The FARM model in Long Island Sound:
How important is nutrient removal through shellfish harvest?

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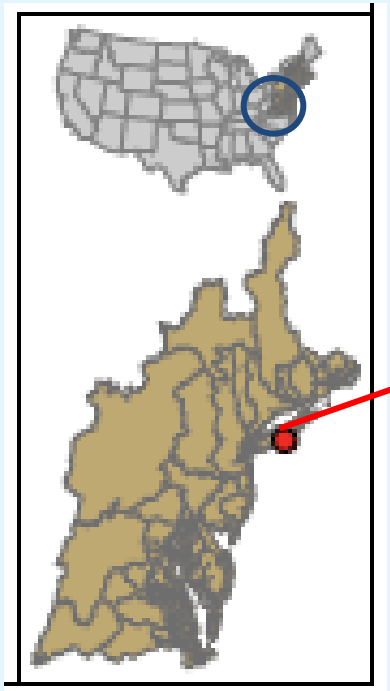
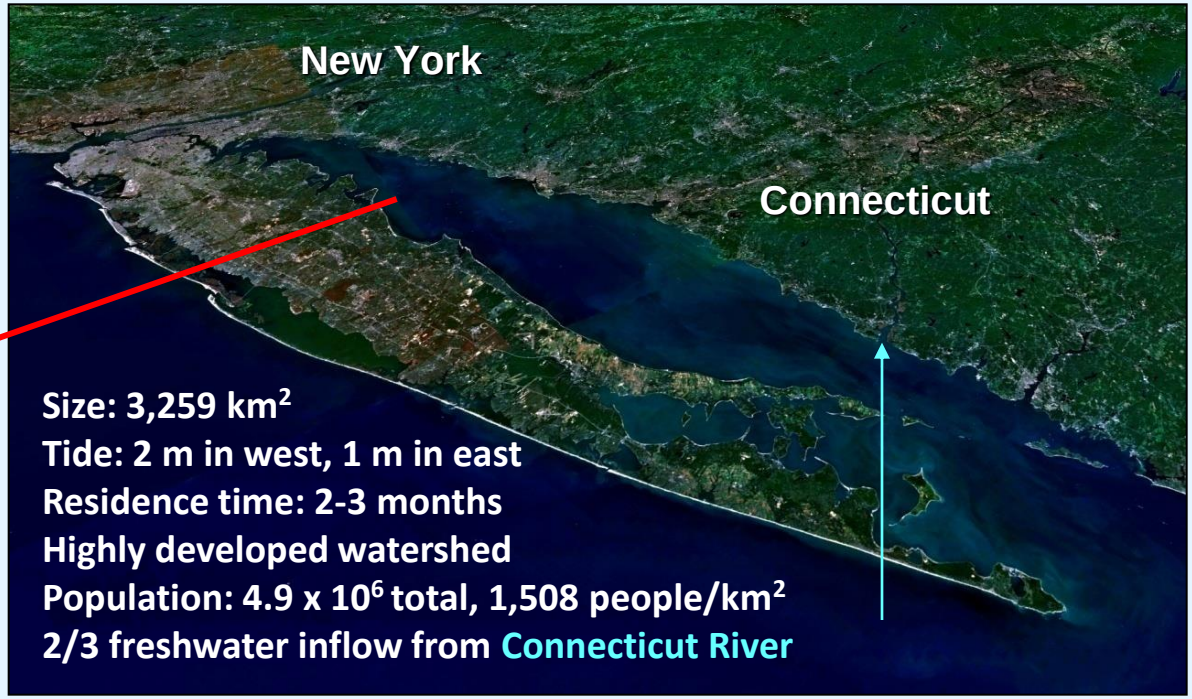
Long Island Sound: Background





Long Island Sound bioextractors

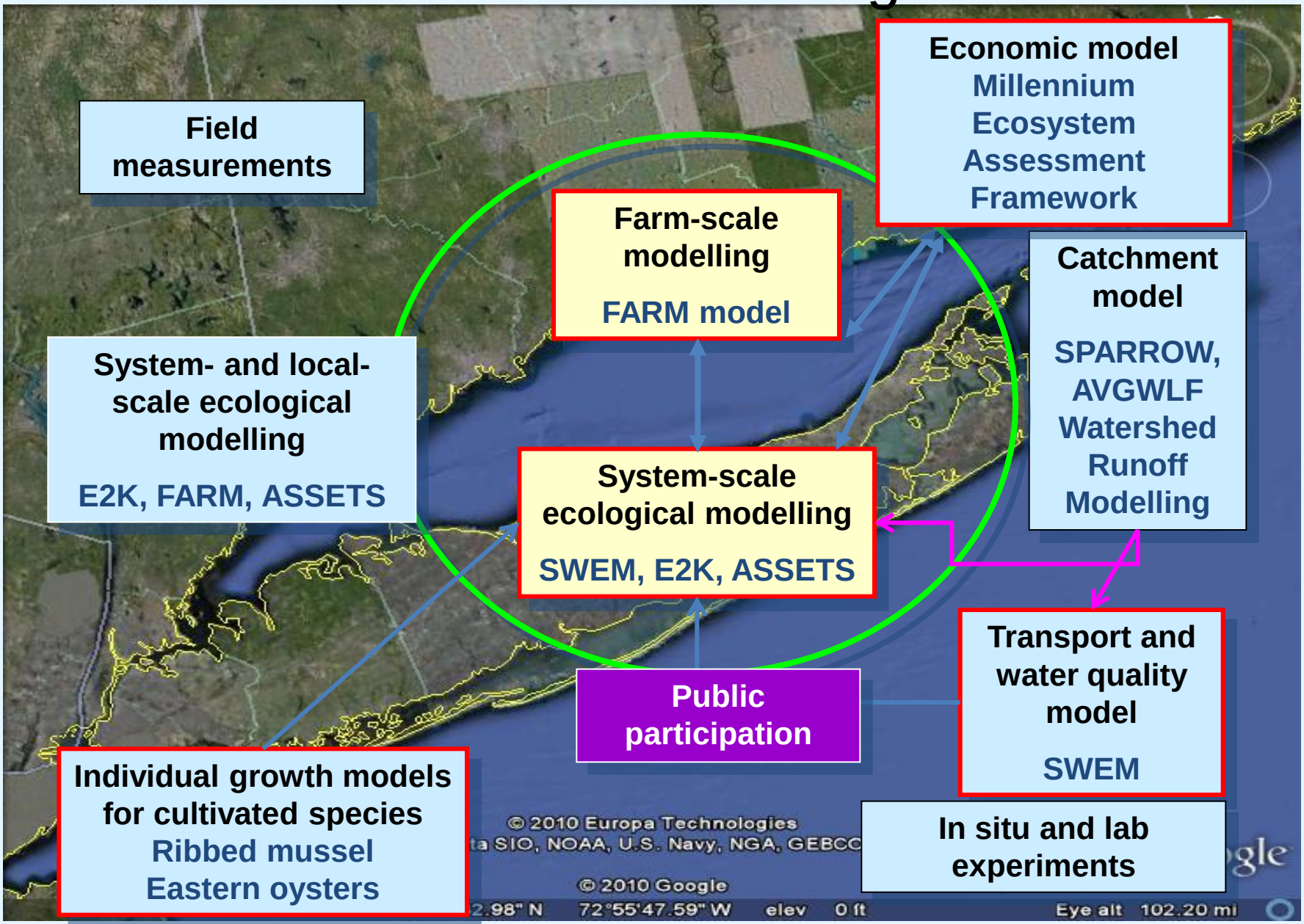
Eastern Oyster
Crassostrea virginica

Northern Quahog
Mercenaria mercenaria

<u>Project results will inform</u>:

- Long Island Sound TMDL
- 2011 NOAA Aquaculture Policies
  National Shellfish Initiative

The Regional Ecosystem Services Program Bioextraction Framework: Long Island Sound

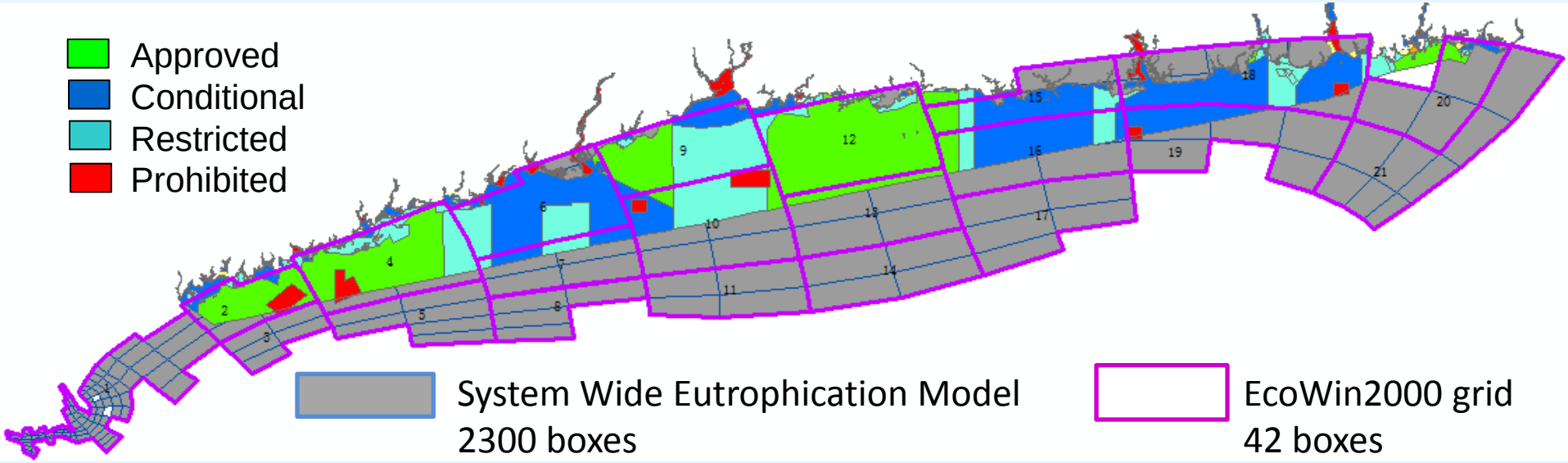


Modelling Eutrophication and shellfish aquaculture

Objective is to estimate the potential nutrient removal from Long Island Sound through shellfish aquaculture. For today:

- Merging of high resolution 3D model and coarser scale ecosystem model,
- Scale individual growth model to population for Eastern oyster,
- Farmscale model for site in Long Island Sound,
- Upscaling site specific results to system scale

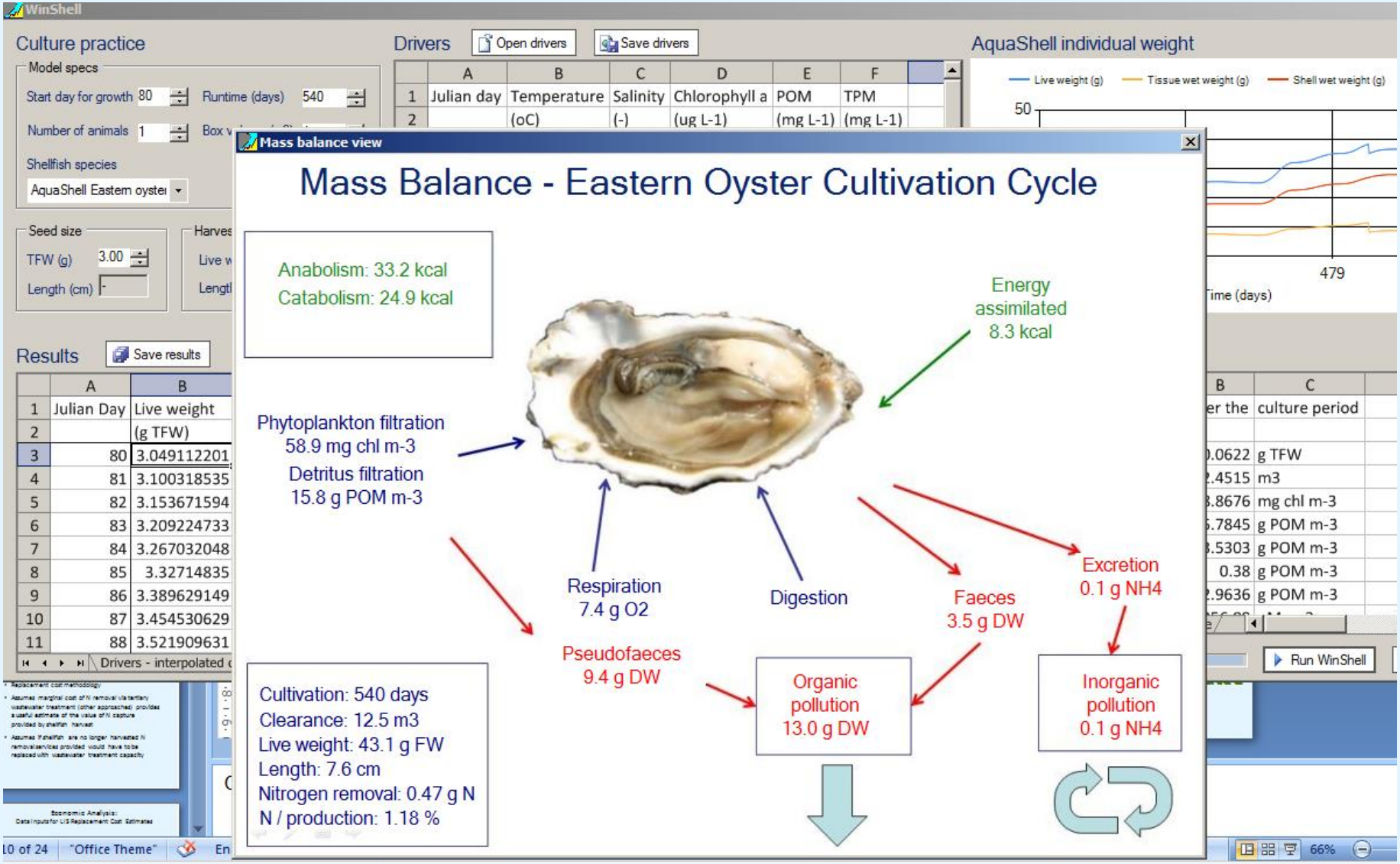
High Resolution 3D → Coarser Ecosystem Model Grid: Merged using legal, physical, water quality, aquaculture criteria



Model	Timeframe	Focus
System Wide Eutrophication Model (SWEM)	one year	water circulation, water quality
EcoWin2000 (E2K)	decadal	aquaculture, water quality, economics

Water quality results for E2K and SWEM can be compared, both models can be used to generate outputs for use in ASSETS eutrophication assessment, as an overall synthesis model, and FARM, as a local scale model

Eastern oyster growth model – simulated mass balance



Growth simulation of oysters feeding on algae and detritus allows population scale models to examine top-down control of eutrophication by shellfish

Scaling individual growth to FARM model: Application to a CT farm using water quality data for LIS

FARM - Onshore Farm Aquaculture Resource Management (FARM onshore Eastern oyster culture standard model)

Shellfish model live | Finfish model off | Run FARM | Exit

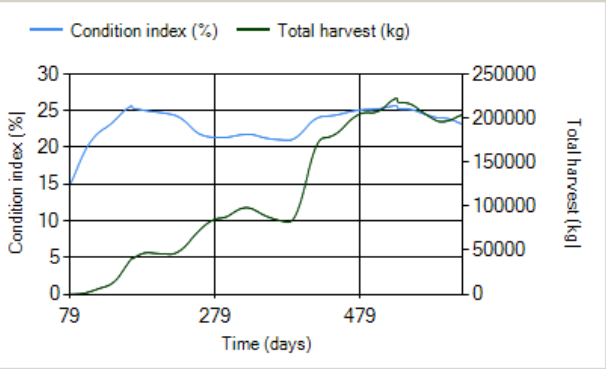
FARM drivers | FARM shellfish outputs | FARM shellfish mass balance

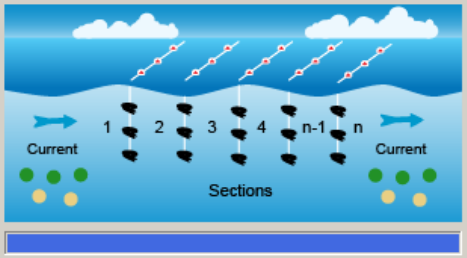
Results — Save results

	A	B	C	D	E	F	G	H	I
1	Julian Day	Live weight	Length	Harvest	Chlorophyll a	Total POM	TPM	Dissolved oxygen	DIN
2		(g TFW)	(cm)	(kg live weight)	(ug L-1)	(mg L-1)	(mg L-1)	(mg L-1)	(umol L-1)
3	80	3.00	3.25	0.00	2.59	1.12	3.33	10.57	9.66
4	81	3.02	3.26	0.02	4.04	0.87	4.24	10.72	5.33
5	82	3.06	3.27	0.31	4.63	0.81	4.62	10.72	3.38
6	83	3.10	3.28	1.53	4.91	0.79	4.78	10.69	2.45
7	84	3.14	3.29	4.61	5.05	0.78	4.85	10.64	2.00
8	85	3.19	3.30	10.57	5.15	0.78	4.88	10.59	1.77
9	86	3.24	3.32	20.55	5.24	0.77	4.90	10.55	1.63
10	87	3.28	3.33	35.80	5.32	0.77	4.90	10.50	1.54

Drivers - interpolated data | Eastern oyster (Box 1)

Harvest





Model specs

Farm volume (m3)	900000
Box volume (m3)	900000
Timestep (days)	0.0417
Live weight (g)	25.07
Length (cm)	6.37
Nº timesteps	12960

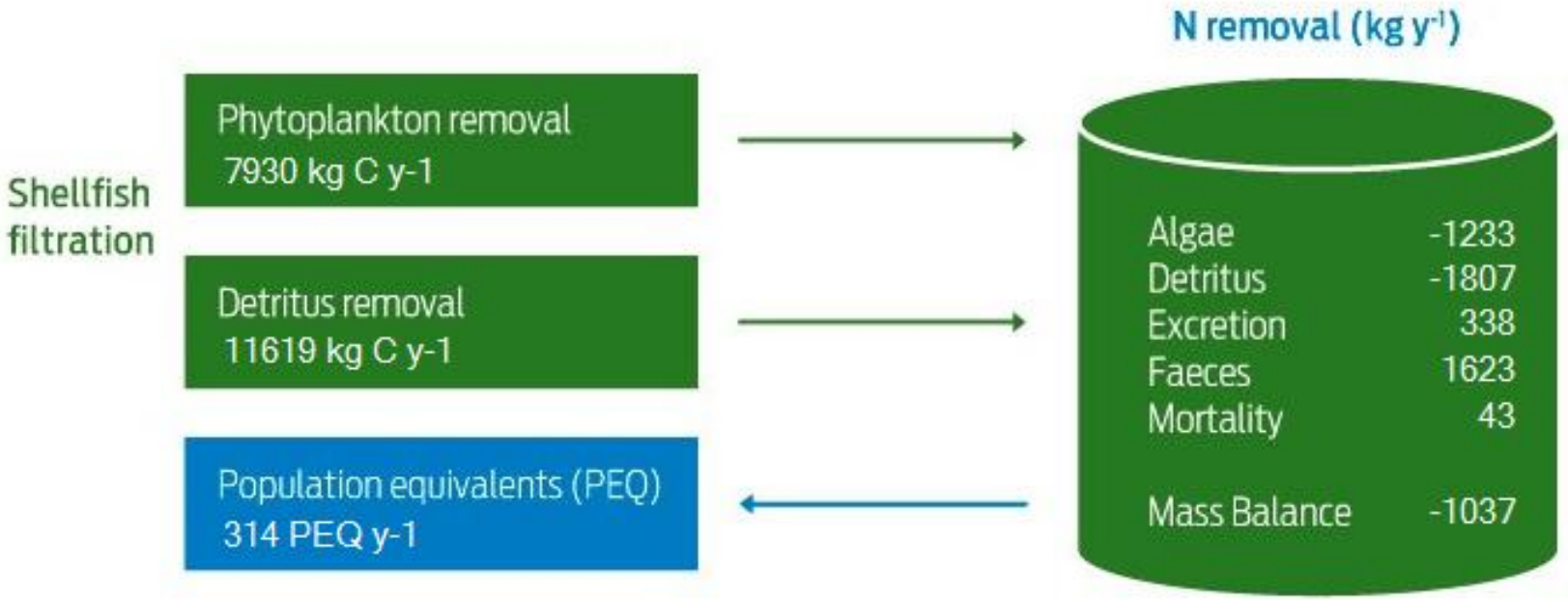
Summary

	A	B	C	D	E	F	G	H	I	J	K
1	Section	Seed	TPP	APP	Revenue	Cost	Profit	Ind. weight	Length		
2		(kg)	(kg)	(-)	(TVP $)	($)	($)	(g TFW)	(cm)		
3	1	16000.0	203645.0	12.7	2036450	160000	1876450	25.07	6.37		
4	Total	16000.0	203645.0	12.7	2036450	160000	1876450	25.07	6.37		
5											
6											
7											

Production | ASSETS | Biodeposition

Predicted oyster harvest for this 50 acre farm in Connecticut is about two hundred metric tons for a culture cycle. FARM also calculates the farm's ASSETS eutrophication score and biodeposition of particulates.

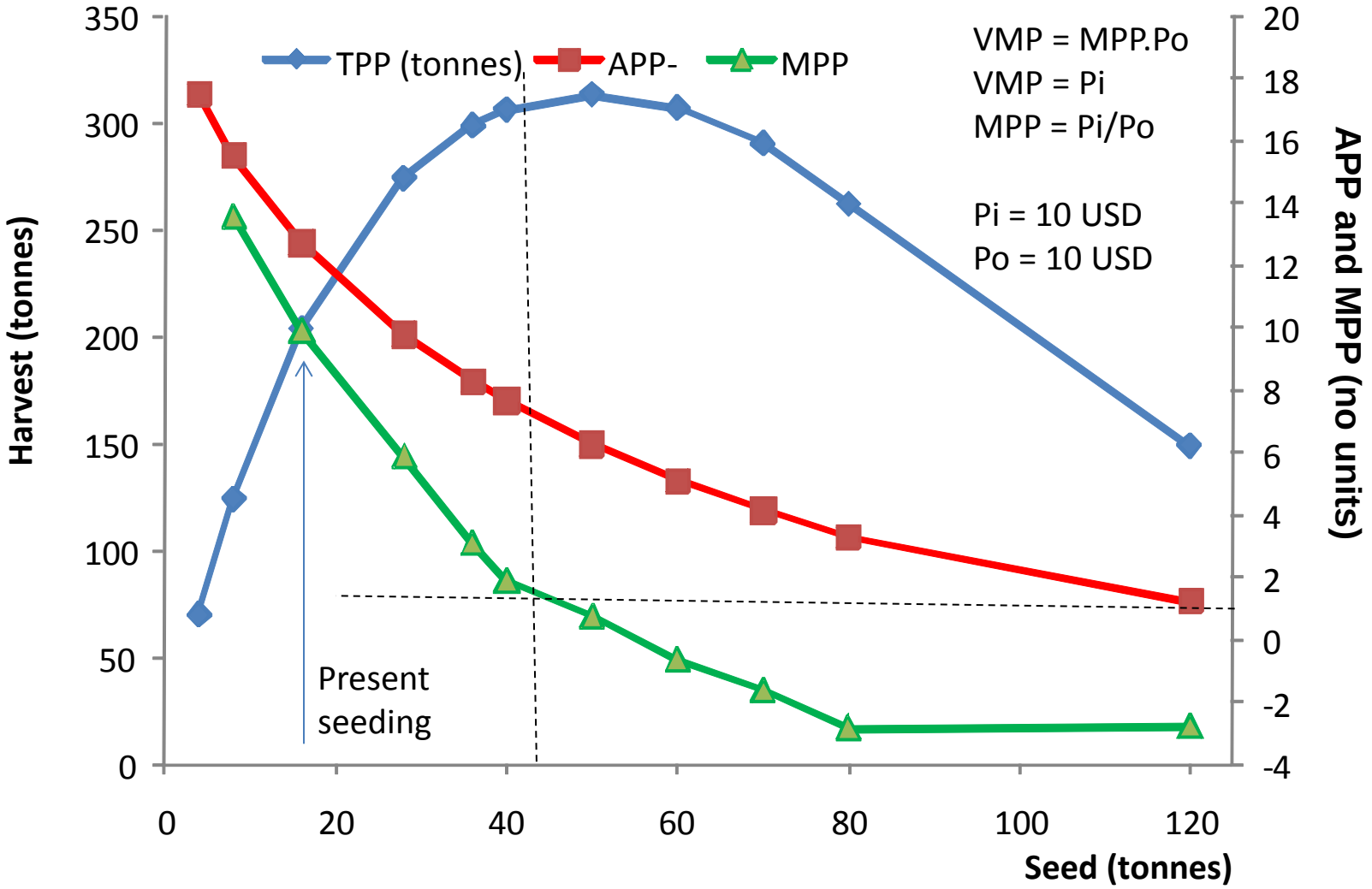
Long Island Sound oyster farm:
FARM model simulation for nutrient trading



Oyster cultivation in this 50 acre farm provides an ecosystem service equivalent to removal of nutrient discharge by over 300 people.

Economic Marginal analysis

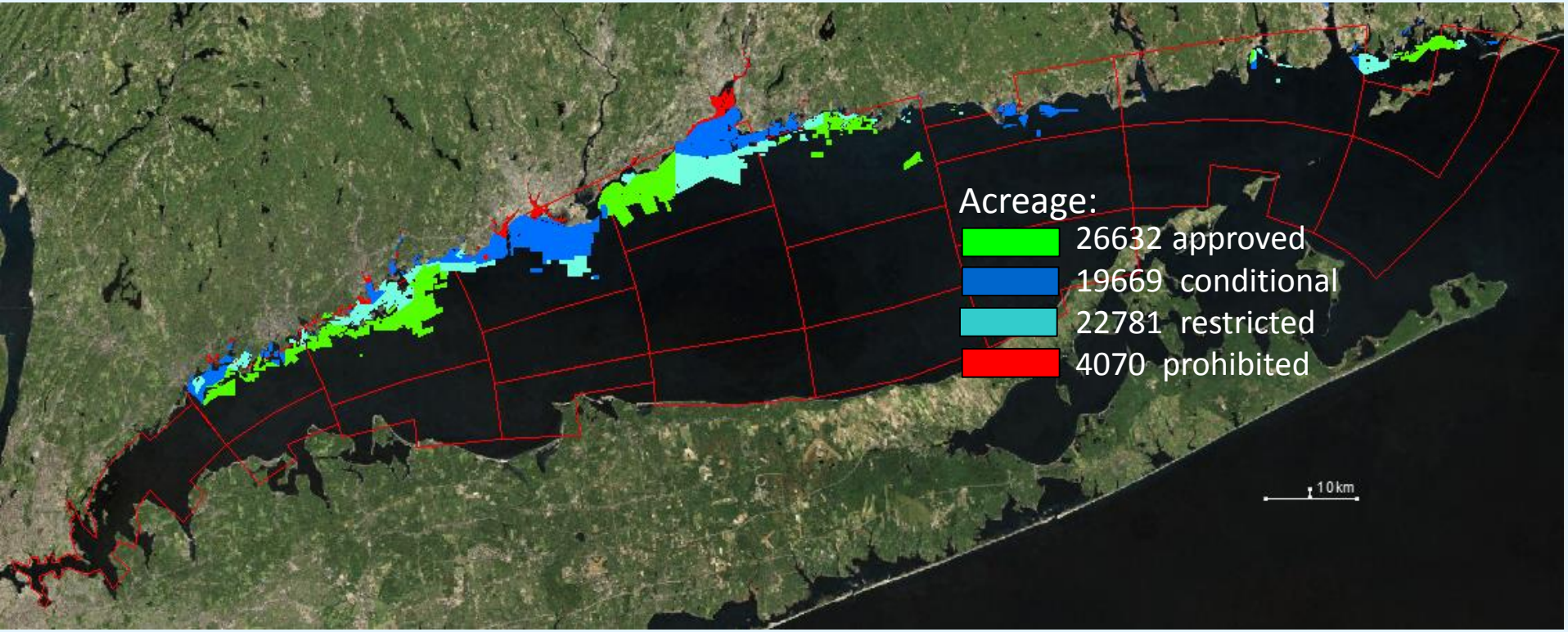
FARM model – application to a Long Island Sound oyster farm



(TPP: production; APP: harvest/seed; MPP: marginal physical product: VMP: Value of marginal product)

Marginal analysis for a farm allows the farmer to determine the optimum profit point – this is not usually the maximum harvest point.

Upscaling Site Specific Nitrogen Removal to Long Island Sound



Site specific:
468 PEQs removal for 50 acre farm

Scaled to Long Island Sound:
~45,000 acres conditional + approved = >400,000 PEQs

Concluding Comments
Bioextraction in Long Island Sound

- SWEM 2300 model boxes reduced to 42 EcoWin2000 boxes using legal, physical, water quality, aquaculture criteria
- Eastern oyster physiological model results incorporated into FARM
- FARM simulation for 50 acre farm provides ecosystem service equivalent to >300 People Equivalents, scaled to system is >400,000 People Equivalents
- Marginal analysis provides basis for optimization of eutrophication reduction and commercial viability of shellfish culture
- Optimistic project - highlights what we can do to provide domestic seafood, improve environment, create jobs