Simulated emergence and synchronisation of a fishery complex

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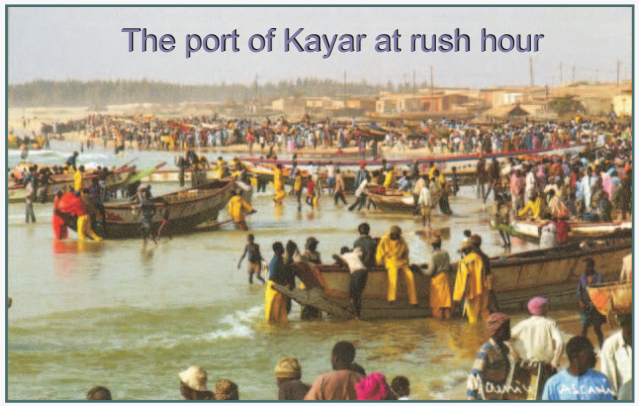
A multi-agent simulation model of the small-scale fishery sector in Senegal is presented. The aim of the study is to formalise the diversity of interactions and evaluate their effect on the overall functioning and possible coordination of the fishery sector.

Keywords: integrated functional process, multi-agent simulation, synchronisation, self-organisation, complex adaptive system, fishery sector, modelling



MODEL PRESENTATION

Agents (active objects)

They coarsly simulate fishermen and fish traders communities.
At a given time step, an agent :

- Owns resources (truck, canoe, fishes, money)
- Is aware of some part of its environment (markets, ports, fish rates, other agents)
- Masters some actions (putting forth a price, negotiate, fish, move, choose a market or a port, etc.)
- Aims at (goals): selling or buying or fishing

Externalities (major inputs)

Fishing yields in each fishing zone as a periodic (seasonal) function

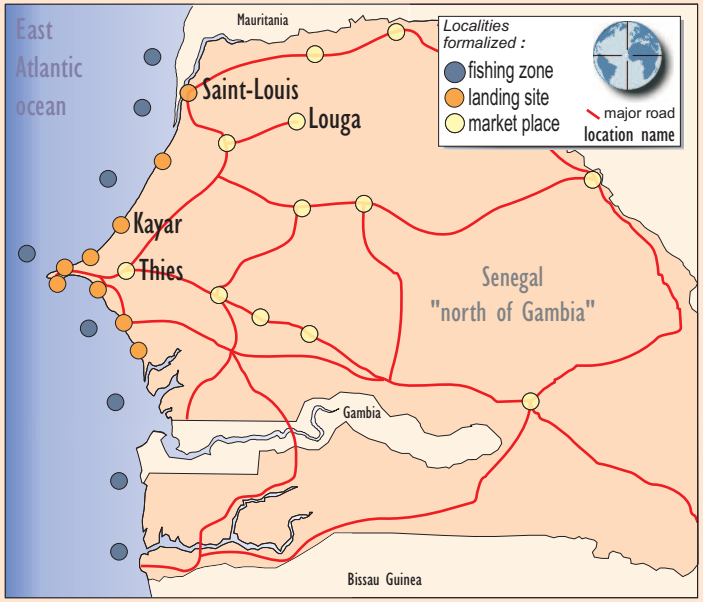
Consumers demand in the major cities of the simulated country as a constant function.

Associated 'selection/creation' mechanism for the working communities

Agents generating a deficit leave the system and are replaced by new agents of the same type but created with a random set of known localities, types of vehicle, etc.

Simulated space and its metrics

The North part of the Senegal territory and its marine economic exclusive zone (EEZ) - **Space as situated spots**

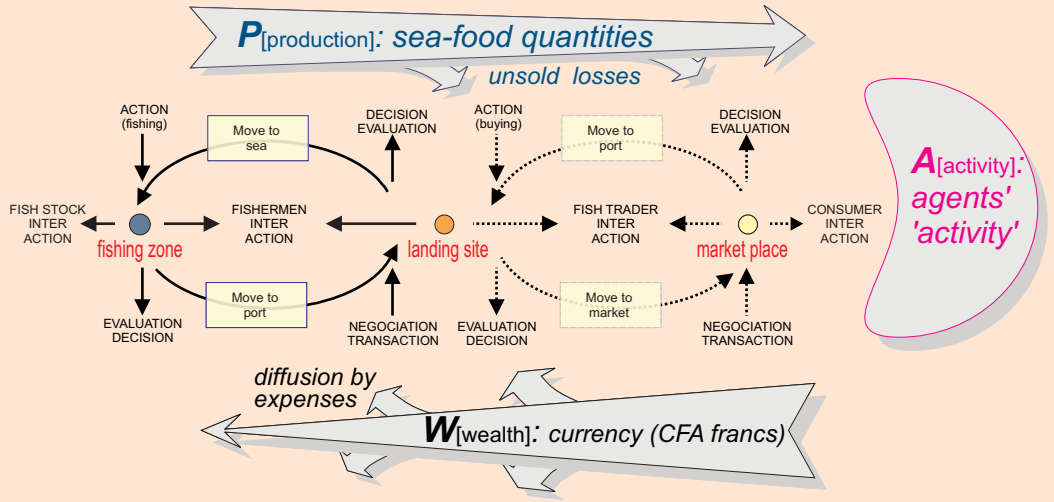


Simulation time step: 15 days

Diverse, localized and characterized objects

8 fishing zones, 9 landing sites, 12 market places, 1 fish species, 4 types of fishing gear, 6 of vehicle (trucks and canoes), 10 communities of consumers, 30 fishermen agents and 40 fish traders agents representing a mean of 2000 activity units are formalised on the basis of observations in the real sector.

Overall dynamics and four selected indicators (P,W,E,A)



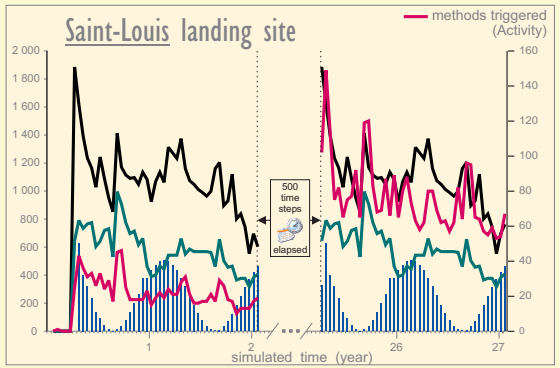
SIMULATION RESULTS

Four selected indicators (units):

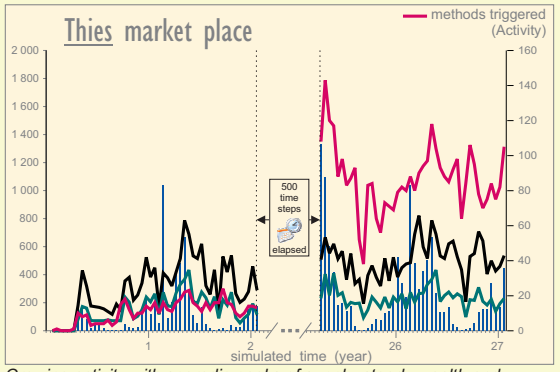
- Production (tons)
- Wealth (currency unit)
- Employment (individuals)
- Activity (methods triggered)

There is a diverse range of local histories for the various sites (four examples are presented here, see map for location).

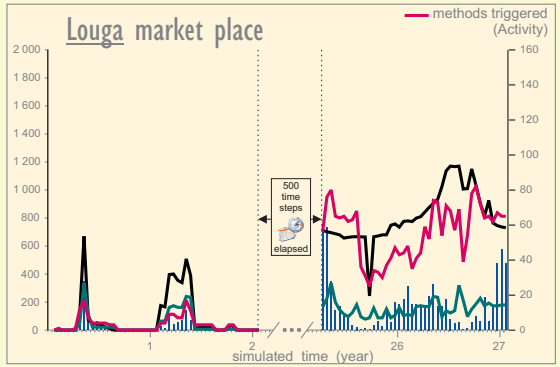
At global fishery level (right), a structured and stable pattern arose, with seasonal production dynamics closely synchronised with resource abundance, a stable workforce and steadily growing wealth. The activity indicator displayed stable fluctuation ("tonus") with a steady pulse at the end of each fishing season.



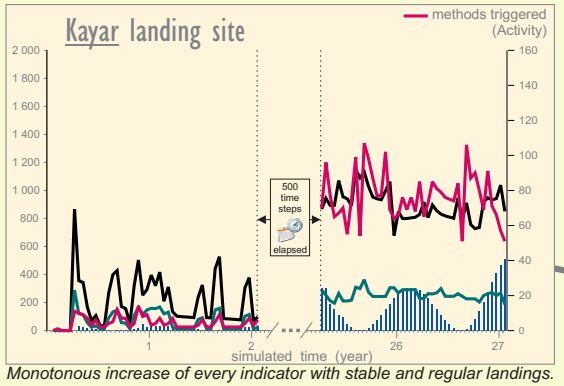
Resilient population (size and wealth) with increasing activity. Gaps in the seasonal supply



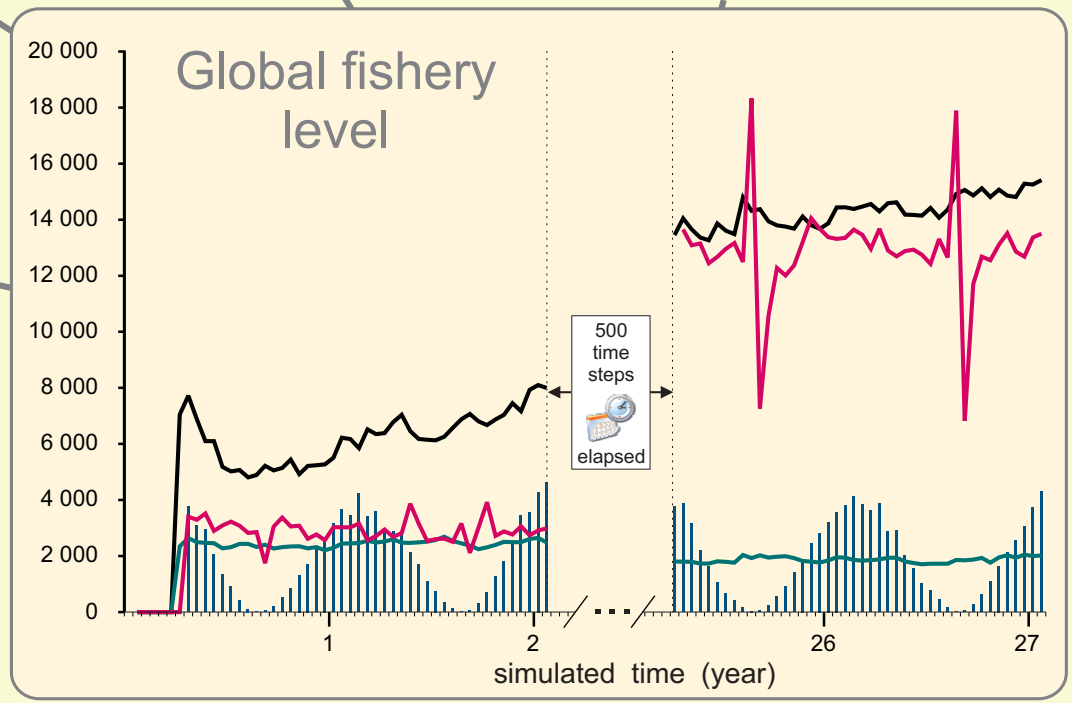
Growing activity with sporadic peaks of supply. steady wealth and population size



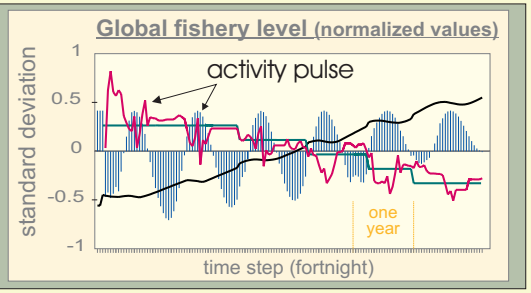
Sporadic then continuous frequentation; growing then decreasing wealth, improvement of supply



Monotonous increase of every indicator with stable and regular landings.



Similar simulations showed that the removal of the selection/creation mechanism induces a gradual deterioration of the activity curve pulse, declining production and employment (wealth increasing in the hands of a few agents).



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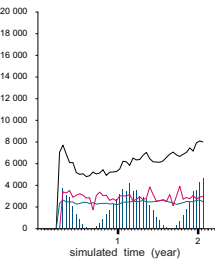
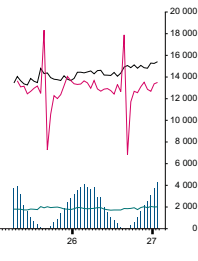
CONCLUSION



Within the model, the fishery sector appeared as an integrated whole (tonus, pulse) with self-organisation depending on the entire set of components and their interactions.
Synchronisation in this model basically required a combination of *(i)* external forcing, *(ii)* a diverse set of objects and interactions, *(iii)* an improvement process and *(iv)* a medium term historical construction.
This was an unexpected result.



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