American Fisheries Society Annual Meeting
August 11-14, Quebec
International eel symposium

A matrix model for the inland part of the European eel population dynamics - Spatial structure of an eel stock within a watershed

P. Lambert [1,3], E. Feunteun [2] et E. Rochard [1]

(1) Cemagref, Unité Ressources Aquatiques Continentales , F-33612 Cestas Cedex FRANCE,
[2] Université de La Rochelle, Laboratoire de Biologie Marine, F-17042 La Rochelle FRANCE
(3) patrick.lambert@Bordeaux.Cemagref.fr

Objectives

- define a point of view for the inland part of the eel population dynamics which is
  - Global (all processes considered)
  - Spatialized (compartment and movement)
- test biological hypotheses, especially density dependence effect (CIEM ToR, Anonyme 2002)

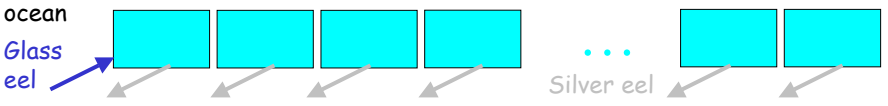
Modelling approach

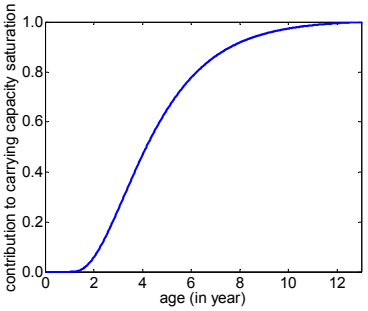
- Based on pattern-oriented modelling approach (Grimm, 1996; Railsback, 2001)
- Without validation with actual field data (« paradigmatic model »)
- Model features
  - Matrix model (Caswell, 2001) structured in sex and age
  - Deterministic
  - Time scale : the week, during 25 years
  - Fixed recruitment (No stock-recruitment relationships)

Cemagref PL, AFS Québec 2003

Model principles

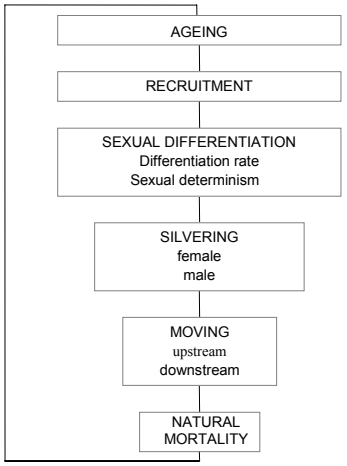
Virtual basin = 25 compartments with a carrying capacity equal to 200 equivalent 13 year old eel





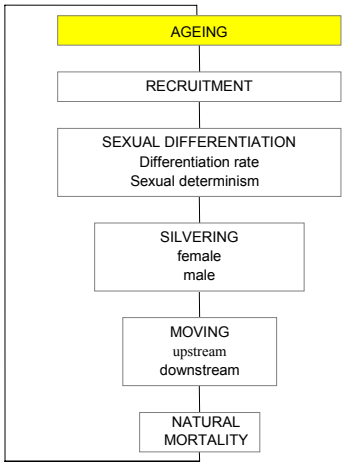
Cemagref PL, AFS Québec 2003

Biological process



Cemagref PL, AFS Québec 2003

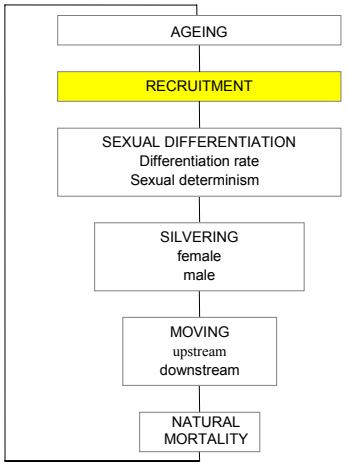
Biological process

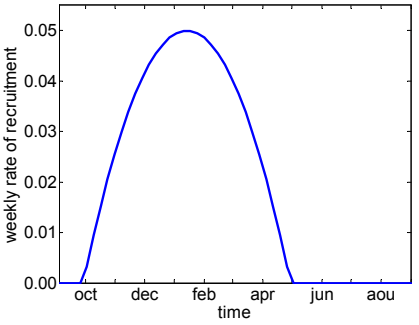


Date of birth = 1st week of May

Cemagref PL, AFS Québec 2003

Biological process



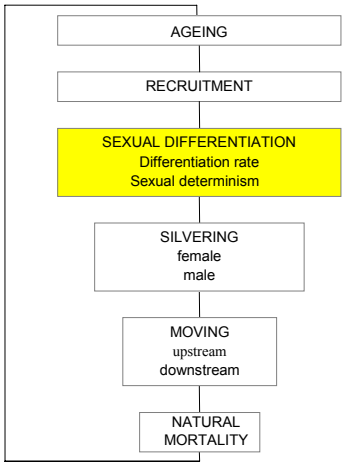


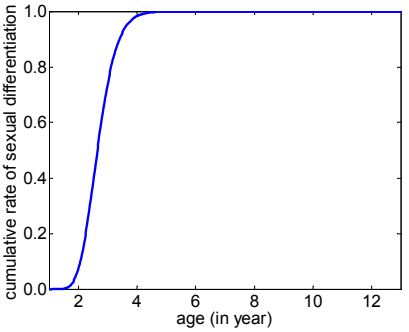
Cemagref

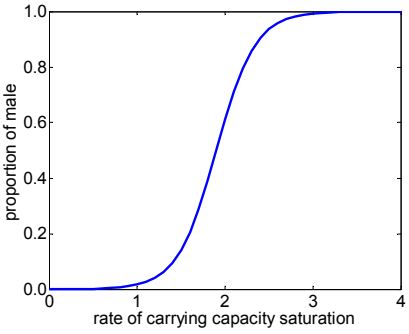
PL, AFS Québec 2003

(Based on Elie and Rochard, 1990)

Biological process





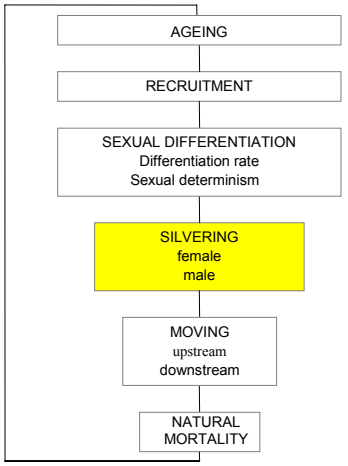


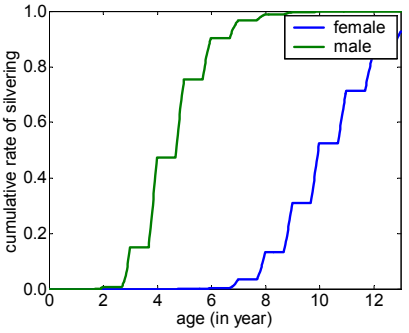
Cemagref

PL, AFS Québec 2003

(Based on Manly, 1990)

Biological process



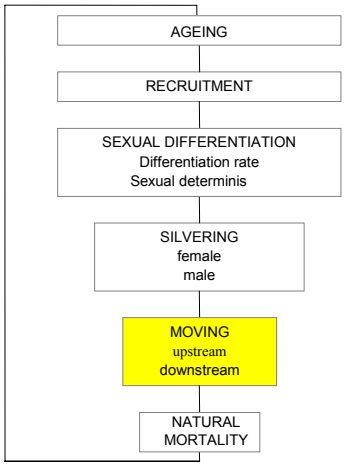


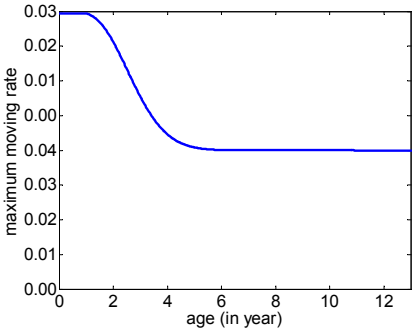
Cemagref

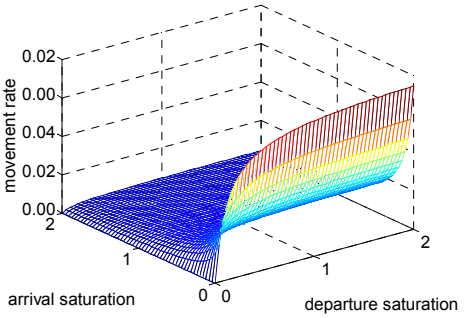
PL, AFS Québec 2003

(Based on Manly, 1990; Vollestad, 1992)

Biological process





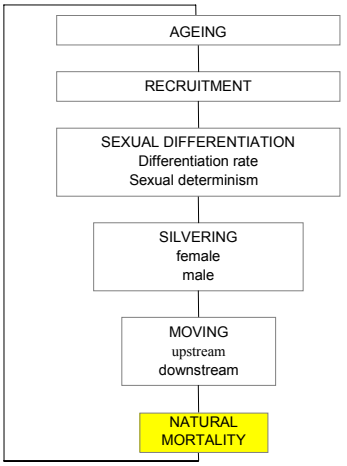


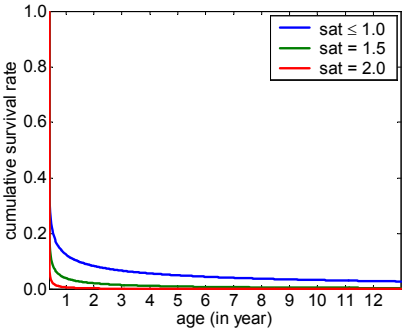
Cemagref

PL, AFS Québec 2003

(Adapted from Whitehead, 2000; based on Smogor at al., 1995; Ibbotson et al., 2002)

Biological process





(Adapted from De Leo and Gatto 1995)

Pattern

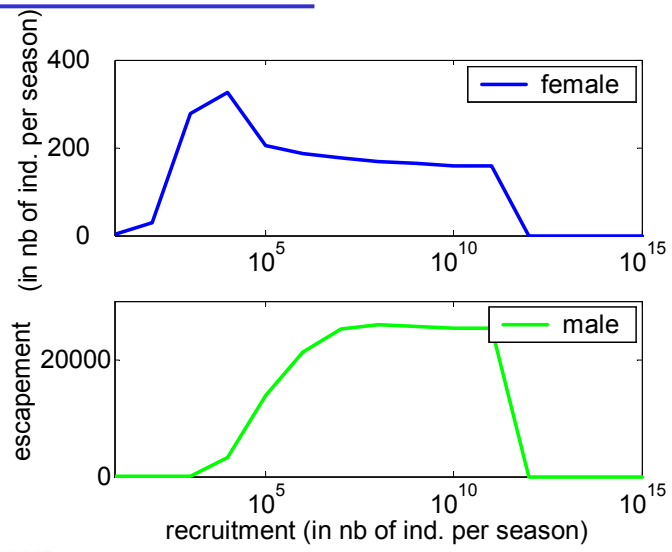
1. Silver eel production in a watershed is not illimited
2. A recruitment decrease results in a sex ratio of the standing stock or the silver escapement in favour of female (ROSSI *et al.*, 1987). This modification can even reverse the sex ratio domination (SVÄRDSON, 1976 ; PARSONS *et al.*, 1977 ; POOLE *et al.*, 1990).
3. Eel abundance exponentially decreases with distance to the sea (SMOGOR *et al.*, 1995 ; IBBOTSON *et al.*, 2002).
4. Sex ratio evolves in favor of females with distance to the sea (APRAHAMIAN, 1988 ; OLIVEIRA, 1999).
5. For all basins, sex ratio evolves from completly female to complety male dominated with increasing recruitment

Calibration results: Hypothesis test

	Hypothesis 1 Syngamic Sexual determinism (6 parameters)	Hypothesis 2 Density independent mortality (7 parameters)	Hypothesis 3 Metagamic + density dependant (8 parameters)
Number of combinations	1000	3000	9000
Compatible with point 1	1000	0	9000
Compatible with point 2	3	3000	2610
Compatible with point 3	999	3000	8992
Compatible with point 4	991	2995	2654
Compatible with the basic pattern	**0**	**0**	**291**
Compatible with the extended pattern			**28**

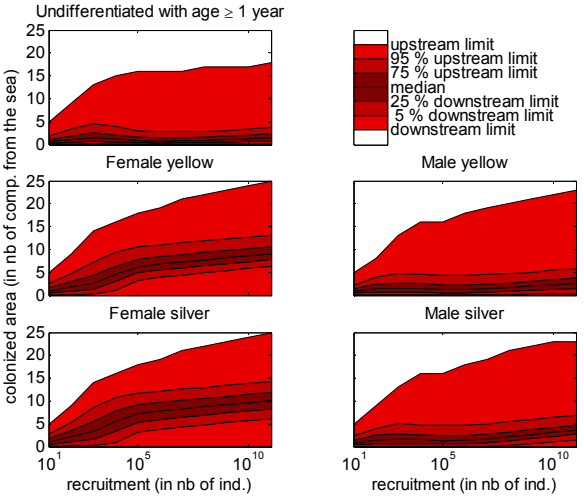
Cemagref PL, AFS Québec 2003

Output



Cemagref PL, AFS Québec 2003

Exploration results : Area used by eel at different states

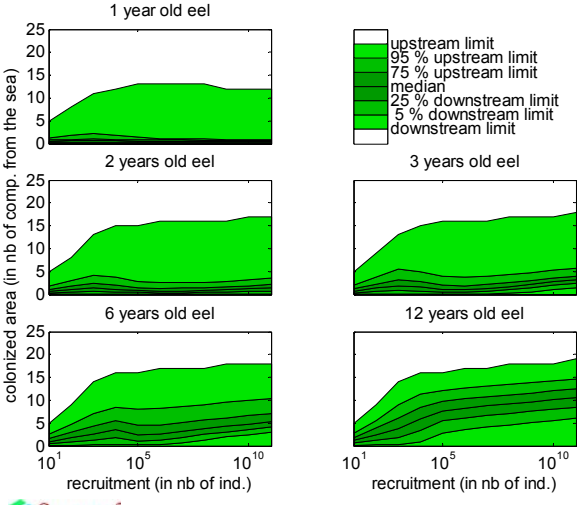


- Zone where sexual determination occurs is more restricted than the zone used by yellow eel, at least for medium and high recruitment level
- Zone with high production of female is superimposed with zone of high production of male for low recruitment

Cemagref

PL, AFS Québec 2003

Exploration results : Area used by eel at different ages



- Even with diffusive movement, we can observe an advective picture when recruitment is huge

Cemagref

PL, AFS Québec 2003

Consequence for management

The eel management should not only focus on the upstream part of a basin because

- sexual determinism takes place rather downstream
- the downstream part could be the maximum production area for male and female

especially when the recruitment is low, like it is at the moment

Conclusion

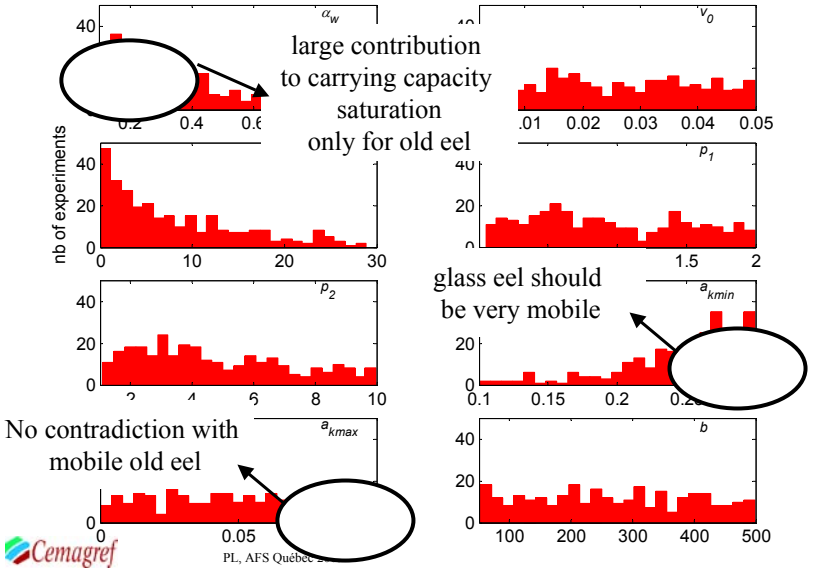
- A model including movements and in agreement with eel ecological pattern
- Mains results
  - An additional argument for the metagamic sexual determinism
  - Zone of sexual determinism is restricted to the lower part of the basin, maximum production area could also be restricted to the lower part

Perspectives

- Questions to *in silico* ecologists
  - Influence of watershed structure (carrying capacity distribution, tributaries)
  - Consequences of length growth on dynamics
- Questions to field ecologists
  - Quality of the pattern, especially point 5
  - Estimation of mouvement rate
- Application with actual geographically referenced data

Cemagref PL, AFS Québec 2003

Calibration result : Selected values for the 8 parameters



Cemagref PL, AFS Québec 2003