ANALYSING UNCERTAINTIES IN SOCIO-ECONOMIC ASSESSMENTS OF FISHERIES AND AQUACULTURE UNDER CLIMATE CHANGE

Thong Tien Nguyen, Magni Laksáfoss, Unn Laksá, Juliana Arias-Hansen, Øystein Hermansen, Marianne Svorken, Sveinn Agnarsson, Elisabeth Ytteborg, Jónas R. Viðarsson, Matteo Zucchetta, Fabio Pranovi and Nikos Papandroulakis

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CONTENT

- Uncertainties in asssessing socio-economics values
- Our approach: Co-creation and output simulation
- Case study 1: Lake Garda fisheries, Italy
- Case study 2: Seabass aquaculture, Greece

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SOCIO-ECONOMIC ASSESSMENT

- **Industry's profit**

$$Profit = \sum_{f=1}^{F} V_f P_f - \sum_{i=1}^{I} (FC + AV_i C_i)$$

- V_f : Catch volume (ton, kg)
- P_f : Market price ($)
- FC: Fixed costs (investment, capital cost)
- $AV_i C_i$: variable costs such as wage, feed, seed, energy.

- **National Income: Gross value added (GVA)**

Incl. Industy's Profit, Wage & Linkage values:

$$GVA = Profit + Wage + Output * Mult_{output} + Input * Mult_{input}$$

- **Other social values**

e.g. Number of Employment, export values

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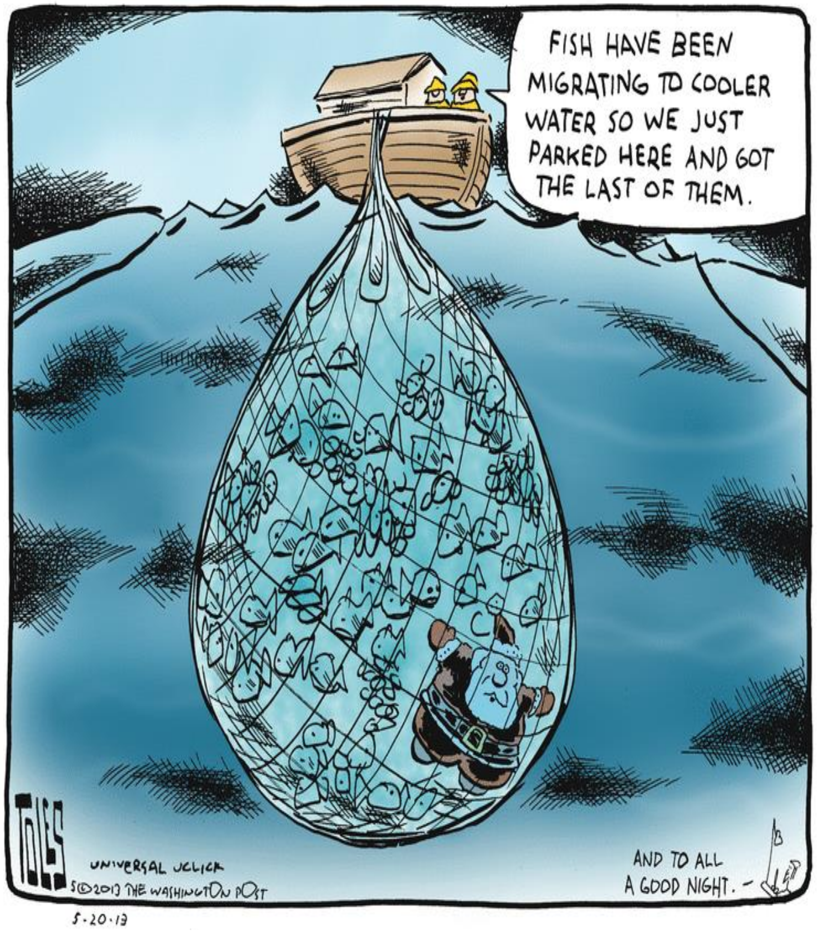
UNCERTAINTIES OF INPUT DATA

Climate change and social change are uncertain factors, impacting on:

- Stock biomass=> Catch volume
- Fish growth=> Farming time & harvest volume
- Survival ratio
- Feed convert ratio
- Energy consumption
- Wages
- Consumer's preference => Market price
- Roles of fisheries and aquaculture in local economy;



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OUR APPROACH

- **Data collection**: Co-creation with two loops
  - *Involving stakeholders in discussion (loop 1) and auditing results (loop 2)*

- **Data analysis**: Output Simulation
  - *Distributions of output instead of fixed values,*
  - *Contribution of each input to output variance;*

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Simulation approach

A sensitive analysis, each input variable assumed following a specific distribution.

Step 1: Data collected, example, in range (max, min) or means and variance/Std.Dev;

Step 2: Calculating the outputs at mean values of inputs;

Step 3: Runing simulation with assumed distributions of inputs;

Step 4: Summarizing the results: means and variance/Std.Dev.

Simulation models:

$$\text{Profit} = \int f(V, P, FC, VC)\, d_V d_P d_{FC} d_{VC}$$

$$\text{GVA} = \int f\left(V, P, FC, VC, \text{Mult}_{\text{input}}, \text{Mult}_{\text{output}}\right) d_V d_P d_{FC} d_{VC} d_{\text{Mult\_input}} d_{\text{Mult\_out}}$$

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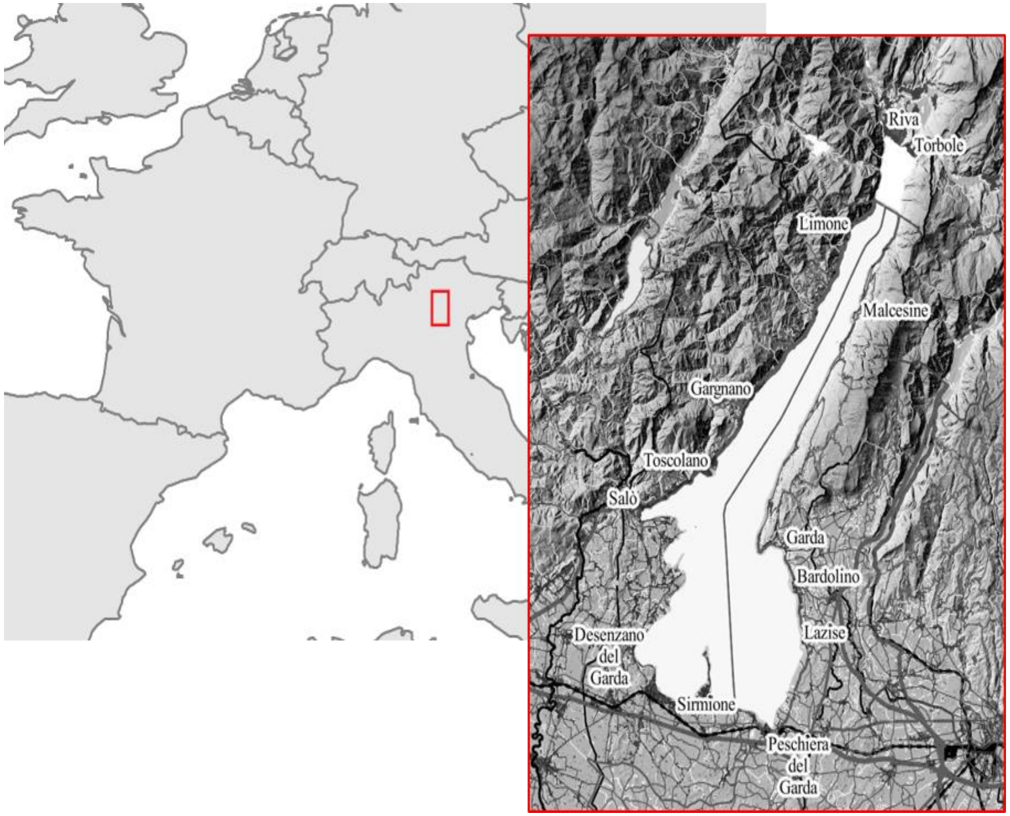
CASE STUDY 1: Lake Garda Fisheries, Italy

- Focusing on the European Whitefish (*Coregonus Lavaretus*);
- Evaluating both professional & recreational fisheries;

➢Three forecasting scenarios (Short, Medium and Long)

➢Two climate scenarios (RCP4.5 and RCP8.5)



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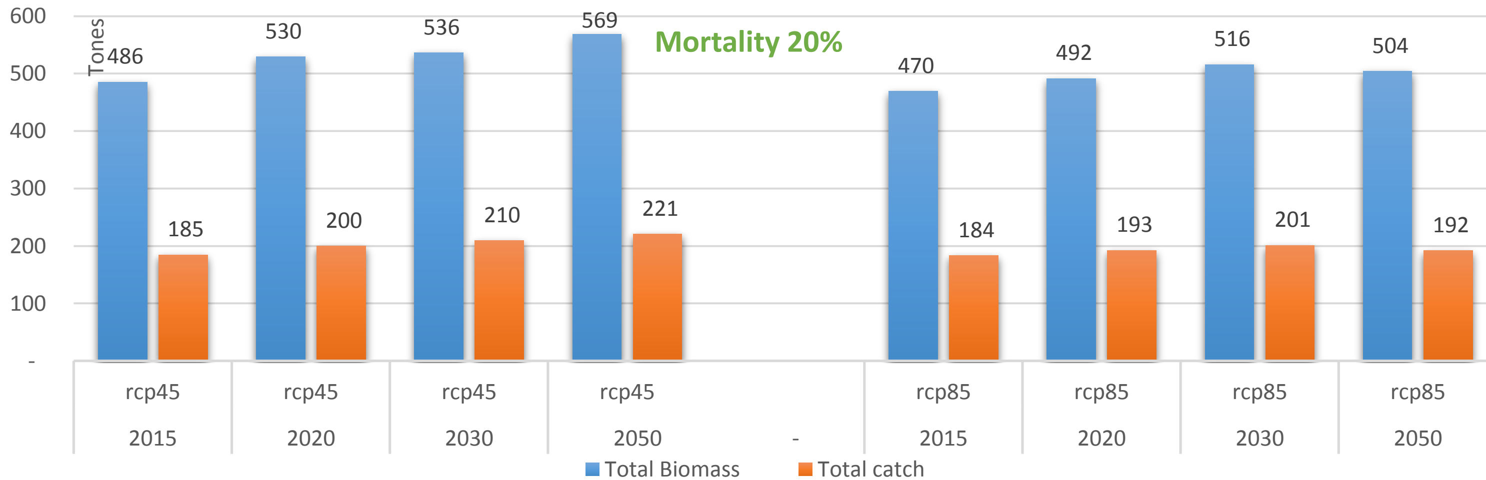
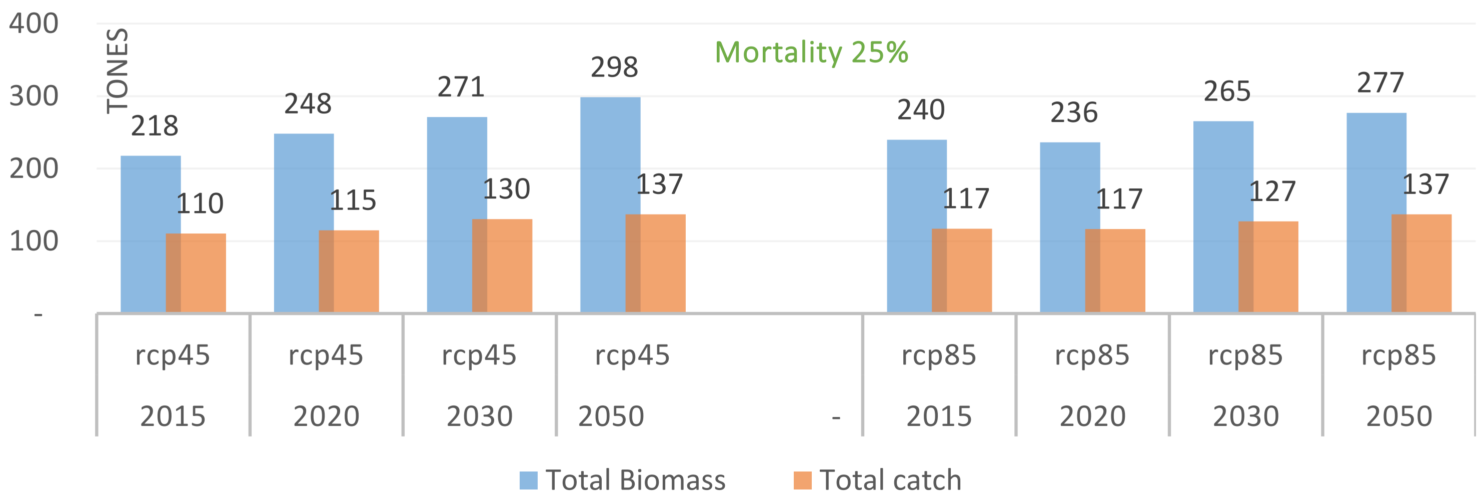
Lake Garda Fisheries: Biomass & Catch under Climate Change





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Lake Garda Fisheries: Cost structure

Professional fisheries	Average Value	Variation (Range)	Distribution Assumption
Number of fishermen	100	70-130	Min-Max
Fuel cost (€/year)	650	600-700	Min-Max
Maintenance cost (€/year)	350	300-400	Min-Max
Gear and equipment cost (€/year)	5,000	4000-6000	Min-Max
% costs assigned to whitefish	50%	40%-60%	Min-Max

Recreational fisheries	Average Value	Variation (Sdt.Dev/Range)	Distribution Assumption
Number of registered fisher	1850		-
Fuel cost (per day)	15	2	Normal distribution
Days fishing whitefish (days/year)	17.5	10-25	Min-Max
Maintenance cost (year/boat)	125	15	Normal distribution
Baits (year/boat)	125	15	Normal distribution
Gear and equipment cost (year/boat)	200	20	Normal distribution
% costs assigned to whitefish	25%	20%-30%	Min-Max
Active recreational fishermen	12.50%	2%	Normal distribution

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Lake Garda Fisheries: Fish price and linkage values

	Average Value	Variation (Sdt.Dev/Range)	Distribution Assumption
Price of whitefish (€/kg)	6.5	0.75	Normal distribution
Backward linkages (€/operational cost)	0.40	0.05	Normal distribution
Flow-on effects (€/sale value)	2.7	0.5	Normal distribution

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Lake Garda Fisheries: Simulation

32 simulation models are developed and each runs 100.000 trials, providing two important results:

1) Means and variance of industry's profit and national income of each senarios;
2) Contribution of uncertain factors (i.e. Biological and economic factors) to variances of the industry's profit and national income.

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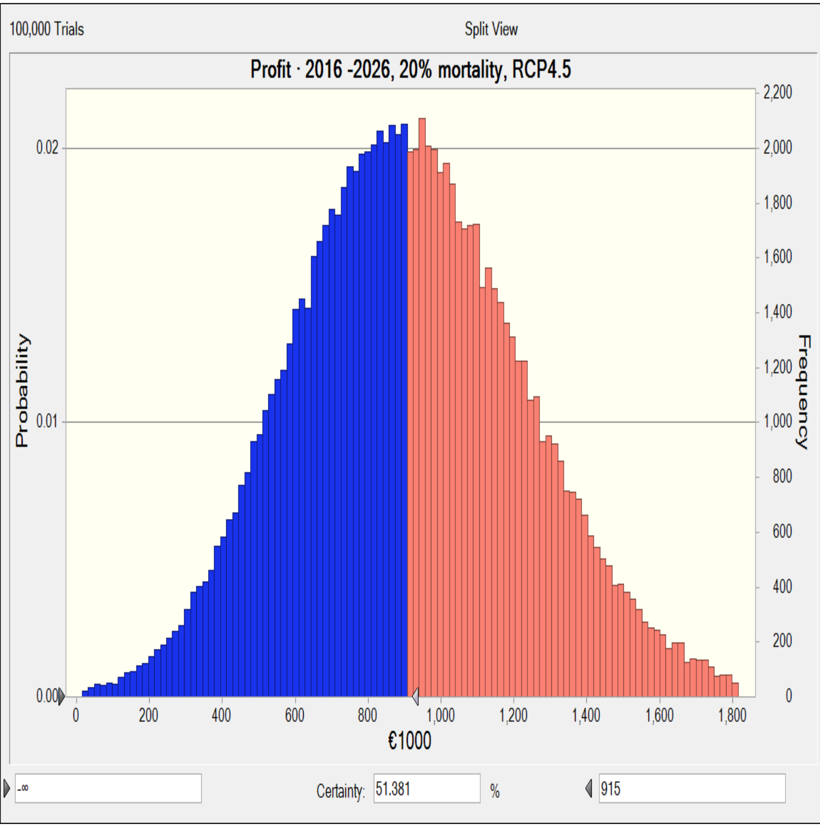
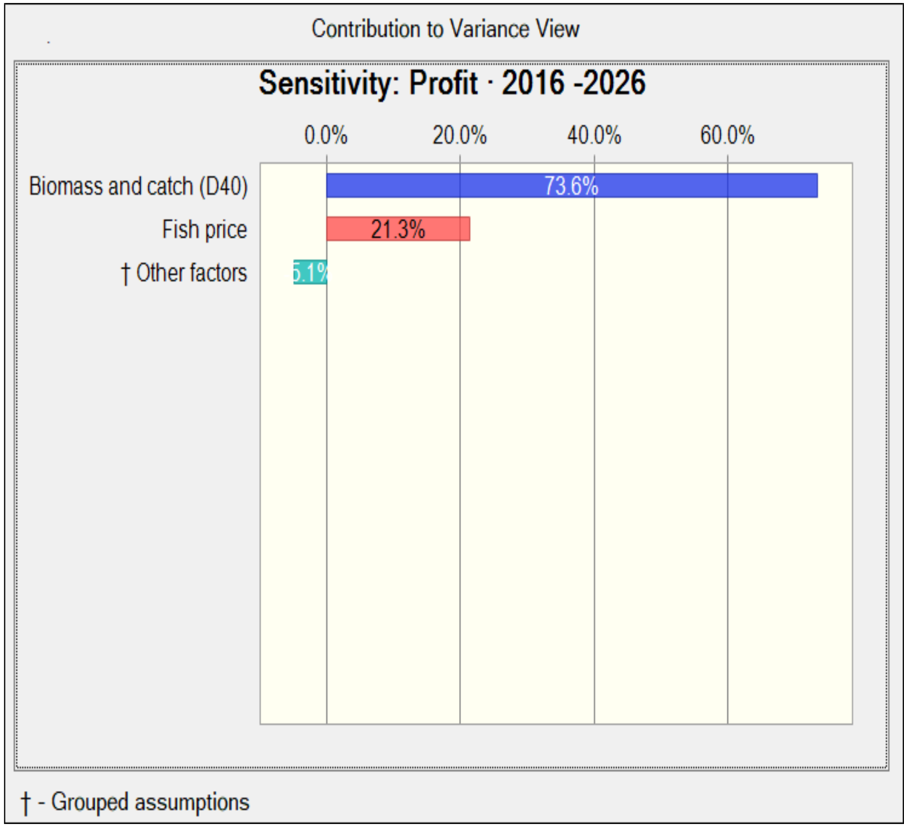
Lake Garda Fisheries:
Profit 2016-2026, 20% mortality under RCP4.5



Statistic	Forecast val
Trials	100,000
Base Case	915
Mean	916
Median	904
Mode	---
Standard De	322
Variance	103,410
Skewness	0.2256
Kurtosis	3.07
Coeff. of Var	0.3511
Minimum	-291
Maximum	2,399

Percentile	Forecast value
0%	-291
10%	512
20%	643
30%	739
40%	824
50%	904
60%	985
70%	1,075
80%	1,182
90%	1,334
100%	2,399



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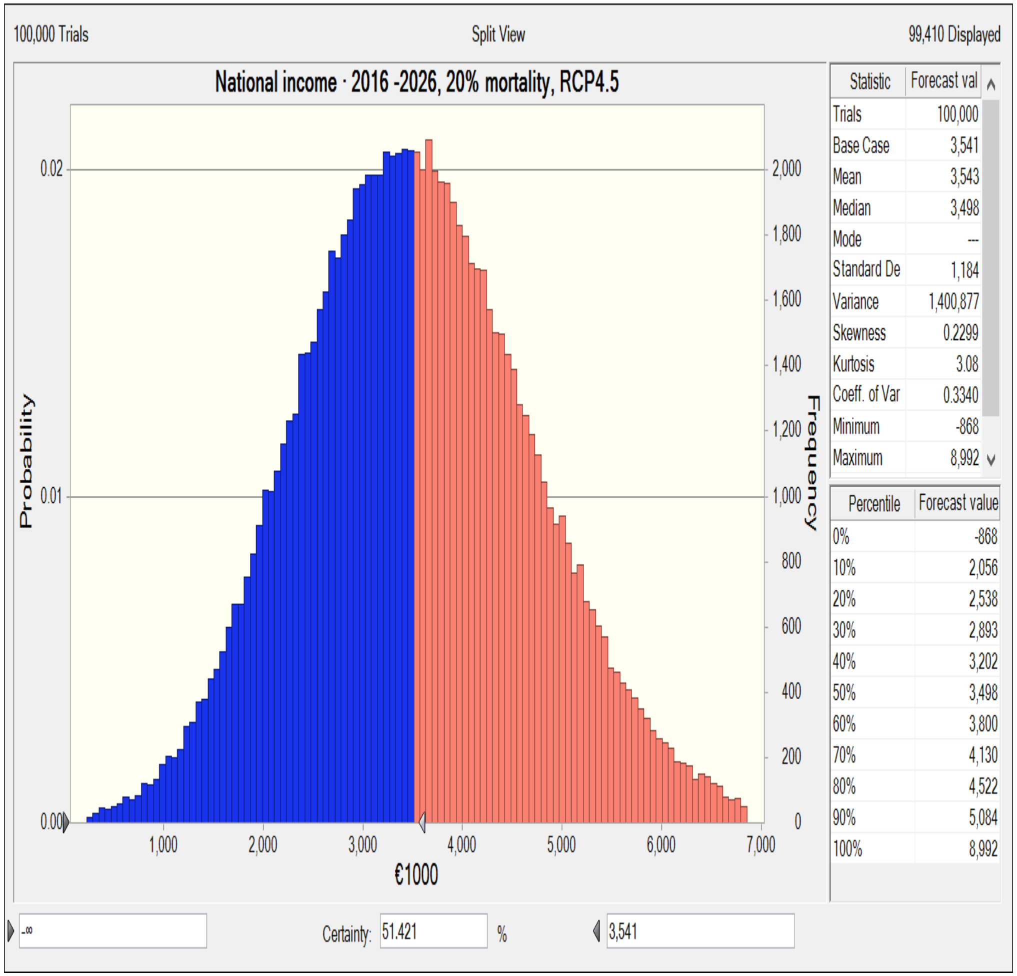
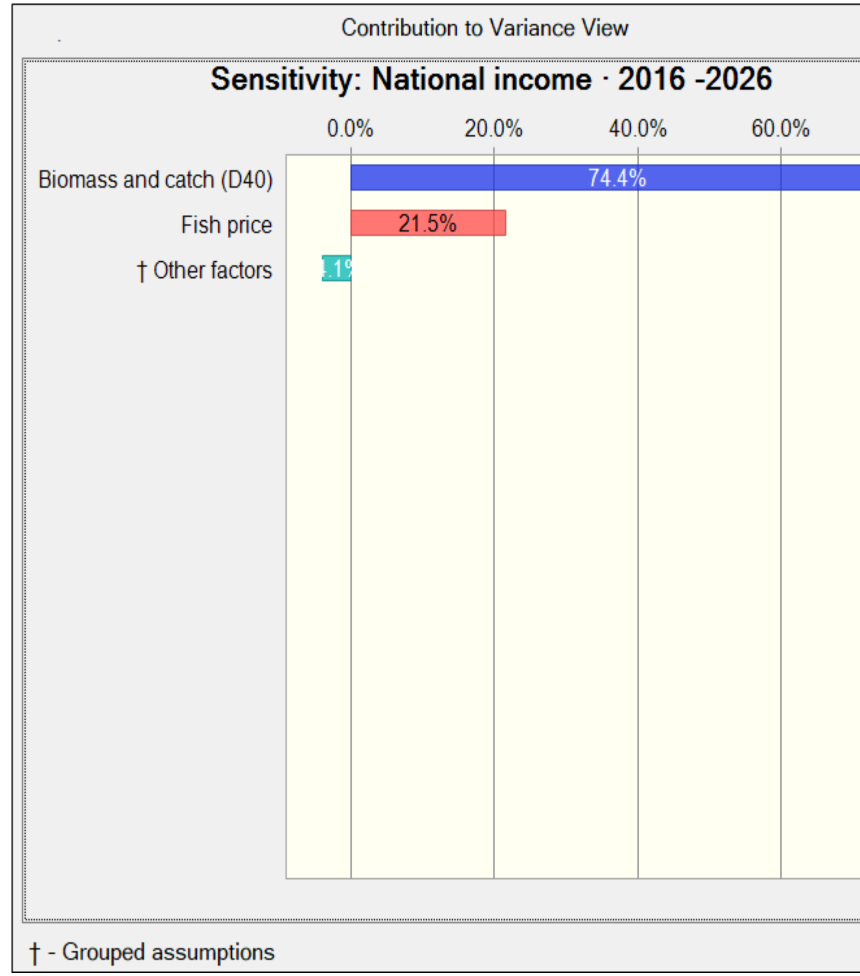
Lake Garda Fisheries:
GVA 2016-2026, 20% mortality under RCP4.5





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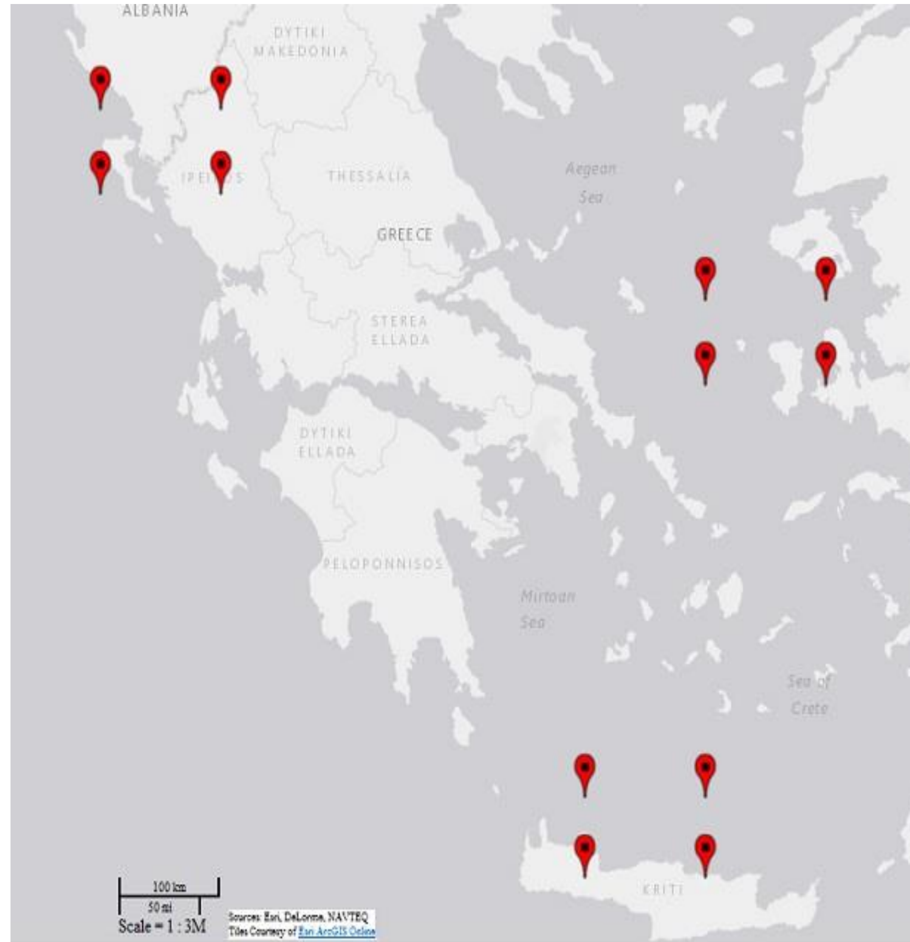
CASE STUDY 2: Seabass aquaculture, Greece

- Three farming locations;
- Climate change impacts directly on biological performance of fish farming (i.e. fish survival, growth and feed required);
- Three forecasting scenarios (Short, Medium and Long)
- Two climate scenarios (RCP4.5 and RCP8.5)
- Three stocking periods (March, June and September)
- Three harvested size of fish (400g, 800g, and 1200g).



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Seabass aquaculture, Greece:

Exp. Biological inputs, RCP4.5, 200.000 juvel. Stocking in March

	Short Run			Mid Run			Long Run		
Market size of fish	**400g**	**800g**	**1200g**	**400g**	**800g**	**1200g**	**400g**	**800g**	**1200g**
Growing days	544	909	1063	529	880	1024	526	872	1016
Std.Dev	*38*	*92*	*148*	*34*	*71*	*141*	*33*	*73*	*141*
Feed consumption (t)	108	282	491	108	283	499	107	283	501
Std.Dev	*7*	*22*	*58*	*6*	*15*	*58*	*6*	*16*	*59*
Survival rate (%)	0.86	0.84	0.83	0.86	0.84	0.83	0.86	0.84	0.83
Std.Dev	*0.04*	*0.04*	*0.04*	*0.04*	*0.04*	*0.04*	*0.04*	*0.04*	*0.04*

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Seabass aquaculture, Greece: Socioeconomic inputs

Inputs	Average	Std.Dev	Unit
Production costs			
Feed	1.15	0.070929	€/kg feed
Juvenile	0.27	0.0321354	€/stk
Wage	0.23	0.063124	€/kg feed
Other	0.05	0.027378	€/prod day
Depreciation	0.07	0.024392	€/kg feed
Financial cost	0.14	0.090966	€/kg feed
Prices of Diff. fish sizes			
400g	4.87	0.23	€/kg
800g	6.27	0.29	€/kg
1200g	8.33	0.61	€/kg
Multiplier effects			
Backward linkage	0.52	0.09	Per one € of cost
Flow-on effect	0.42	0.07	Per one € of sale

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Seabass aquaculture, Greece: Simulation

- **54 simulation models, combining:** 2 climate change scenarios, 3 periods, 3 stocking times, and 3 fish sizes.
- **Indicators:**

- Industry profit
- National income
- Unit cost (€/kg of harvested fish)
- Profit ratio (profit/sale)

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Seabass aquaculture, Greece: Exp. Forecasting profits

	4.5 Scenario			8.5 Scenario		
	Short	Medium	Long	Short	Medium	Long
Industry Profit (€)						
Mean	415	410	409	413	415	409
Std. Dev	65	64	64	65	65	64
Min-Max value	128-701	129-685	136-711	147-704	138-695	125-687
Contribution to the variance						
Sale price	*47.4%*	*47.3%*	*47.6%*	*49.0%*	*48.7%*	*49.1%*
Feed and juveniles price	*16.8%*	*17.1%*	*17.3%*	*11.4%*	*11.3%*	*17.2%*
Other cost	*14.2%*	*13.3%*	*13.1%*	*14.4%*	*14.9%*	*13.0%*
Feed consumption	*11.9%*	*12.8%*	*12.1%*	*16.3%*	*16.2%*	*11.8%*
Growing time&survival rate	*9.7%*	*9.5%*	*9.9%*	*8.9%*	*8.9%*	*8.9%*

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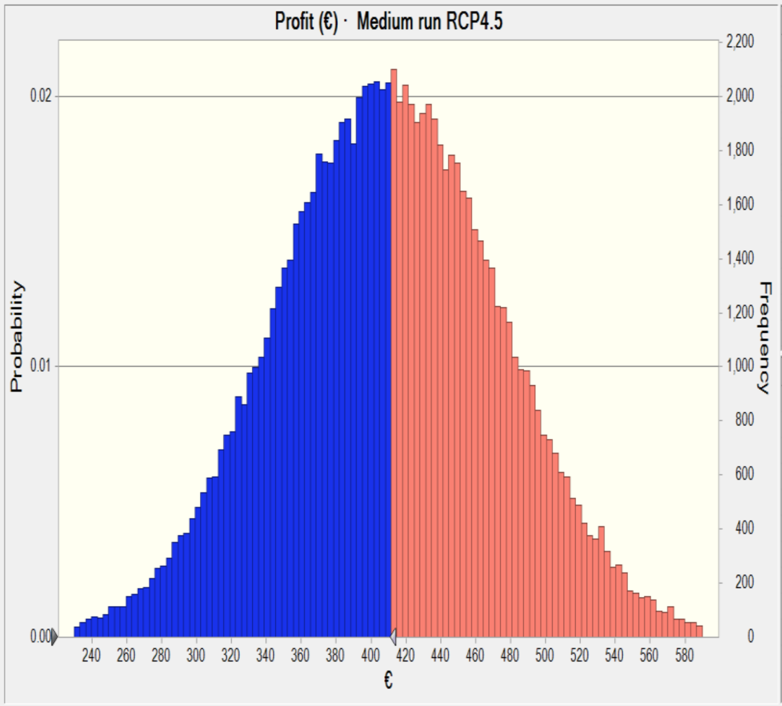
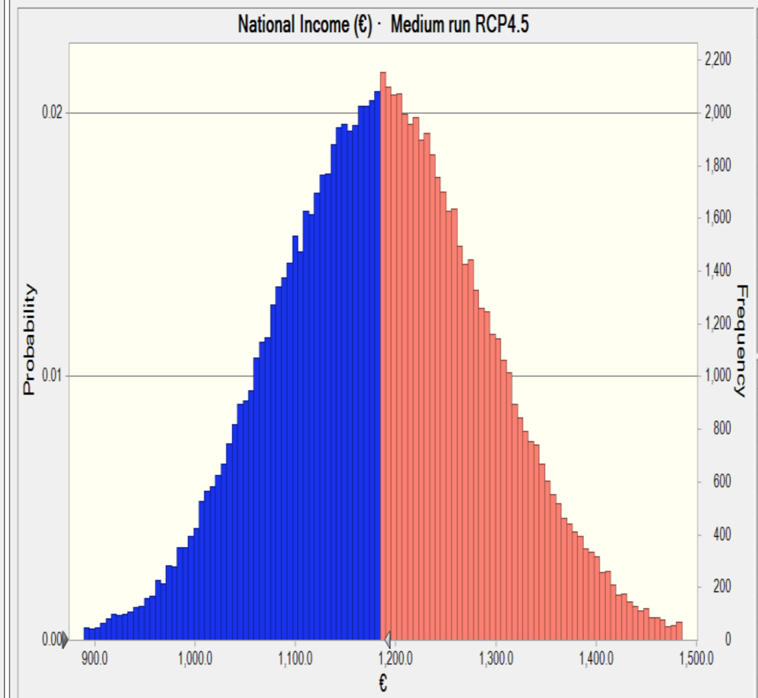
Seabass aquaculture, Greece:
Exp. Distribution of profit RCP4.5, medium run



Statistic	Forecast val
Trials	100,000
Base Case	410
Mean	410
Median	410
Mode	---
Standard De	64
Variance	4133
Skewness	0.0101
Kurtosis	3.01
Coeff. of Var	0.1568
Minimum	132
Maximum	687

Percentile	Forecast value
0%	132
10%	328
20%	356
30%	376
40%	394
50%	410
60%	426
70%	444
80%	464
90%	492
100%	687



Statistic	Forecast val
Trials	100,000
Base Case	1,187.2
Mean	1,187.4
Median	1,186.5
Mode	---
Standard De	106.5
Variance	11,352.7
Skewness	0.0846
Kurtosis	3.01
Coeff. of Var	0.0897
Minimum	746.8
Maximum	1,693.7

Percentile	Forecast value
0%	746.8
10%	1,051.6
20%	1,097.1
30%	1,130.9
40%	1,159.5
50%	1,186.5
60%	1,212.9
70%	1,241.5
80%	1,276.2
90%	1,324.9
100%	1,693.7

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Conclusions

- Uncertainty => less effective MP and policy;
- Co-creating approach and simulation => improving accuracy and enriching information;
- Active interactions of producers, associate members, policy maker, and scientists;
- Increasing temperature increases profitability of Lake Garda fisheries; fishing mortality & biological factors contributes 95% of variance of economic values;
- Increasing temperature promotes Seabass growth in Greece but market price contributes to nearly 50% of the profit variance; Profitability seems to be insignificantly changed.

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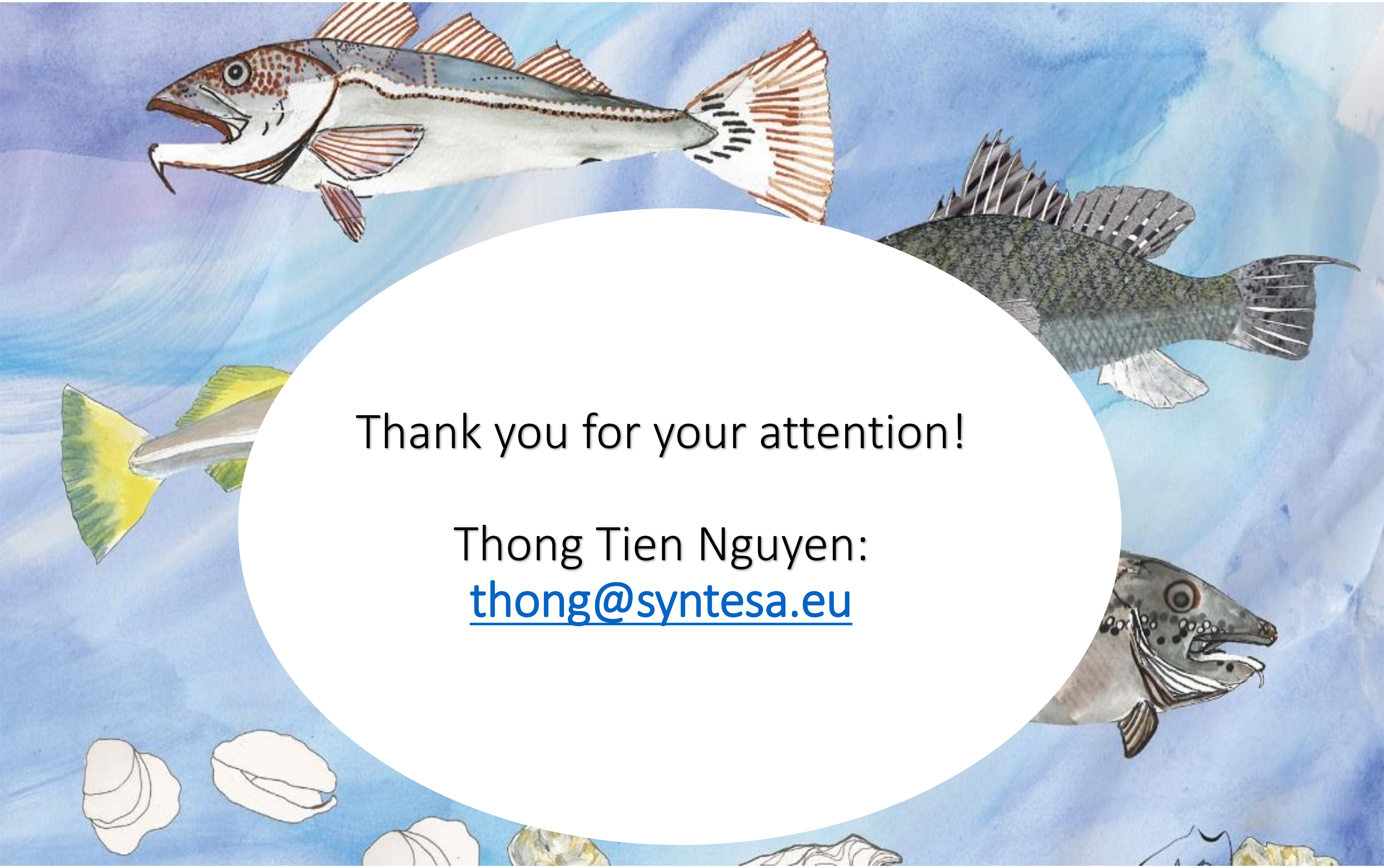

Thank you for your attention!

Thong Tien Nguyen:
thong@syntesa.eu

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