General concept of carrying capacity modelling using Delft3D

Maarten Kuijper
WL | Delft Hydraulics

Why determine carrying capacity?

- Optimize population size that can be supported by available resources?
- economic perspective – maximize profitability
- environmental perspective – maximize sustainability
- social perspective – maximize social acceptance

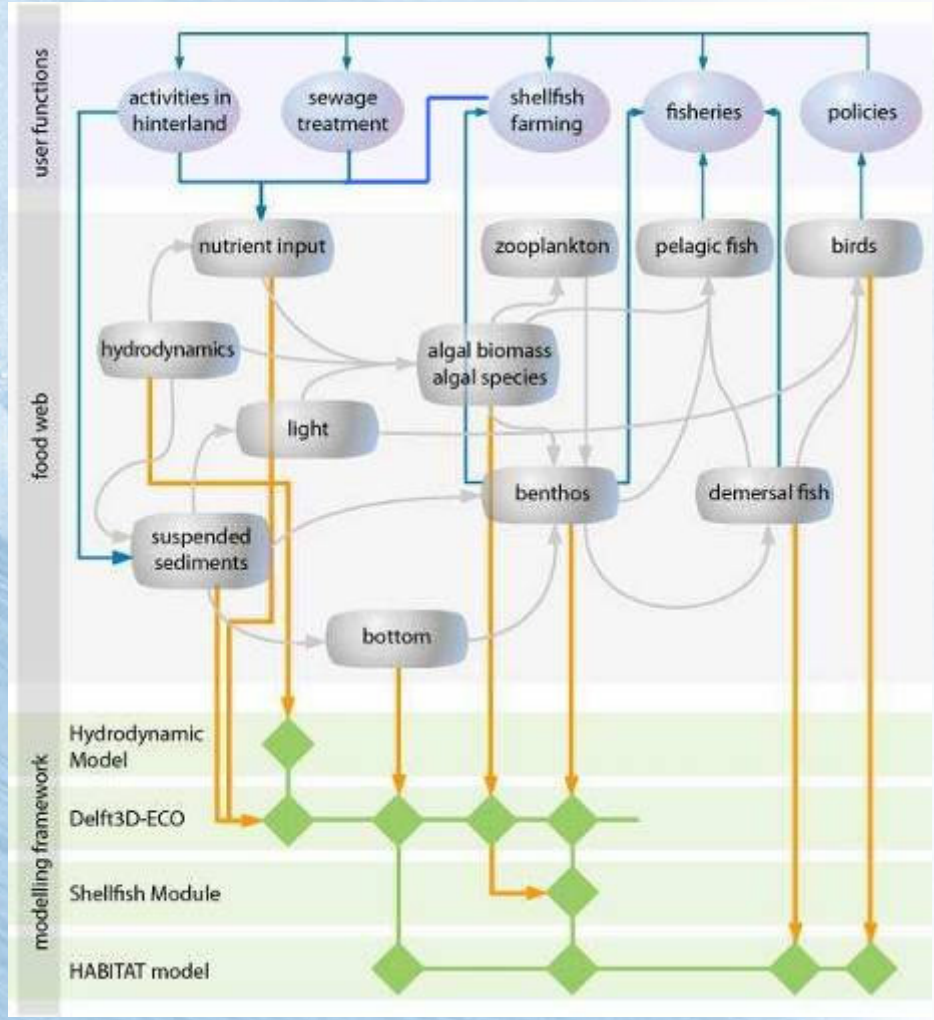
What is carrying capacity?

- Physical carrying capacity
  - total area of farms that can be accommodated in available physical space
- Production carrying capacity
  - stocking density of cultured shellfish at which harvests are maximised
- Ecosystem carrying capacity
  - maximum standing stock that can be supported by a given ecosystem for a given period of time
- Social carrying capacity
  - level of farm activity that causes unacceptable social impacts

Modelling carrying capacity

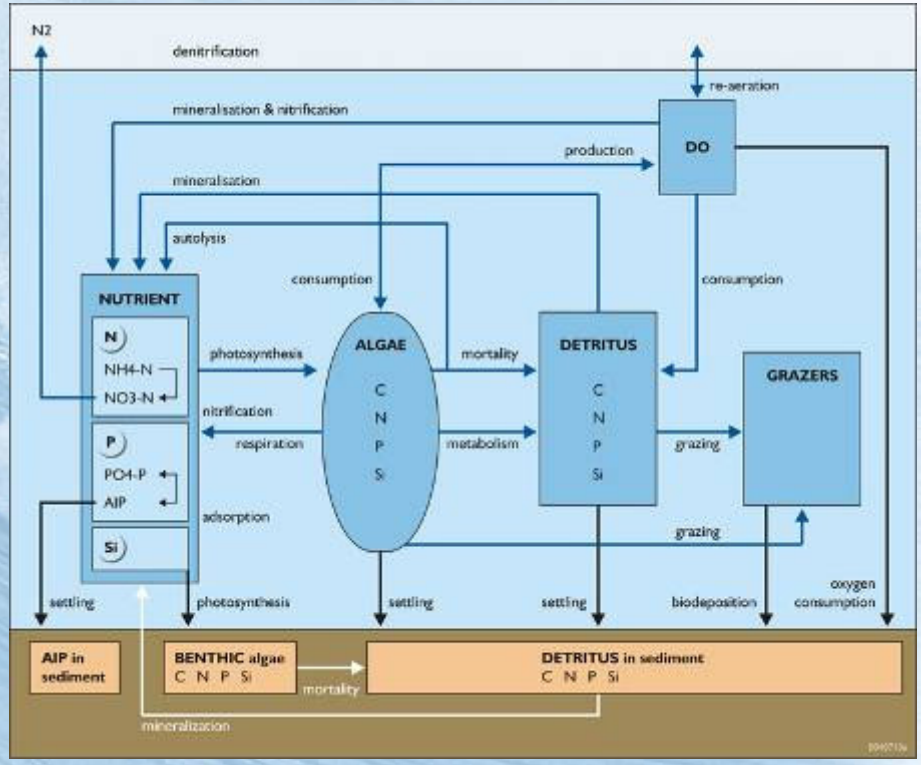
- Quantify the relationship between different levels of shellfish farming and its environmental effects

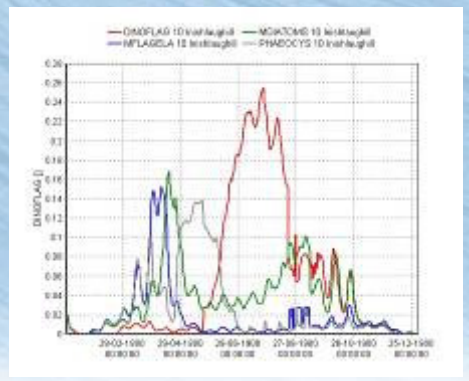
- Concentration of food particles available to cultured species or wild stock is a function of:
  - hydrodynamics (tides, currents, stratification)
  - sunshine
  - internal sources and sinks (phytoplankton, detritus pool, sediments)



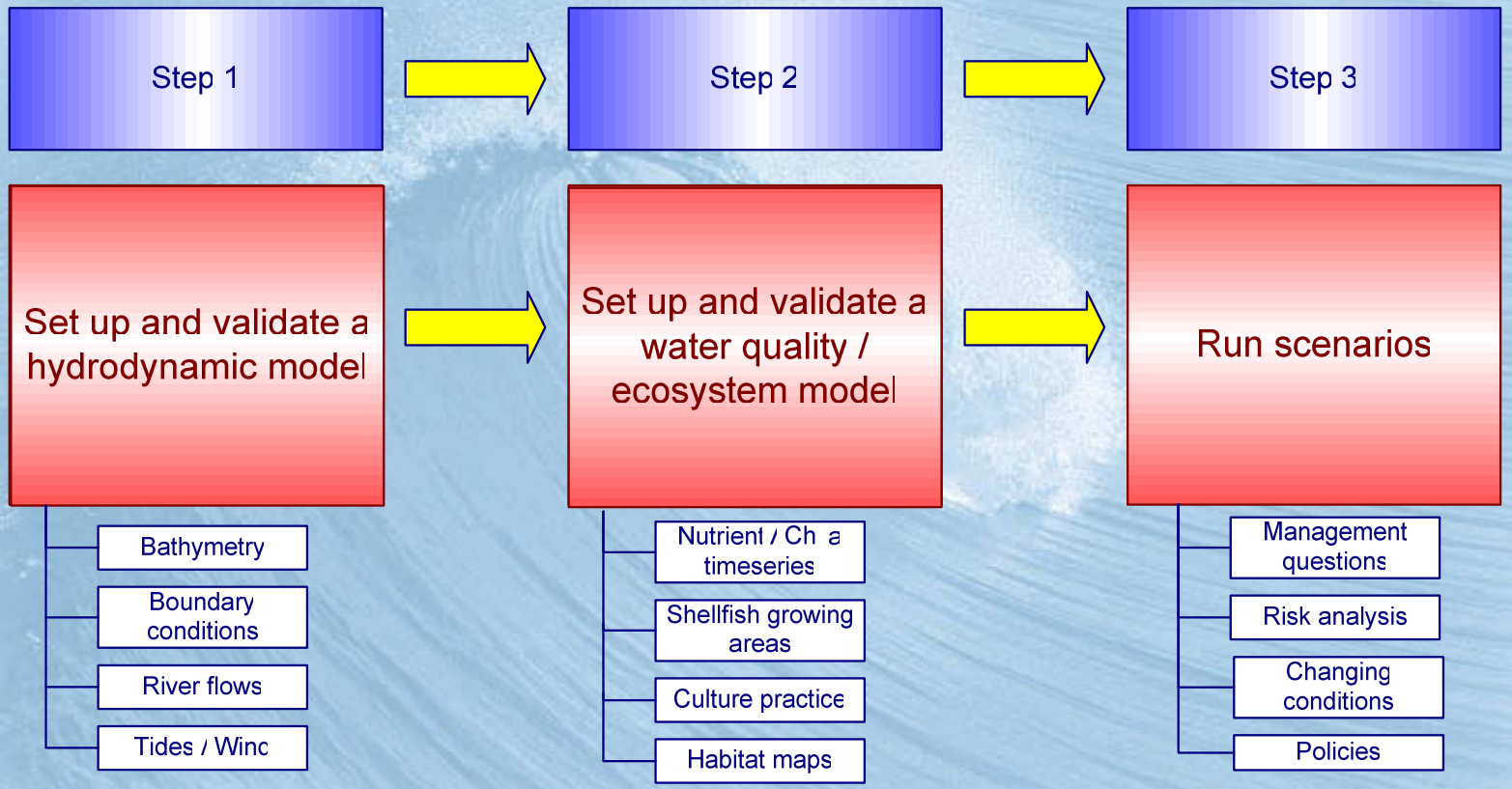
A complex ecosystem

- Food supply and ingestion: phytoplankton, detritus → carbon
- Available nutrients (N, P, Si) ←→ phytoplankton
- Feedback mechanisms – shellfish farms affect nutrient cycle
- Competition between cultured stock and wild stock and/or zooplankton
- Population dynamics





Modelling carrying capacity



Delft3D- FLOW

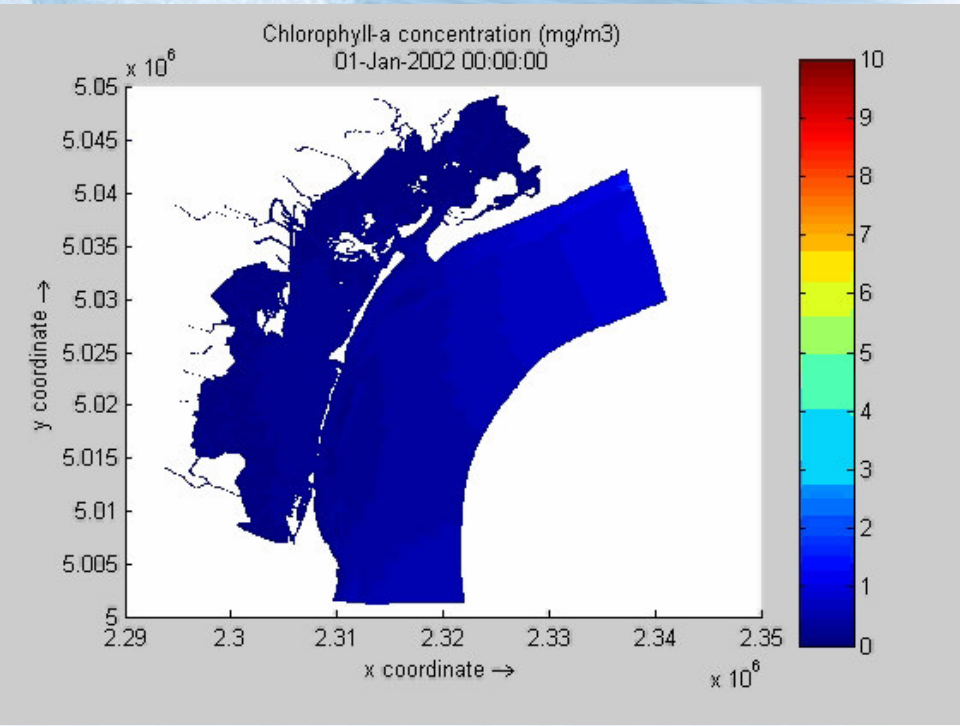
Delft3D- WAQ/ECO

ShellSIM

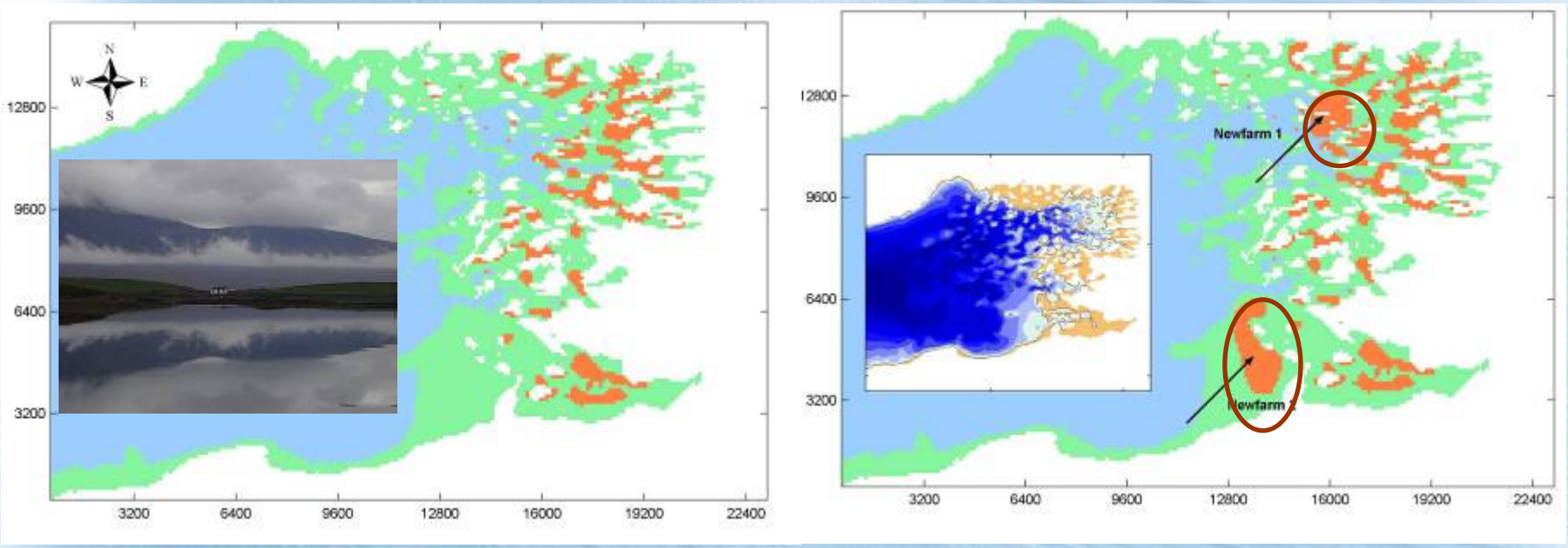
Case management tool

Ecosystem Model Requirements

- Spatial resolution adequate to differentiate in level of food supply in different parts of estuary / bay
- Simulation period sufficient to simulate shellfish growth from supply to harvest
- Able to simulate culture practice (possibility to add and harvest different types of shellfish at discrete time intervals)
- Demonstrate realistic shellfish growth and overall productivity
- Validated against field data (water quality parameters)



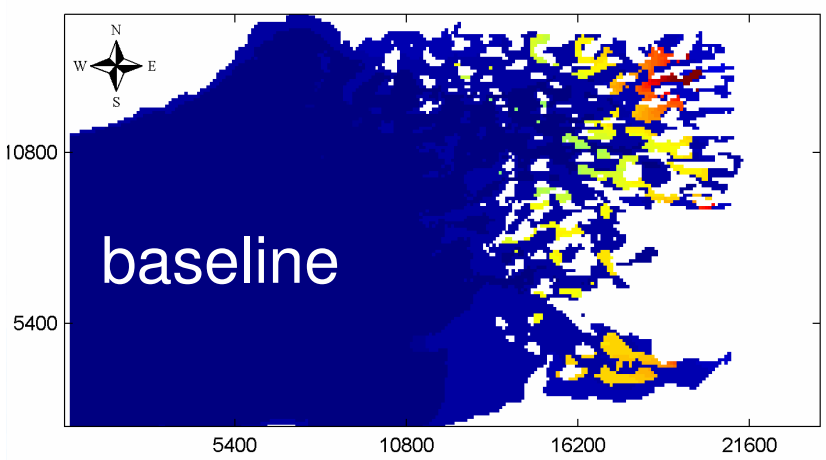
Clew Bay – Adding mussel farms

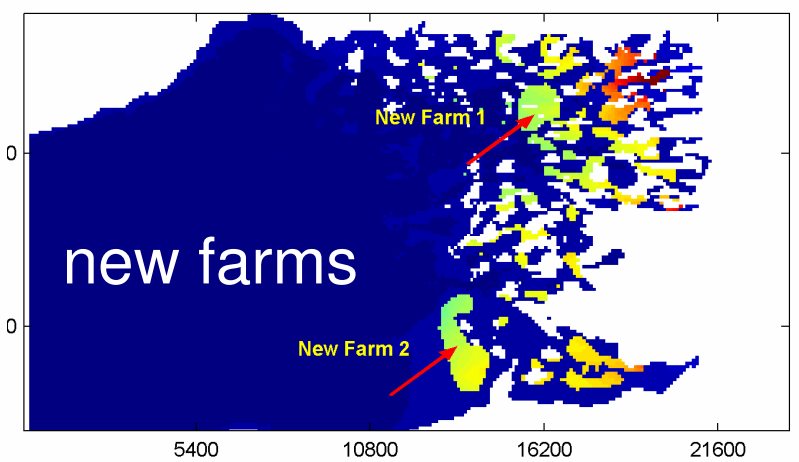


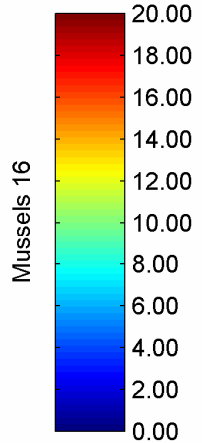
Two mussel farms added replacing mussel wild stock; no other species

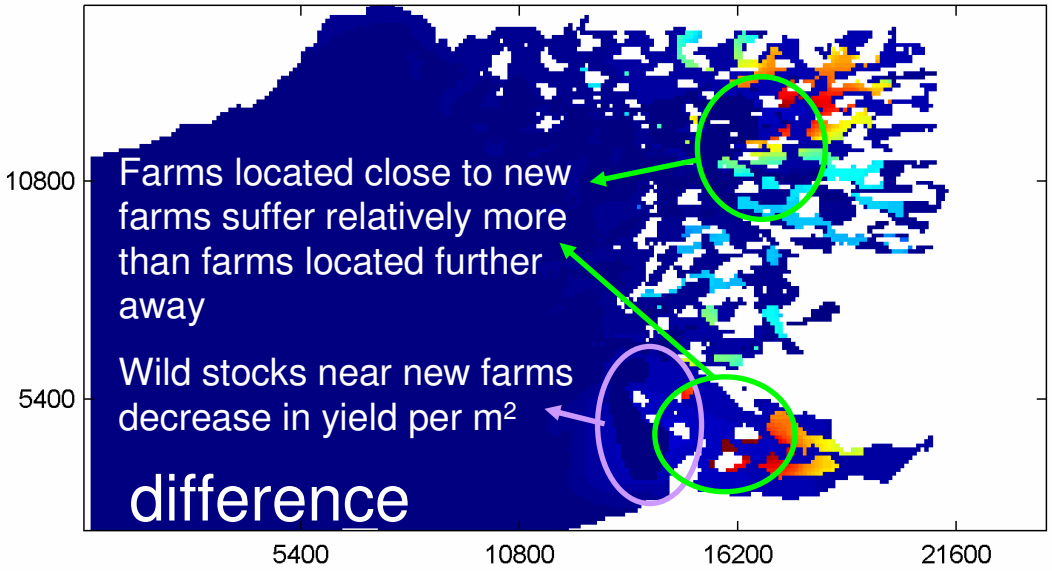
Questions:

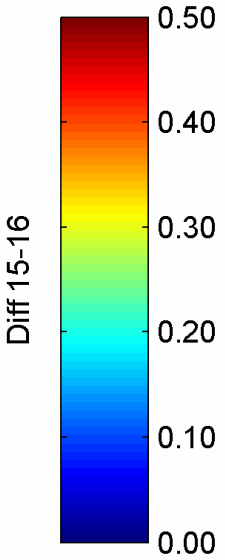
- What happens to overall productivity in the Bay?
- What happens to individual yields of the present shellfish farms?
- What will be the yield of the newly added farms?
- What will be the reduction in yield of wild stock?


N
W
E
S
baseline
10800
5400
5400
10800
16200
21600

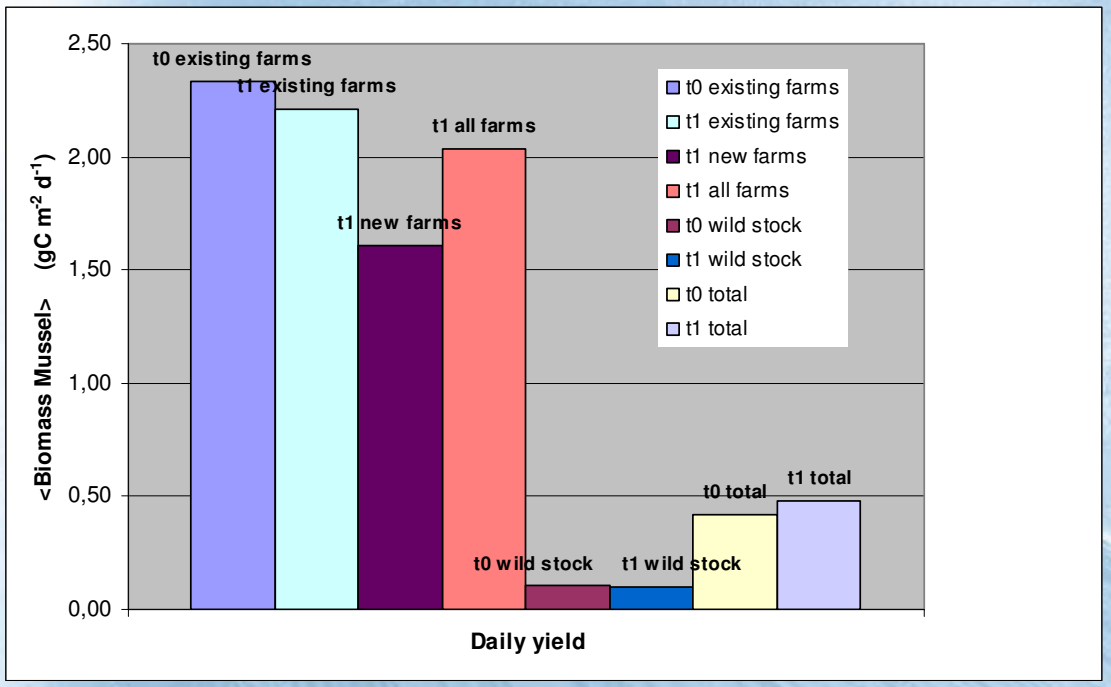

New Farm 1
New Farm 2
new farms
0
0
5400
10800
16200
21600


Mussels 16
20.00
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00


Farms located close to new farms suffer relatively more than farms located further away
Wild stocks near new farms decrease in yield per m²
difference
10800
5400
5400
10800
16200
21600


Diff 15-16
0.50
0.40
0.30
0.20
0.10
0.00

Clew Bay – adding mussel farms



- New farms have lower yield because they are located farther away from rivers
- Overall yield per m^2 of all farms is lower than in baseline situation
- Adding new farms will also decrease overall yield of wild stock
- ... But total productivity of the whole bay is higher (larger area is cultivated)
- Despite decrease in yield per m^2 (13%), 20% more mussels to sell on the market

Note that this represents a hypothetical baseline situation with a not yet fully validated model


The End