**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

**Application in the eastern Channel**

1. Sole juveniles nurseries map
   - Coupling GLM and GIS
   - Influent factors (known exhaustively)
     - Sole
     - Nursery grounds
     - Bathymetry
     - Sediment
     - Spatial heterogeneity
   - Model of habitat suitability
   - Nursery = f(Bathy, Sediment)
   - 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, ≈6 months in September)
Descriptors of juvenile habitat

- Available maps to describe juvenile habitat

Habitat map

- Available maps
  - Sectors
  - Bathymetry
  - Sediment structure

Coupling GLModel and GIS

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

GIS

Survey data and habitat descriptors (HSI)

1 trawl haul
1 juvenile sole density
1 bathy \cap 1 sediment
\cap 1 sector
Habitat suitability model (HSI)

Statistical model:

Juvenile density ~ \(\text{Bathymetry} + \text{Sediment} + \text{sector}\)

Trawl survey data

Juvenile density

Surface

Habitat suitability model (HSI)

Statistical model:

Juvenile density ~ \(\text{Bathymetry} + \text{Sediment} + \text{sector}\)

Trawl survey data

Juvenile density

Surface

Number of juvenile fish: Contribution to the stock

\[\text{Surface} \times \text{Density} = \text{Number}\]

Statistical model: results

- Effect of Bathymetry

- Effect of sediment structure

\[\text{0-group density}\]

\[0\text{-group per class of Sediment (number per 1000 m²/fuel)}\]

- Effect of Bathymetry

- Effect of sediment structure
Statistical model: results
- Effect of Bathymetry
- Effect of sediment structure
- Sector effect

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

Habitat map: present situation
- Distribution map for 0-group

Focus on the Seine estuary
- ~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

Pieces of Explanation (in 150 years)
- 33% surface,
- 75% fine sediment

Focus on the Seine estuary

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

Application in the eastern Channel

- Sole juveniles nurseries map
  - Coupling GLM and GIS

- > 150 years of transformation in the Seine
  - Effects on juveniles biomass
Historical maps

- Hypothesis: the Seine quality is constant over time

Abundance index

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

Total stock of juveniles

- Loss of 4% of total 0-group juveniles

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?

PBDE
- Seine / Veys
- 8.3 in liver
- 8.8 in muscle

PCB
- Seine / Veys
- Contamination

Data Solbémol-Pop project (2003)
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

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 juveniles 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

February  
March  
April  
May  
June

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
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)

Juvenile
Eggs
Larval drift
Larvae
Nursery habitat degradation
Pollution
Hydrodynamic larval drift model
Mortality (natural + fishing)

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)