Effect of nursery habitat degradation on flatfish population renewal

Application to *Solea solea* in the Eastern Channel (Western Europe)

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General context

- Estuaries and coastal waters
  - Essential fish habitat
  - Nurseries for many species

- Important human pressure
  - Fish population renewal hardly affected

- What are the effects of these human pressure on fish populations?

- Evaluating consequences of habitat degradation
  - Coupling Generalized Linear Models and Geographical Information System
  - Evaluate historical production
Application in the Eastern Channel

- Common sole (*Solea solea*)
  - Commercially important species
  - Juvenile life exclusively on coastal waters

- Seine estuary
  - Habitat destruction
  - Quality alteration

- What are the effects of habitat degradation in the Seine estuary on sole population in the Eastern Channel?
Outline

- Sole juveniles nurseries map
  - Coupling GLM and GIS
    - Method
    - Results

- > 150 years of habitat degradation in the Seine estuary
  - Effects on juveniles population
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Statistical model: data

- Trawl surveys in eastern Channel
  - From 1974 to 2007
  - French and English coasts
  - > 5000 trawl hauls in September
  - 0-group juveniles
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- Description of densities distribution
  - Bathymetry
  - Sediment structure
  - Spatial heterogeneity
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- Densities of sole in haul
  - Zero inflated data (2/3 empty hauls)
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- Densities of sole in haul
  - Zero inflated data (2/3 empty hauls)
  - Log normal distribution of positive values

⇒ Delta distribution model
Statistical model

- Delta model
  - Known to work for young sole (YS) nurseries (*Le Pape et al, 2003*)
  - Average year
  - Presence / absence: binomial distribution

\[ YS_{0/1} \sim \text{Sector} + \text{Bathymetry} + \text{Sediment} \]

- Positive densities: log normal distribution

\[ \log(YS_{+}) \sim \text{Sector} + \text{Bathymetry} + \text{Sediment} \]

- Estimate habitat suitability by coupling

\[
\hat{YS} = \hat{YS}_{0/1} \times e^{\ln(YS_{+})} \times e^{\sigma_{\ln(YS_{+})}^2}\
\]
Habitat map

- Available maps
  - Bathymetry
  - Sediment structure
  - Coastal sectors
Habitat suitability model
Habitat suitability model
Habitat suitability model

Eastern Channel

Bathymetry
Sediment
Sectors

Bathymetry
Sediment
Sector
Surface
Habitat suitability model

- Eastern Channel
- Bathymetry
- Sediment
- Sectors

Trawl surveys

- Bathymetry
- Sediment
- Sector
- Surface
Habitat suitability model

- **Eastern Channel**
- **Bathymetry**
- **Sediment**
- **Sectors**

**Trawl surveys**

**GLM**: Delta distribution

**Density of juveniles** ~ Sector + Bathymetry + Sediment

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**Eastern Channel**

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**Density of juveniles ~**

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**Surface**

**Density of juveniles**

**Number of fish: Abundance indices**

Contribution to the stock

**Trawl surveys**
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- Effect of Bathymetry
Statistical model: results

- Effect of Bathymetry
  - Preference for low bathymetry

Diagram: 0-group per class of Bathymetry (number per 1000 m² haul)
Statistical model: results

- Effect of Bathymetry
- Effect of sediment structure

![Graph showing the relationship between juvenile density and bathymetry and sediment type.](image)
Statistical model: results

- Effect of Bathymetry
- Effect of sediment structure
  - Preference for muddy sediments
Statistical model: results

- Effect of Bathymetry
- Effect of sediment structure
- Sector effect

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**Juvenile density**

0-group per Sector (number per 1000 m² haul)

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**Sediment**

- Gravels
- Sand
- Mud

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**Bathymetry (m)**

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Statistical model: results

- Effect of Bathymetry
- Effect of sediment structure
- Sector effect

![Diagram showing statistical model results with graphs and sector comparisons.]
Habitat suitability model

Eastern Channel

Bathymetry

Sediment

Sectors

GLM: Delta distribution

Trawl surveys

Density of juveniles ~ Sector + Bathymetry + Sediment

Number of fish: Abundance indices
Contribution to the stock

Surface × Density
Habitat suitability map: present situation

- Distribution map for 0-group juvenile soles
- Update of existing model (Riou et al., 2001)
Focus on the Seine estuary
Focus on the Seine estuary

- The single large estuary of the Eastern Channel
- ~20% of the potential nursery in surface

Number of juvenile soles in %
Focus on the Seine estuary

- The single large estuary of the Eastern Channel
- But only ~10% contribution to the stock

Number of juvenile soles in %

![Graph showing the number of juvenile soles in different areas](image)
Focus on the Seine estuary

- The single large estuary of the Eastern Channel
- But only ~10% contribution to the stock
- Pieces of Explanation
  - 33% surface, 75% fine sediment in 150 years
    - building dikes, dig a channel, enlarge the port

(Delsinne, 2005)
Focus on the Seine estuary

- The single large estuary of the Eastern Channel
- But only ~10% contribution to the stock
- Pieces of Explanation
  - 33% surface, 75% fine sediment in 150 years
  - Low quality

(Gilliers et al., 2006)
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Habitat suitability on historical maps

- Eastern Channel
- Bathymetry
- Sediment
- Sectors

**Density of juveniles**
~ Sector + Bathymetry + Sediment

**GLM**: Delta distribution

**Trawl surveys**

**Number of fish**: Abundance indices
Contribution to the stock

Surface × Density
Habitat suitability on historical maps

- Hyp: Seine quality is constant over time
  - "Seine" sector effect from the delta model
Abundance index

- 39% of Seine juveniles lost

(Maps: Delsinne, 2005)
Abundance index

- 39% of Seine juveniles lost
  - 33% of surface lost

(Maps: Delsinne, 2005)
Contribution to the stock

- ~12% contribution to the stock in the 1850s

Number of juvenile soles in %
Total stock of juveniles

- Loss of 2% of total 0-group juveniles population
If the Seine was an average sector?

- Nowadays: low sector effect
  - Low quality
If the Seine was an average sector?

- Nowadays: low sector effect
- 1850s: average sector effect
  - Higher water quality in 1850
If the Seine was an average sector?

- Nowadays: low sector effect
- 1850s: average sector effect
If the Seine was an average sector?

~1850: constant quality

~1850: average quality

~1850: constant quality
If the Seine was an average sector?

- ~25% contribution to the stock
If the Seine was an average sector?

- ~25% contribution to the stock
- Loss of 16% of total 0-group juveniles population
  - No changes in other sectors

~1850: average quality

Today: present situation
Conclusion

- The Seine estuary
  - Today: 10% contribution in eastern Channel
  - During the last 150 years:
    - 33% surface lost
    - 39% potential nursery in the Seine estuary
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  - Habitat destruction in the Seine estuary: 2% juvenile population
  - Habitat destruction + quality: 16% juvenile population
  - Underestimation of habitat degradation (other sectors)
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⇒ Hardly influence sole population renewal

⇒ Indicator of effects on other estuarine-dependent species
Thanks for attention