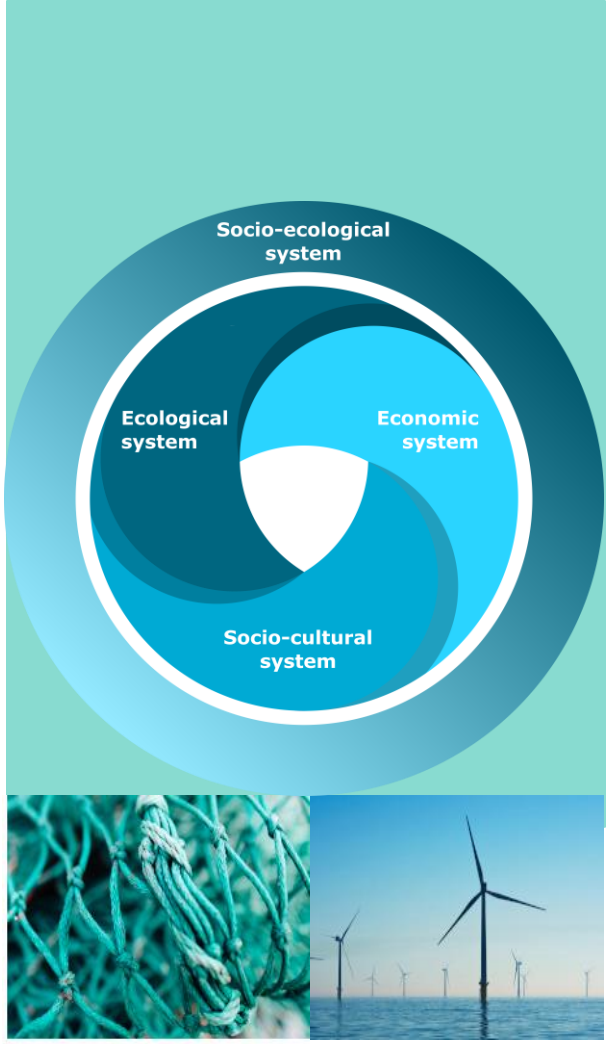

More than the sum of its parts: Assessing the vulnerability of an interlinked marine socio-ecological system

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SeaUseTip FONA Research for sustainability

Universität Hamburg DER FORSCHUNG | DER LEHRE | DER BILDUNG

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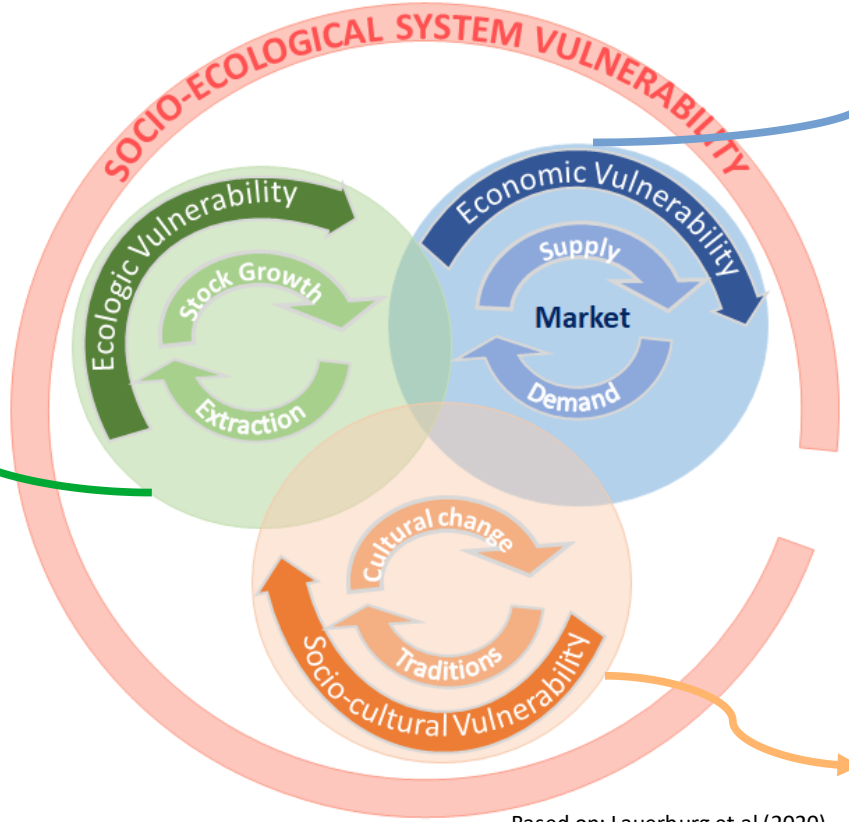
Outline

1. Background
2. Objective
3. Vulnerability Framework
4. Case Study: North Sea Flatfish Fishery
5. Results
6. Conclusion

Background

SOCIO-ECOLOGICAL SYSTEM (SES) ARE EXPOSED TO SEVERAL HAZARDS

Ecosystems are increasingly exposed to severe environmental events, like extreme climatic events, pollution[1].



Economic systems are exposed to economic, governmental, and social **crises**[2]

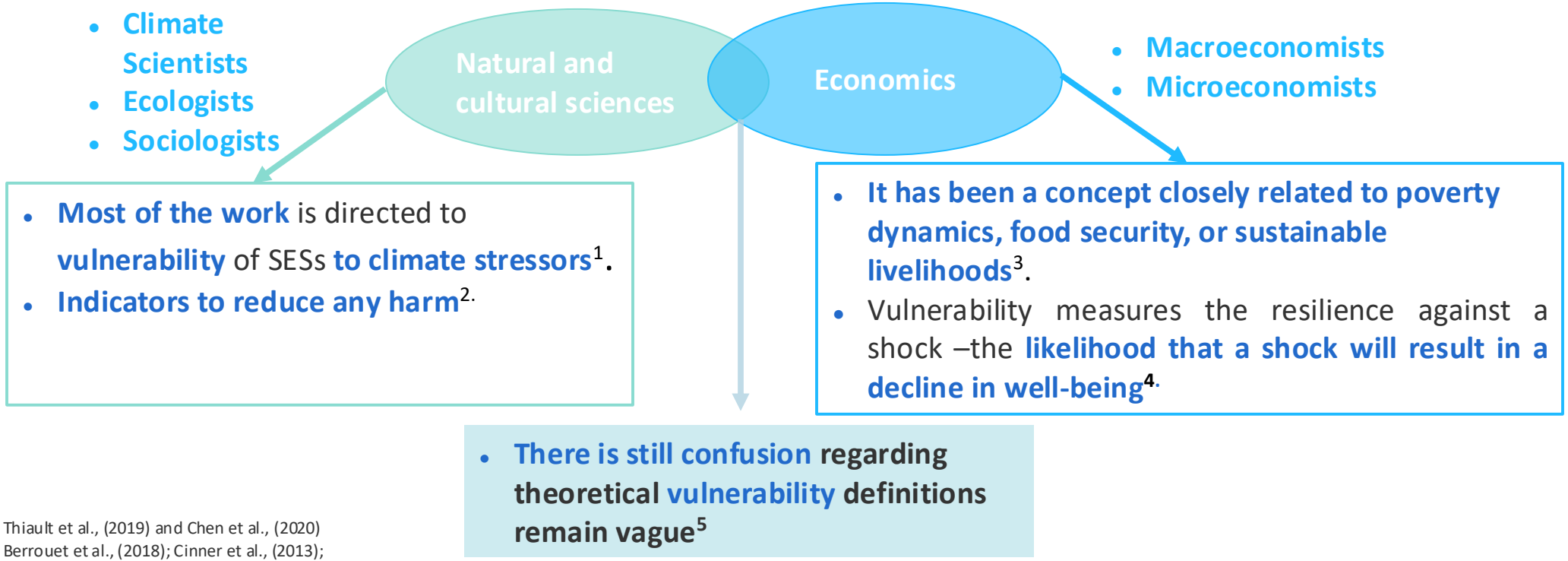
Social systems are also exposed to changes in preferences, tradition or culture.

Based on: Lauerburg et al (2020)

1. Baggio et al., (2020)
2. Carr, (2020); Cinner et al, (2013)

Background

THE VULNERABILITY OF SES IS AN INTERDISCIPLINARY APPROACH



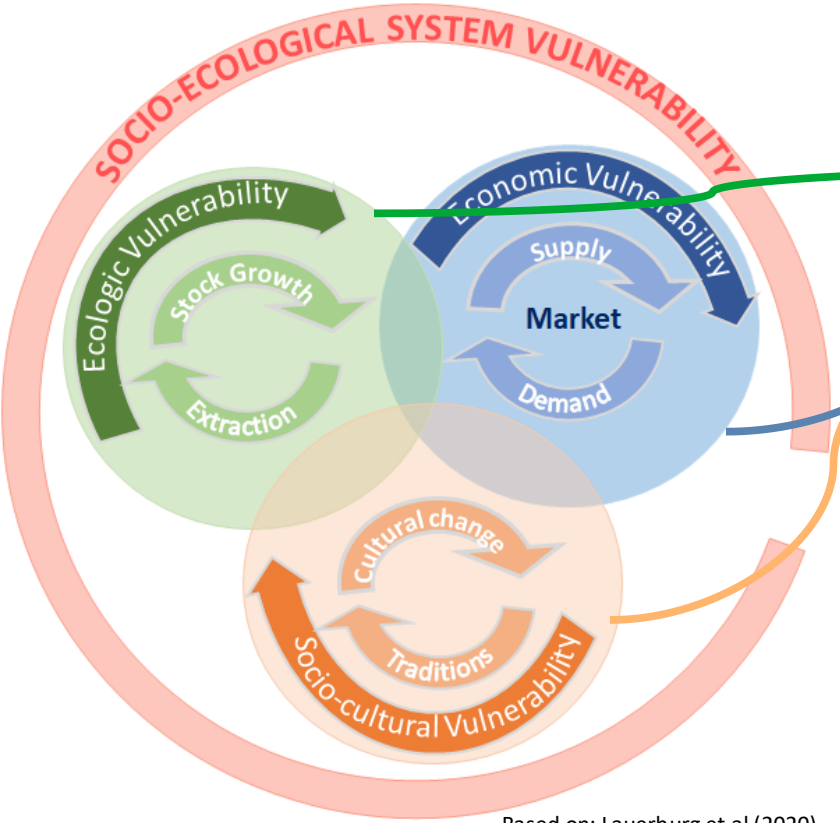
1. Thiault et al., (2019) and Chen et al., (2020)
2. Berrouet et al., (2018); Cinner et al., (2013); Milner-Gulland, (2012); Willaert et al., (2019)
3. Moret,(2014)
4. Wolrd Bank (2003)
5. Hinkel, (2011); Wolf et al., (2013).

Objective

- Develop an **analytical framework that defines vulnerabilities of SESs to multiple drivers** based on derivatives of system properties to drivers.

- **Provide quantitative results** of the vulnerabilities through an analytical framework.
- Disentangle **effects** and **trade-offs** when there is a **positive and a negative impact** in an SES.
- Form a **bridge** between the interdisciplinary **area of vulnerability assessment** and the **bio-economic modeling** domain.

Analytical Framework



Vulnerability of what to what?

VULNERABILITY OF

Property of the system

The observed variable that is affected by the drivers.

TO

Drivers

TO ecological drivers

TO economic drivers

TO social drivers

Based on: Lauerburg et al (2020)

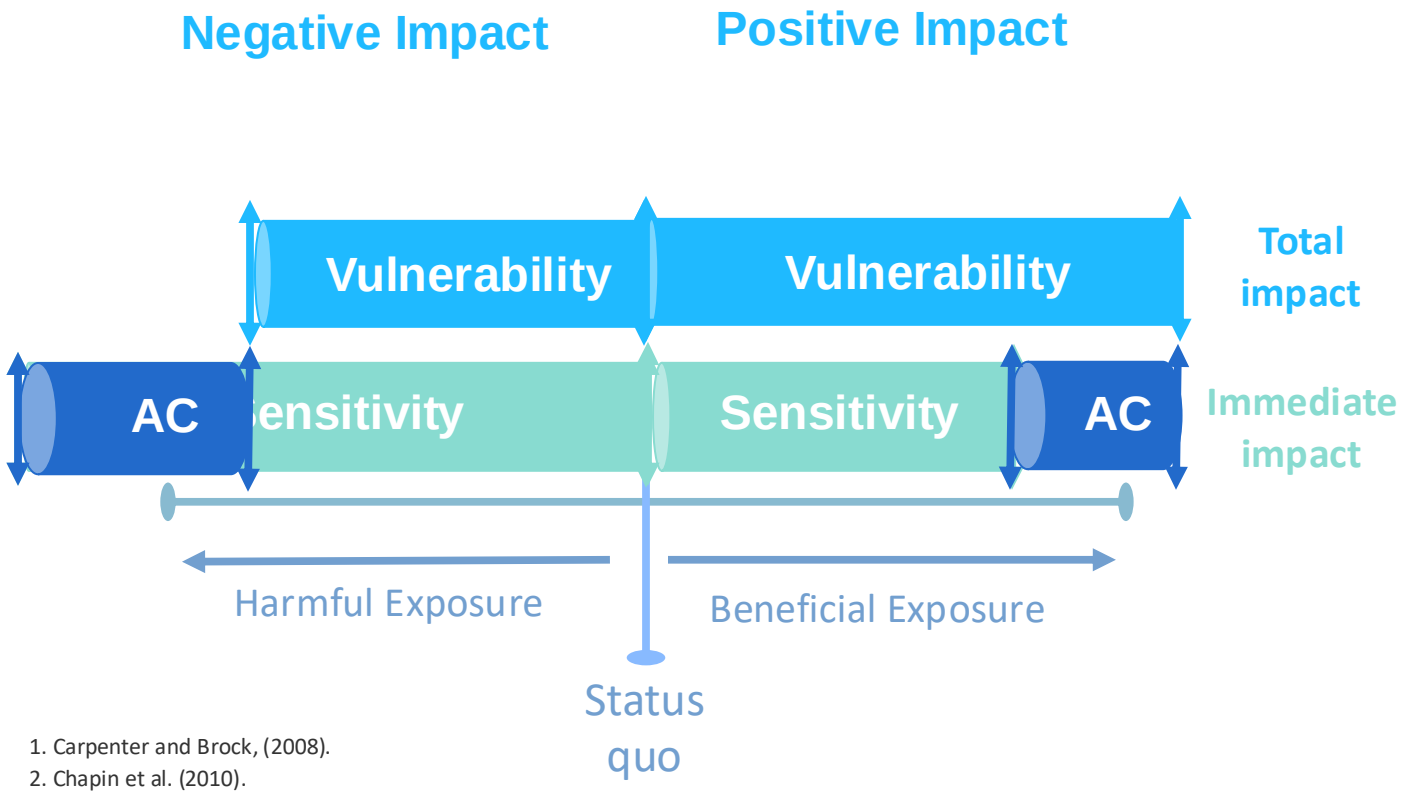
Analytical Framework

Exposure: refers to the magnitude of the driver that affects a component of the system. **It can be positive or negative.**

Sensitivity: indicates the degree to which a system component is affected by the driver.

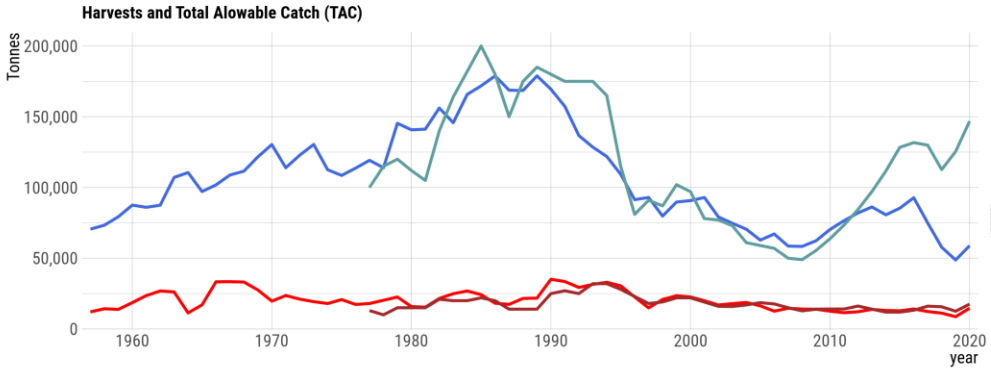
Adaptive Capacity: represents a system's ability to adjust responses to changing internal demands and external drivers[1].

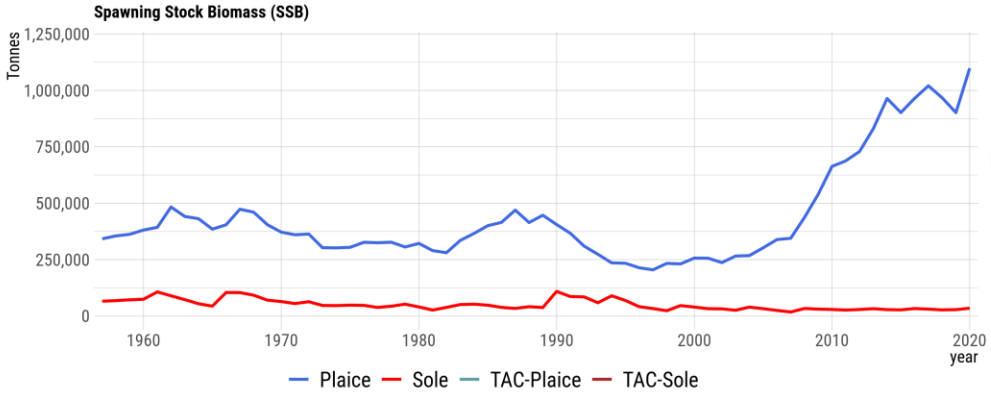
Vulnerability: as a system's susceptibility to harm **[or benefit]** due to exposure and sensitivity to a specified driver and its adaptive capacity to respond to it[2].



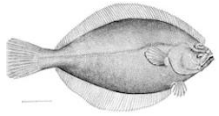
1. Carpenter and Brock, (2008).
2. Chapin et al. (2010).

Case Study: North Sea Flatfish Fishery





Plaice



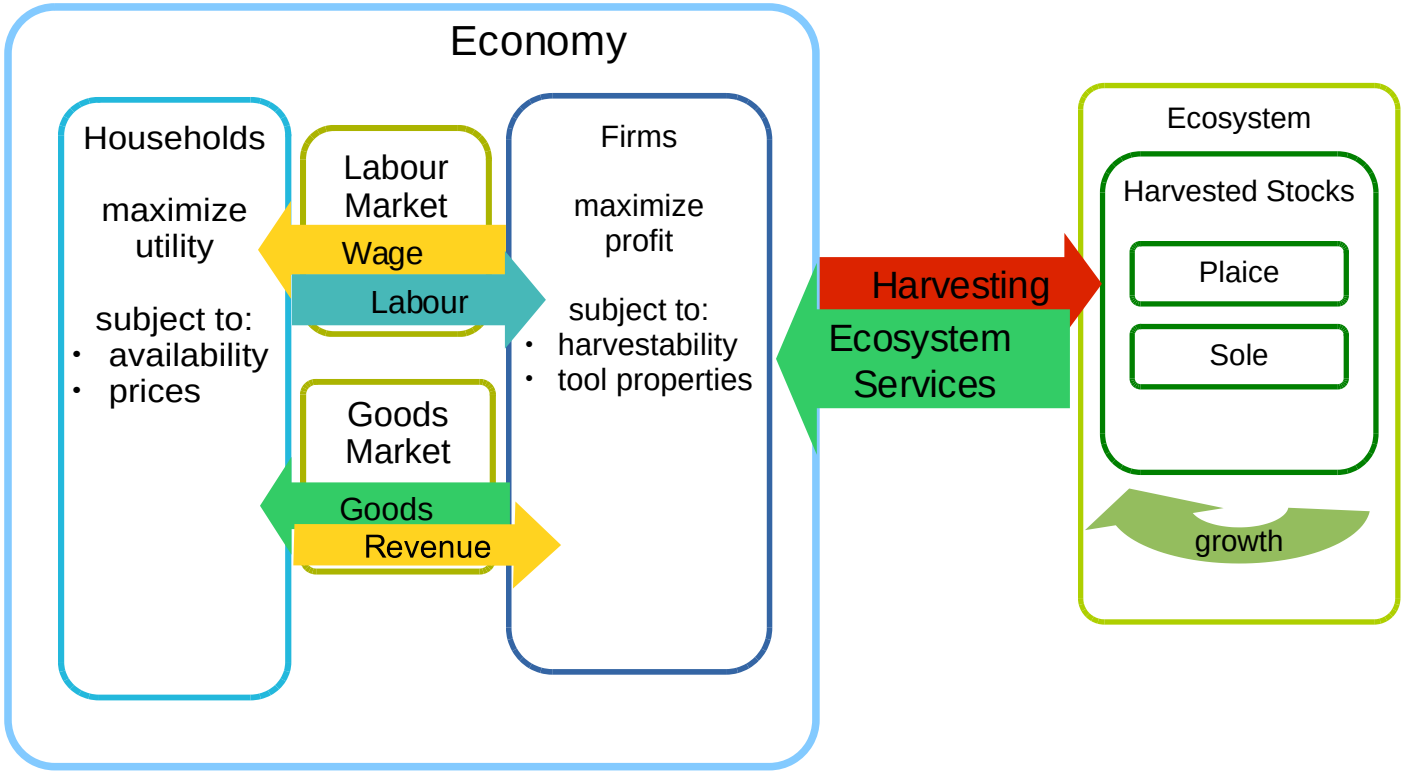
Sole

1. **The North Sea** is one of the most important fishing grounds. **Account for 32% of the total landings by the EU fleet**, with the **highest total landed value** in all Europe[1].
2. **A decrease in stocks until 2000** for both plaice and sole, due to **overfishing**, pollution and the challenges faced by climate change[2].
3. **The North Sea flatfish fishery experiences increasing regulative instruments**[3].
   - Introduction of **bans regarding the harvest quantity.**
   - **Establishing conservation areas** to reduce the space available to fish, and
   - **Measures to improve selectivity**.

1. STECF, (2019).
2. Engelhard et al., (2011)
3. Engelhard et al., (2011); European Commission, (2014); Keeken et al., (2007).

Case Study: Bio-Economic Model[1]

- Dynamic model.
- Ecosystem component with two species that are harvested and grow per period.
- Economic component that involves a labor and goods market.



1. Blanz (2019)

Case Study: Bio-Economic Model[1]

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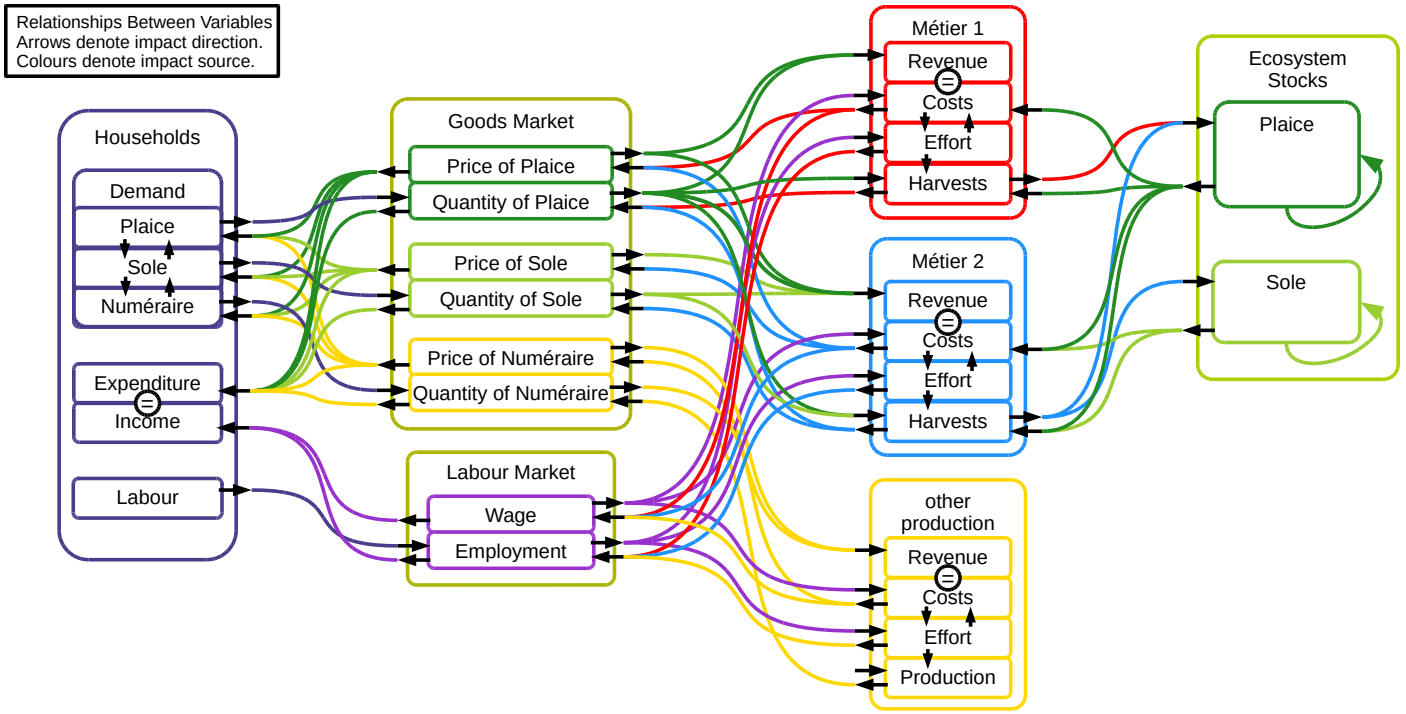
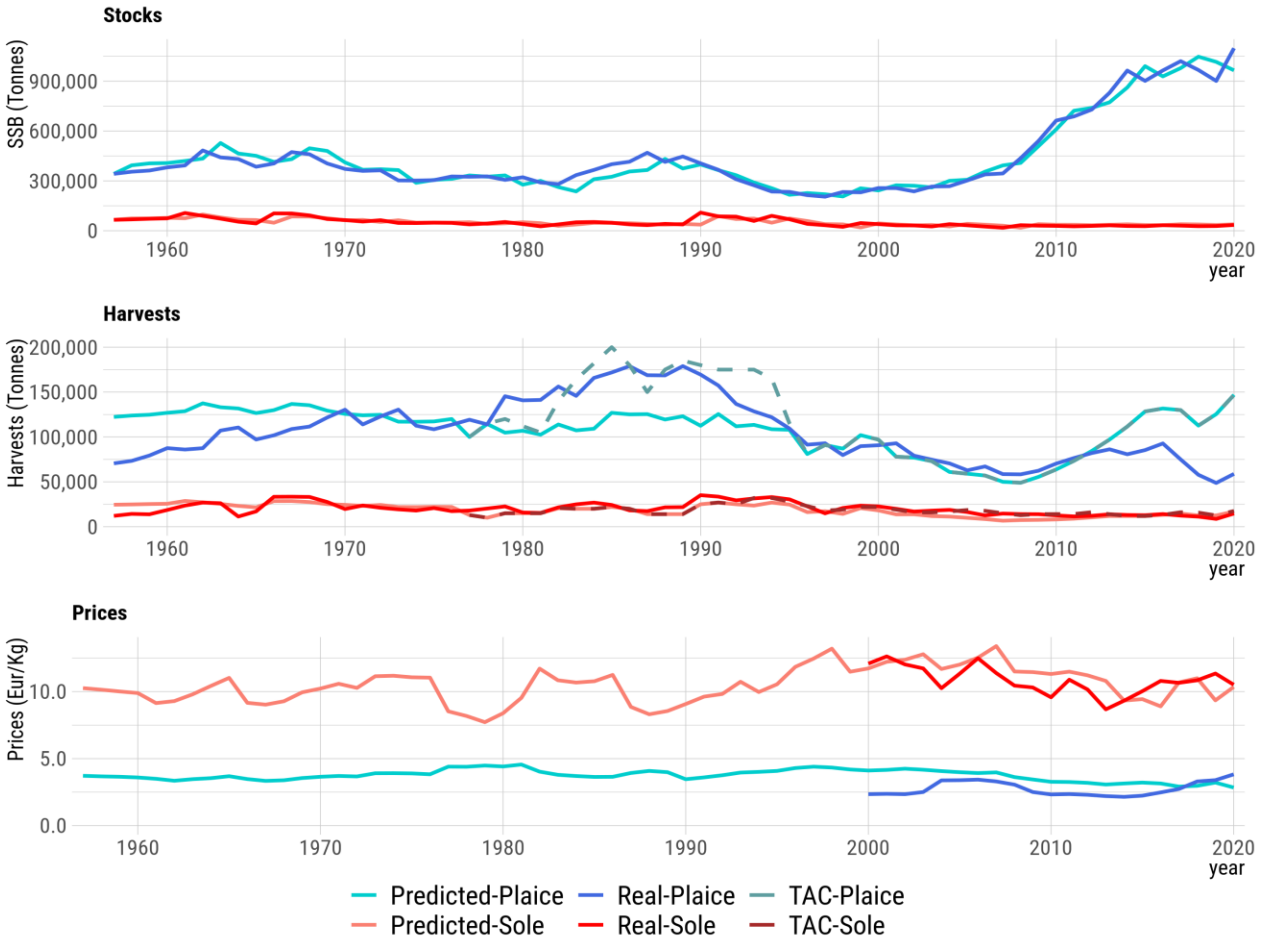


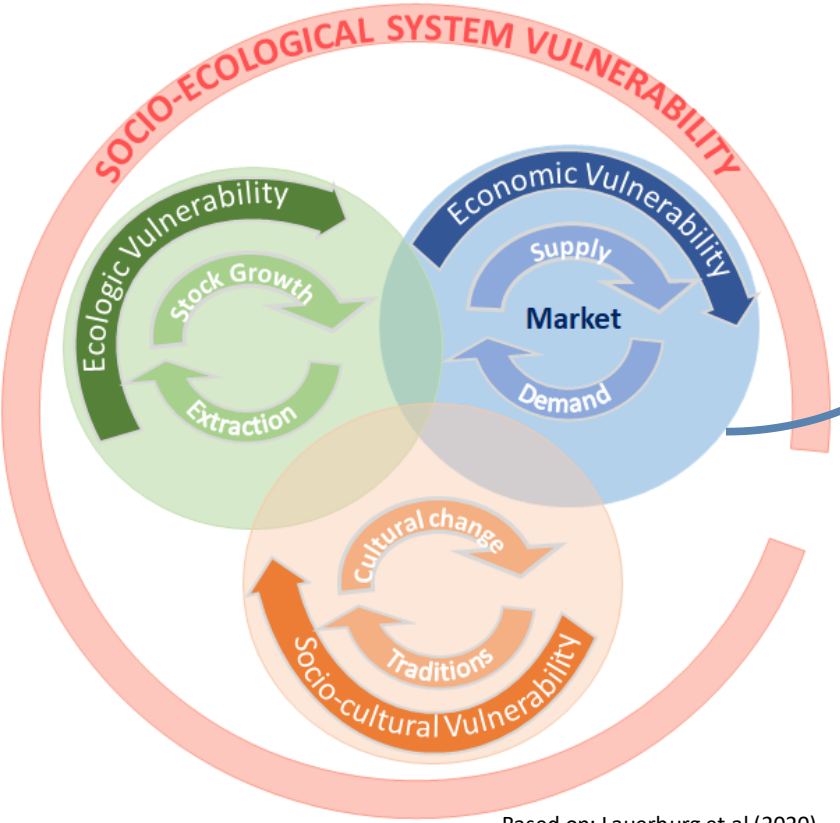
1. Blanz (2019)

Case Study: Calibration of the Model



- **Parameters calibrated:**
- Fishers' returns to effort
- Stock harvesting efficiency of plaice and sole.
- Wages
- Household preference parameters.

Analytical Framework



Vulnerability of what to what?

VULNERABILITY OF

Fishers Profits

The observed variable that is affected by the drivers.

TO

Drivers

TO market drivers

TO household preferences drivers

TO harvesting drivers

TO ecological drivers

Based on: Lauerburg et al (2020)

Case Study: Framework Application

- **EXPOSURE TO:**

Harvest

Driver	Meaning	Examples
	Returns to effort	• Changes in **average vessel size or capacity**
	stock harvesting efficiency of the specie *i*	• Increasing **marine protected areas**
	gear specific harvesting efficiency of the métier *k* to catch the specie *i*	• Changes in **harvesting technology** through • innovation or policy requirements

Ecological

	Stock	• Random events, unaccounted harvesting.

Case Study: Framework Application

- **EXPOSURE TO:**

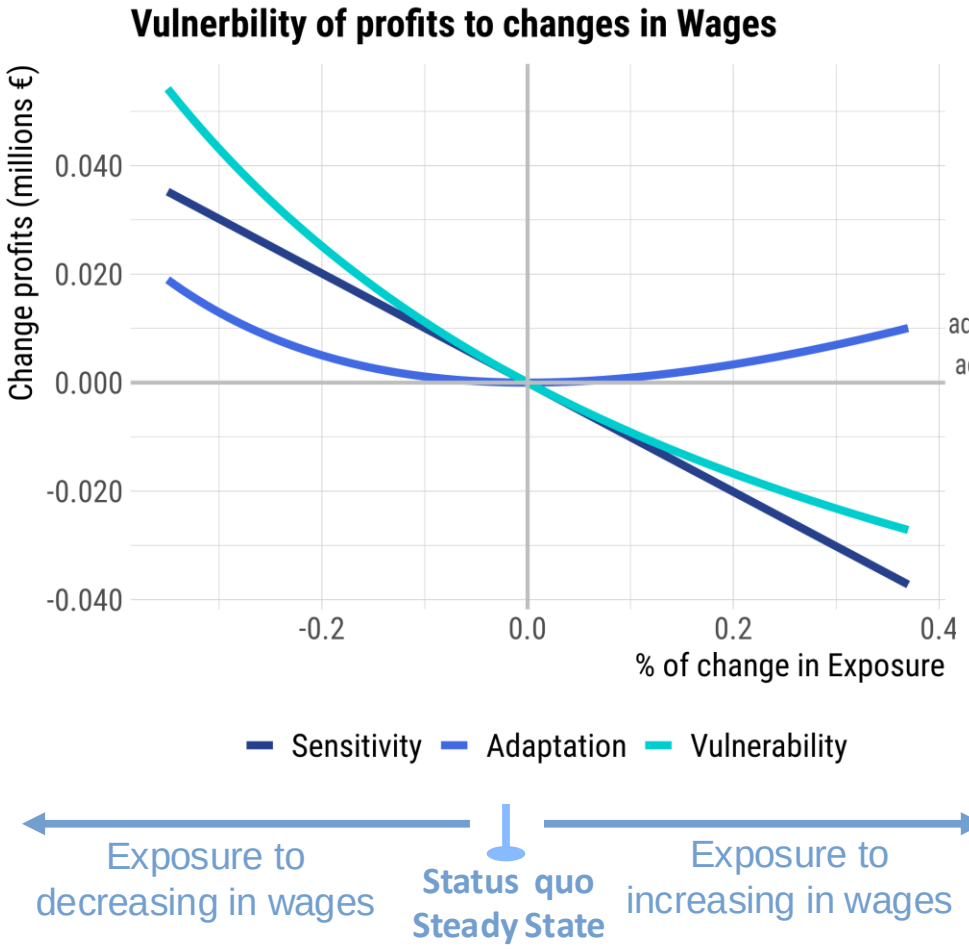
Market

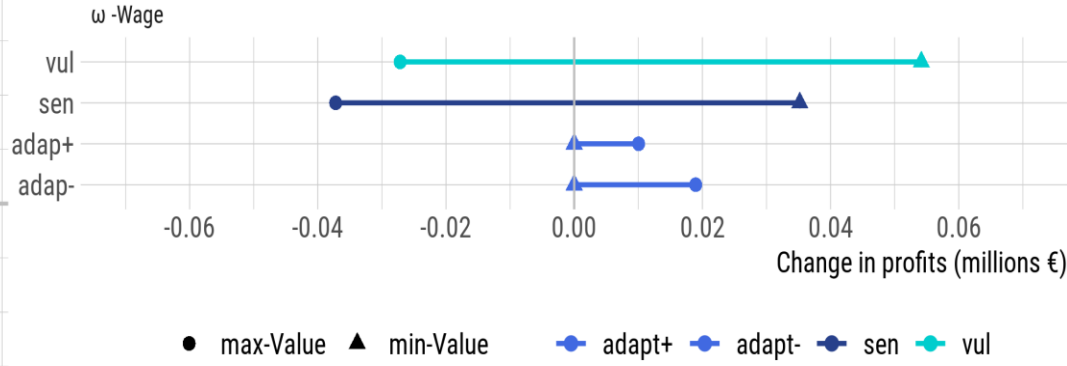
Driver	Meaning	Examples
	fixed costs of harvesting per gear type	• Implemented policy of a entry fee for • fishing in certain areas
	wages	• Market or policy decision to change wages. • Less or more availability of fishing workers

Household Preferences

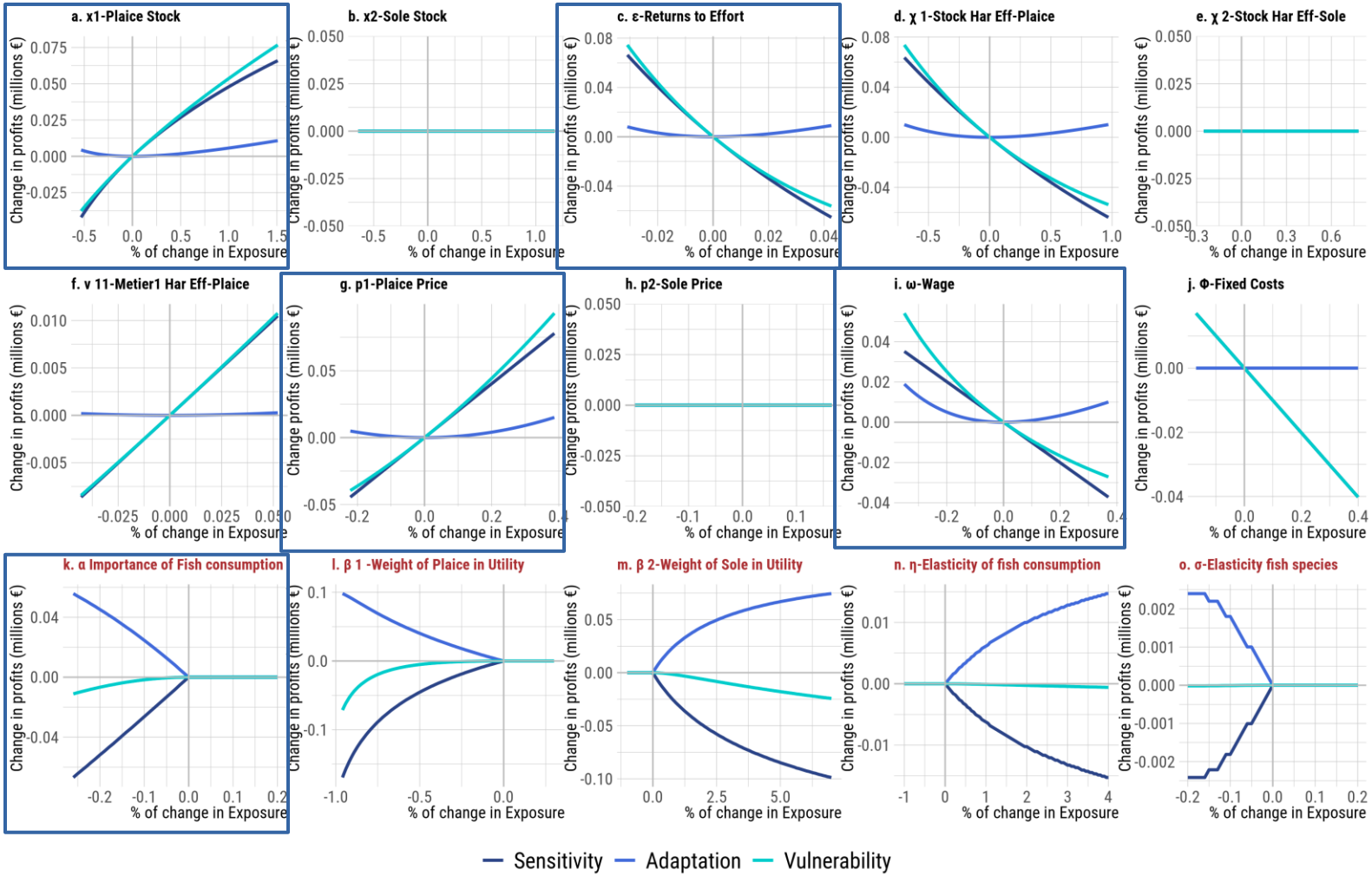
	Weight of the species *i* in the household utility function	**Campaign in favor of one specific specie of fish**, which increases the consumption of one specie with respect to the other.
	Substitution elasticity between plaice and sole	Change in the **willingness to substitute different fish species** in consumption
	Elasticity of fish consumption	Changes in consumer preferences on how much **fish is needed to be satisfied** with fish consumption
	Relative importance of fish consumption for households	**Changes** in consumers preferences towards fish, regarding the **importance of fish consumption**

Results

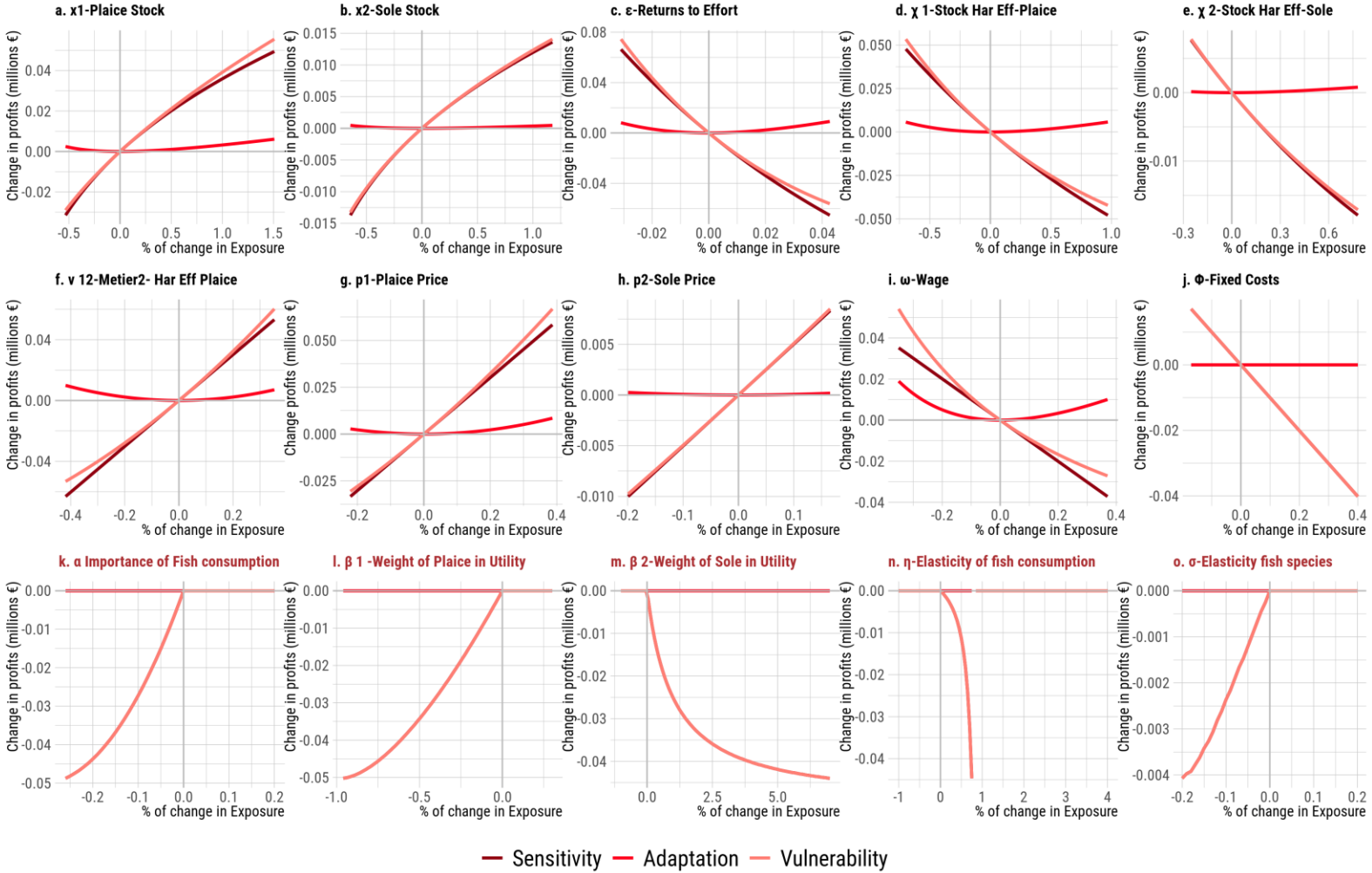

Vulnerbility of profits to changes in Wages
Change profits (millions €)
0.040
0.020
0.000
-0.020
-0.040
-0.2
0.0
0.2
0.4
% of change in Exposure
Sensitivity
Adaptation
Vulnerability
Exposure to decreasing in wages
Status quo Steady State
Exposure to increasing in wages


ω -Wage
vul
sen
adap+
adap-
-0.06
-0.04
-0.02
0.00
0.02
0.04
0.06
Change in profits (millions €)
max-Value
min-Value
adapt+
adapt-
sen
vul

Results: Métier 1-Plaice



Results: Métier 2- Sole



Results

1. Among the sixteen stressors examined, **fishers' profits are most vulnerable to** changes in plaice prices, returns to effort, stock harvesting efficiency of plaice, plaice stocks and wages. Besides, **a marginal increase in fixed costs decrease significantly profits**, and adaptive effort

2. Moreover, our analysis shows that **fishers have a higher adaptive capacity** to changes in **household preferences and wages** than other stressors evaluated.

3. We found that the stressor with the **highest impact on profits is returns to effort.**

4. We show that if **stocks changes** stay within the historical range they **affect profits in a less proportion** than prices, returns to effort or fixed costs.

Conclusion

1. The **framework we developed** disentangle the concepts of sensitivity, adaptive capacity and vulnerability.

2. The **results** enable us to **distinguish** the **most important drivers** that affect **fishers' profits**.

3. **Most of the empirical studies** assess the vulnerability of a system to a **'harm or loss'**, but our results show that by studying also changes in exposure that causes a **'gain in well-being'** allows policy-makers to counteract negative impacts.

4. This **framework** can also be **applied** to other fisheries regions and be used with a **different bio-economic model**.

5. Open research is directed to identify **interactions among multiple stressors** and include another **adaptive capacity** measures.