

# Quantitative diagnostics of the impact of management measures on fisheries using ISIS-Fish

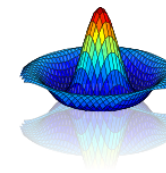
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NANTES



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**MEXICO**  
WEXICO

# Integration of Spatial Information for Simulation of Fisheries dynamics (ISIS-Fish)

## Issues addressed :

- Assessing the impact of management measures
- Mixed fisheries
- Spatial and seasonal dynamics of fishery
- Fishers' response to management

## Approach : a modelling toolbox for fisheries simulation

- Generic : application to many fisheries
- Flexible : evolution of knowledge
- Discrete, spatially-explicit, bio-economic
- Populations, fishing activities, management models
- Integration of existing knowledge and information
- Facilities to run many simulations



# ISIS-Fish

<http://www.ifremer.fr/isis-fish/>

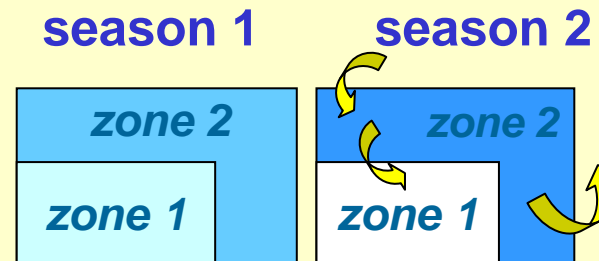
- ISIS JAVA / ISIS FLR
- Open source and Free download of the software
- Available librairies to explore the outputs with R

Dominique Pelletier, Stéphanie Mahévas, Benjamin Poussin, Olivier Thebaud, Olivier Guyader, François Bastardie, Hilaire Drouineau, Youen Vermard, Sigrid Lehuta

# Model description

## 1. Population model

### Zones and seasons



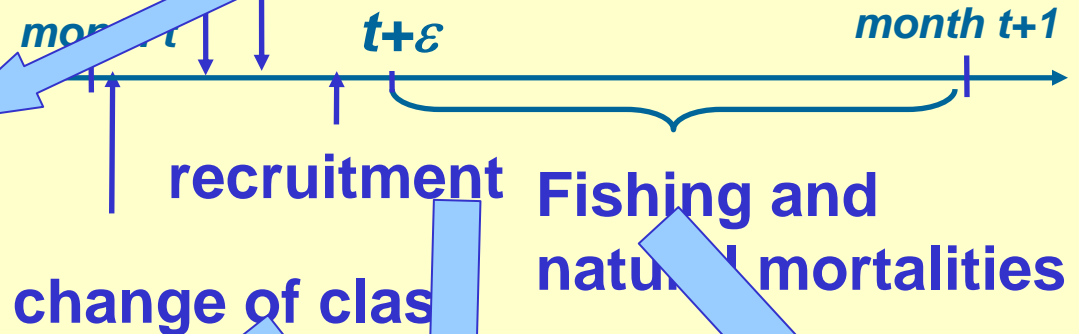
- timing and zoning of reproduction
- spawner-egg relationship

### CORE MODEL

### Stage-structured model



migrations  
reproduction



Prices

**FLEXIBLE COMPONENTS**

growth model

timing and zoning of recruitment

accessibility per area

## Glossary

- **Métier** : fishing operation (trip scale) – target species \* fishing area \* gear
- **Fleet** : group of vessels with similar technical characteristics attached to a port and characterized by a list of possible **métiers** (split in **strategies**)
- **Strategy** : group of vessels within a **Fleet** characterized by the same fishing tactics (year time-scale) – succession of **métiers**



## 2. Fleet dynamics

Set of Vessels 1



Set of Vessels 2

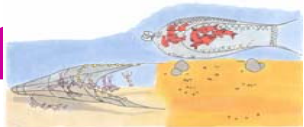


Set of Vessels 3

Set of Vessels 4

- Vessel type (technical characteristics, technical and owner costs)
- List of possible métiers (costs per métier)

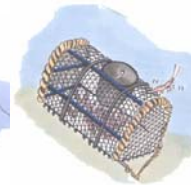
Strategy 1



Strategy 2



Strategy 3



Strategy 4

- Number of vessels
- Monthly fishing time distribution among métiers

	1	2	month	12
Métier1	$\frac{1}{4}$	$\frac{1}{2}$	• • •	
Métier2	$\frac{3}{4}$	$\frac{1}{2}$	• • •	

### Monthly fishing time dynamics :

- static effort distribution + fishers' response to management (decision rules)
- statistic model (RUM, gravity,...)

$$\text{Fishing effort} = f(\text{nb vessels}, \text{time spent fishing}, \text{fishing activity})$$

# Economic metrics

Derived from fishing time per strategy and metier, from metier characteristics (technical, spatial, ...), from catch, from prices and from costs

➤ **GrossValueLandings(str,met,pop)**

➤ **NetValueLandings(str,met,pop)**

*Variable costs shared by crew and owner*

- FuelCostTravel(str,met) - area
- FuelCostFishing (str,met) - gear
- OtherRunningCosts (str) – ice, port
- LandingsCosts(port)

➤ **NetRevenue(str,met) including revenues from other activities**

➤ **CrewShare(str,met)**

➤ **OwnerMargin(str)**

*Variable costs only borne by owner*

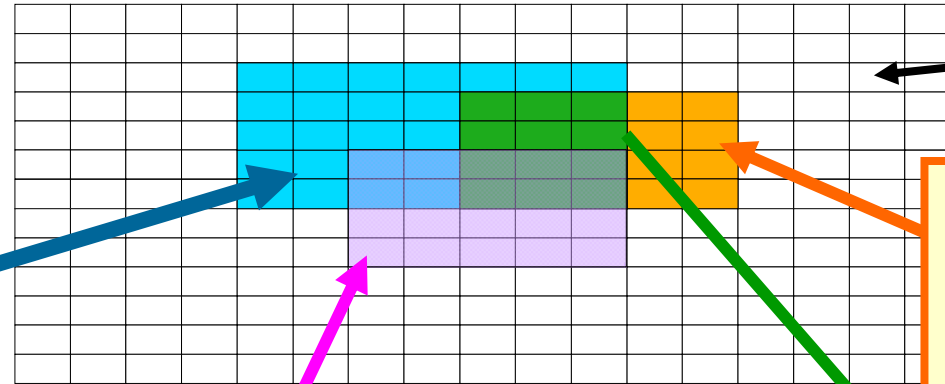
- GearAndMaintenanceCosts(str,met)

*Fixed costs only borne by owner*

- FixedCosts(str) administration costs, insurance costs, land-based equipment

## 3. From fishing effort to fishing mortality

Each month:



Effort(métier1,  
métier zone1)

Abundance (pop2,  
pop zone2, class)

Abundance  
(pop1, pop  
zone1, class)

FishingMortality  
(pop1, pop zone1,  
class, métier1)

GrossValueLandings(strategy, métier1)  
NetRevenue(strategy, métier1)  
CrewShareRevenue (strategy,métier1)  
OwnerMargin(strategy)



# ISIS-Fish : Guidelines

## 1. Parameterization

- Compilation of available parameters values from literature
- Estimation of missing parameters : available data and statistical methods (factorial analyses, maximum likelihood,...)
- Calibration of accessibility (simplex method, likelihood, ...)

## 2. Sensitivity analysis

- Identification of most sensitive parameters
- Implementation of simulations following statistical experimental designs

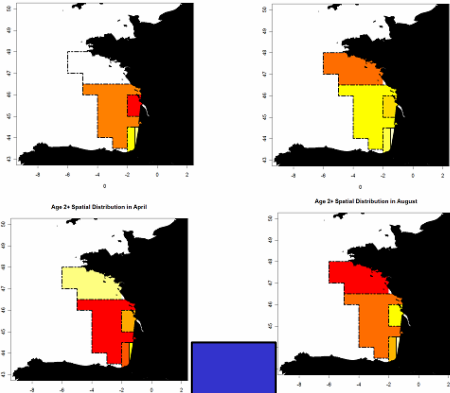
## 3. Simulations for assessing management scenarios impact including parameters uncertainty

- Definition of management scenarios
- Definition of the range of varying highly sensitive parameters
- Implementation of simulations following statistical experimental designs

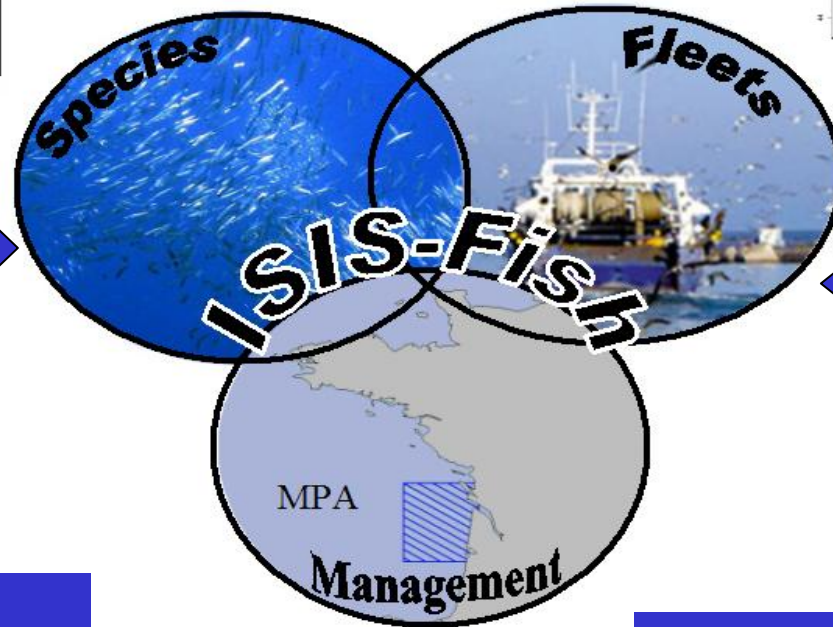
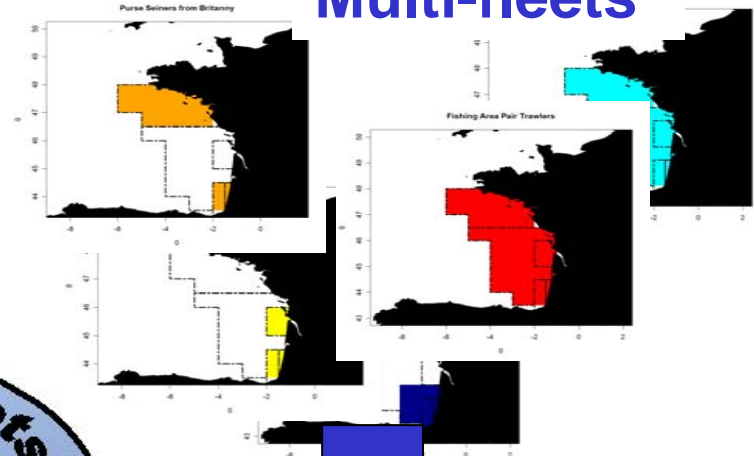
# Anchovy fishery in the bay of Biscay

[www.ifremer.fr](http://www.ifremer.fr)

## Single species



## Multi-fleets



French and spanish trawlers, seiners....

TAC-managed  
Closed from 2005

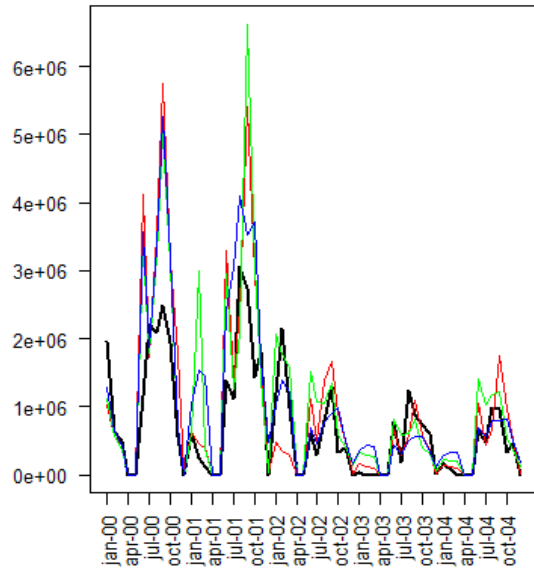
Calibrated over 2000-2004  
Sensitive parameters :  
fecundity and natural mortality

Management  
measures

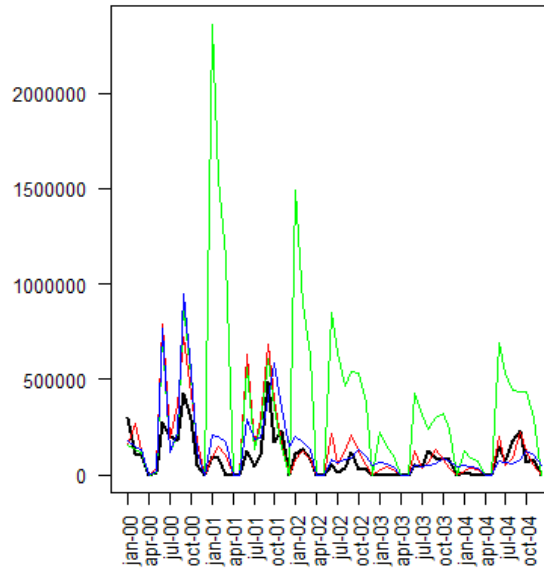
# Model validation: Catches per fleet

— observations  
 — Static model  
 — Gravity model  
 — RUM

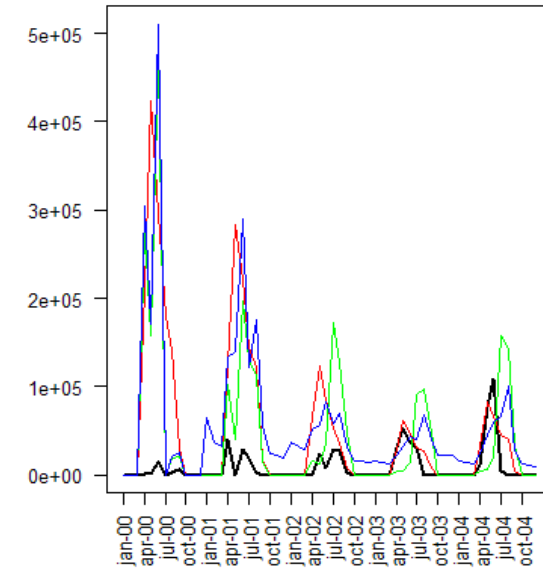
Catches in kg French Trawlers profil1



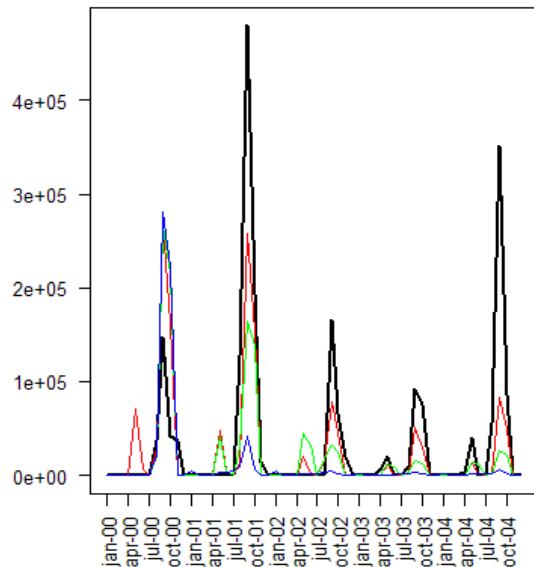
Catches in kg French Trawlers profil2



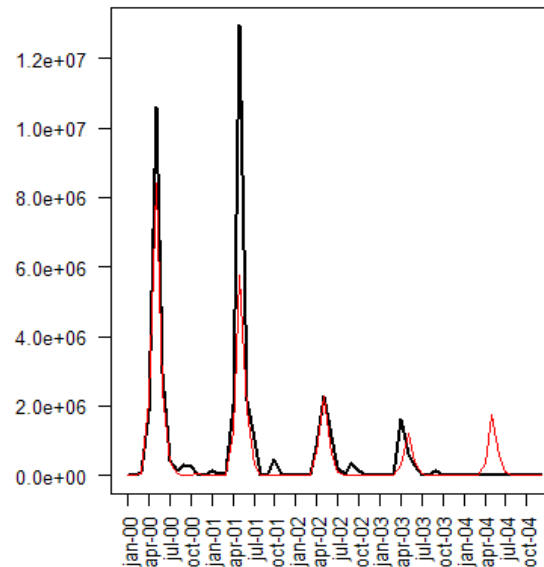
Catches in kg Purse seiners Basque Country



Catches in kg Purse seiners Brittany



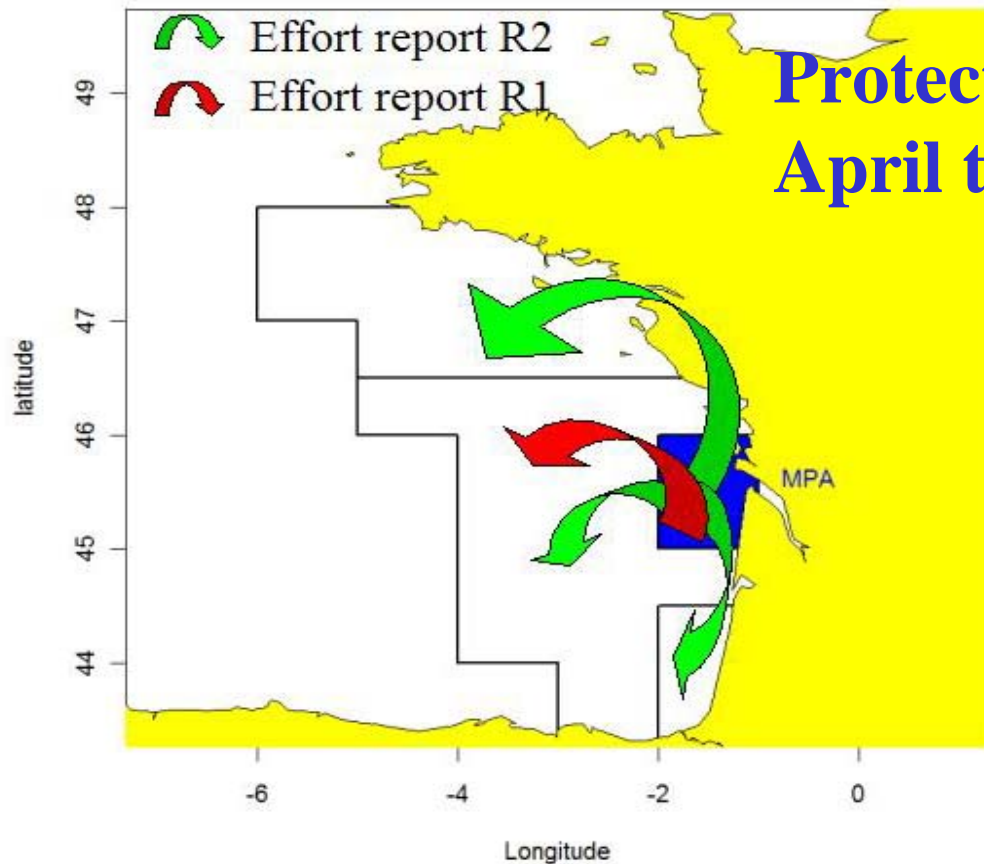
Catches in kg Spanish Purse seiners



- RUM & Static reproduce the observed catches per fleet
- Bad fit with the gravity model

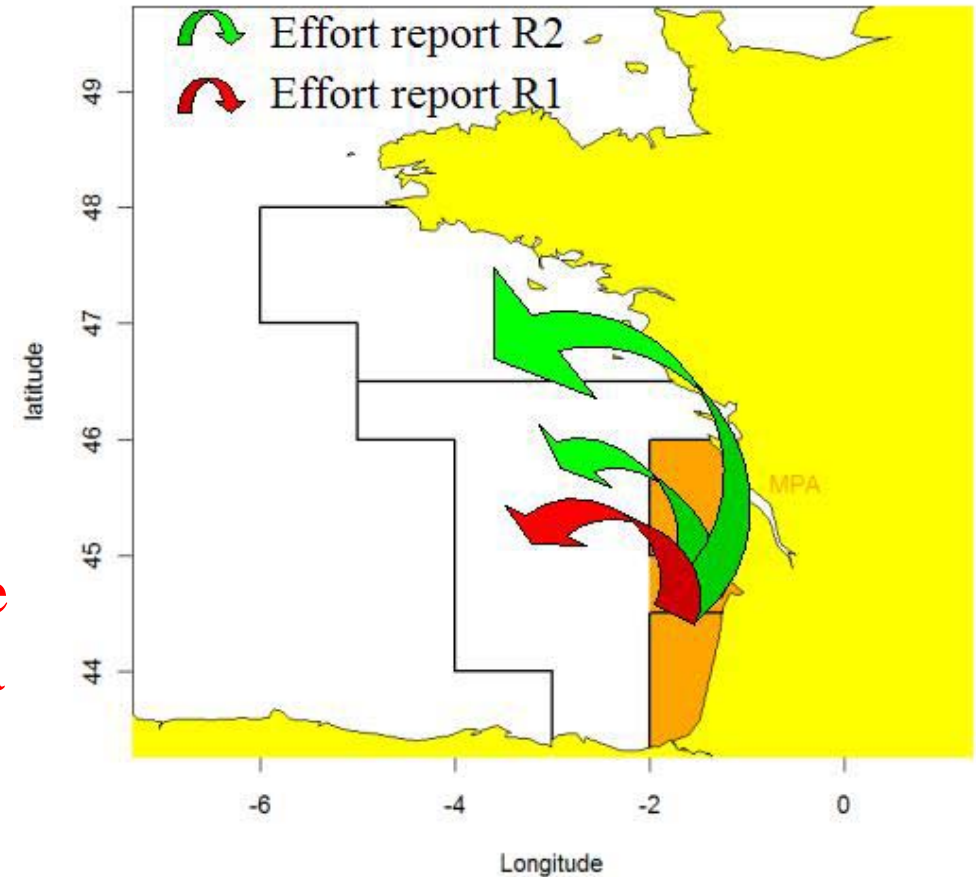
*Vermard, Lehuta, Mahevas, Marchal, Thebaud, In Prep; presented to Ices 2008 annual symposium*

# Marine protected areas and fishermen reactions



Protecting adults from  
April to July

Protecting juveniles from  
August to December

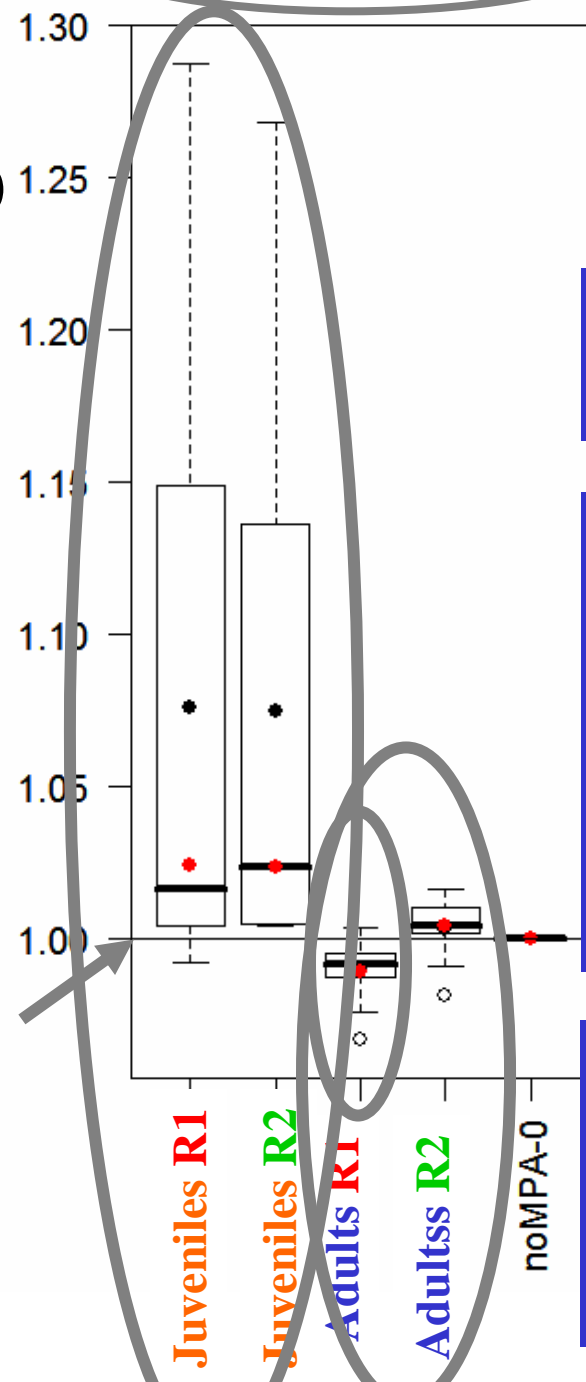
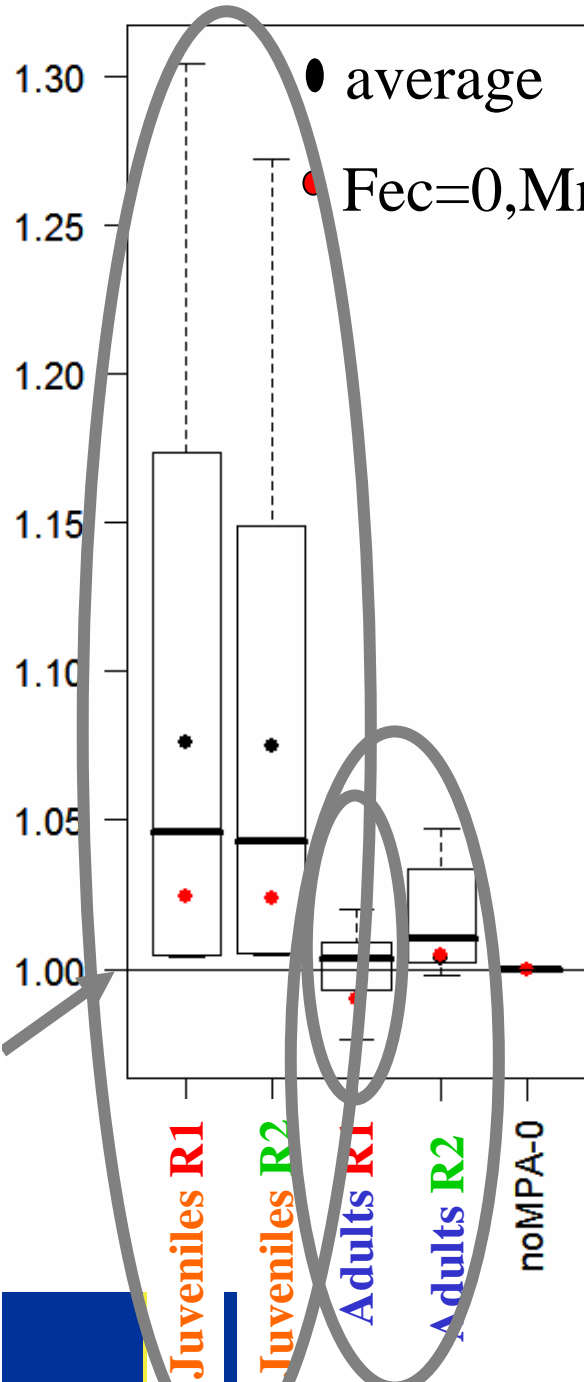


R1 = fishing effort reallocated to the metier in use in the MPA adjacent area

R2 = fishing effort reallocated to all the metiers of the fleet

**Biomass MPA/NoMPA**

**Catch MPA/NoMPA**



**Full simulation design with fec and M interval uncertainty**

Protecting juveniles increases biomass and catch

Protecting adults decreases biomass and catch when fishermen reallocate their effort closest the MPA but increases when reallocating their effort on all accessible fishing areas of the fleet

Protecting matures is more risky than protecting juveniles with respect to uncertainty on fecundity and natural Mortality

# Tasmanian scalefish fishery

- **Test the suitability of ISIS for supporting fisheries management decision-making**
- **Why choosing isis? Mixed fishery, spatial patterns, fleet dynamics (fishermen reaction), management scenarios**
- **How modelling fleet dynamics?**
  - Historical data, which and when management measures
  - Fishermen interviews (behaviour)2 possible approaches to describe fishing effort allocation
  - Derive relevant variables from interviews that should driven fleet dynamics and fit a statistical model to historical data including previous selected variables
  - Derive decisions ' rules from interviews and calculate an average fishing effort allocation using historical dataValidation-selection process : confronting model outputs and fisheries observations (including interviews)

# Project steps

- **Preliminary approach**
  1. exploring the data
  2. defining management scenarios
  3. carrying out interviews
  4. parametrisation and exploration of the system
- **Quantitative diagnostics**
  1. simulating management strategies with uncertainty
  2. computing relevant metrics for testing management objectives
- **Feed back from industry and fishermen**

# Merci pour votre attention



$$\triangleright \text{FuelCostsTravel}(str, met, t) = \text{TravelTime}(sov, met, t) \text{UnitFuelCostsTravel}(vt)$$

$$\text{FuelCostsFishing}(str, met, t) =$$

$$\triangleright \text{FishingTime}(str, met, t) \text{NbOpePerDay}(sov, met) \text{UnitFuelCostsFishing}(sov, met) / 24$$

$$\triangleright \text{OtherRunningCosts}(str, met, t) = \text{FishingTime}(str, met, t) \text{OtherRunningCostsPerDay}(sov, met) / 24$$

$$\triangleright \text{SharedCosts}(str, met, t) = \text{FuelCosts}(str, met, t) + \text{OtherRunningCosts}(str, met, t)$$

$$\text{GearMaintenanceCosts}(str, met, t) =$$

$$\triangleright \text{FishingTime}(str, met, t) \text{GearMaintenanceCostsPerDay}(sov, met) / 24$$

$$\text{GrossValueLandings}(str, met, pop, t) =$$

$$\triangleright \sum_{classes} \text{Price}(pop, cl, t) (\text{CW}(str, met, cl, t) - \text{DiscW}(str, met, cl, t))$$

$$\text{NetValueLandings}(str, met, pop, t) =$$

$$\triangleright \text{GrossValueLandings}(str, met, pop, t) (1 - \text{LandingCostRate}(str, met))$$

$$\begin{aligned} NetRevenue(str, met, t) = & \sum_{populations} NetValueLandings(str, met, pop, t) \\ & + (1 - LandingCostRate(str, met)) OtherSpeciesGrossValue(str, met) - SharedCosts(str, met, t) \end{aligned}$$

$$CrewShare(str, met, t) = NetRevenue_{str}^{met}(str, met, t) CrewShareRate(sov, met)$$

$$\begin{aligned} VesselMarginPerVessel(str, met, t) &= NetRevenue_{str}^{met}(str, met, t) - GearMaintenanceCosts(str, met, t) \\ OwnerMarginPerVessel(str, met, t) &= VesselMarginPerVessel(str, met, t) - CrewShare(str, met, t) \end{aligned}$$