

#### Regional and sectorial impacts of cost allocation rules & impacts of ecological restoration schedule: input-output/system dynamics modeling

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#### Regional and sectorial impacts of cost allocation rules & impacts of ecological restoration schedule :

#### input-output/system dynamics modeling

**Mateo Cordier** 

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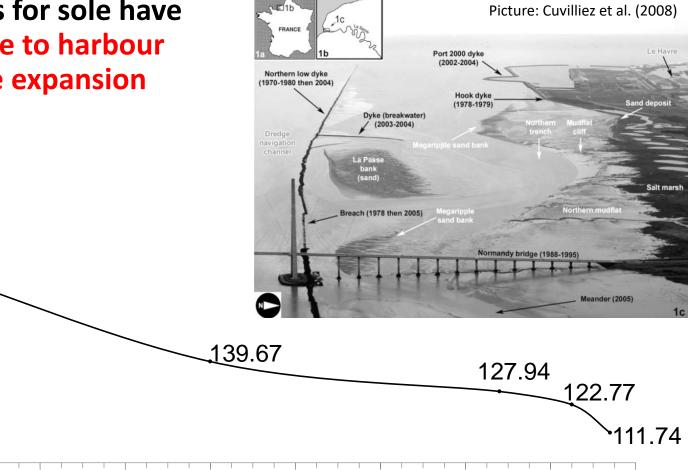
**Takuro Uehara** *Ritsumeikan University* 

September 2018

# Method and study area

#### Study Area: The Seine Estuary (France)

• Nursery areas for sole have decreased due to harbour infrastructure expansion



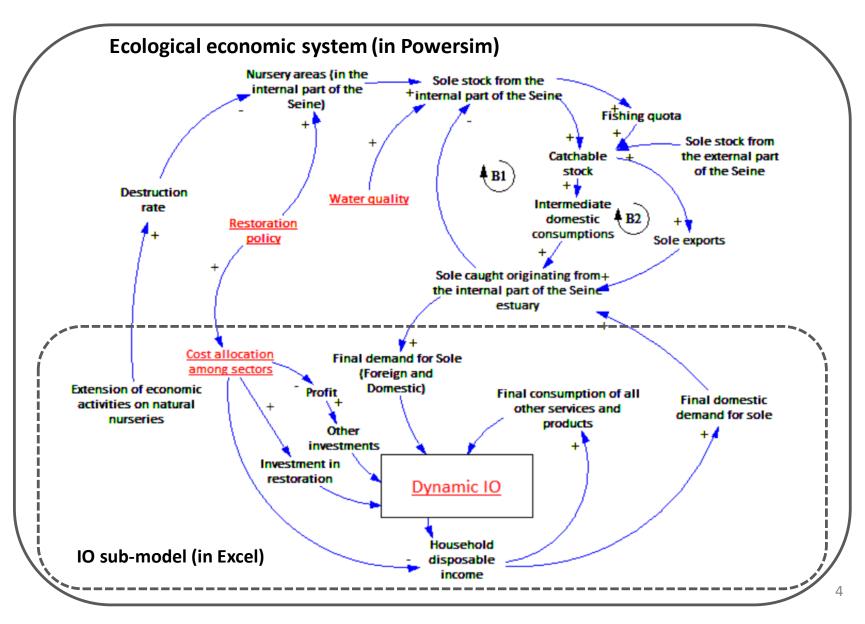
#### Evolution of nursery areas of the internal part of the Seine estuary.

181.91

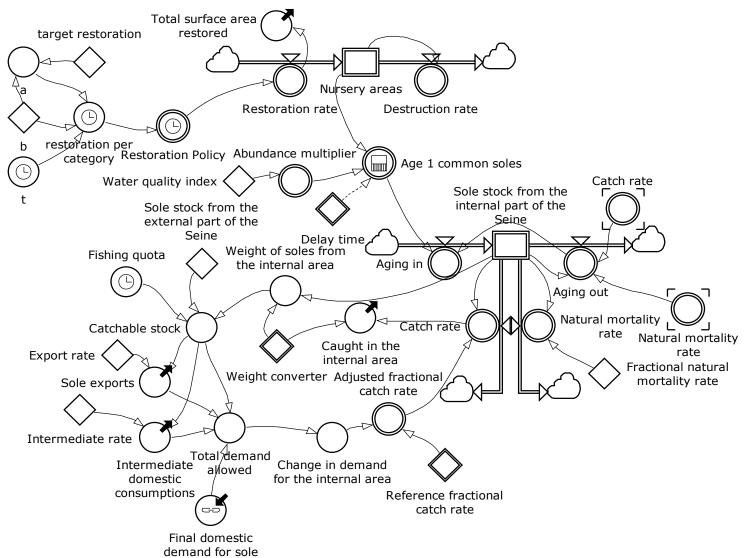
Nursery areas (km<sup>2</sup>)

Source of data: Rochette et al. (2010)

## Conceptual scheme of the IO/SD model



#### The SD ecological-economic model



#### The IO sub-model

	Buying Sector	Final Demand	Total Output
	(j = 1,, n; n = 37)	(K = 1,, J; J = 8)	
Selling Sector	X	F	Х
(i = 1,, n; n = 37)	$x_{ij}$	f <sub>ik</sub>	$x_i$
Imports	mi′	mf′	m
	mi <sub>j</sub>	$mf_k$	
Value Added	V		V
(l = 1,, p; p = 3)	$ u_{lj}$		v <sub>l</sub>
Total Outlays	<b>x</b> ′		
	$x_j$		

#### Dynamization of the IO sub-model

$$\mathbf{x}_{t} = \left[ \left( \mathbf{I} - \widehat{\boldsymbol{\beta}}_{t} \mathbf{A} \right)^{-1} \widehat{\boldsymbol{\beta}}_{t} \right] \mathbf{f}_{t} \qquad \forall t = 1, \dots, T$$

where  $\widehat{\beta}_t$  is a diagonal matrix with the elements,  $\widehat{\beta}_{i,t}$ , computed as:

$$\widehat{\boldsymbol{\beta}}_{i,t} = \exp\left[\alpha_0 + \alpha_z \log\left(\frac{x_{i,t-1}}{z_{i,t-1}}\right) + \alpha_g g_{i,t}\right] \qquad \forall i = 1, \dots, n$$

# Changes in IO technical coefficients over the period 2012-2032

Positive changes: dark color. Negative changes: lighter color. No changes: white cells

			Prin	nary						s	econd	lary												Servio	ces					
			1	2	3	4 5	6	7	8	9	10 1	1 1	2 13	14	15 10	6 17 1	8	9 20	21 2	2 23	24	25	26 2	7 28	29	30	31 3	2 33	34 3	5 36
Prim ary		Agri, Fish, Forest																												
P B	2	Mining and quarrying																												
	3	Food products, etc.																												
	4	Textiles, etc.																												
		Wood, paper, printing	]															_												
		Coke and refined petroleum products										_	_			_														
		Chemicals and chemical products																												
	8	Basic pharmaceutical products, etc.					_					_				_														
≥	9	Rubber, plastics, etc.																												
] da	10	Basic and fabricated metals	]																											
Secondary	11	Computer, electronic and optical products																												
v	12	Electrical equipment	]																											
	13	Machinery and equipment n.e.c.	1																											
	14	Motor vehicles, trailers, etc.	1																											
	15	Manufacture of furniture, etc.	1																											
	16	Electricity, gas, steam, etc.	1																											
	17	Water collection, treatment and supply, etc.	1																											
	18	Constructions and construction works	1																											
	19	Wholesale and retail trade, etc.																												
	20	Land transport, etc.																												
	21	Accommodation and food services	1																											
	22	Publishing activities, etc.	1																											
		Telecommunications services	1																											
	24	Computer programming, etc.	1																											
		Financial service activities, etc.	1																											
	26	Real estate activities, etc.	1																											
ß	27	Legal and accounting activities, etc.	1																							_				
<u></u>		Scientific research, development services	1																											
Services		Advertising and market research, etc.	1																											
		Rental and leasing activities, etc.	1																											
		Public administration and defence services, etc.	1																											
	-	Education services	1																											
	33	Human health services	1																											
		Social work services	1																											
		Creative, arts and entertainment activities, etc.																												
		Activities of membership organisations, etc.																												
		Services of households as employers, etc.	1																											

## Scenarios simulated

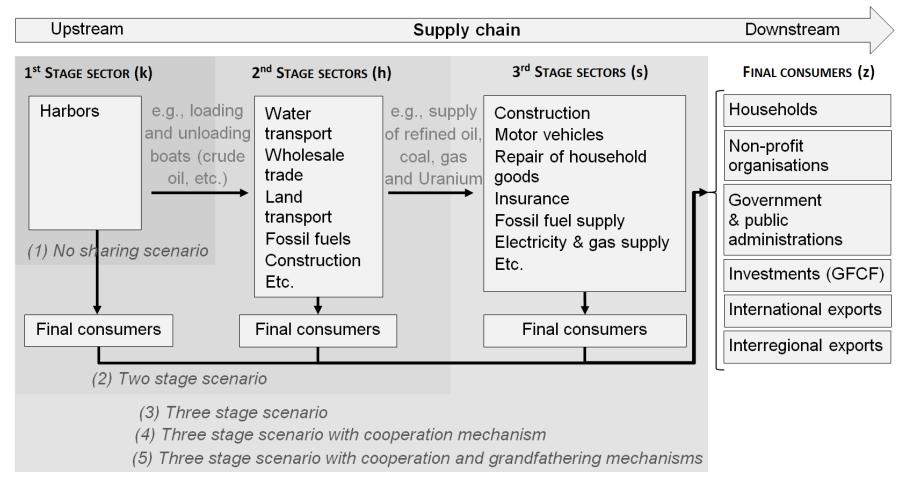
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Scenarios	Policy impact Assessment
	Restoration schedule
Business as usual (BAU)	No restoration
	1. Increasing
Restoration scenarios	2. Constant
scenarios	3. Decreasing

Scenarios			Policy impact Assessment
	Restoration schedule		Cost allocation
Business as usual (BAU)			No restoration
Restoration scenarios	<ol> <li>Increasing</li> <li>Constant</li> <li>Decreasing</li> </ol>	R R W R W	ule 1: No sharing ule 2: Two stage sharing ule 3: Three stage sharing ule 4: Three stage sharing rith cooperation mechanism ule 5: Three stage sharing rith cooperation and randfathering mechanisms

#### **Cost allocation rules**

The cost allocation rules are, *inter alia*, based on the **shared environmental responsibility principle**\*



\* Gallego and Lenzen (2005), Lenzen et al. (2007), Lenzen and Murray (2010), Cordier et al., (2018)

Scenarios			Policy impact Assessment
	Restoration schedule		Cost allocation
Business as usual (BAU)			No restoration
Restoration scenarios	<ol> <li>Increasing</li> <li>Constant</li> <li>Decreasing</li> </ol>	R R W R W	ule 1: No sharing ule 2: Two stage sharing ule 3: Three stage sharing ule 4: Three stage sharing rith cooperation mechanism ule 5: Three stage sharing rith cooperation and randfathering mechanisms

Scenarios	Policy impact Assessment								
	Restoration schedule	Cost allocation	Restoration responsibility						
Business as usual (BAU)		No restoration							
	1. Increasing	Rule 1: No sharing Rule 2: Two stage sharing Rule 3: Three stage sharing	<ul><li>Stage responsibility calculation:</li><li>1. Value added/Net output</li></ul>						
Restoration scenarios	<ol> <li>Constant</li> <li>Decreasing</li> </ol>	Rule 4: Three stage sharing with cooperation mechanism	<ol> <li>Gross operating surplus (GOS)/output</li> </ol>						
		Rule 5: Three stage sharing with cooperation and grandfathering mechanisms	3. Return on investment (ROI)						

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Scenarios		Policy sensitivity analysis		
	Restoration schedule	Cost allocation	Restoration responsibility	Water quality
Business as usual (BAU)		No restoration		0.77
Restoration	<ol> <li>Increasing</li> <li>Constant</li> </ol>	Rule 1: No sharing Rule 2: Two stage sharing Rule 3: Three stage sharing	<ul><li>Stage responsibility calculation:</li><li>1. Value added/Net output</li></ul>	
scenarios	3. Decreasing	Rule 4: Three stage sharing with cooperation mechanism Rule 5: Three stage sharing with cooperation and grandfathering mechanisms	<ul> <li>2. Gross operating surplus (GOS)/output</li> <li>3. Return on investment (ROI)</li> </ul>	[0.50, 1.00]

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• Inputs entered to feed the IO/SD model and outputs delivered by the model:

Model inputs	Model outputs (outcome indicators )
<ul> <li>Economic inputs entered in the model:</li> <li>1. Exogenous annual economic growth (%)</li> <li>2. Investments required for the restoration of nurseries (M€/year)</li> </ul>	<ul> <li>Economic outcome indicators:</li> <li>1. Gross Domestic Product (GDP) (M€)</li> <li>2. Disposable income (M€)</li> <li>3. Gross Operating Surplus (GOS) (M€)</li> </ul>
<ul> <li><i>Ecological inputs entered in the model:</i></li> <li>1. Nursery area restored (km<sup>2</sup>/year)</li> <li>2. Exogenous water quality (%)</li> </ul>	<ul> <li>Ecological outcome indicators:</li> <li>Sole caught originating from the internal area of the estuary (tons)</li> <li>Nursery areas <ul> <li>Km<sup>2</sup></li> <li>Total Economic Value (TEV, M€) excluding food and nursery services</li> </ul> </li> </ul>

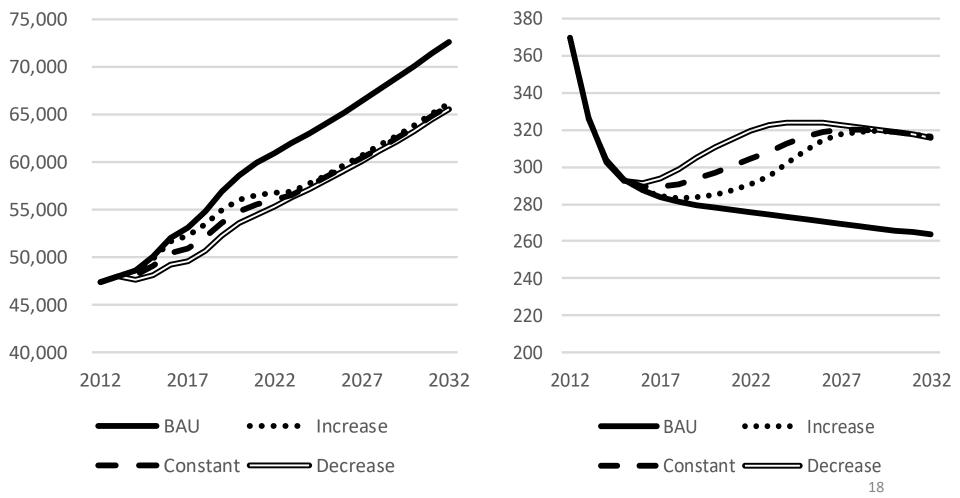
# Results

#### Regional impacts of restoration schedules

GDP (Million €)

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Sole caught in the internal area (tons)

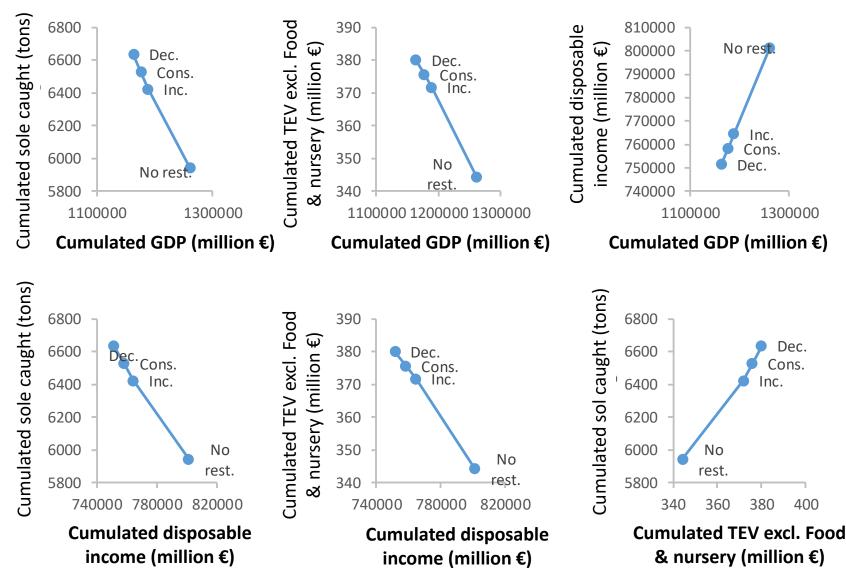


#### Relationships between key outcome indicators

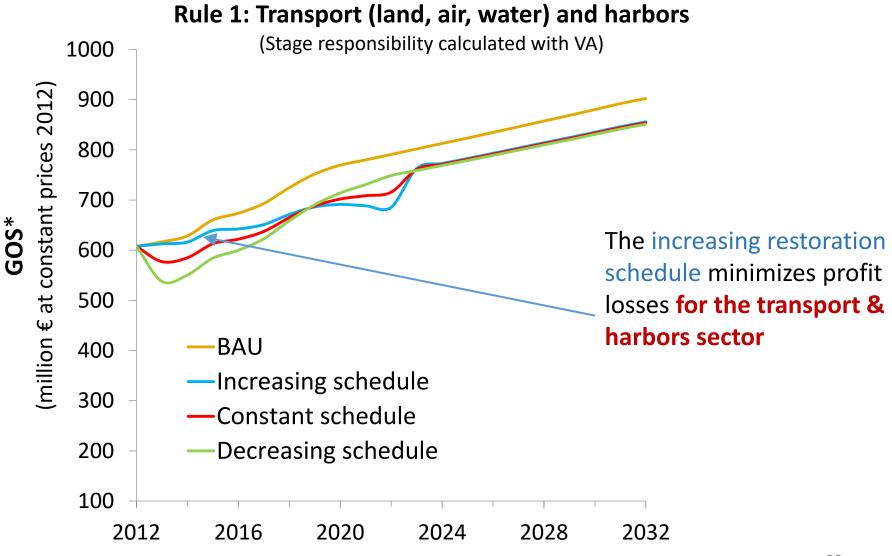
• Graphs display cumulated values summed over the 2012-2032 period.

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• They show trade-offs between economic indicators and ecological indicators



#### Sectorial impacts of restoration schedules

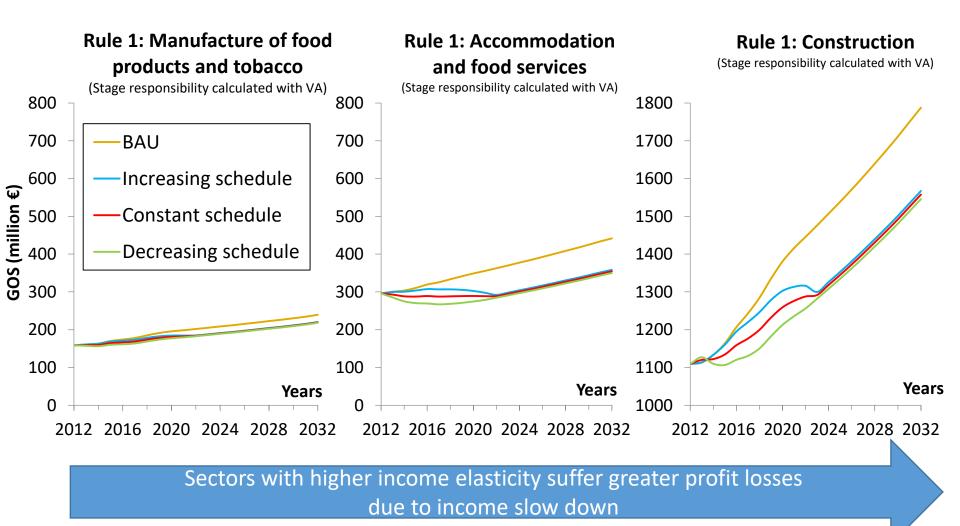


\* GOS (gross operating surplus ) is a measure of profit

#### Sectorial impacts of restoration schedules

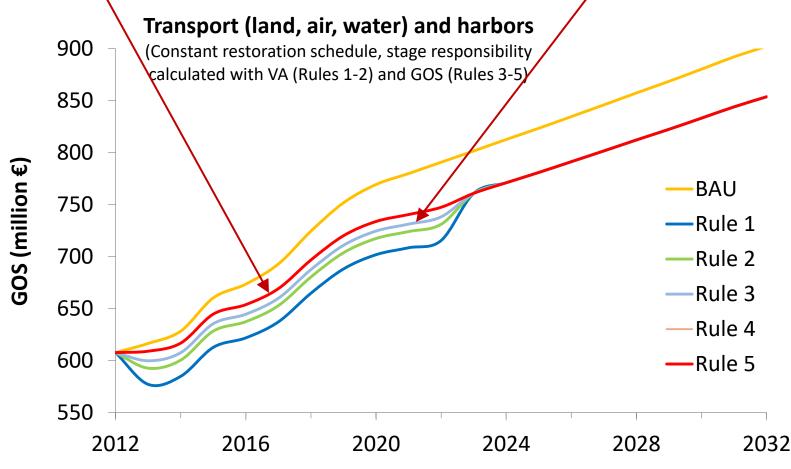
• The increasing restoration schedule minimizes profit losses for other sectors

Μ



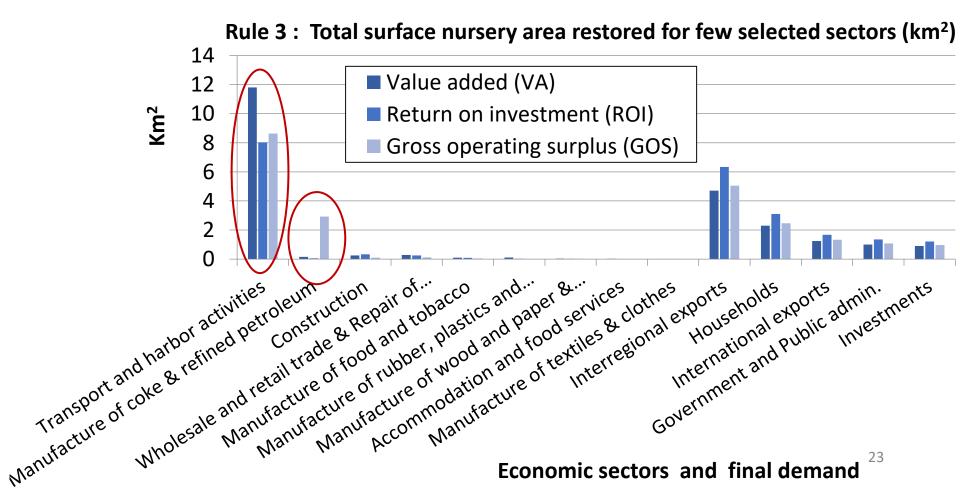
#### Sectorial impact of cost allocation rules

- Rules 4 and 5 (they overlap) minimize profit losses for the transport & harbors sector thanks to cooperation and grandfathering mechanisms.
- Would economic sectors disagree on such mechanisms, rule 3 provides a second best option for profit loss minimization.

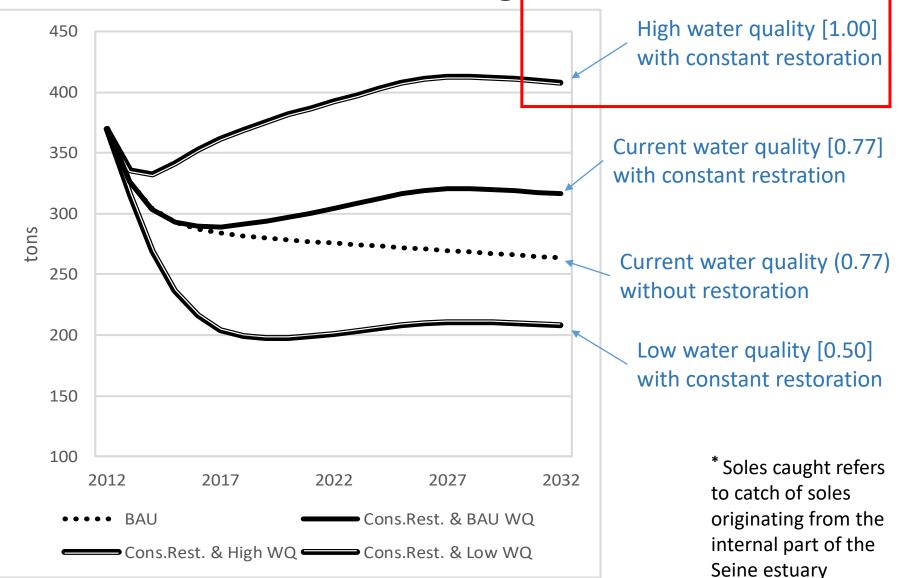


# Sectorial impacts of stage responsibility calculations

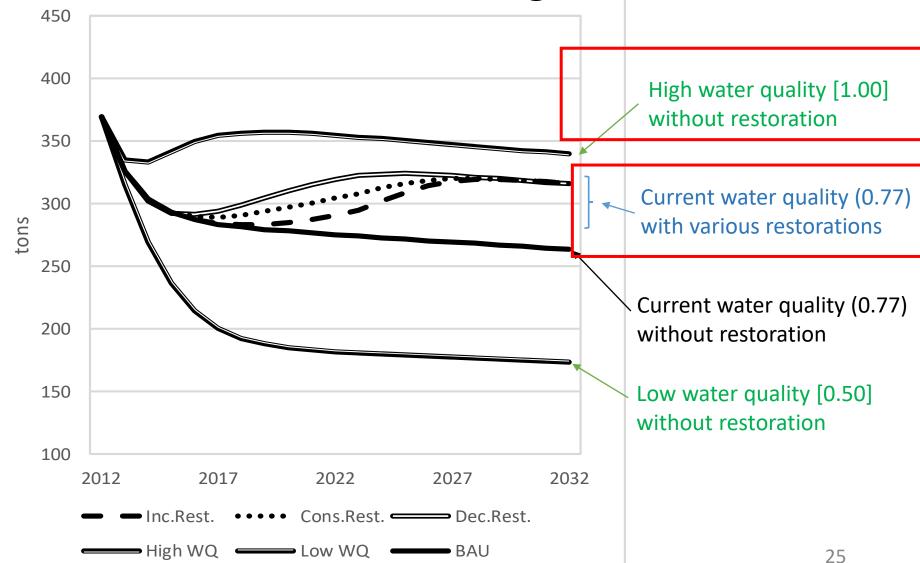
• The **GOS ratio** helps to improve the social legitimacy of the shared environmental responsibility principle as it includes a sector bearing an important second stage responsibility : manufacture of coke and refined petroleum.



#### Impact of water quality & restoration on Soles caught\*



#### Impact of water quality vs. restoration on Soles caught\*



## Conclusions

## Limitations and future research

• Longer term trade-offs could change our conclusions.

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- Reflecting ecological thresholds could change our conclusions.
- It is important to further delve into the impact of water quality due to contaminants such as endocrine disruptors:
- **Alkylphenols:** used in detergents in textile industry, plastics, pesticides, paper production, water paintings.
- **Organotin:** compounds of biocide paintings such as TBT on ships but production is forbidden nowadays. However, historical contamination remains in sediments.
- Phthalates (DBP, DiBP, DEP, DEHP, MEHP): used in plastics, cosmetics, textiles, and insecticides.
- **PolyBromoDiphénylEthers (PBDE):** used as flame retardant additive in textiles, furniture made of textile components, etc. Suspected to be an endocrine disruptor.
- **PCB (PolyChloroBiphényles):** not used anymore, have been forbidden a long time ago but historical contamination remains in sediments.
- PAHs (Polycyclic aromatic hydrocarbons): result from incomplete combustion of organic matter (wood-burning and combustion of other biofuels, industrial processes and the extraction and use of fossil fuels, wildfires, tobacco smoking, etc.)

→ involves sectoral and spatial (i.e., within and outside the region) responsibilities.

#### For more details, read us :-)

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Economic

	Ecological Economics 140 (2017) 46–57	Reconciliants of the second se						
ELSEVIER	journal homepage: www.elsevier.com/locate/ecolecon	(*) MER						
Methodological and Ideolo	ogical Options							
	conomic Model Integrated Within a System Dynamics Feedback Loop Methodology Applied to Fish on	CrossMark						
Mateo Cordier <sup>a,b,*</sup> , Takı	uro Uehara <sup>c</sup> , Jeffrey Weih <sup>e</sup> , Bertrand Hamaide <sup>d</sup>							
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Article								
Fully Dynan	nic Input-Output/System Dynamics							
Modeling for Ecological-Economic System Analysis								
Takuro Uehara <sup>1,</sup> * <sup>(D)</sup> , Mateo Cordier <sup>2,3</sup> and Bertrand Hamaide <sup>4</sup>								

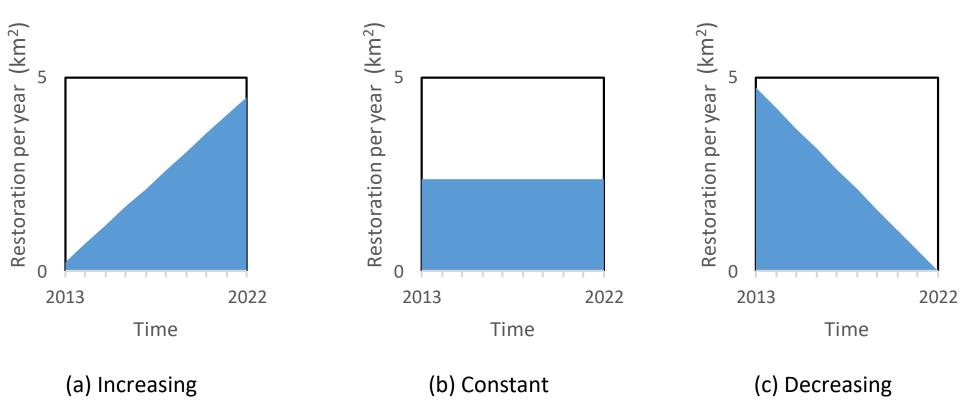
#### The shared environmental responsibility principle: new developments applied to the case of marine ecosystems stems Research

Mateo Cordier, Thomas Poitelon, Walter Hecq (2018, under press)

# Appendix

#### **Restoration schedule**

• 3 schedules distributing annual restoration of nursery areas through time have been simulated:



## Water quality

- Juvenile density in the Seine estuary is **23%** lower today compared to 1850 because of water quality degradation (Rochette et al., 2010).
- We assume that water quality improvement can recover the juvenile abundance by 23% maximum as follows:

Abundance  $Multiplier_i = Water Quality Index * Abundance Multiplier_i^{max}$ 

- With that equation, we carry out a sensitivity analysis in which we assume juvenile abundance to be proportional to water quality.
- The current Water Quality Index (**BAU scenario**) = 0.77 (= 100%–23%).
- In policy sensitivity analysis, Water Quality Index varies between [0.50, 1.00].
- The Water Quality Index is exogenously given as this variable is determined out of the system boundary.