Consequences of human disturbances on the common sole population

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Outline

- Essential fish habitat
  - estuaries and coastal waters
  - notably for common sole

- Important human pressure

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

- Evaluating consequences of habitat degradation
  - Coupling Generalized Linear Models and Geographical Information System
  - Evaluate historical production

- Transfer to population model
  - Coupling
    - Larval drift IBM
    - Matrix population model
  - Estimate the respective influence of different anthropogenic pressure
    - degradation of coastal and estuarine nursery habitat & fishing mortality
1. Sole juveniles nurseries map
   - Coupling GLM and GIS

Influent factors (known exhaustively)

Model of habitat suitability

\[ \text{Nursery} = f(\text{Bathy}, \text{Sediment}) + \text{spatial heterogeneity} \]

Exhaustive Knowledge of juvenile habitats
Statistical model: data

- Trawl surveys in eastern Channel
  - From 1974 to 2007
  - French and English coasts
  - > 5000 trawl hauls in September
    - Factors: bathymetry, sediment structure, sector
  - 0-group juvenile sole (young of the year, \(\approx\) 6 months in September)
Descriptors of juvenile habitat

- Available maps to describe juvenile habitat

- Bathymetry

- Sediment
Habitat map

- Available maps
  - Sectors
  - Bathymetry
  - Sediment structure

- Coupling GLModel and GIS
  - Model:
    - Sole = f(Bathymetry × Sediment × Sector)
    - Density estimates
  - GIS: Map & Surface
  - Model × GIS
    - Mapping +
    - Number of fish: Abundance Indices
    - Contribution to the stock
      (I explain just after !)
GIS

Bathymetry

Sediment

Sector

Surface
Survey data and habitat descriptors (HSI)

- Bathymetry
- Sediment
- Sector
- Surface

Trawl survey data

1 trawl haul

1 juvenile sole density

1 bathy \( \cap \) 1 sediment

\( \cap \) 1 sector
Habitat suitability model (HSI)

Statistical model:
Juvenile density ~ Bathymetry + Sediment + sector

Bathymetry + Sediment + Sector

Trawl survey data

Juvenile density

Nursery maps
Habitat suitability model (HSI)

- Bathymetry
- Sediment
- Sector
- Surface

Number of juvenile fish: Contribution to the stock

Statistical model:
Juvenile density ~ Bathymetry + Sediment + sector

Trawl survey data

Juvenile density

Surface × Density = Number
Statistical model: results

- Effect of Bathymetry

![Graph showing the effect of Bathymetry on 0-group density.]
Statistical model: results

- Effect of Bathymetry
- Effect of sediment structure

0-group per class of Sediment (number per 1000 m² haul)

- Gravels
- Sand
- Mud

Y0 density

Bathymetry
Statistical model: results

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

![Graph showing statistical model results with data points for different locations and sediment types.]

Map showing regional locations: Solent, Rye Bay, South Downs, Veys, Seine, Boulogne, Somme.
Habitat map: present situation

Distribution map for 0-group
Focus on the Seine estuary
Focus on the Seine estuary

- The single large estuary of the zone
- ~20% of the potential nursery in surface
- But only ~15% contribution to the stock
Focus on the Seine estuary

- The single large estuary of the zone
- ~20% of the potential nursery in surface
- But only ~15% 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 zone
- ~20% of the potential nursery in surface
- But only ~15% contribution to the stock
- Pieces of Explanation
  - 33% surface, 75% fine sediment in 150 years
  - Low quality

(Gilliers et al., 2006)
Focus on the Seine estuary

- The single large estuary of the zone
- ~20% of the potential nursery in surface
- But only ~15% contribution to the stock
- Pieces of Explanation (in 150 years)
  - 33% surface, 75% fine sediment
  - Low quality

(Gilliers et al., 2006)
Application in the eastern Channel

1. Sole juveniles nurseries map
   - Coupling GLM and GIS

2. > 150 years of transformation in the Seine
   - Effects on juveniles biomass

(Maps: Delsinne, 2005)
Historical maps

- Hypothesis: the Seine quality is constant over time

- ~1850
- ~1910
- ~1980
- Today
Abundance index

- 42% of Seine production lost
  - 33% of surface lost

Maps: Delsinne, 2005

42% of Seine production lost
33% of surface lost

-42%
-33%
Total stock of juveniles

- Loss of 4% of total 0-group juveniles

Loss of juvenile and Seine contribution at the Eastern Channel population scale

- Veys
- Somme
- Boulogne
- Rye Bay
- Solent
- Sdowns

<table>
<thead>
<tr>
<th>Year</th>
<th>Veys</th>
<th>Somme</th>
<th>Boulogne</th>
<th>Rye Bay</th>
<th>Solent</th>
<th>Sdowns</th>
</tr>
</thead>
<tbody>
<tr>
<td>~1850</td>
<td>20</td>
<td>30</td>
<td>15</td>
<td>25</td>
<td>10</td>
<td>5</td>
</tr>
<tr>
<td>~1910</td>
<td>10</td>
<td>20</td>
<td>10</td>
<td>15</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>~1980</td>
<td>5</td>
<td>10</td>
<td>5</td>
<td>10</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Today</td>
<td>2</td>
<td>5</td>
<td>2</td>
<td>5</td>
<td>1</td>
<td>0.5</td>
</tr>
</tbody>
</table>

Bar chart showing the number of juvenile soleis in % for different locations and years.

Graph showing the loss of juvenile and Seine contribution at the Eastern Channel population scale from ~1850 to today.
Application in the eastern Channel

1. Sole juveniles nurseries map
   - Coupling GLM and GIS

2. > 150 years of transformation in the Seine estuary
   - Effects on juveniles biomass

3. If the habitat quality was good in the Seine estuary?

<table>
<thead>
<tr>
<th>Contamination</th>
<th>PBDE Seine / Veys</th>
<th>PCB Seine / Veys</th>
</tr>
</thead>
<tbody>
<tr>
<td>In liver</td>
<td>5.6</td>
<td>8.3</td>
</tr>
<tr>
<td>In muscle</td>
<td>6.1</td>
<td>8.8</td>
</tr>
</tbody>
</table>

Data Solbémol-Pop project (2003)
If the Seine was a “contamination safe” sector?

- Seine with a “Bay of Veys effect” in the 1850s
If the Seine was a “contamination safe” sector?

- Seine with a “Bay of Veys effect” in the 1850s
- Loss of 17% of total 0-group juveniles population

- Diagram showing the relative contribution to the stock of different sectors (Veys, Seine, Somme, Roulogne, RyeBay, Solent, Sdowns) in 1850 and today.

- Graph comparing the contamination levels in the Seine sector in 1850 and today.

- ~1850: ~1850 concentration levels.
- Today: Current concentration levels.
Conclusion

- The Seine estuary
  - Today: 15% contribution in eastern Channel
  - During the last 150 years:
    - 33% surface lost
    - 42% potential nursery in the Seine estuary

- Eastern Channel population
  - From 4% (constant quality) to 17% (Bay des Veys quality) decrease of total 0-group juvenile population

- Sharp decrease in sole population

- Consequences on fishing activities
Application in the eastern Channel

1. Sole juveniles nurseries map
   - Coupling GLM and GIS

2. > 150 years of transformation in the Seine estuary
   - Effects on juveniles biomass

3. If the habitat quality was good in the Seine estuary?

4. Perspective: population model
   - Estimate the respective influence of different anthropogenic pressure
     - Degradation of coastal and estuarine nursery habitat & fishing mortality
From eggs

- Spawning areas

<table>
<thead>
<tr>
<th>Month</th>
<th>Eggs / day</th>
</tr>
</thead>
<tbody>
<tr>
<td>March</td>
<td>15 March</td>
</tr>
<tr>
<td>April</td>
<td>15 April</td>
</tr>
<tr>
<td>May</td>
<td>1st June</td>
</tr>
</tbody>
</table>

- February: 50,000 Eggs/day
- March: 10,000 Eggs/day
- April: 5,000 Eggs/day
- May: 1,000 Eggs/day
- June: 500 Eggs/day
Larval drift

Hydrodynamic model of pelagic larval life: dissemination of spawning products from spawning areas to nursery grounds

Amount of arriving larvae

- Solent
- St. Brides
- Rye Bay
- Seine
- Somme
- Yevs

A B C D E F

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UE Interreg Charm III Public meeting
2010, March, 31st. Rouen, France
From the larval drift model

- Respective influence of larval drift and habitat quality on amount of juvenile on nursery grounds
- Amount of arriving larvae (Part 4, last slide)

- Densities of juvenile (Part 1, habitat mapping)

- Effect of nursery habitat quality on mortality?
From the larval drift model

- Respective influence of larval drift and habitat quality on amount of juvenile on nursery grounds
  - Amount of arriving larvae
    - (Part 4, last slide)
  - Densities of juvenile
    - (Part 1, habitat mapping)

- Effect of nursery habitat quality on mortality?
  - Contamination in nursery ground
    - French & English monitoring networks
  - Mortality from juvenile (0 & 1 group) /
    - larval drift ratios

Larval settlement ≠ juvenile densities
To population model (Work in progress)

- Spatialized matrix model **including**:
  
  - Stock assessment (ICES WG)
  - Larval drift model (other running project)
  - Nursery habitat model (previous slides)

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**Nursery habitat model**

- Juvenile Age 0
- Age 1
- Adult exploited stock
- Mortality (natural+fishing)
- Age 12+

**Larvae**

- Nursery capacity

**Eggs**

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**Hydrodynamic larval drift**

**IBM model**

**Nursery habitat degradation**

**Pollution (mortality)**

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**VPA, stock assessment**
To population model (Work in progress)

- Estimate, on the whole life cycle of the common sole, the influence of:
  - Degradation of coastal and estuarine nursery habitat
    - Habitat size
    - Habitat quality
    - Increased mortality of larvae and juvenile
    - Consequences of lower survival and altered fecundity on future reproduction, including the effect of fishing.
  - Fishing pressure
    - Mortality on older sole and population structure

- At the population scale (Eastern Channel)
- On fisheries
  - Impacts of anthropogenic disturbances on ecosystem services
5. Transfer to Marxan (future work)

From the previous parts of the work
A tool to design marine protected areas and their effects
In accordance with others advances in the Charm III project

5.1. Sole nursery habitats (part 1)
with their respective influence on population renewal (part 2)

5.2. Possible introduction of spawning habitats (part 2)
Schedules:

- Population model: 2010
- Transfer of the results to Marxan: 2011

Thanks for attention
Questions?

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