# Improving the ecological efficiency of the bottom trawl fishery in the Western Mediterranean

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# Improving the ecological efficiency of the bottom trawl fishery in the Western Mediterranean: It's about time!

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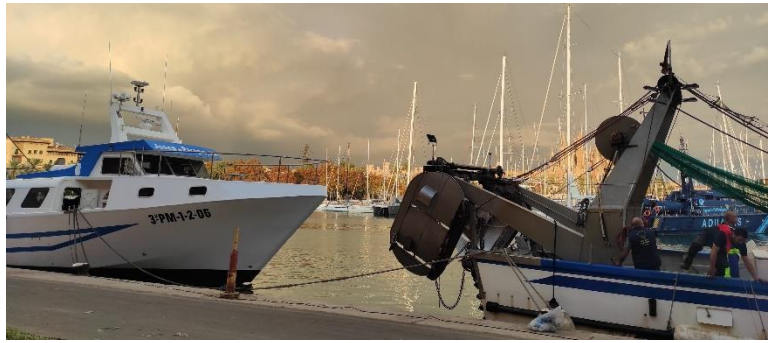
ABSTRACT

The improvement of fishing technology has been detrimental to the sustainability of fisheries, which is particularly clear for the bottom trawl fishery. Reducing its environmental impact is a key point for the development of a more sustainable fishery. The present work analyzed different possibilities to mitigate the impact of gears on the seabed and to increase the efficiency of the bottom trawl fishery of the Western Mediterranean. The analysis of three experiments showed that innovative technical and regulation measures can lead to benefits such as the reduction of fishing effort, the improvement of the cost-benefit relation and the reduction of the direct impact on the seabed and the indirect effect on the ecosystems through reduce discards and the emission of $CO_2$ into the atmosphere. After years of studies focused on improving the sustainability of this fishery, it's about time to turn this improvement into reality.

# Introduction



- Improvement fisheries technology → increase fishing capacity
  - More efficient vessel design
  - More powerful engines
  - Mechanization of fishing operations
  - Vessel positioning systems
  - Eco-sounders and radar
- More stocks exploited at unsustainable levels → reducing fishing mortality (fleet reduction, time at sea, catch limits, changes in mesh regulation)
- Ecosystem approach to fisheries management: social, economic and ecological aspects
  - Short term need for catches & long term need for sustainability of target species, ecosystems and fisheries
- Advances in fishing gear technology would allow to mitigate some of the unwanted effects of fishing → environmentally responsible fishing

# Introduction

- Direct and indirect environmental impacts of fishing activities: seabed, target and non-target species, habitats, trophic webs, biological and functional diversity and emission of $CO_2$ into the atmosphere
- Bottom trawling: low ecological efficiency, impact on the seabed (doors, sweeps and net), discarded catches and fuel consumption per fish harvested
- Measures minimizing impact in the marine environment and entire ecosystem:
  - Improving selectivity
  - Reducing impact on the seabed and benthic habitats
  - Reducing $CO_2$ emissions (reduction of fuel consumption)
- Fuel consumption: Currently an environmental but also an economic problem
- Fuel reduction: modifications in vessel operation routines and innovative fuel-efficiency gears rather than commissioning new energy-saving vessels
  - Highest fuel consumption during fishing trip?

    Coastal fish trawlers in Portugal: trawling > navigation (24%). Simple changes at the trawl level (steeper cuttings in the wings and bellies, and mesh sizes increases in the respective net sections) represented a reduction of up to 18% of fuel consumption

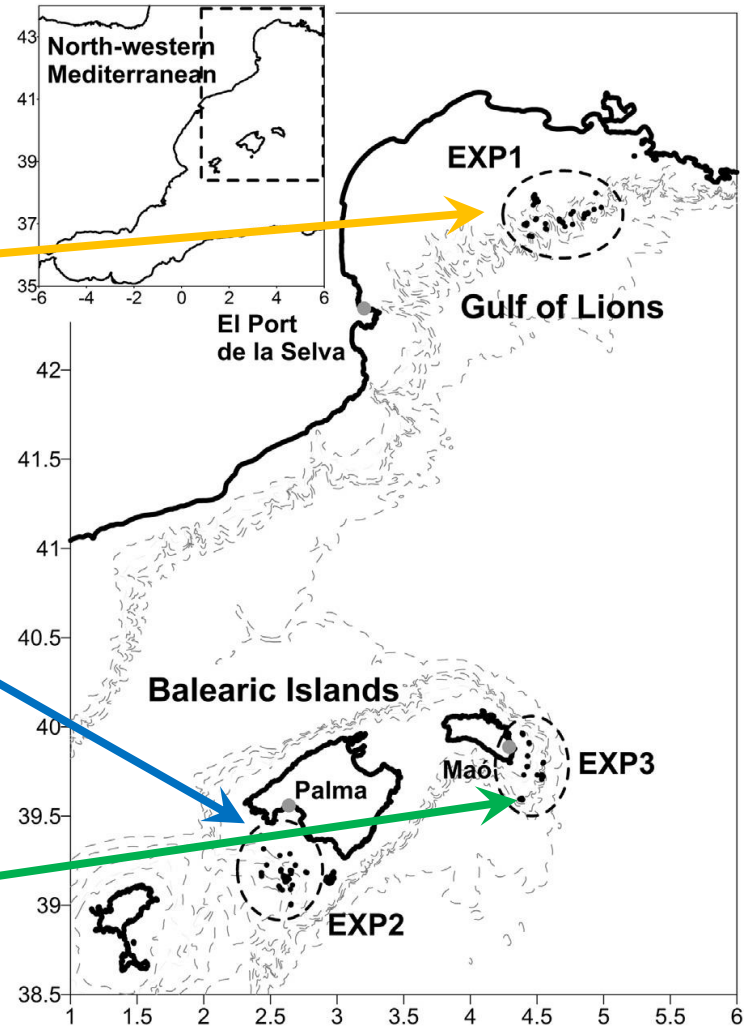
# Objective

- To show different ways to mitigate the impact of fishing gears on the seabed and to increase the efficiency of the bottom trawl fishery of the western Mediterranean, by
  - Improving selectivity (reduction of fishing mortality)
  - Reducing fuel consumption

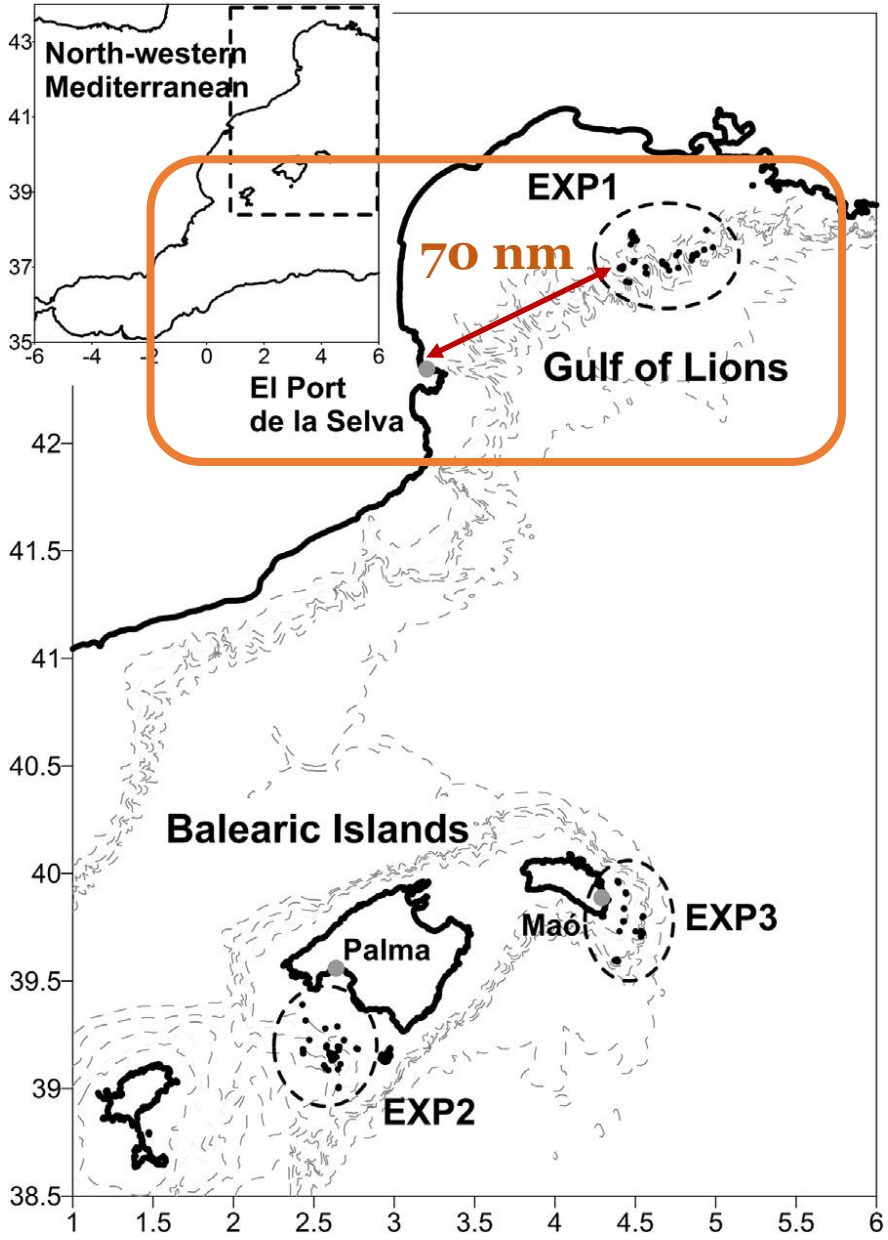
EXP1 (Gulf of Lions)
Changes in vessel operation
From 5-days/week daily trips (12-16h)
to continuous work (46h)

EXP2 (Mallorca)
Change from the traditional doors to more hydrodynamic and lighter doors, shorter sweeps and lighter net

EXP3 (Menorca)
Change from the traditional doors to mid-water doors not touching the seabed



# Material & methods: EXP 1 (Gulf of Lions)




## Changes in vessel operation

Oct-Dec 2007. Two commercial vessels, parallel hauls, changing the net between vessel after each trip

**"TRADITIONAL" Fishing trips**
Mon-Tue: 12 h/day
Wed-Fri: 16h/day

**Mesh in the codend**
40 mm diamond

**"EXPERIMENTAL" Fishing trips**
Total 46 h/week
Mon 2:00 – Tue 23:59

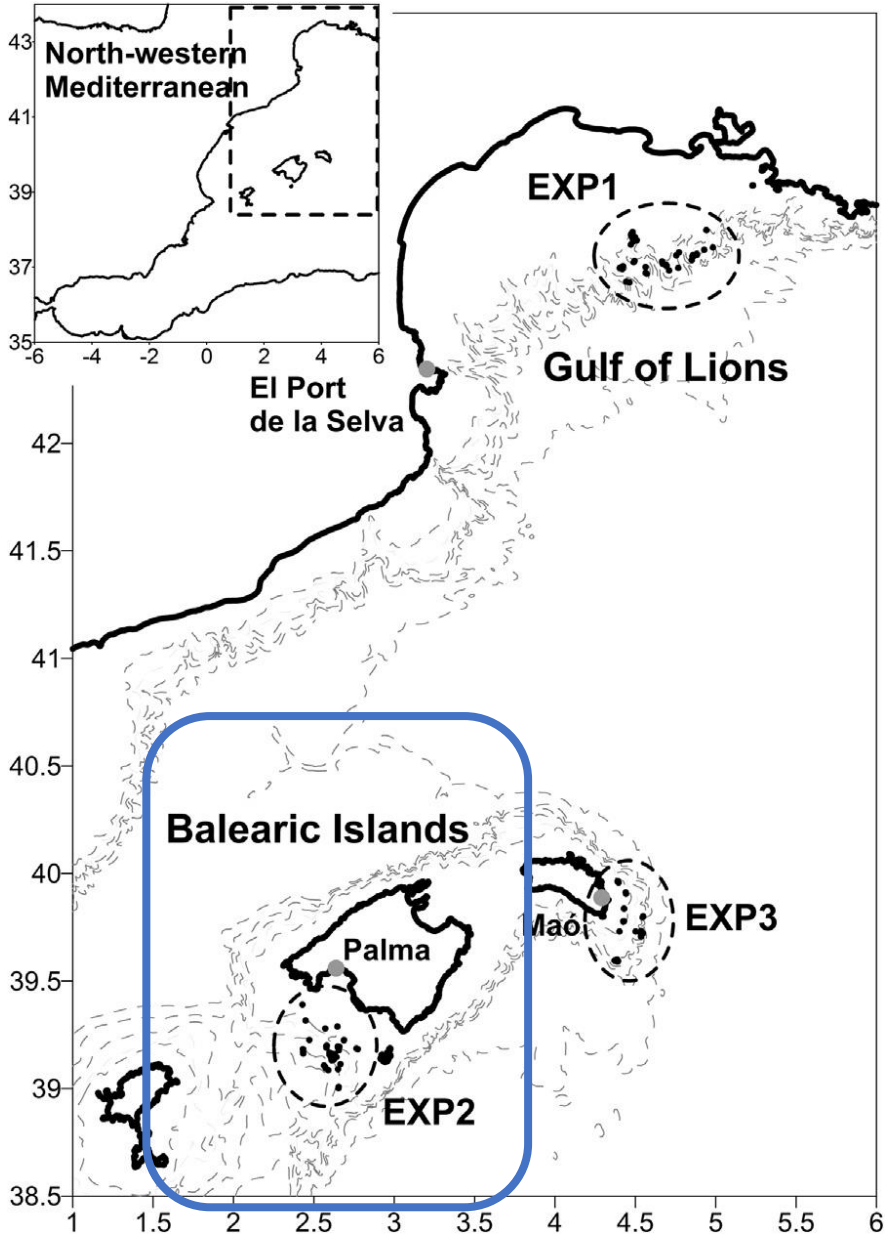
**Mesh in the codend**
40 mm square with 3 mm twine thickness

## STRATA SAMPLED

i) **Upper slope (300-500 m depth):** Norway lobster (*Nephrops norvegicus*)

ii) **Middle slope (500-700 m depth):** blue and red shrimp (*Aristeus antennatus*)

# Material & methods: EXP 2 (Mallorca)




## Changes in doors and gear

Oct-Dec 2008. One commercial vessel, alternative hauls (gear changed weekly)

**"TRADITIONAL" Gear**

Net (900 kg) + 360 m sweeps + doors (670 kg)

**Mesh in the codend**

40 mm diamond

**"EXPERIMENTAL" Gear**

Net (800 kg) + 310 m sweeps + doors (588 kg)

**Mesh in the codend**

40 mm square with 3 mm twine thickness

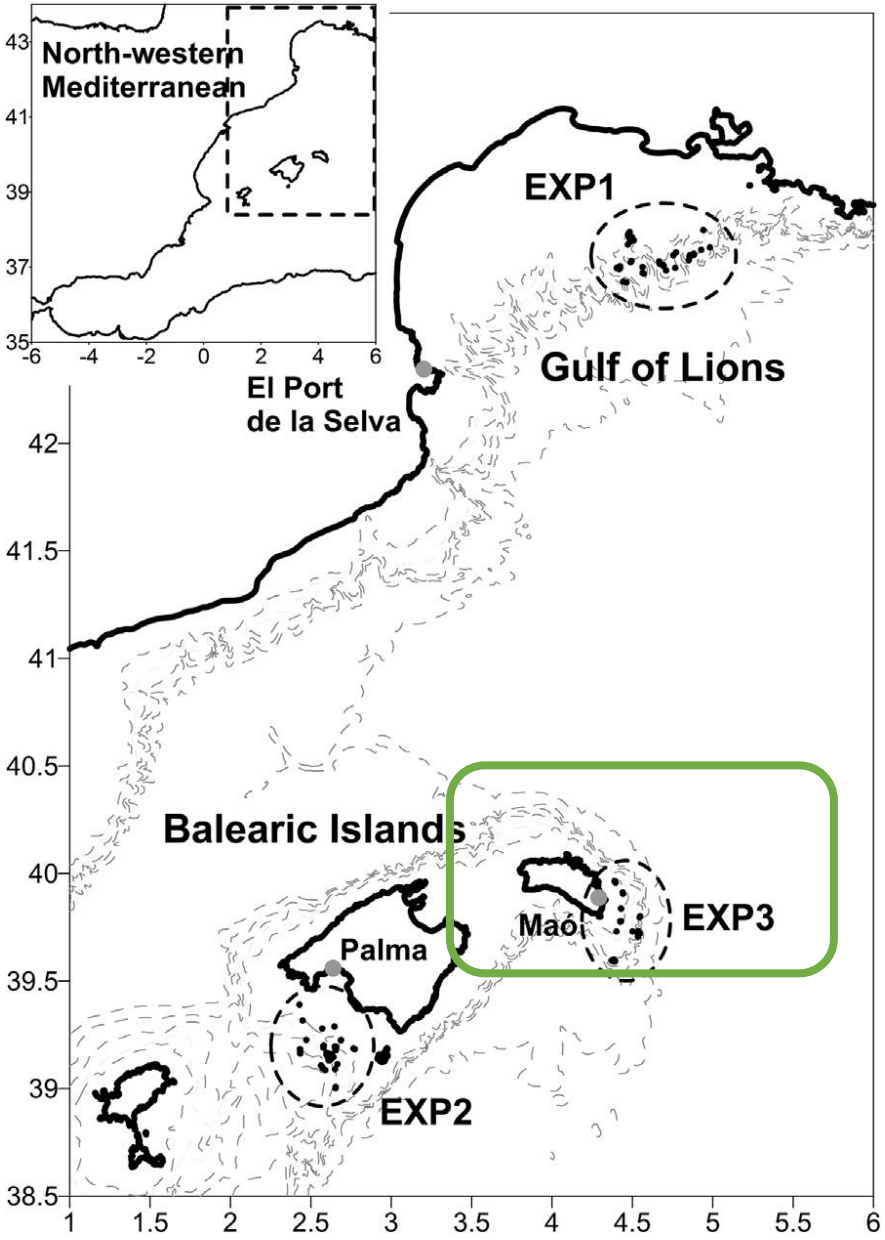
## STRATA SAMPLED

i) **Deep shelf (80-200 m):** hake (*Merluccius merluccius*)

ii) **Upper slope (300-500 m depth):** Norway lobster (*Nephrops norvegicus*)

iii) **Middle slope (500-700 m depth):** blue and red shrimp (*Aristeus antennatus*)

# Material & methods: EXP 3 (Menorca)




## Changes to mid-water doors

Apr-May 2011. One commercial vessel, alternative hauls (gear changed every 10 days aprox.)

**"TRADITIONAL" Gear**

Net + sweeps (690 kg) + doors (550 kg)

**Mesh in the codend**

40 mm diamond with 3 mm twine thickness

**"EXPERIMENTAL" Gear**

Net + sweeps (170 kg) + doors (340 kg) which work 2 m above bottom

**Mesh in the codend**

40 mm square with 3 mm twine thickness

## STRATA SAMPLED

i) **Deep shelf (120-160 m):** hake (*Merluccius merluccius*)

ii) **Middle slope (500-700 m depth):** blue and red shrimp (*Aristeus antennatus*)

# Material & methods: Data analysis


Taxonomic & commercial categories
Weight & number
~~Length distribution →~~ Selectivity

- **Gear behaviour and geometry → Student t-test**
- **Catch composition → RDA, factors:**
  - **EXP1: Vessel and mesh type**
  - **EXP2 & EXP3: Gear type**
- **Yields →Two-way ANOVA**
  - **Catches, landings & discards**
  - **n/hour & kg/hour**

**Fuel efficiency (Student t-test)**

## EXP 1 (G. Lions)
Changes in vessel operation

Fuel cost/first sale value (%€)
Daily fuel consumption/first sale value (l/€)

**By trip**

## EXP 2 (Mallorca)
Changes in doors and gear

Fuel consumption by hour (l/h)
Fuel consumption during fishing time/first sale value (l/€)

**By stratum**

## EXP3 (Menorca)
Changes to mid-water doors

Fuel consumption by hour (l/h)
Fuel consumption during fishing time/first sale value (l/€)

**By stratum**

# Results: Gear behaviour

## EXP1 (Gulf of Lions)
### Changes in vessel operation

| Depth | VO |
|---|---|
| 300-500 m | ns |
| 500-700 m | B1>B2 |

## EXP3 (Menorca)
### Changes to mid-water doors

| Depth | DO | HO | VO |
|---|---|---|---|
| 120-160 m | TRA<EXP | ns | TRA<EXP |
| 500-700 m | TRA<EXP | ns | ns |

## EXP 2 (Mallorca)
### Changes in doors and gear

| Depth | DO | HO | VO |
|---|---|---|---|
| 80-200 m | TRA<EXP | TRA<EXP | TRA<EXP |
| 300-500 m | TRA<EXP | TRA<EXP | ns |
| 500-700 m | TRA<EXP | TRA<EXP | TRA>EXP |

| Depth | Tension | Water flow | |
|---|---|---|---|
| | | Funnel | Codend |
| 80-200 m | TRA>EXP | TRA<EXP | TRA<EXP |
| 300-500 m | TRA<EXP | TRA<EXP | TRA<EXP |
| 500-700 m | TRA<EXP | TRA<EXP | TRA<EXP |

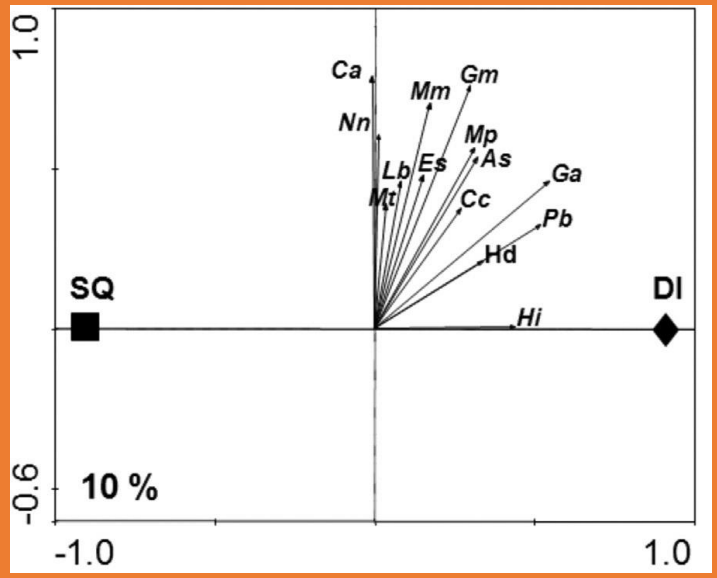
DO: door opening; HO: horizontal opening; VO: vertical opening

# Results: Yields and catch composition

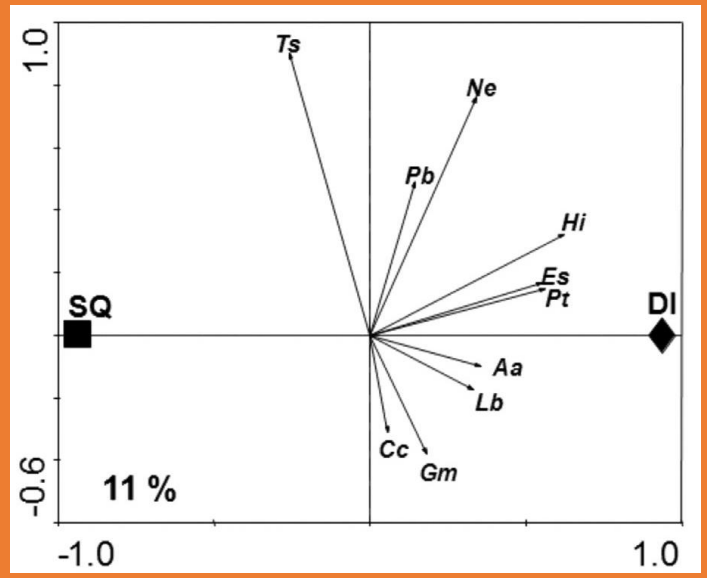
## EXP 1 (Gulf of Lions). Changes in vessel operation

| Depth | Mesh type | n/h | kg/h |
|---|---|---|---|
| 300-500 m | COM | ns | ns |
| | DISC | DI>SQ | ns |
| | TOT | DI>SQ | ns |
| 500-700 m | COM | ns | ns |
| | DISC | ns | ns |
| | TOT | ns | ns |

**Discards (n/h) 300-500 m**




**Discards (n/h) 500-700 m**

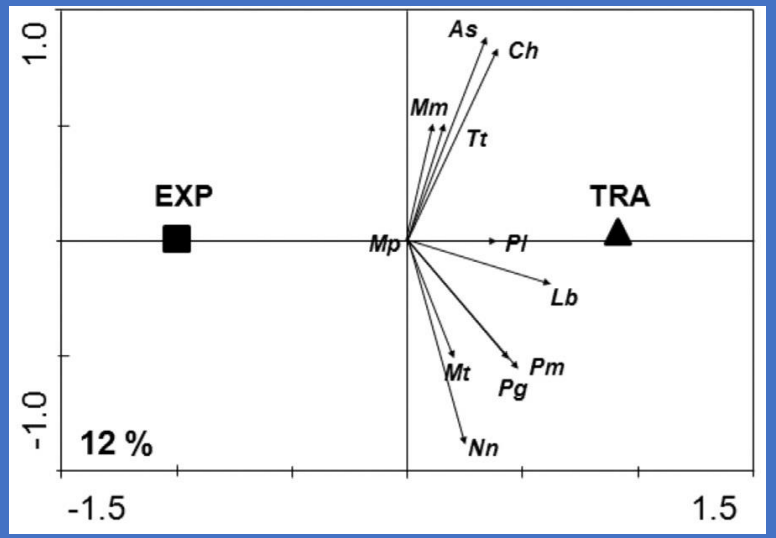



**COM: commercial catches; DISC: discards; TOT: total catch**
**DI: diamond mesh; SQ: square mesh**

# Results: Yields and catch composition

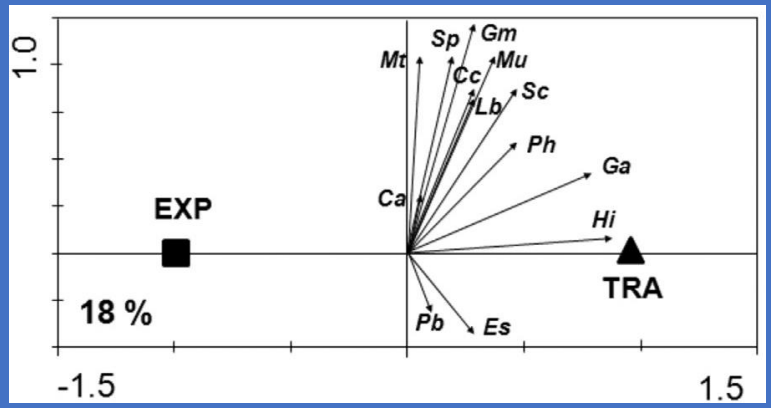
## EXP2 (Mallorca). Changes in doors and gear

| Depth | Mesh type | n/h | kg/h |
|---|---|---|---|
| 80-200 m | COM | ns | ns |
| | DISC | ns | ns |
| | TOT | ns | ns |
| 300-500 m | COM | TRA>EXP | ns |
| | DISC | TRA>EXP | ns |
| | TOT | TRA>EXP | ns |
| 600-700 m | COM | ns | ns |
| | DISC | ns | ns |
| | TOT | ns | ns |




**Commercial (n/h)**
**300-500 m**

**Discards (n/h)**
**300-500 m**




**COM: commercial catches; DISC: discards; TOT: total catch**
**TRA: traditional gear; EXP: experimental gear**

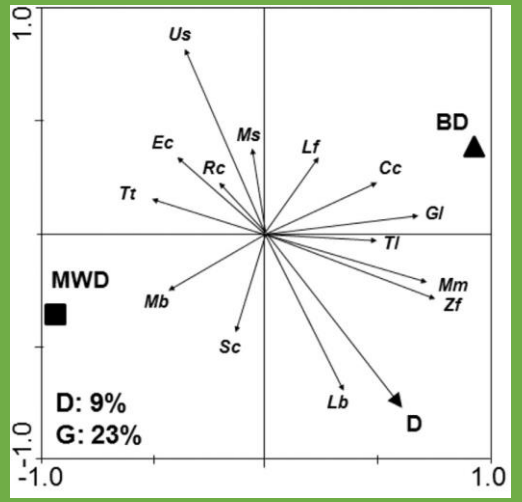
# Results: Yields and catch composition

## EXP3 (Menorca). Changes to mid-water doors

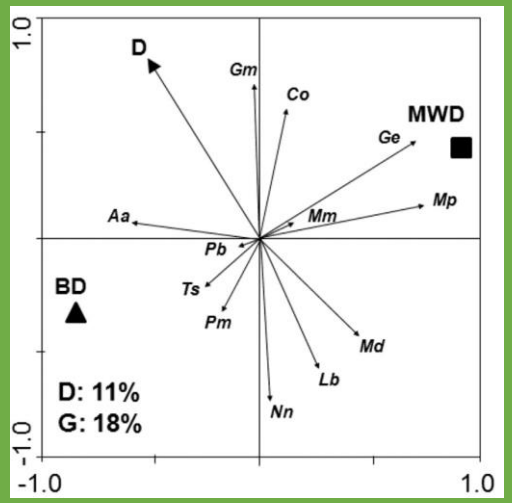
| Depth | Mesh type | n/h | kg/h |
|---|---|---|---|
| 120-160 m | COM | TRA>EXP | ns |
| | DISC | ns | ns |
| | TOT | ns | ns |
| 500-700 m | COM | TRA>EXP | ns |
| | DISC | ns | ns |
| | TOT | TRA>EXP | ns |

COM: commercial catches;
DISC: discards; TOT: total catch
TRA: traditional gear;
EXP: experimental gear

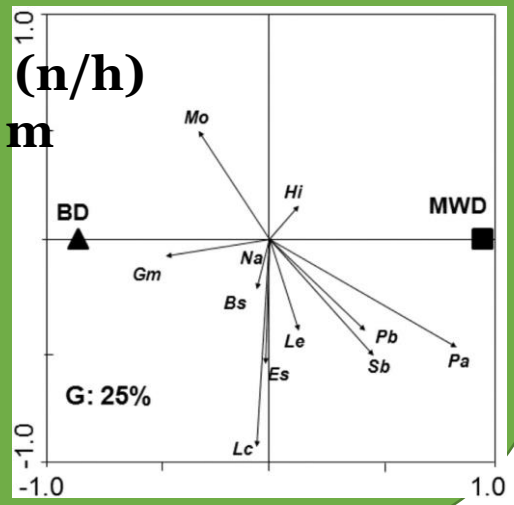
**Commercial (n/h)**
**120-160 m**




**Commercial (n/h)**
**500-700 m**




**Discards (n/h)**
**500-700 m**



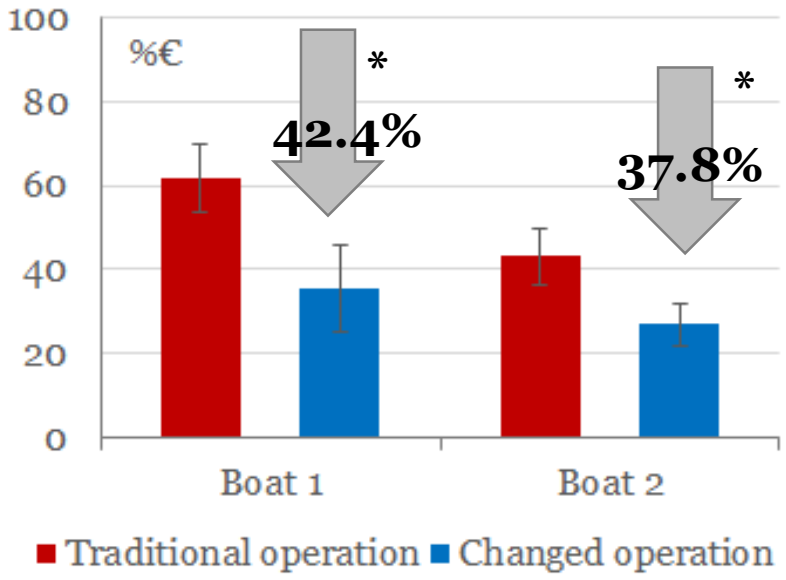
# Results: Fuel efficiency

## EXP 1 (Gulf of Lions). Changes in vessel operation

*: p<0.05; **: p<0.01; ***: p<0.001

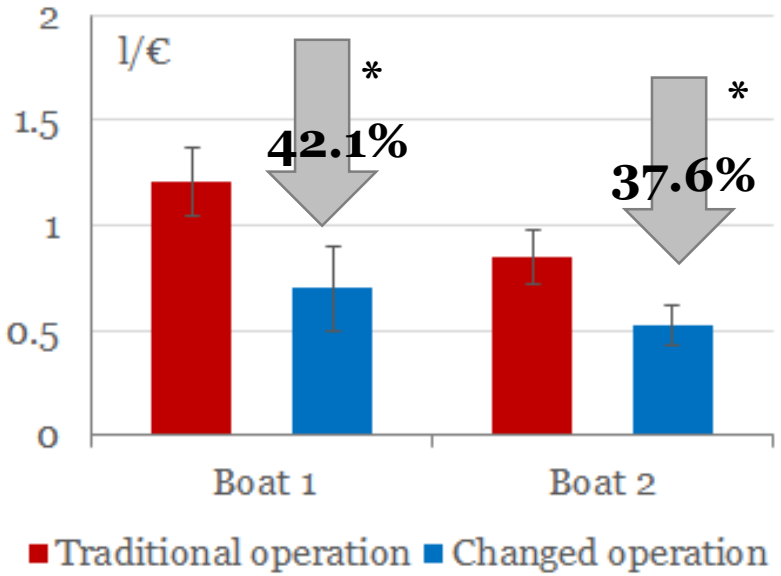
### Fuel cost/first sale value (%€)

Comparison between two periods
By trip




### Daily fuel consumption/first sale value (l/€)

Comparison between two periods
By trip



# Results: Fuel efficiency

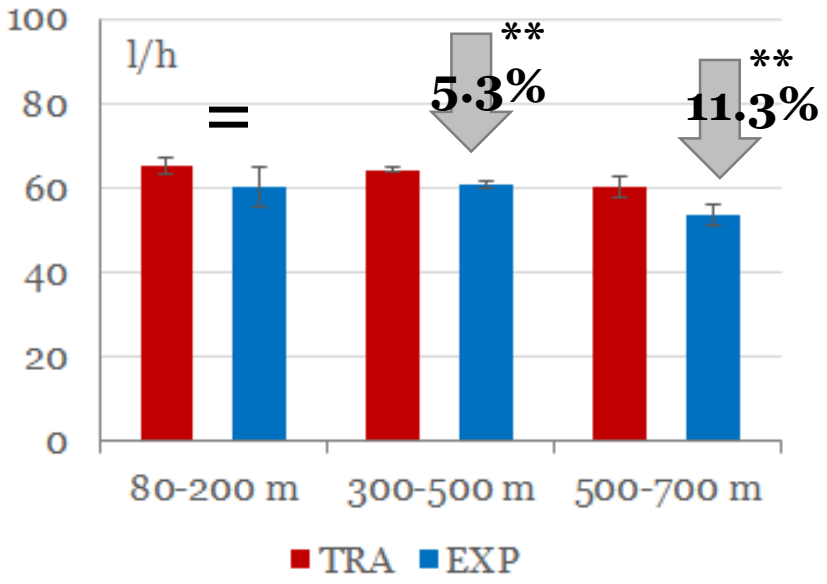
## EXP2 (Mallorca). Changes in doors and gear

*: p<0.05; **: p<0.01; ***: p<0.001

### Fuel consumption by hour (l/h)

Traditional vs experimental

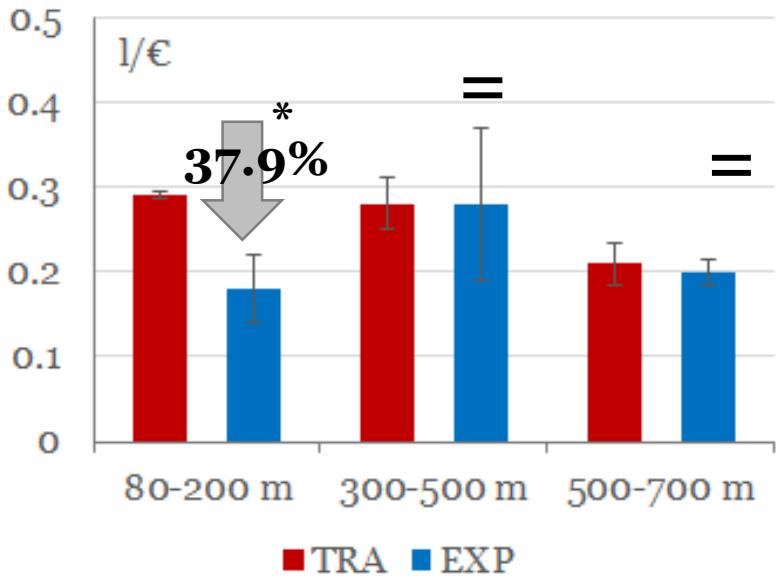
By stratum




### Fuel consumption during fishing time/first sale value (l/€)

Traditional vs experimental

By stratum

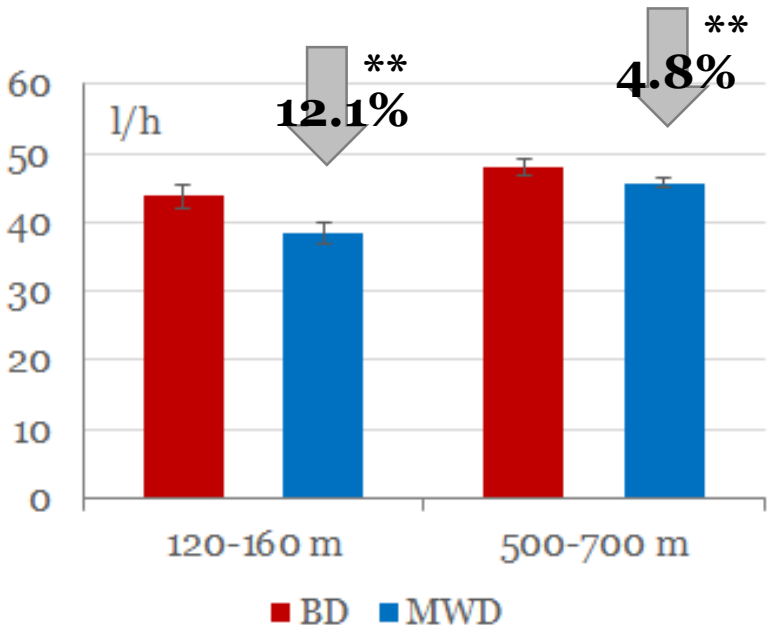


# Results: Fuel efficiency

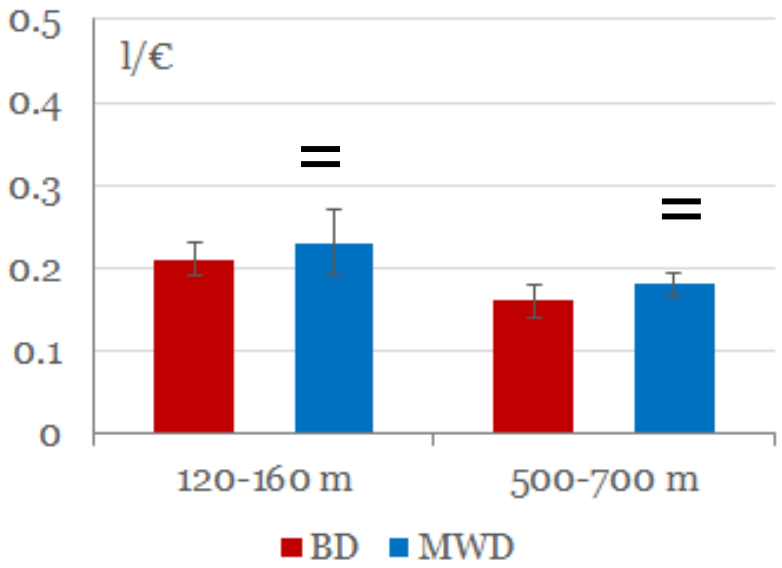
## EXP3 (Menorca). Changes to mid-water doors

*: p<0.05; **: p<0.01; ***: p<0.001

**Fuel consumption by hour (l/h)**
Bottom doors vs mid-water doors
By stratum



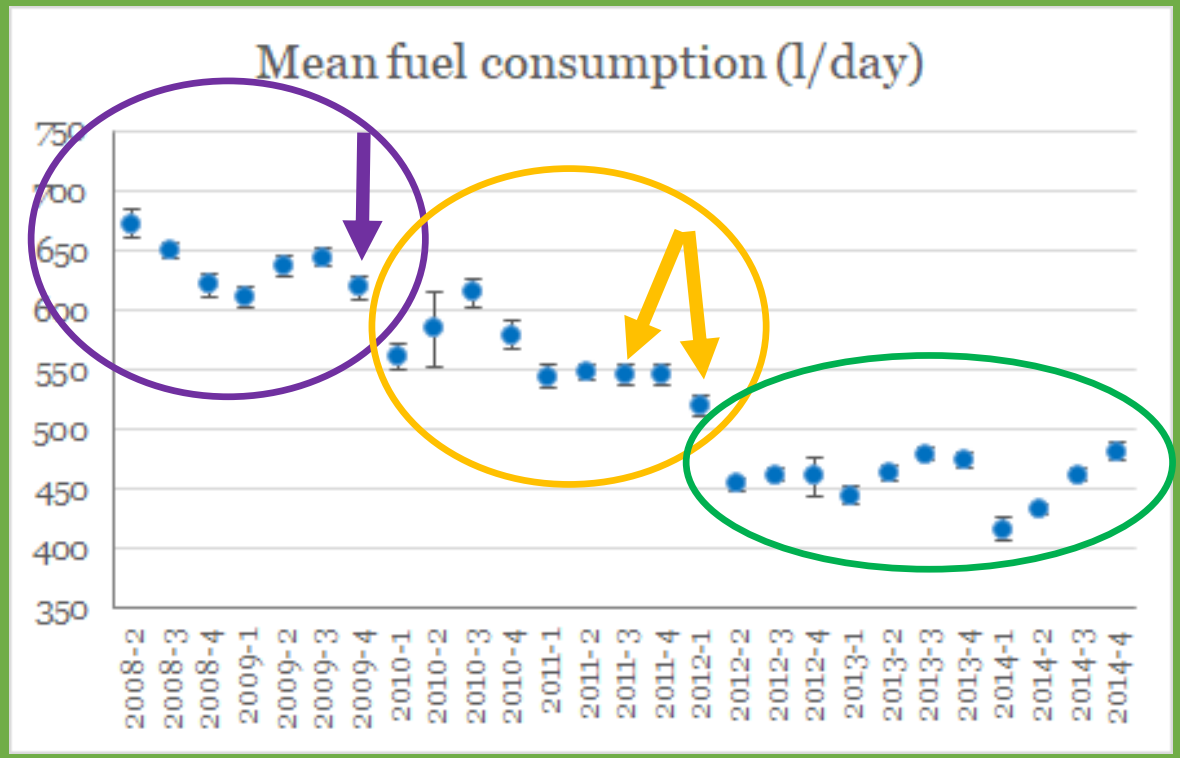

**Fuel consumption during fishing time/first sale value (l/€)**
Bottom doors vs mid-water doors
By stratum



# Results: Fuel efficiency

## EXP3 (Menorca). Changes to mid-water doors

**Fuel saving measures: reduction of boat speed when sailing to fishing grounds and a change of gear netting to low the drag coefficient**




**Beginning of EXP3 and the end of the adjustments in the gear (weight reduction of the in-line chain and reduction of sweeps' length)**

**0.54 l/€**
**628 l/day**

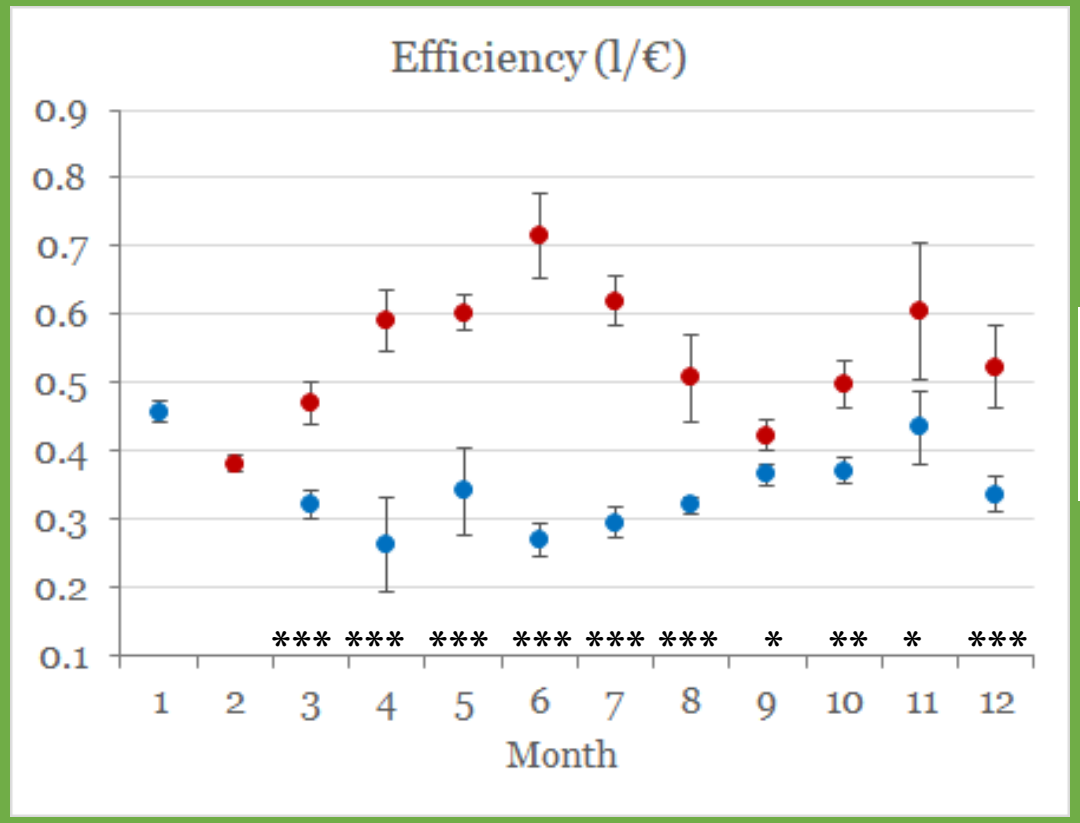
**0.34 l/€**
**463 l/day**

**37.0%**
**26.3%**

# Results: Fuel efficiency

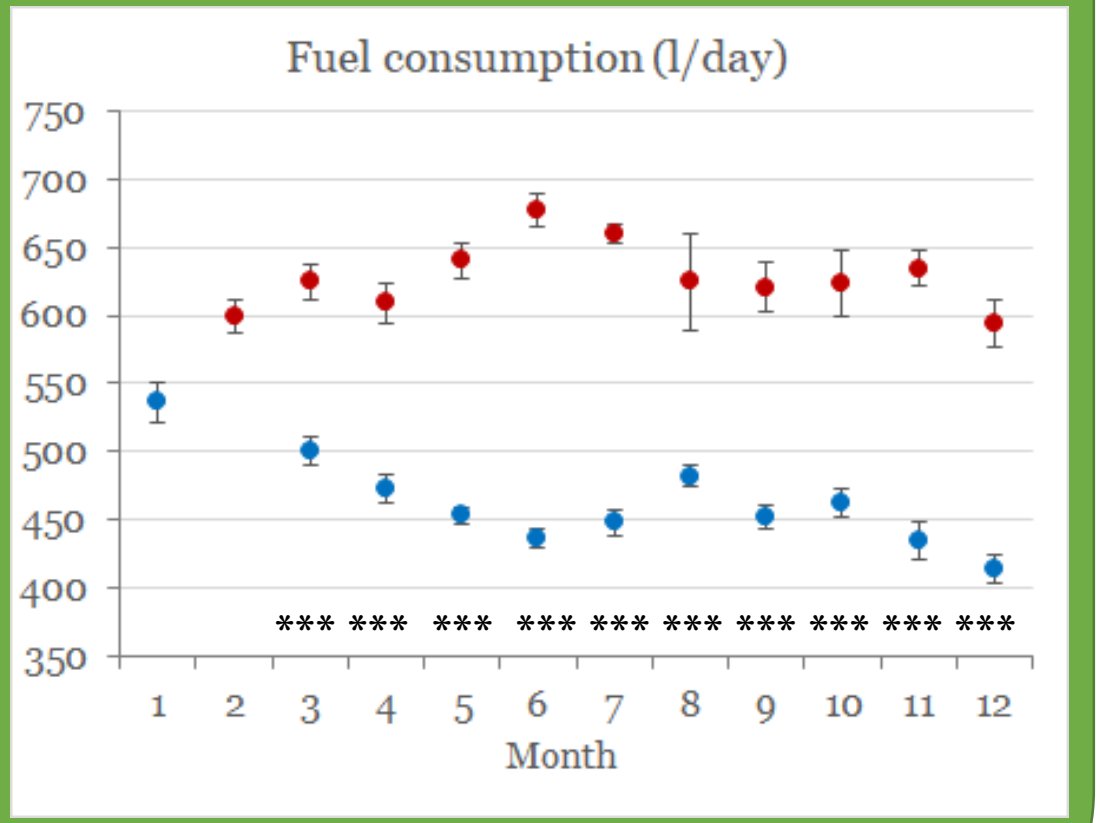
## EXP3 (Menorca). Changes to mid-water doors

*: p<0.05; **: p<0.01; ***: p<0.001




2009

2012



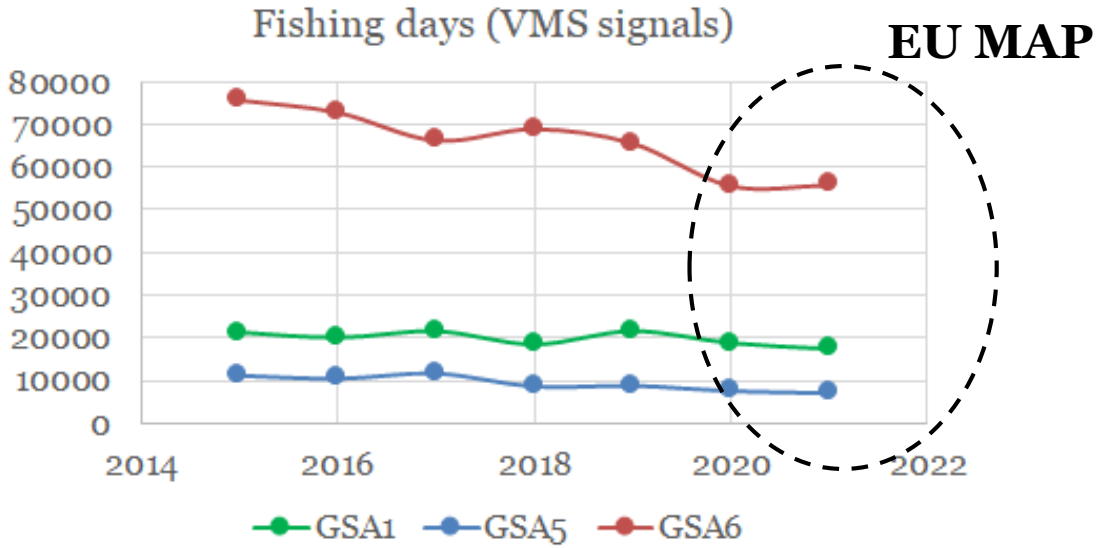

2009: bottom doors, without fuel-saving measures
2012: mid-water doors and additional fuel-saving measures

# Final remarks

- Specific surveys carried out under commercial conditions:
  - ➢ Statistically valid sampling design vs absence of interference with commercial routines
- Reduction of discards with square mesh codend (EXP1, EXP2)
- EXP1 (Change in vessel operation. Gulf of Lions):
  - ✓ No differences in commercial landings
  - ✓ Fishing effort reduction (Effective fishing time by week: 18 h vs 20-30 h)
  - ✓ Increase fishing and ecological efficiency (reduction of $CO_2$ emissions)
  - ✓ Life quality
  - x Un- or low-exploited grounds accessible to trawl fishery (currently FRA)
- EXP2 (Lighter gear. Mallorca):
  - ✓ Reduction of fuel consumption during effective fishing time
  - ✓ Lighter gear: reduction of direct impact of the gear on the seabed
  - x Increase doors opening: increase of the impacted seabed surface (reducing sweeps' length)
- EXP 3 (Mid-water doors. Menorca):
  - ✓ Larger door opening but same horizontal opening of the net
  - ✓ Reduction seabed impact from the doors, reduction of fuel consumption (absence of friction)
  - x Five months to adjust the gear (ballast chain and sweeps length reduction)

# Final remarks

- All are plausible technical measures to be taken and to properly reduce the impact of bottom trawling on the seabed and the emission of $CO_2$ into the atmosphere
- Improvement of the ecological efficiency and direct positive consequences in the short term → reduction of operation costs and improvement of economic efficiency
  - Some measures proposed in the management of fisheries do not show in the short term the expected results that will only be reached in the medium and long term (acceptance and understanding means successful implementation)
- Current state




**EU MAP**

**2015-2017 vs 2021 – Fishing days reduction bottom trawl fleet**

GSA 1 (Northern Alboran Sea): 15.9%

GSA 5 (Balearic Islands): 35.2%

GSA 6 (Northern Spain): 22.0%

**Total: 25.4%**

2022: 6%

2023: 3.5% coastal; 7% deep-water

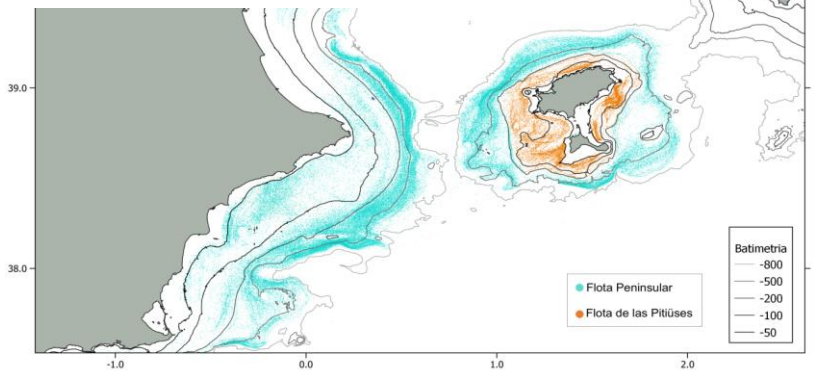
# Final remarks

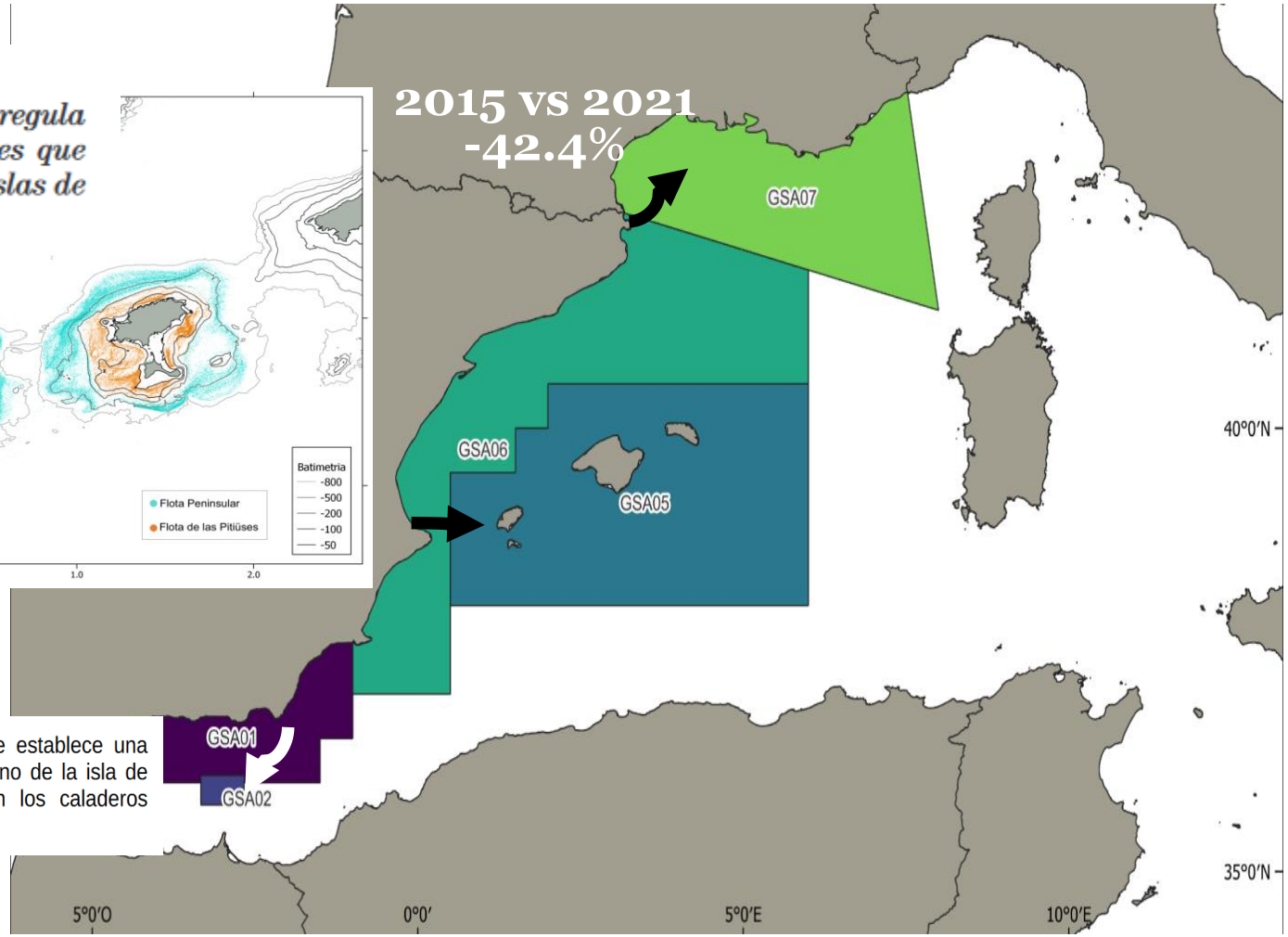
- Current state

EXP1
Changes in vessel operation

Not used. Other areas

*ORDEN APA/1728/2005, de 3 de junio, por la que se regula la actividad de los buques de arrastre peninsulares que faenan en aguas profundas de los caladeros de las islas de Ibiza y Formentera.*




Orden de 8 de septiembre de 1998 por la que se establece una reserva marina y una reserva de pesca en el entorno de la isla de Alborán y se regula el ejercicio de la pesca en los caladeros adyacentes.

# Final remarks

- Current state

EXP2
Change to more hydrodynamic and lighter doors and lighter net

Still in use.

Other initiatives.

EXP3
Change to mid-water doors

Still in use.

Other boats, unequal implementation, but all along the Mediterranean coast

Plans to implement them in 2023

# Thanks for your attention

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