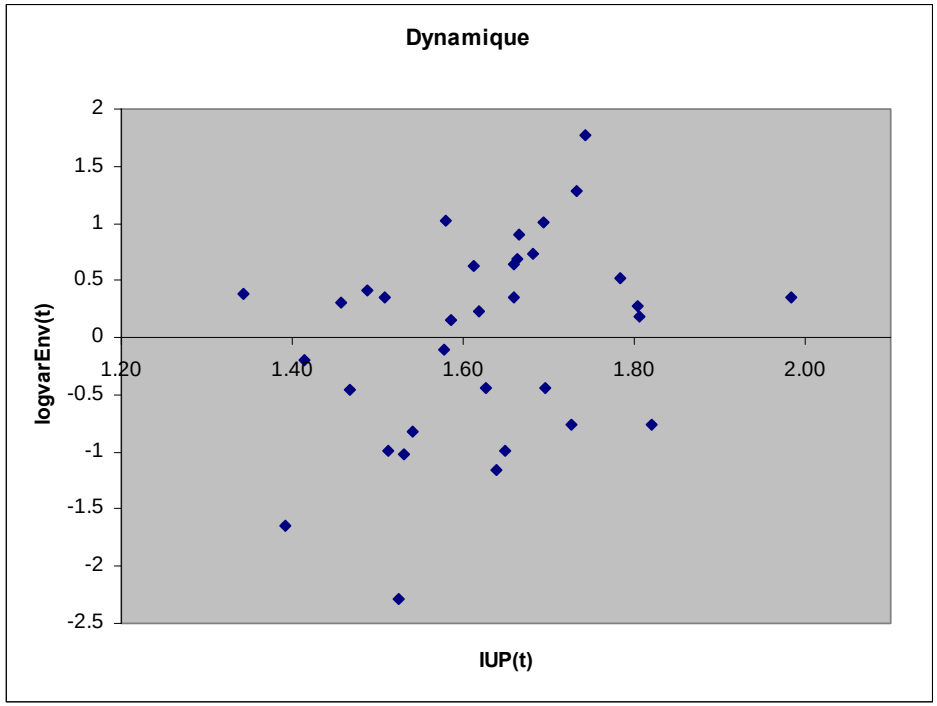


(from Solari et al. ISTAM report)

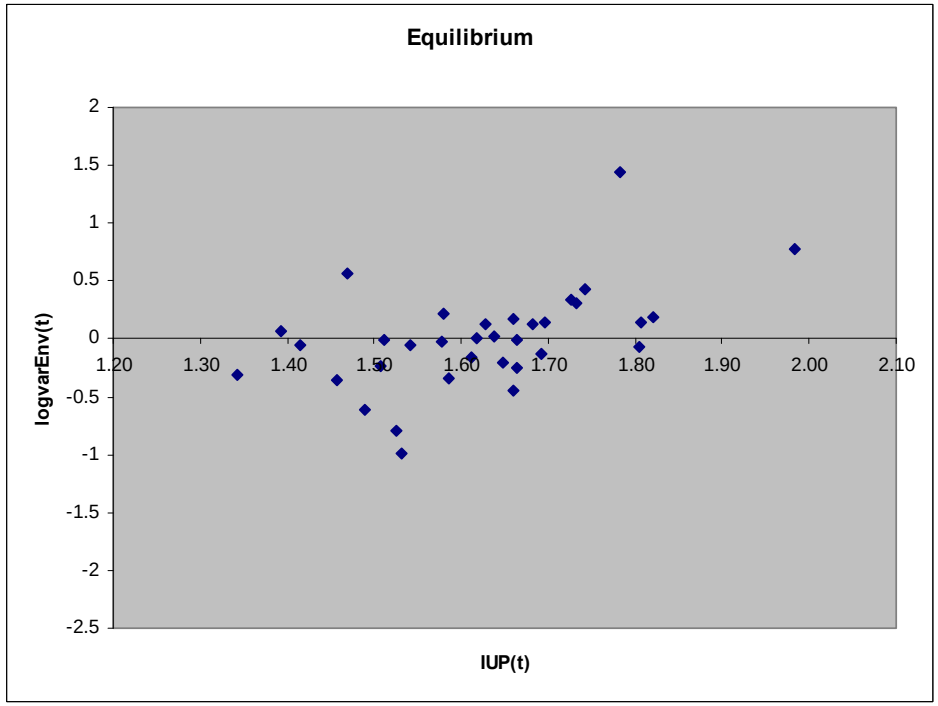
Environnemental effect

- **Relation residuals (t) – E (t)** **(from « process-error model »)**

➢ **Dynamic**



➢ **Equilibrium**



Environnemental effect

- **Parameterization choice**

  - **Linear effect on the log-scale of B (K)**

$$K(t) = K_0 \cdot e^{\beta \cdot (I(t) - \bar{I})}$$

Prior

$$r(t) = h \cdot \log(K(t))$$

  - **To be discussed (Fréon 1991)**
    - **Effect on catchability**
    - **h = Constant (effect on both K and r)**

Environnemental effect

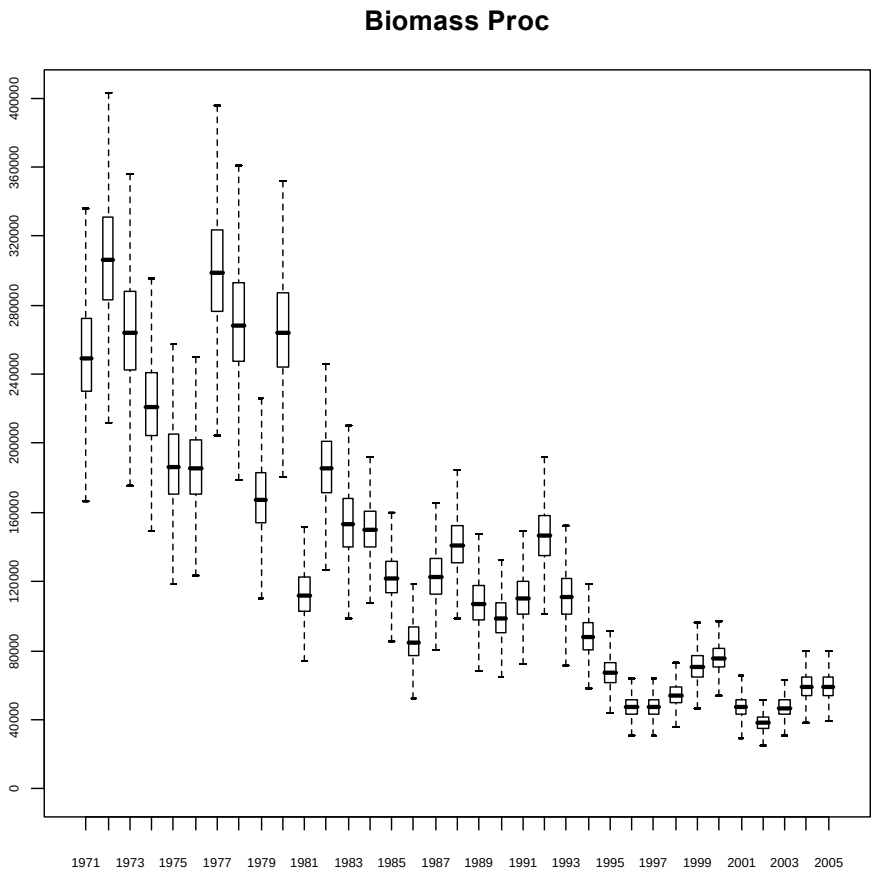
- **Model selection**

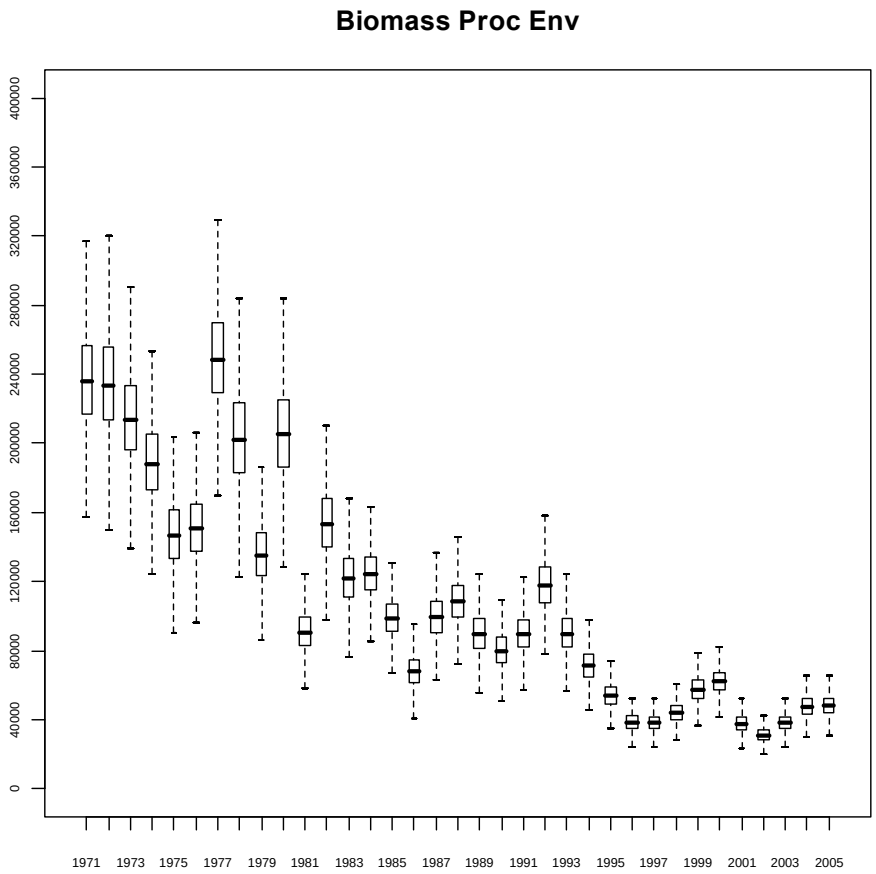
$$K(t) = K_0 \cdot e^{\beta \cdot (I(t) - \bar{I})}$$

	pD	DIC
➢ No env. effect (β=0)	29.1	- 55
➢ Env. effect	29.6	- 62

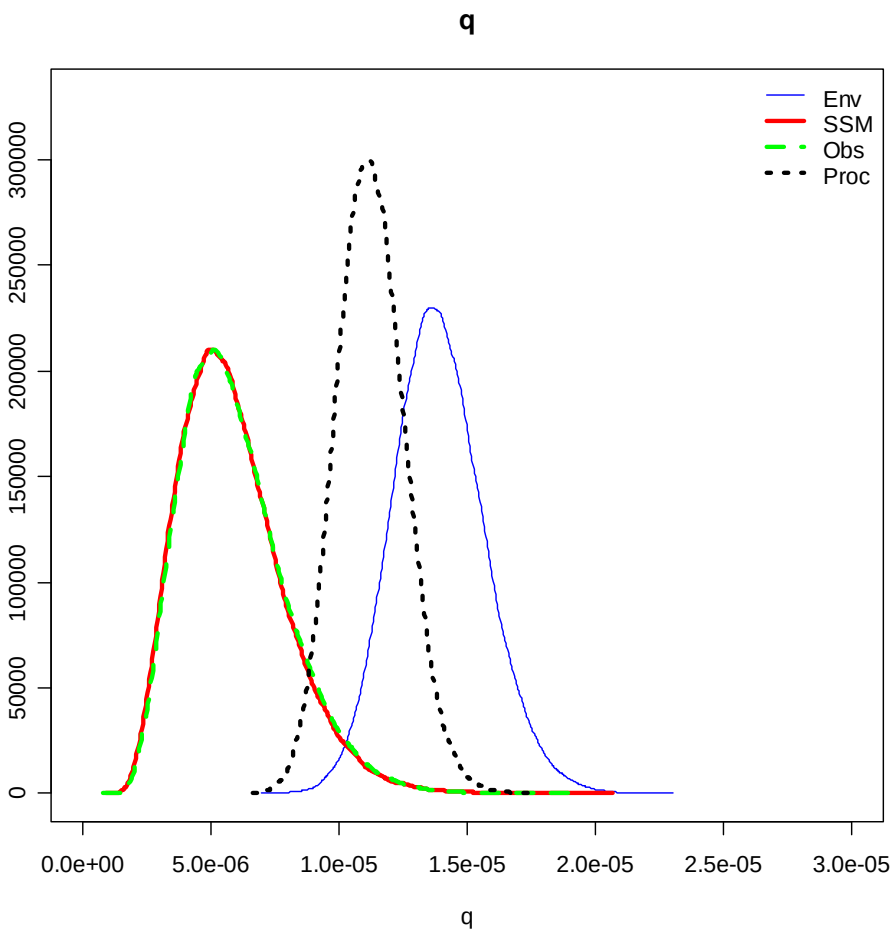
Environnemental effect (Dynamic model)

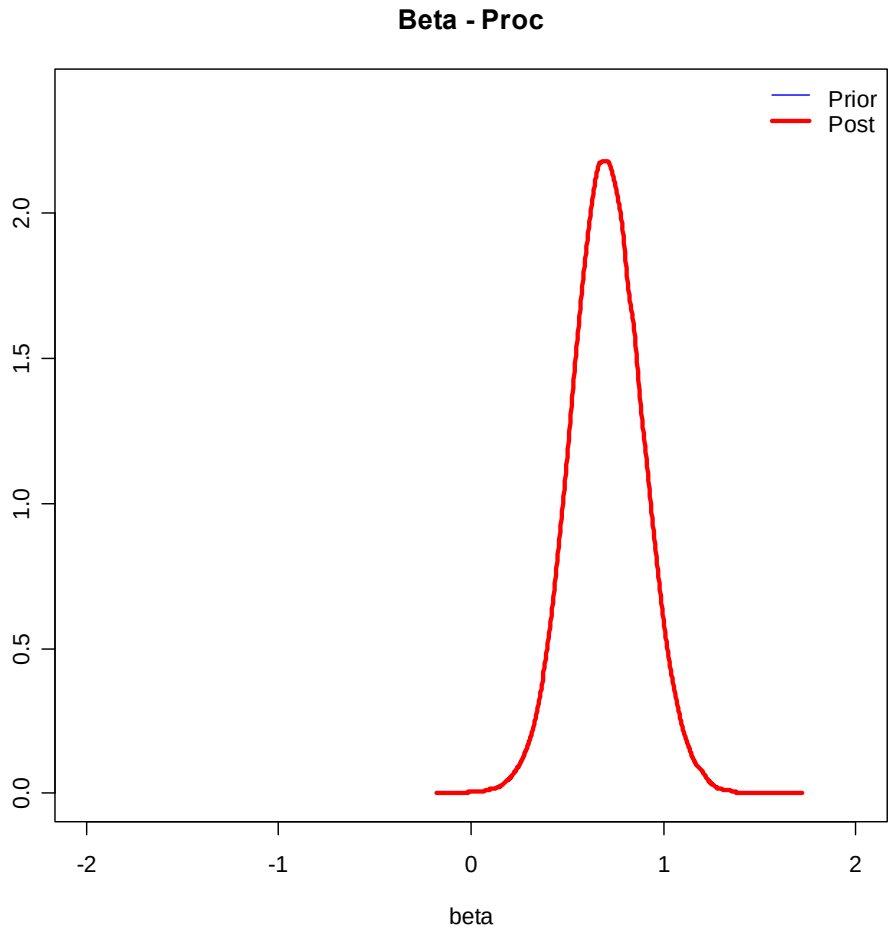
- **Biomass**





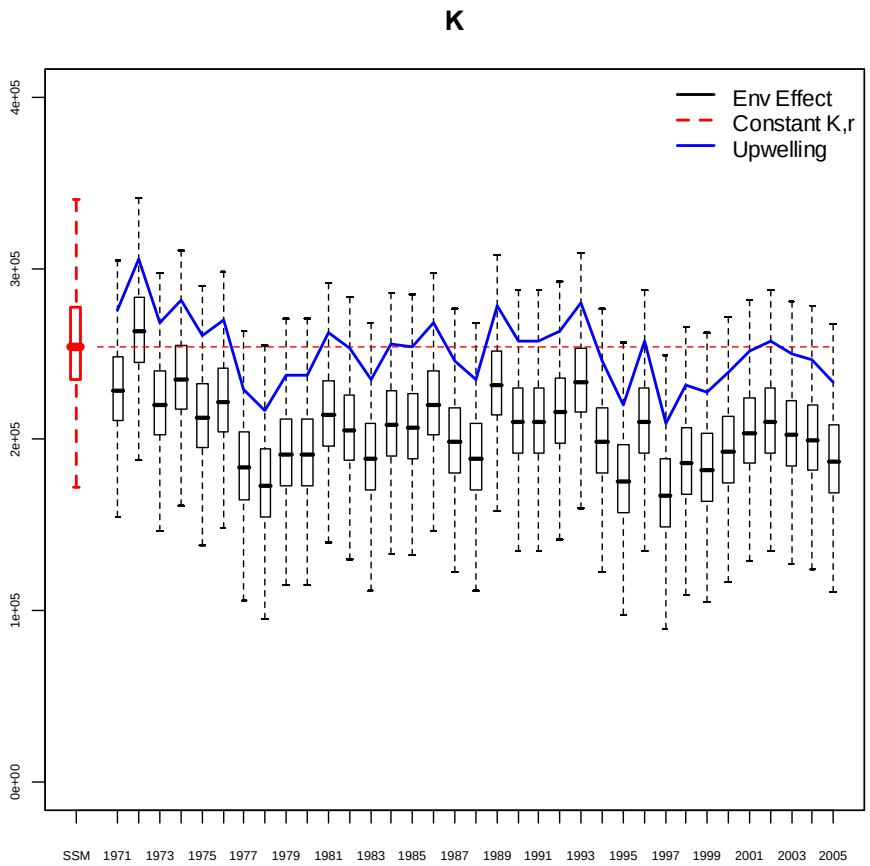
Environnemental effect (Dynamic model)



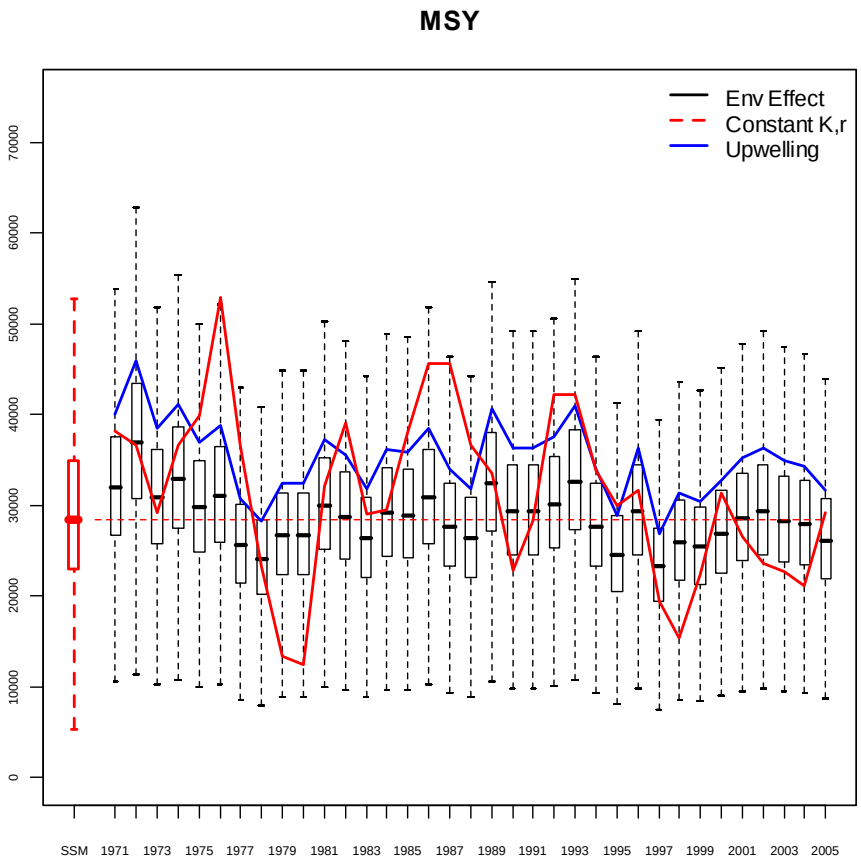


Environnemental effect (Dynamic model)

- **K(t)**

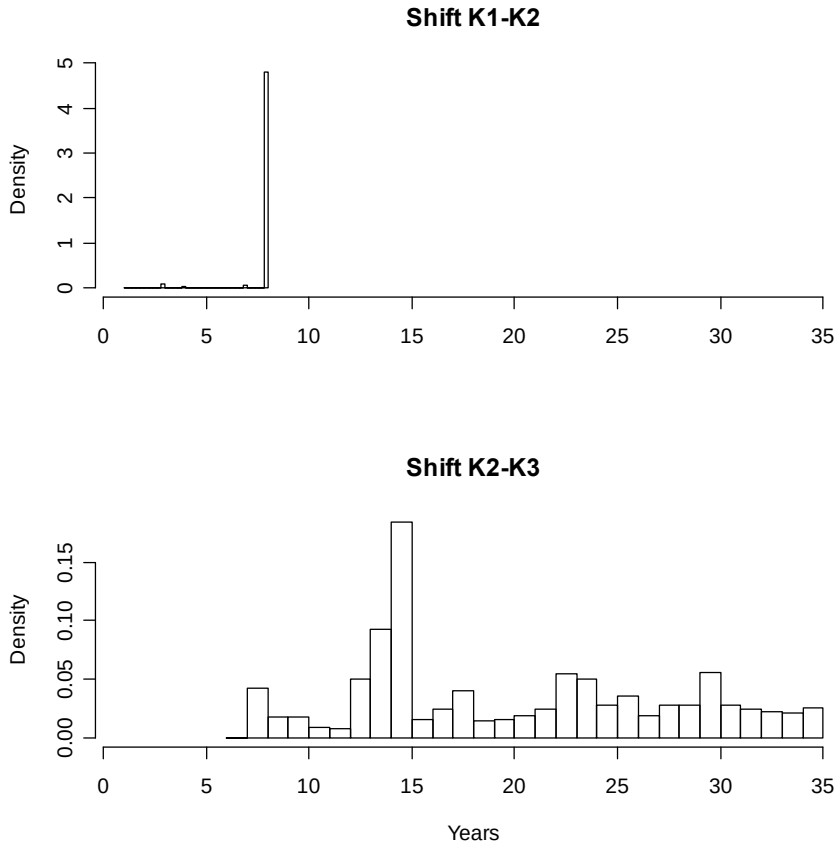


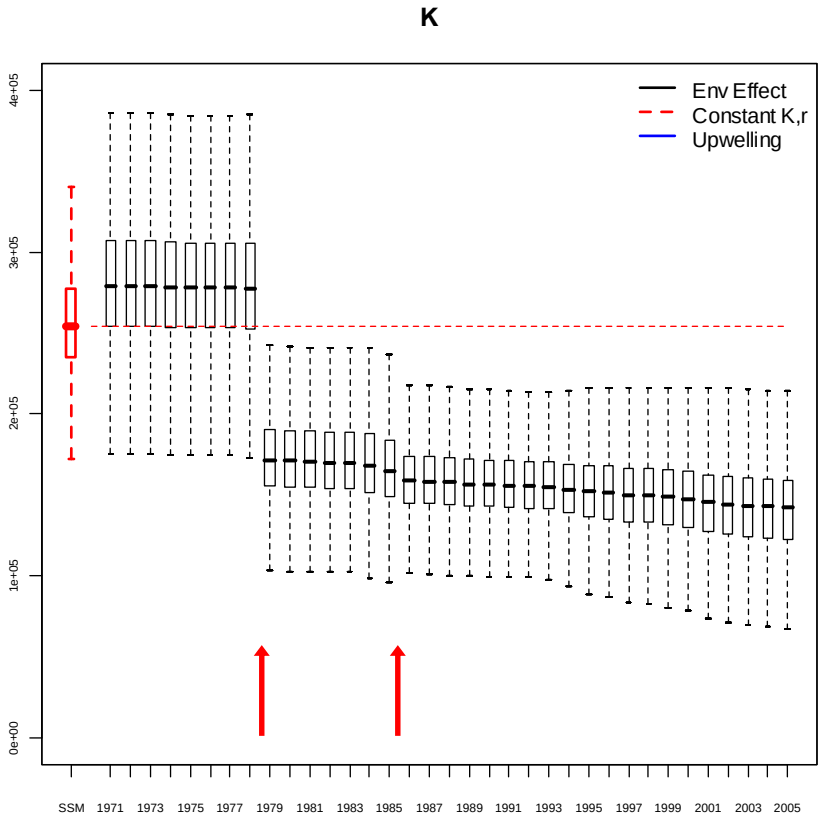
- **MSY(t)**



Environnemental effect (Dynamic model)

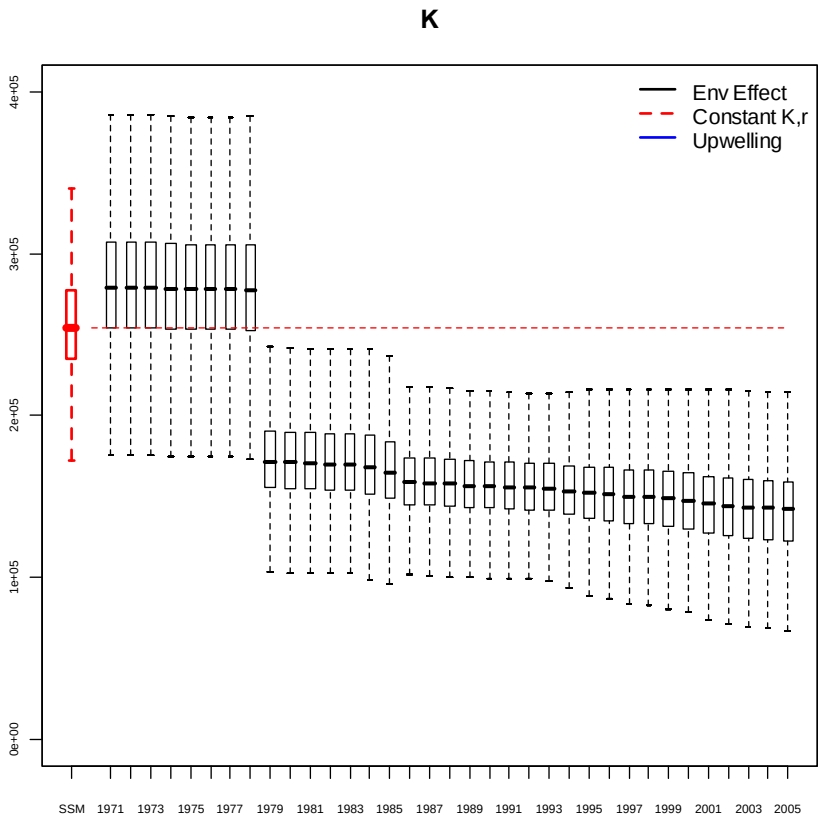
- **Model with 3 values of K (Dynamic)**

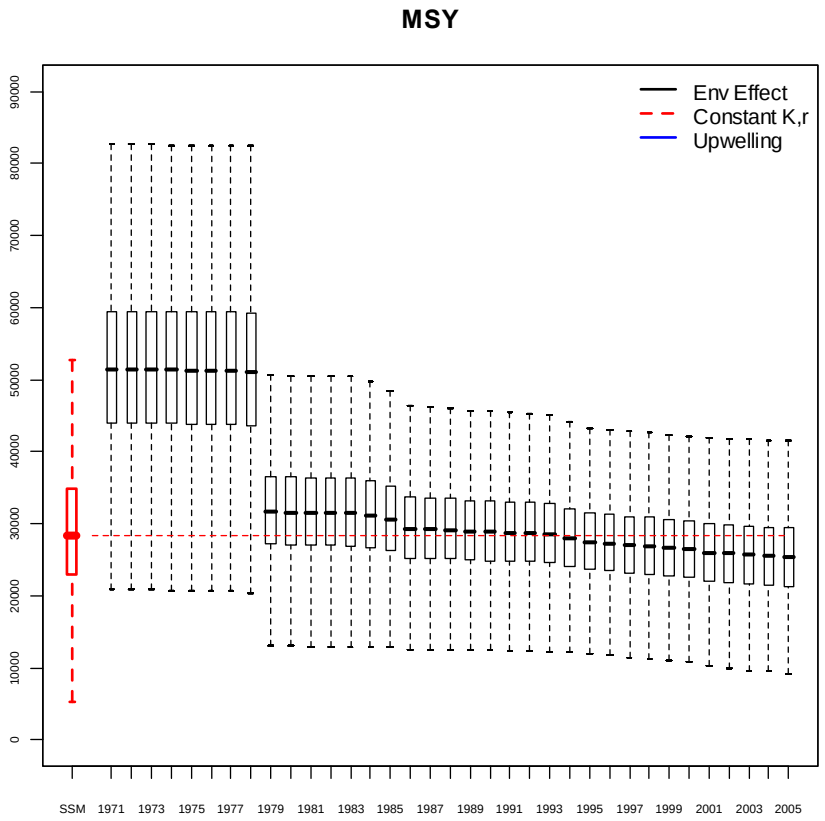




Environnemental effect (Dynamic model)

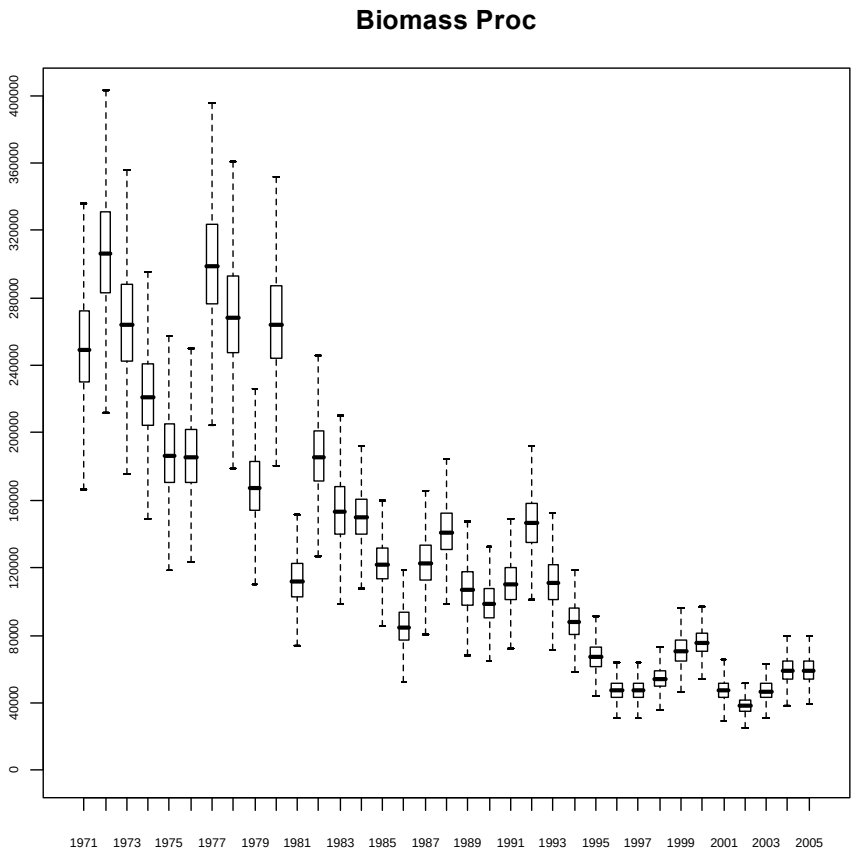
- **Model with 3 values of K**

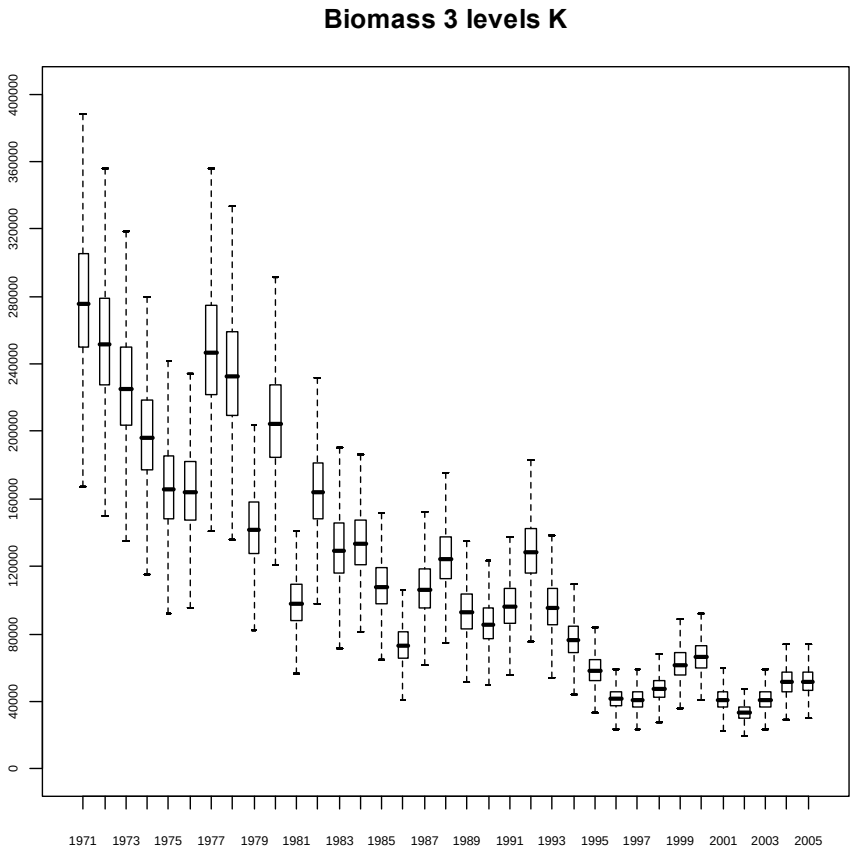




Environnemental effect

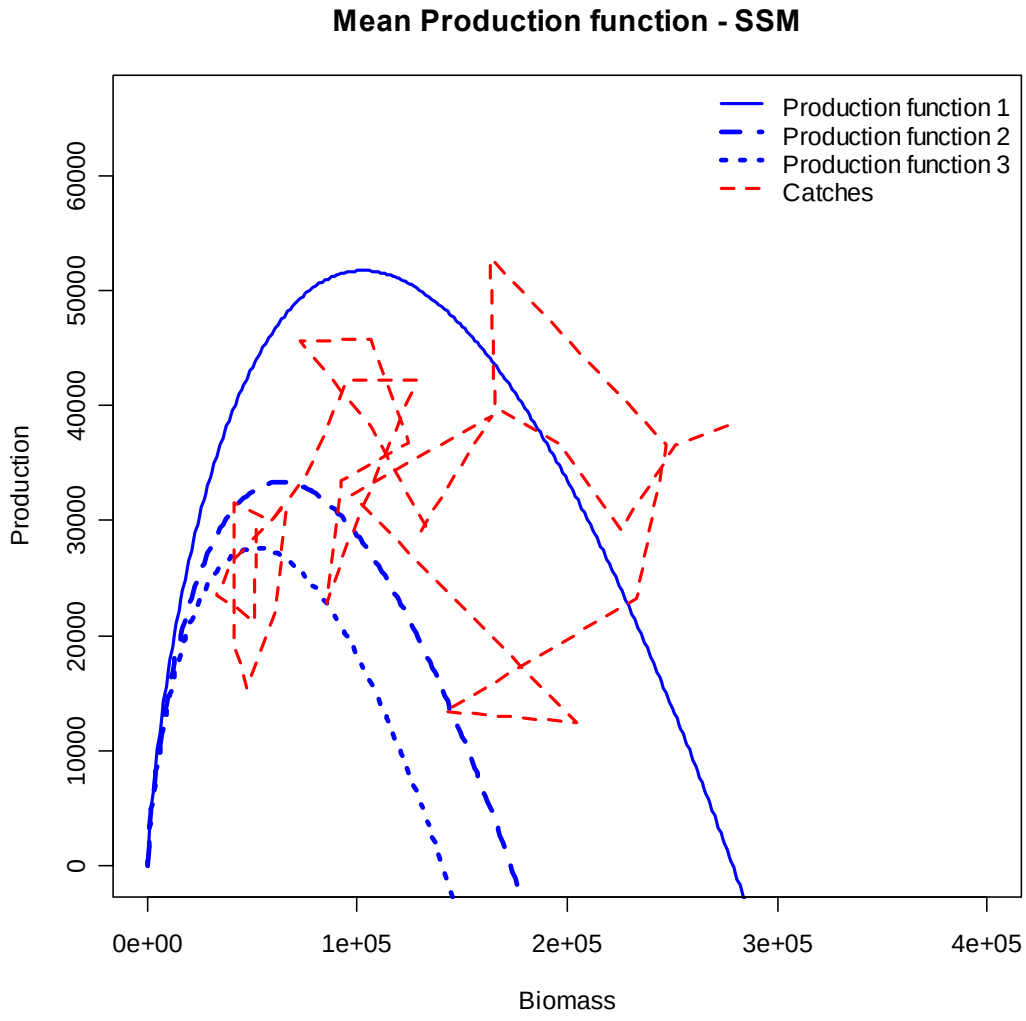
- **Model with 3 values of K (Dynamic)**





Environnemental effect (Dynamic model)

- **Dynamic with env. effect vs Dyn. 3K**

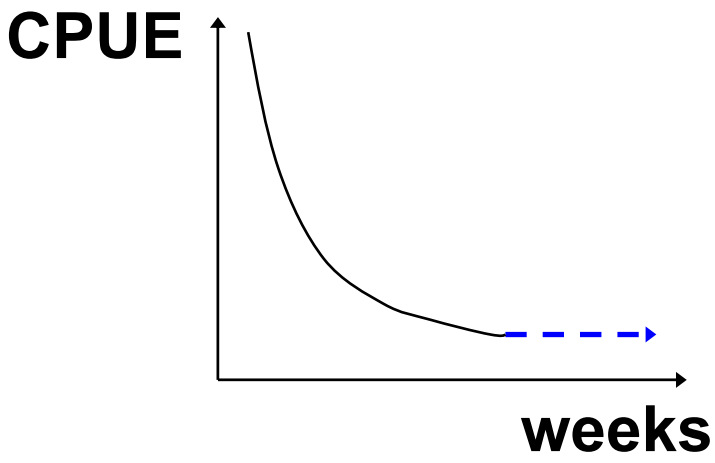


Perspectives

- **Extending to other stocks (Marocco, Senegal)**
- **Environmental indices (under progress with S. Bonhommeau)**
  - **SST-based Upwelling index**
  - **CRI index**
- **Time step (6 months ?)**

Depletion model

- **Application (from Malek Farajh, INRH)**
  - Marocan fishery
  - Winter 2006
  - Catches – CPUE / 16 consecutive weeks



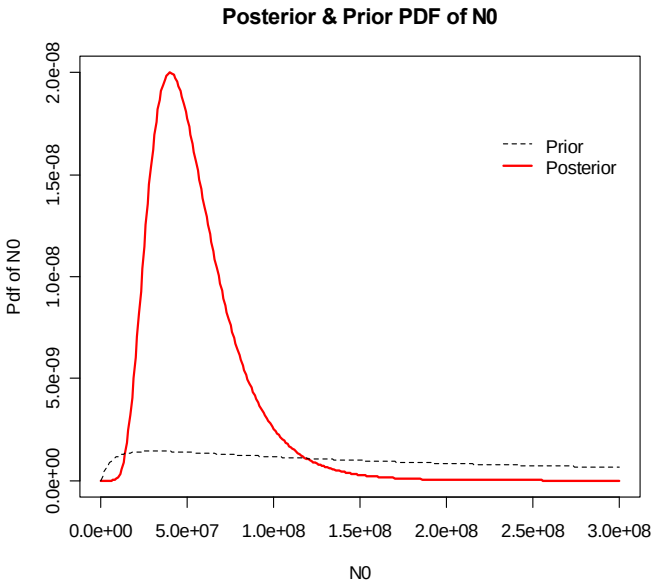
$I_{artisanal}(t) = q_{artisanal}\ N(t)$

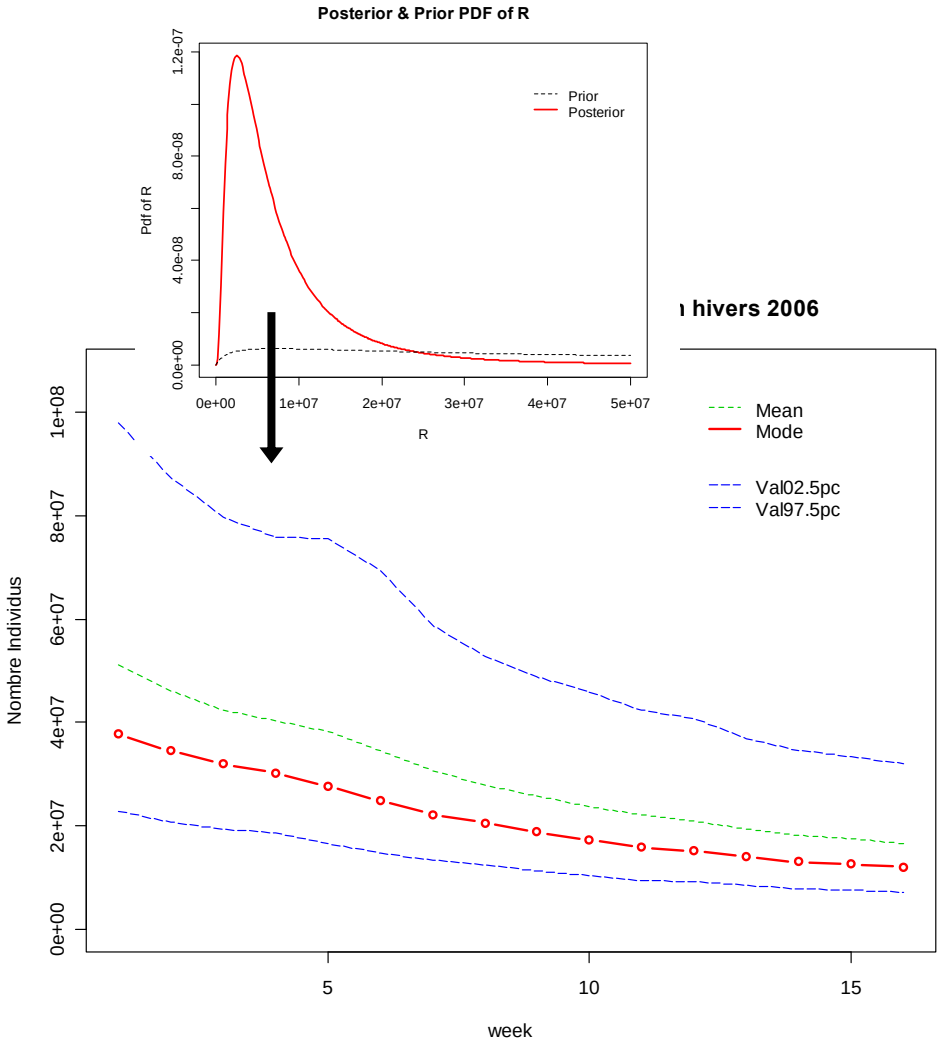
$I_{côtier}(t) = q_{côtier}\ N(t)$

$I_{hauturier}(t) = q_{hauturier}\ N(t)$

Depletion model

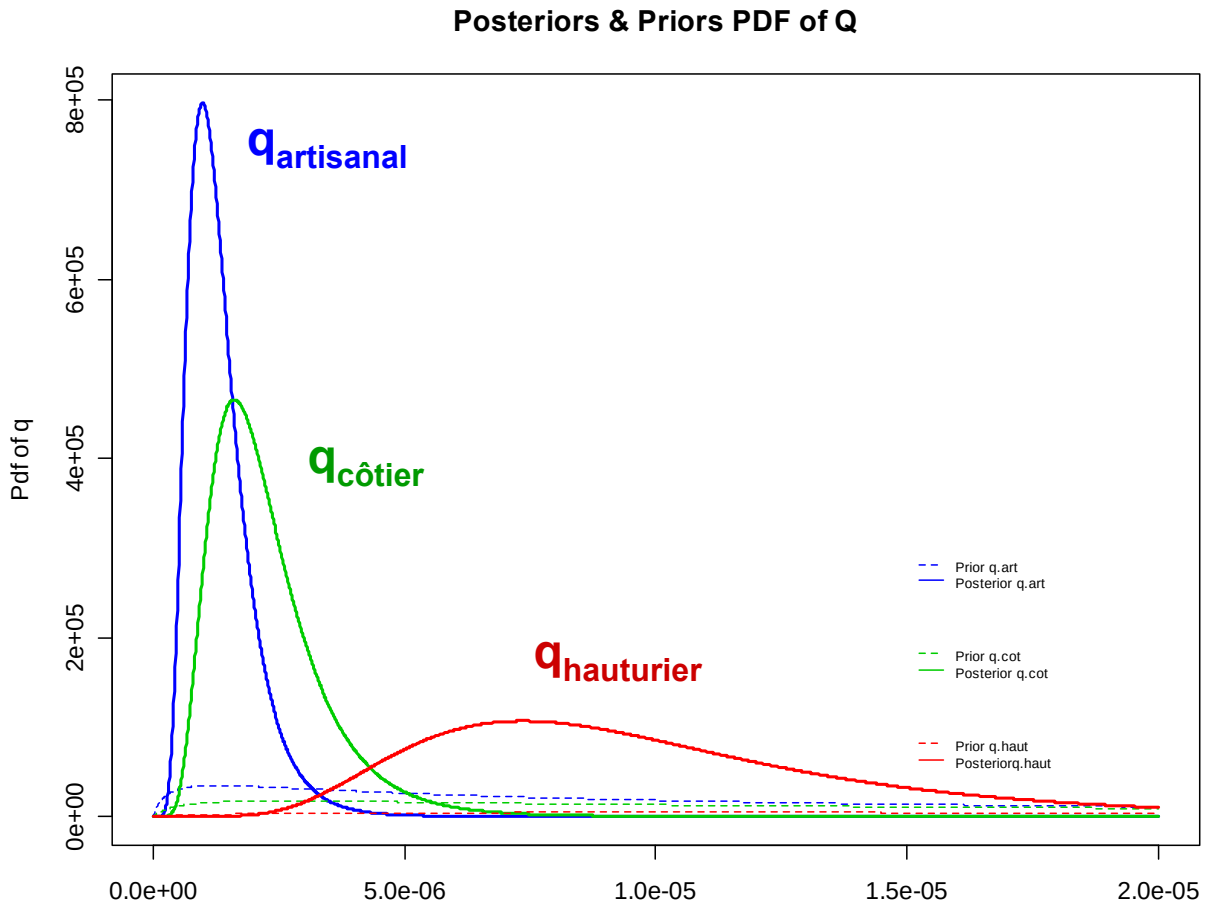
- **Recontruction of abundance history and recruitment**





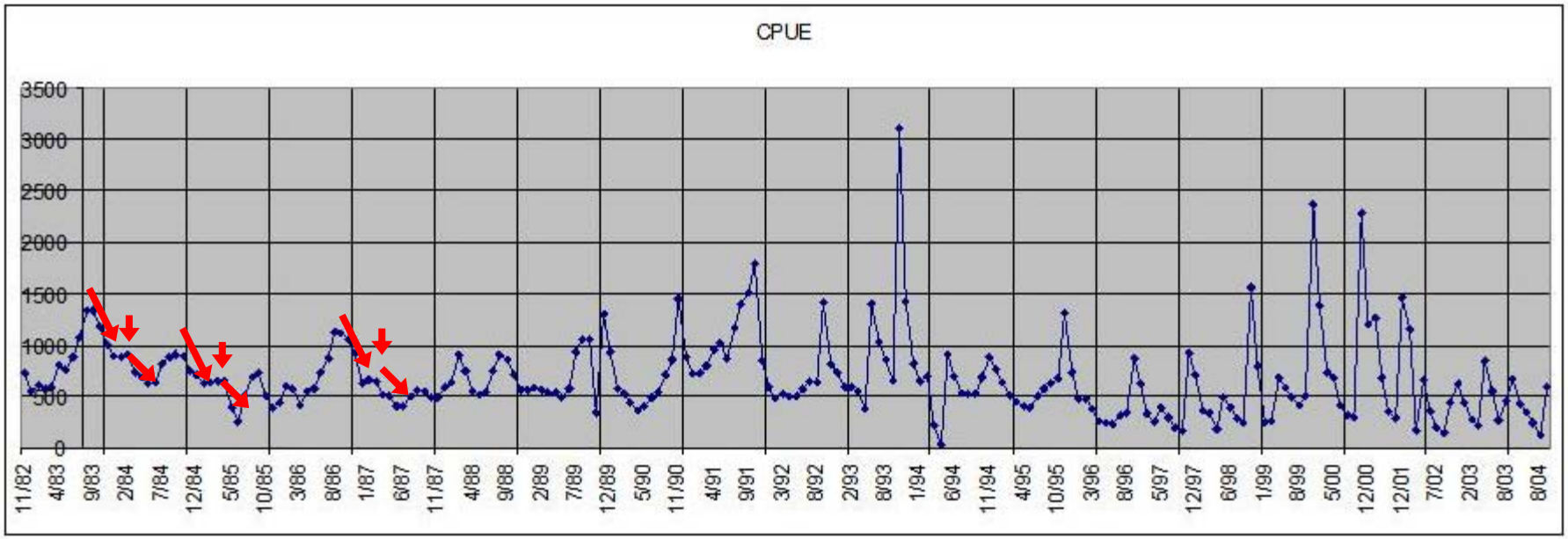
Depletion model

- Posterior $q_{hauturier}$, $q_{côtier}$, $q_{artisanal}$



Perspectives

- **Reconstruction of (long) series of recruitment ersective**
  - **Mauritania (work in progress – B. Tfeil, collab. IMROP)**
  - **Marocco (work in progress – M. Robert, collab. INRH - IEO)**



(from Faraj, INRH, com. pers.)