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DecarbonyT-Collaborative efforts towards a greener fishing industry in the Mediterranean and Black Sea

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Project Officer at WWF Mediterranean

Partnership: Sala, A., Accadia P., Adamidou, A., Barbetti, L., Besbes, M.K., Bitetto I., Buzzi, A., Carbonara, P., Casini, M., Ceballos, V., Cerdà, M., Coll, M., Conides, A., Costantini, M., Damalas, D., Danilov, C.S., De Carlo, F., Dimitrov, D., Ferrà, C., Galea, J., Geraci, M.L., Guijarro, B., Koutrakis, E., Isajlović, I., Liontakis, A., Li Veli, D., Lucchetti, A., Mangano, M.C., Mantas, G.D., Maravelias, C., Medvesek D., Mytilineou, C., Neglia, C., Notti, E., Ordinas, F., Ortega, Petetta, A., Raykov, V., Rinalduzzi, S., Rosini, A., Russo, T., Sbrana, M., Scarcella, G., Stagioni, M., Tassetti, A.N., Tiganov, G., Touloumis, K., Vianson, G., Vitale, S., Vrgoc, N., Zlateva, I.

25 November 2025

Overview of the *DecarbonyT* project

Project management and scientific coordination *(Antonello Sala)*

Review of the state of play *(Tommaso Russo)*

Pilot project for improved fishing gears development and testing at sea *(Antonello Sala / Beatriz Guijarro)*

Socio-economic analysis and conclusions from gear testing *(Paolo Accadia)*

Dissemination and stakeholder engagement *(Marco Costantini / Valentina Ceballos)*

Project website

DecarbonyT
DECARBONISATION OF THE FISHING FLEET
IN THE MEDITERRANEAN AND BLACK SEA

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DECARBONISATION OF THE FISHING FLEET
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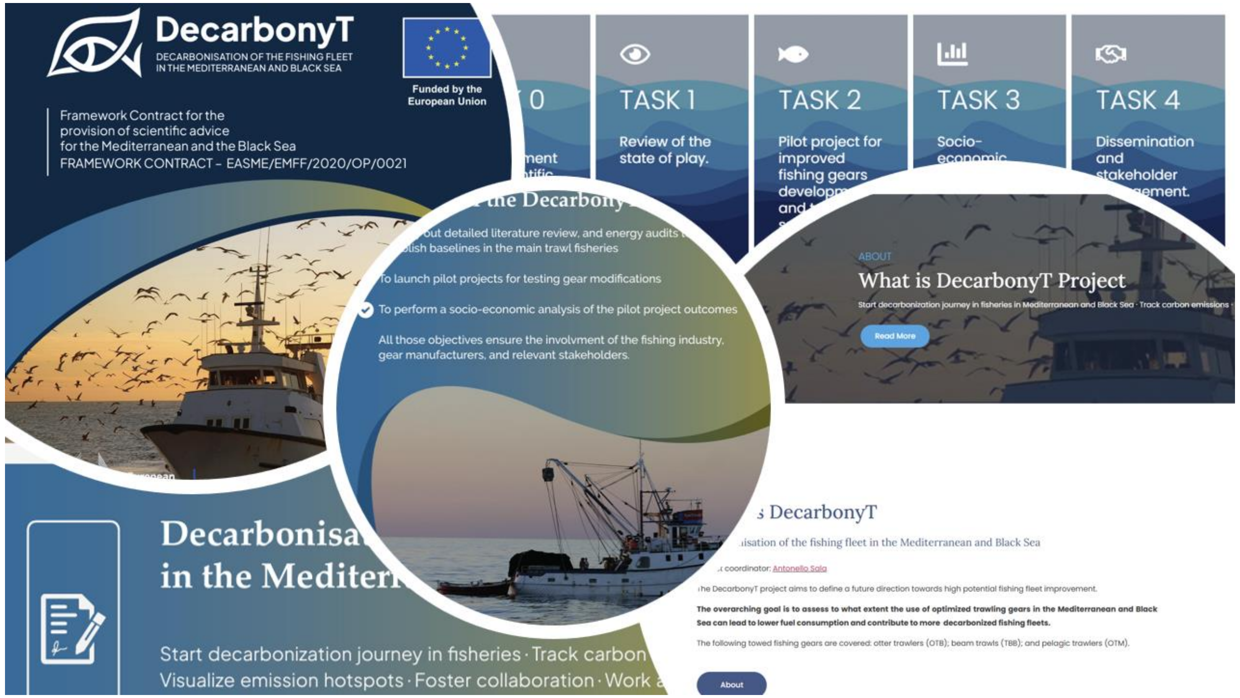

https://www.decarbonyt.eu

DecarbonyT-Collaborative efforts towards a greener fishing industry in the Mediterranean and Black Sea

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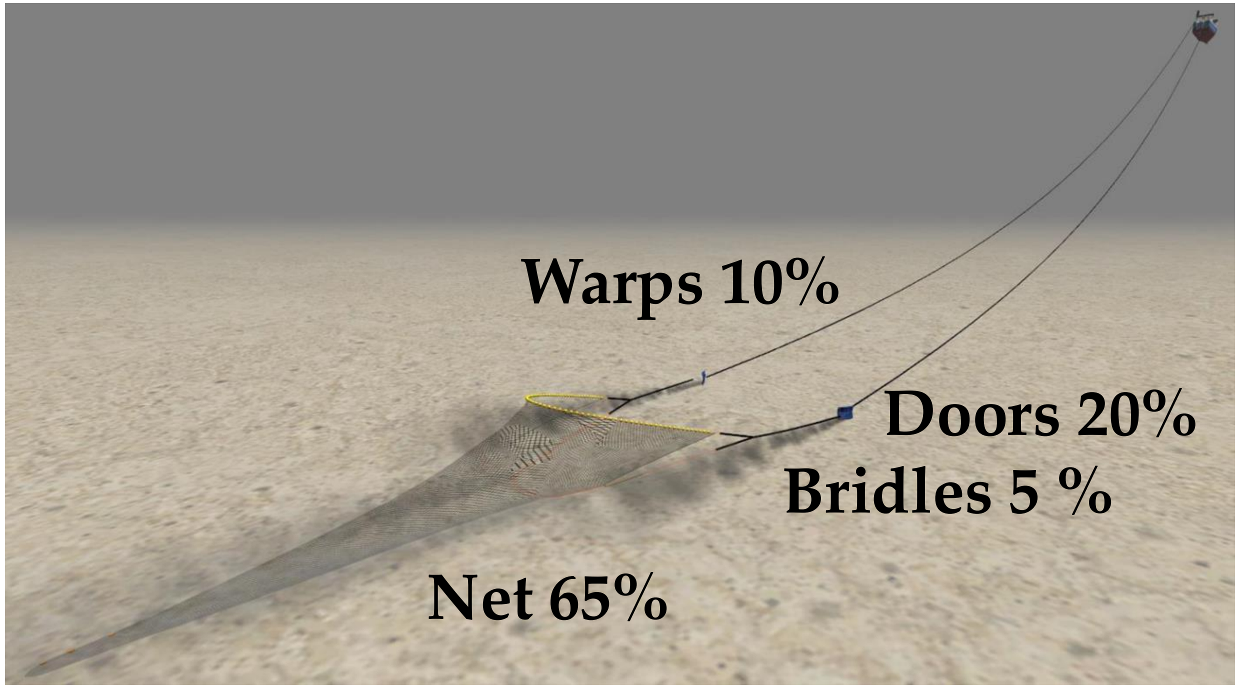
Presentation Overview

1) Pilot studies for fuel saving trawling gears
2) Energy audits
3) Development of low impact and fuel-efficient gears
4) ~~Methodological framework and instrumentation~~

Gear drag significantly impacts fuel consumption



Source: modified and adapted from Fiorentini and Hansen (1995), Sala et al. (2008).

- Sala *et al.* (2008): replacement of knotless polyamide netting sections in the wings with knotted *Rubitech* panels and redesigning the trawl wings: energy saving of 30% while maintaining the same engine power.
- Novel otterboard designs to reduce hydrodynamic drag coefficient and seabed impact (Sala *et al.*, 2010; 2023): fuel savings of up to 15-20%.

Pilot studies defined by gear and area combinations

Pilot	Gear (Area)	Leader	Partners	Topic(s)	LOA[m] Power[kW]	Depth [m]	Target species
1	OTB Western Mediterranean (GSA1-7)	Francesc Ordines	IEO-CSIC, CNR	Shift to midwater doors, fuel-saving net design, including sweeps reduction, elimination of bridles, lower vertical opening, hydrodynamic floats, square-mesh panels in the extension.	LOA 25 323 kW	69-93	HKE MUT MNZ
2	OTB Tyrrhenian (GSA9-10)	Mario Sbrana	CIBM, CNR, SZN, CONISMA	Novel otterboards (semi-pelagic). Redesigned net features on upper netting panels, while maintaining the lower panels and commercial groundgear. Increasing mesh sizes in upper wings and square, modifying cutting angles, and hanging ratio between headline and top wings to enhance waterflow. Reducing width of bosoms.	LOA 19 441 kW	100-200	DPS HKE
3	OTB Central Mediterranean (GSA15-16)	Sergio Vitale	CNR, ABT	Alternative lighter otterboards made by steel frames and Plexiglas plates. Trawl's upper panels manufactured with high density polyethylene (PE) fibre and larger meshes in the wings. Replacement of the headline with 4 strands 28 mm polysteel, and the groundrope with a 38 mm PA to minimise seabed friction.	LOA 29.50 720 kW	400-800	ARA ARS
4	OTB Adriatic and Ionian (GSA17-19)	Pierluigi Carbonara	COISPA, CNR, CONISMA	Shifting from conventional demersal otterboards to semi-pelagic otterboards. New trawl design and use of high strength material, larger meshes a different groundrope.	LOA 20 447 kW	150-250	HKE DPS MUT SQM
5	OTB Adriatic and Ionian (GSA17-19)	Nedo Vrgoc	IOF, CNR	New hydrodynamic efficient trawl doors, designed to reduce hydrodynamic drag coefficient and increase spread. Optimization of trawl design including use of high strength material and larger meshes. Use of lighter drag components running over the seabed to reduce contact and therefore fuel consumption.	LOA 23 223 kW	80-120	HKE MUT NEP DPS MON EOI

Pilot studies defined by gear and area combinations

Pilot	Gear (Area)	Leader	Partners	Topic(s)	LOA[m] Power[kW]	Depth [m]	Target species
6	OTB Eastern Mediterranean (GSA22-23)	Alexis Conides	HCMR, FRI, CNR	New trawl net design manufactured with high strength and lighter (thinner twine) netting material (Dyneema). Novel semi-pelagic otterboard towed at 2-3 m above the seabed.	LOA 33.2 367 kW	25-120	HKE MUX DPS
7	OTB Black Sea (GSA29)	Violin Raykov	IO-BAS, NIMRD, CNR	Lighter otterboards contrasted with traditional flat wooden otterboards. Experimental trawl designed with the aim of obtaining lower towing resistance. Full scale experimental trawl manufactured based on the results from mathematical simulations.	LOA 14.90 220 kW	20-80	TUR RJC
8	TBB Adriatic and Ionian (GSA17-19)	Alessandro Lucchetti	CNR	Change the orientation of the teeth in the Rapido trawl. Teeth are rotated 180°, positioning their convex side facing the codend. To ensure proper contact with the seabed, an additional metal bar was installed approximately 30 cm from the front of the sleds to support the repositioned teeth.	LOA 25.64 623 kW	20-50	SOL BOY
9	TBB Black Sea (GSA29)	Violin Raykov	IO-BAS, NIMRD, CNR	Same beam width, ground plate chain measures 10x50 mm, the experimental TBB has high-strength lower plate chain of 6x30 mm, reducing overall weight and drag. Traditional TBB features a metal net of 42 mm steel with a 6 mm diameter in the bottom section (removed in the experimental TBB). Experimental TBB with 10 mm high-density polyethylene (HDPE) lower panel for protection, to reduce friction with the seabed.	LOA 14.90 220 kW	20-40	RPW
10	OTM Black Sea (GSA29)	Cristian Danilov	IO-BAS, NIMRD, CNR	Shifting to lighter demersal otterboards. New net design developed to reduce unnecessary components and using lighter netting materials in the aft parts of the trawl net. Additionally, larger meshes in specific sections and lower-drag gear configurations will further strengthen fuel savings.	LOA 11.75 336 kW	20-50	MUT HMM BLU

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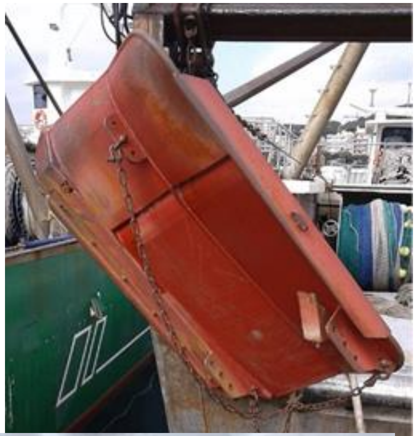
Bottom otter trawl (OTB) fisheries

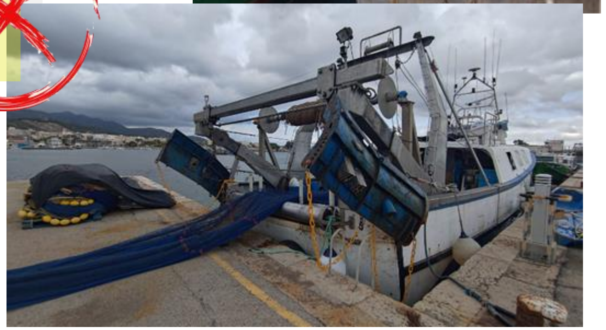
Western Mediterranean (OTB, GSA1-7)

Shift to midwater doors, fuel-saving net design, including sweeps reduction, elimination of bridles, lower vertical opening, hydrodynamic floats, square-mesh panels in the extension.

Parameter / Gear	Q [l/h]	LPUE [kg/h]	DPUE [kg/h]	FUI [l/kg]	Income [Eur/h]
1st Traditional	**89.4** (1.3)	**36.1** (2.0)	**6.6** (0.5)	**2.564** (0.127)	**223.9** (11.2)
Experimental	**83.4** (1.5) (**)	**33.0** (2.0)	**8.3** (1.0)	**2.653** (0.163)	**213.0** (13.0)
2nd Traditional	**104.6** (3.9)	**36.3** (2.9)	**6.1** (0.3)	**2.927** (0.171)	**258.7** (16.4)
Experimental	**88.0** (1.4) (**)	**38.9** (2.1)	**10.2** (2.7)	**2.292** (0.137)	**241.9** (16.2)

Fuel consumption, Q[l/h]; landing and discards per unit effort, LPUE and DPUE [kg/h]; fuel use intensity, FUI[l/kg fish] for each gear configuration.





Tyrrhenian (OTB, GSA9-10)

Novel otterboards (semi-pelagic). Redesigned net features on upper netting panels, while maintaining the lower panels and commercial groundgear. Increasing mesh sizes in upper wings and square, modifying cutting angles, and hanging ratio top wings to enhance waterflow.

Parameter / Gear	Q [l/h]	LPUE [kg/h]	DPUE [kg/h]	FUI [l/kg]
Traditional	46.4 (3.6)	31.2 (3.7)	11.0 (2.5)	1.510 (0.219)
Experimental	39.0 (1.4)	26.9 (4.5)	11.1 (5.3)	1.491 (0.255)

Fuel consumption, Q[l/h]; landing and discards per unit effort, LPUE and DPUE [kg/h]; fuel use intensity, FUI[l/kg fish] for each gear configuration.

Improvement of otterboard design

	Parameter		VEE	VF15	Diff.	Diff%
Towing speed	TS	[kn]	3.85	3.25	-0.60	-15.6%
Horizontal door spread	HDS	[m]	61.13	86.57	25.45	41.6%
Horizontal net opening	HNO	[m]	19.88	24.61	4.74	23.8%
Vertical net opening	VNO	[m]	1.67	1.70	0.03	1.6%
Fuel consumption rate	FCR	[kg/h]	58.74	48.16	-10.59	-18.0%
Area explored in 1-hour-haul	AEH	[$1000m^2$]	141.72	148.15	6.43	4.5%
Fuel consumption per area explored	FCH	[$kg/1000m^2$]	0.41	0.33	-0.09	-21.6%

Improvement of otterboard design

Hour/Day	OTB, TBB			
	Mon	Tue-Wed	Thu	Week
Harbour (H)	2	1	15	19
Sailing (S)	3	4	2	13
Towing (T)	19	19	7	64

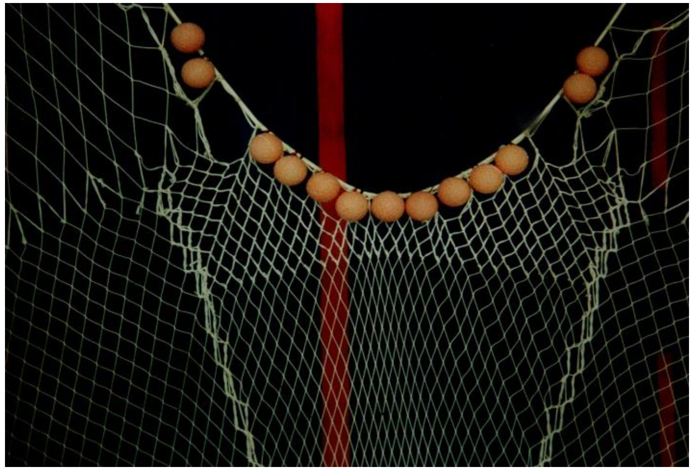
Profile for a vessel of Ancona (Italy)	
Trawling hours/week	*64*
Working weeks per year	*47*
Trawling hours/year	*3,008*
Fuel cost (EUR/l)	*1.00*
Consumption VEE (l/hr)	*50.5*
VF15 (l/hr)	*41.4*
Door investement	*EUR*
VEE	*3,500*
VF15	*7,000*
Monitoring acoustic system	*30,000*
Extra Investement	**33,500**
Fuel cost per year	
VEE	*151,904*
VF15	*124,531*
Comparison	***27,373***

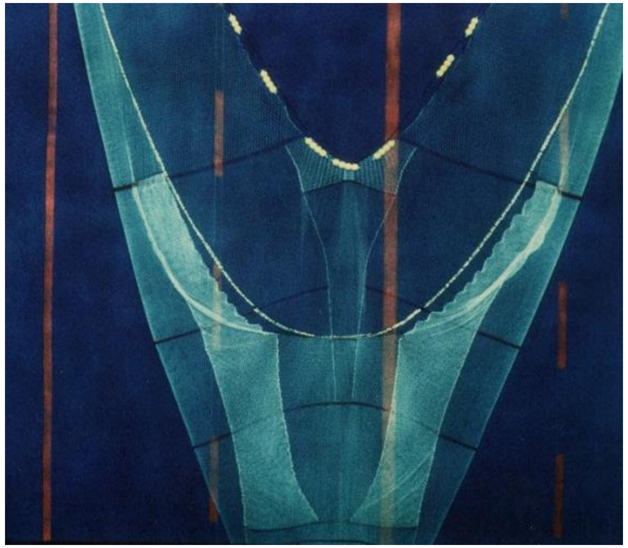
Payback time around 15 months

Net design and high strength materials

Traditional trawl: Commonly used in the Italian commercial fishery (reference trawl)

Experimental trawl: Knotted *Rubitech* netting sections in the wings; new net design; reduction of the netting area





Characteristics		N Direction			
		Breaking load		Tenacity	
RTEX	Mesh bar length [mm]	Dry [kg]	Wet [kg]	Dry [g/RTEX]	Wet [g/RTEX]
Knotless PA					
1200	22	43.5	39.1	18.1	16.3
1200	24	43.4	38.7	18.1	16.1
1200	30	35.3	30.8	14.7	12.8
1500	**55**	**41.0**	39.0	**13.7**	**13.0**
3600	22	95.7	88.1	13.3	12.2
4500	22	127.9	121.0	14.2	13.4
6000	24	144.9	136.1	12.1	11.3
9000	30	256.8	-	14.3	-
Knotted Rubitech					
624	**55**	**92.0**	94.6	**73.7**	**75.8**

Net design and high strength materials

	Traditional Trawl		Experimental Trawl		
Speed knots	Power HP	Fuel consumption [l/hour]	Power HP	Fuel consumption [l/hour]	Fuel saving [l/hour]
3.25	274	51.8	254	48.8	2.9
3.50	308	56.6	283	53.1	3.5
3.75	341	61.4	313	57.4	4.0
4.00	375	66.2	343	61.6	4.6
4.25	408	71.0	373	65.9	5.1

Profile for a vessel of Ancona (Italy)

Trawling hours/week		*64*
Working weeks per year		*47*
Trawling hours/year		*3,008*
Fuel cost (EUR/l)		*1*
Consumption	*Traditional (l/hr)*	*66.2*
	Experimental (l/hr)	*61.6*
Gear Investments (Euro)	*Traditional trawl*	*2,345*
	Experimental trawl	*3,815*
	Extra investment	*1,470*

Fuel cost per year (Euro)

Traditional trawl	*199,130*
Experimental trawl	*185,293*
Comparison	***13,837***

Payback time around 2 months

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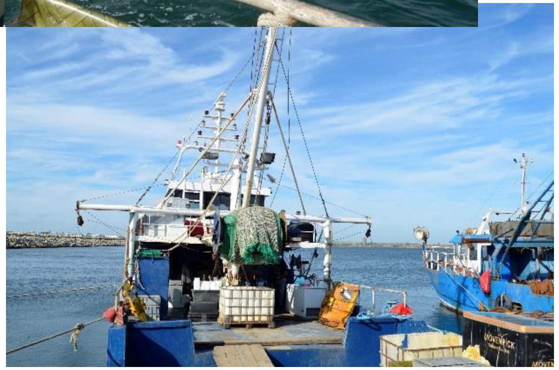
Midwater otter trawl (OTM) fisheries

Black Sea (OTM, GSA29)

Shifting to lighter demersal otterboards. New net design developed to reduce unnecessary components and using lighter netting materials in the aft parts of the trawl net. Additionally, larger meshes in specific sections and lower-drag gear configurations will further strengthen fuel savings.

Gear setup / parameter	Traditional	Experimental
DBS [m]	**22.6** (1.2)	**22.7** (2.8)
VTG [kn]	**3.2** (0.1)	**3.2** (0.1)
HDS [m]	**110.2** (0.3)	**111.2** (0.6)
HNO [m]	**46.9** (3.1)	**45.3** (1.3)
VNO [m]	**1.76** (0.13)	**1.83** (0.07)
Q [l/h]	**23.1** (1.2)	**13.2** (0.8)
LPUE [kg/h]	**220.0** (78.3)	**153.9** (97.4)
FUI [l/kg]	**0.146** (0.155)	**0.126** (0.086)

Fishing depth, DBS[m]; towing speed, VTG[kn]; horizontal door spread, HDS[m]; horizontal net opening, HNO[m]; vertical net opening, VNO[m]; fuel consumption, Q[l/h]; landing per unit effort, LPUE [kg/h]; fuel use intensity, FUI[l/kg fish].



Beam trawl (TBB) fisheries

Adriatic and Ionian (TBB, GSA17)

Change the orientation of the teeth in the Rapido trawl. Teeth are rotated 180°, positioning their convex side facing the codend. To ensure proper contact with the seabed, an additional metal bar was installed approximately 30 cm from the front of the sleds to support the repositioned teeth.

Gear type	Q [l/h]	Species		CPUE [kg/h]	FUI [l/kg]
Traditional	133.0 (3.1)	*Bolinus brandaris*	Purple dye murex	114.7 (9.9)	1.160 (0.211)
		Solea solea	Common sole	24.7 (0.7)	5.351 (0.203)
		Other species		6.1 (1.4)	35.174 (8.300)
		Total catch		140.0 (10.9)	0.950 (0.154)
Experimental	123.1 (1.6)	*Bolinus brandaris*	Purple dye murex	73.3 (9.1)	1.680 (0.178)
		Solea solea	Common sole	25.8 (3.6)	4.777 (0.550)
		Other species		9.9 (1.4)	14.457 (2.063)
		Total catch		108.9 (13.0)	1.130 (0.112)

Presentation Overview

1) Pilot studies for fuel saving trawling gears
2) Energy audits
3) Development of low impact and fuel-efficient gears
4) Methodological framework and instrumentation

Where the energy is going? Energy audit in fisheries

www.nature.com/scientificdata

scientific **data**

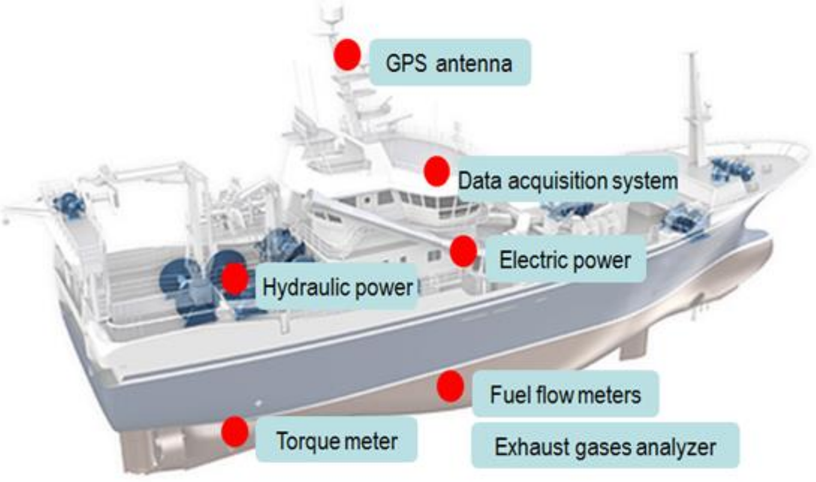
OPEN

DATA DESCRIPTOR

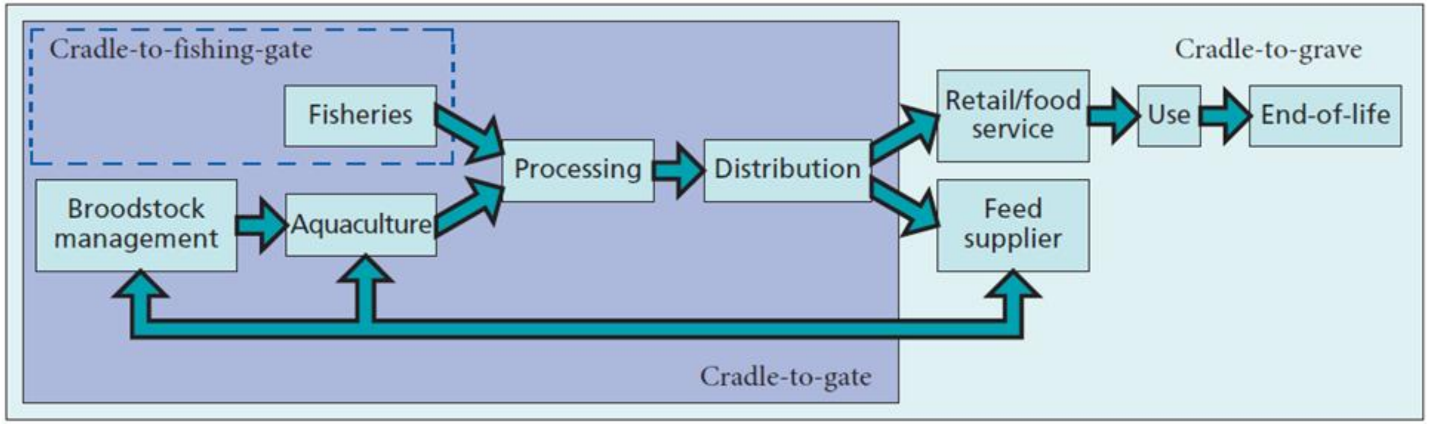
Energy audit and carbon footprint in trawl fisheries

Antonello Sala[1]✉, Dimitrios Damalas[2], Lucio Labanchi[3], Jann Martinsohn[4], Fabrizio Moro[1], Rosaria Sabatella[5] & Emilio Notti[1]

SCIENTIFIC DATA | *(2022) 9:428* | https://doi.org/10.1038/s41597-022-01478-0



Energy audit is a systematic approach to evaluate energy consumption in fisheries



Energy audit is a systematic approach to evaluate energy consumption in fisheries

Objectives

- to **define the energetic profile** of the fishing vessel through energy indicators
- to **identify technological improvements**
- to evaluate the **technical and economical benefits** of improvements

Case study: European Legislation

- ✓ *Council Regulation (EC) Nr. 2371/2002 Art. 33: "Conservation and sustainable exploitation of fisheries"*
- ✓ *Council Regulation (EC) Nr. 744/2008 del 24/07/2008: "A Community contribution should also be provided for collective actions aimed at delivering expertise to vessel owners in relation to **energy audits** for vessels"*

Energy audits

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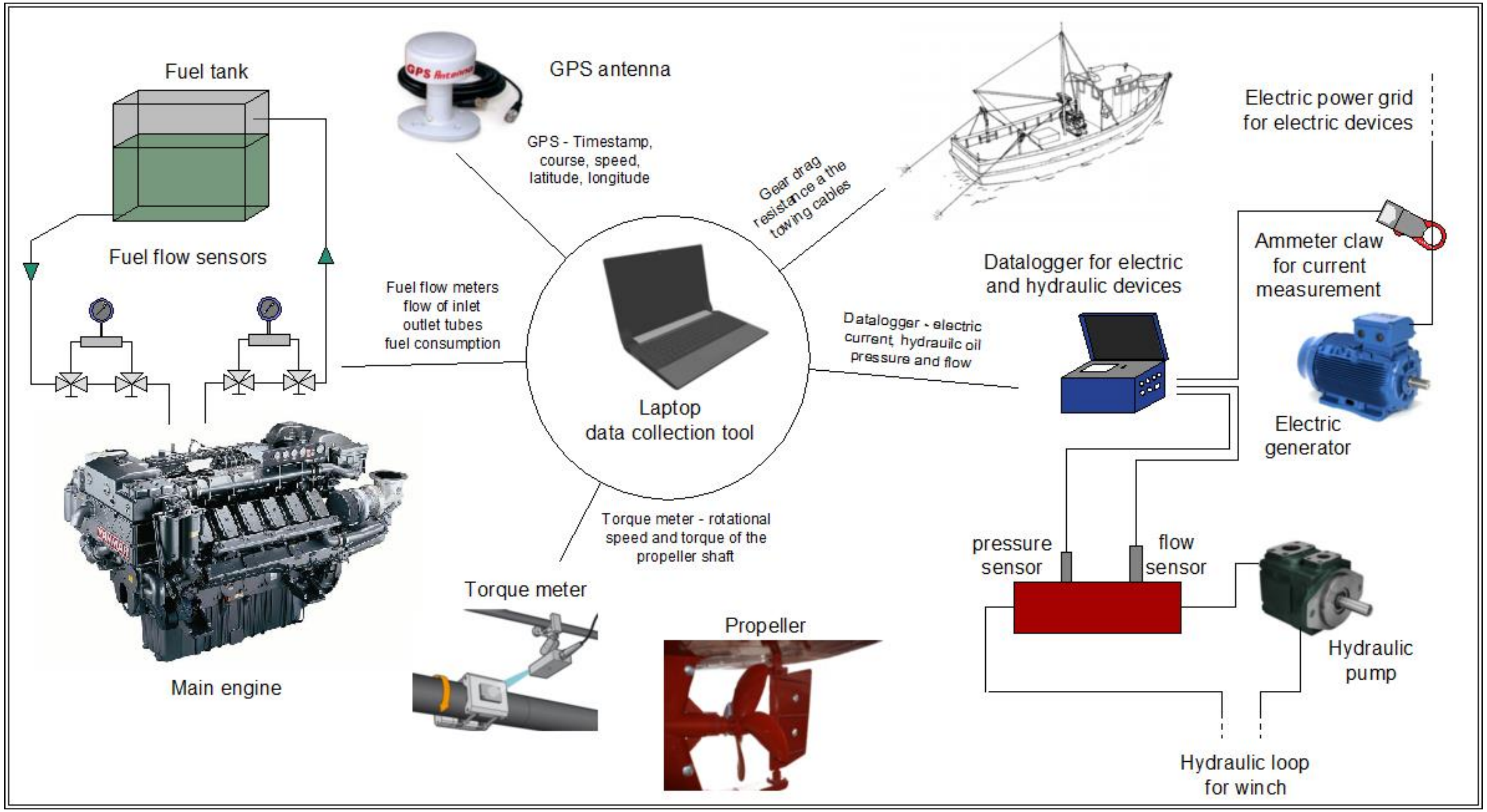
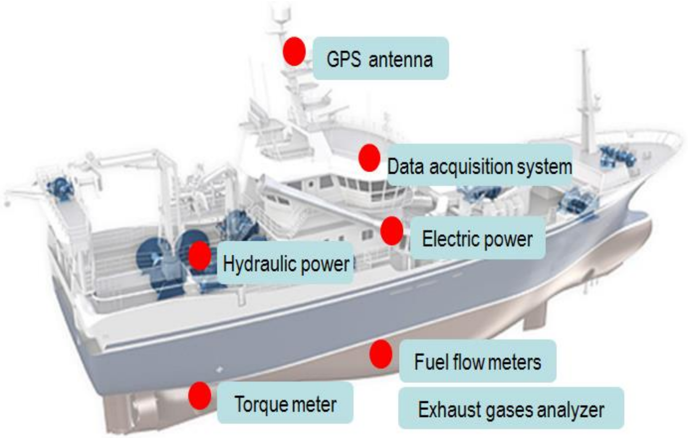
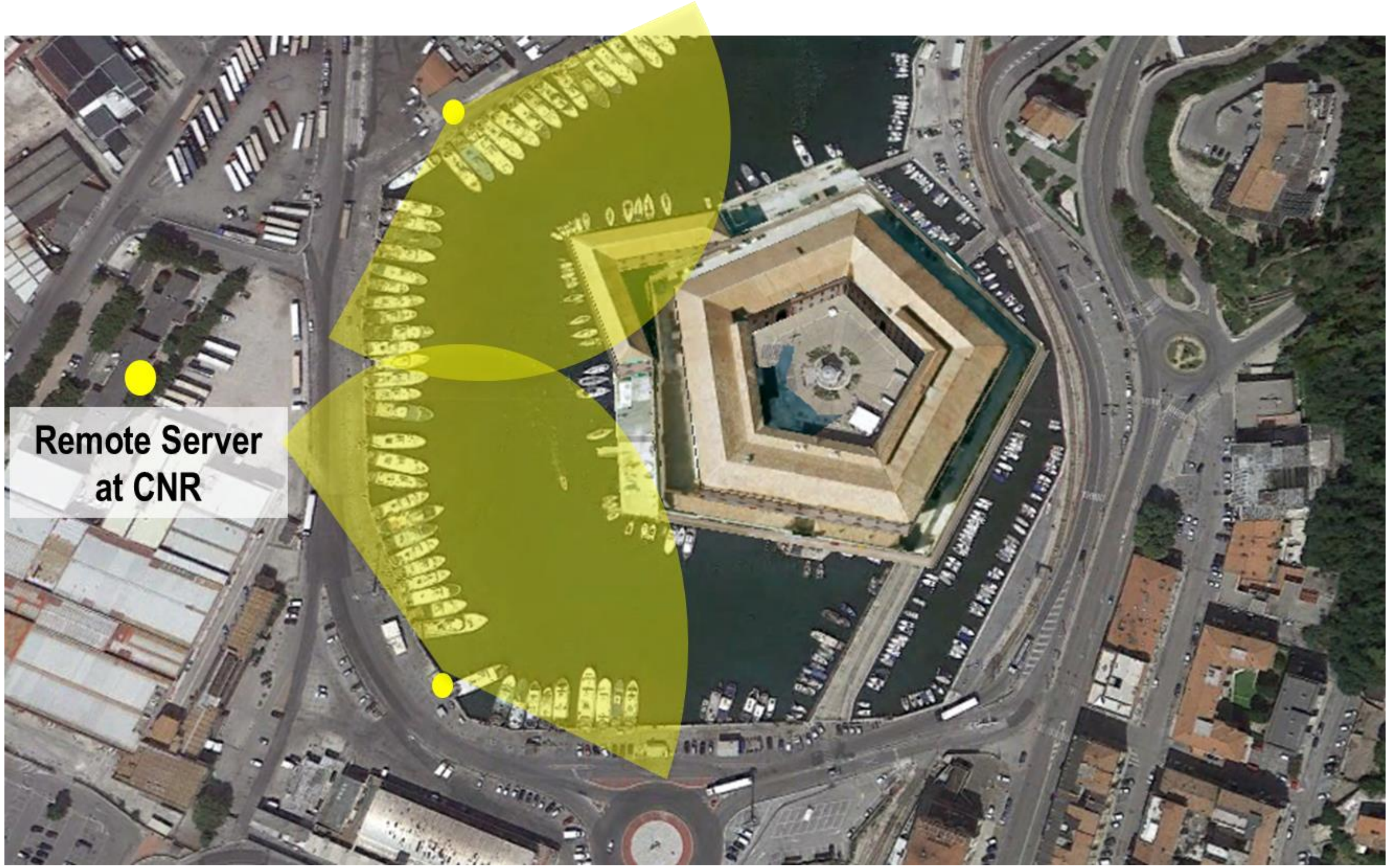
- Updated Information: the dataset has been revised and enriched with the latest available data, ensuring greater accuracy and relevance.
- Expansion to the Mediterranean and Black Sea: The data coverage has been extended to include the entire Mediterranean and Black Sea regions, providing a more comprehensive and representative foundation for assessments and comparisons.

Case study in Italy: measurement system layout for energy audit in fisheries





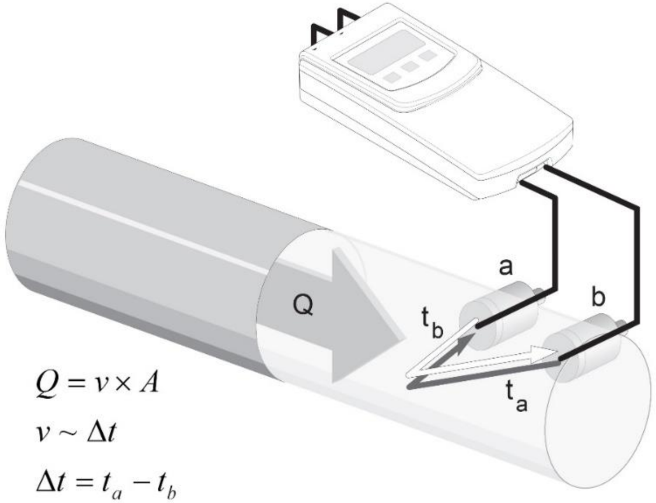
Free Wi-Fi area for fishers and data communication



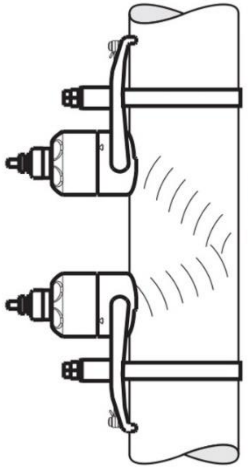
Remote Server

Mass fuel flow sensor

Portable ultrasonic flow meter

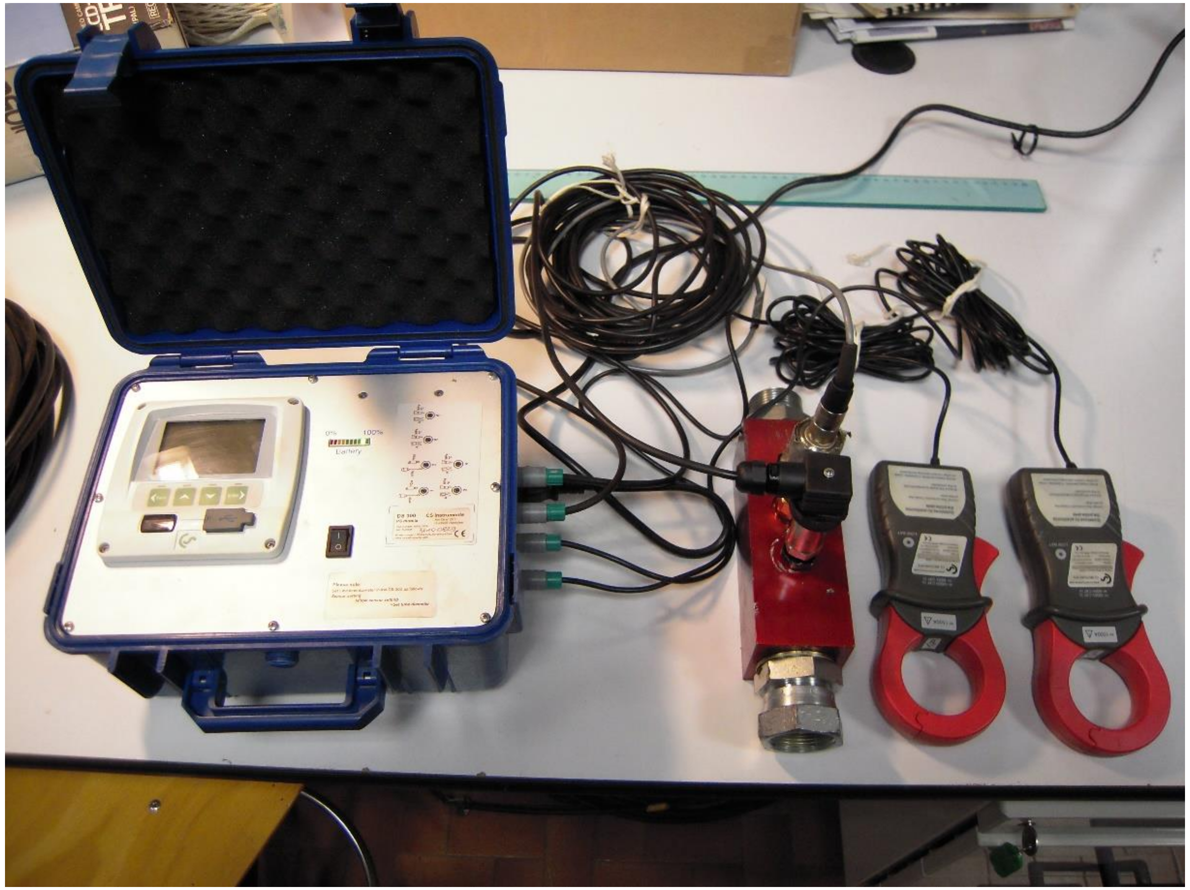


$$Q = v \times A$$
$$v \sim \Delta t$$
$$\Delta t = t_a - t_b$$

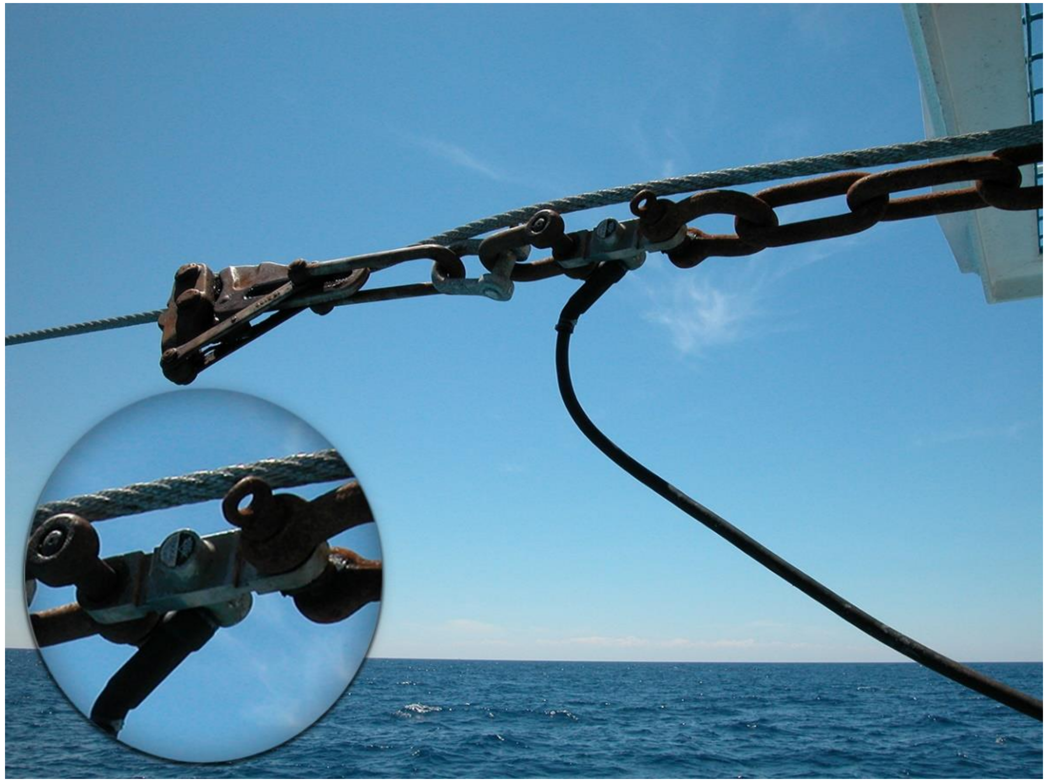


Torque meter measurement

AC electric and hydraulic data collection system



Load cell for gear drag measurement

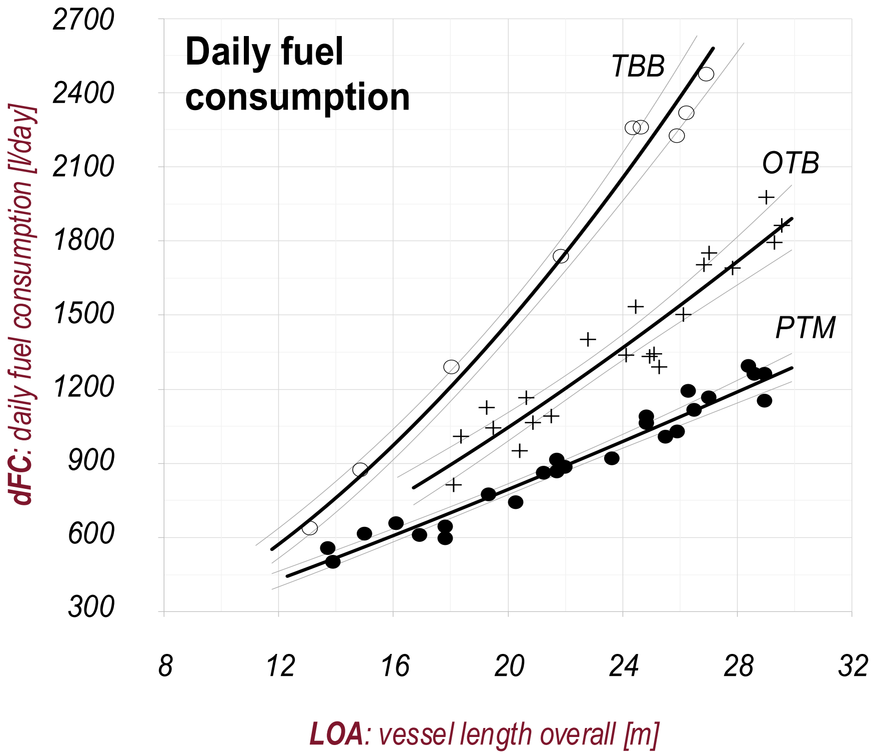


Main characteristics of the monitored fishing vessels

Vessel	VL	LOA [m]	PB [kW]
OTB01	VL1824	21.5	478
OTB02	VL1824	22.8	574
TBB01	VL2440	25.9	884
PTM01	VL2440	28.6	940
PTM02	VL2440	29.0	940
PTM03	VL2440	26.5	870
PTM04	VL2440	25.5	772
PTM05	VL2440	25.9	884
PTM06	VL2440	29.0	940
PTM07	VL2440	27.0	809

OTB: bottom otter trawler
PTM: midwater pair trawler
TBB: Rapido beam trawler

Mean daily fuel consumption against vessel length overall (LOA)



OTB: bottom otter trawler
PTM: midwater pair trawler
TBB: Rapido beam trawler

General linear model: $FC[l/day] = q \times LOA^{m}$

Parameters/vessel type	Daily consumption (dFC)		
	OTB	PTM	TBB
slope, *m*	1.470	1.196	1.838
intercept, *q*	12.811	22.104	5.973
F	*158.1*	*475.7*	*666.6*
d.o.f	19	23	7
R-square	*0.893*	*0.954*	*0.990*

Fuel use intensity (FUI) and carbon footprint in trawl fisheries

Gear	Target species	FUI [l fuel/t fish]	Carbon footprint [kg CO2/t fish]
Single boat bottom otter trawl (OTB)	*Mixed demersal species*	**4,085** *(3,778-4,391)*	**10,784** *(9,974-11,593)*
Beam trawl (TBB)	*Sole, murex*	**5,418** *(3,967-6,869)*	**14,304** *(10,472-18,135)*
Midwater pair trawl (PTM)	*Anchovy, sardine*	**349** *(330-369)*	**922** *(871-973)*
Overall		**2,895** *(2,696-3,095)*	**7,643** *(7,116-8,170)*

Target species/Gears	FUI [l/t]			
	No.	Min	Max	Mean
Demersal species				
Bottom otter trawls	139	326	17,560	2,970
Beam trawls	2	980	2,610	1,795
Small pelagics				
Midwater otter trawls	26	81	1,097	360
Overall				2,832
All trawl gears				2,469

Source: modified and adapted from Sala et al. (2022)

- Trawl fisheries in Med use approximately 2.9 litres of fuel per kg of fish
- Fuel consumption rate varies according to gear type and vessel size: approximately 7.6 kg·CO2/kg fish

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Overall		**2,895** *(2,696-3,095)*	**7,643** *(7,116-8,170)*

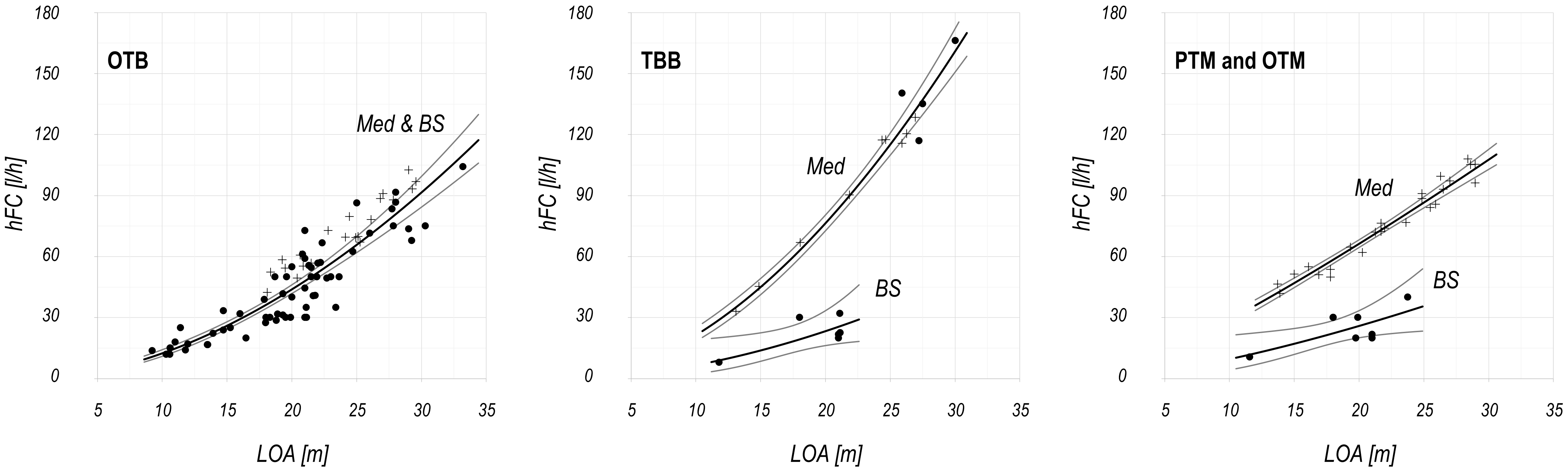
Source: modified and adapted from Sala et al. (2022)

Carbon footprint per kilogram of product from LCA studies (*cradle to retail*). An additional 500 kg CO2-eq/t of fish is added to account for processing, packaging and transportation emissions

Products	Carbon footprint [kg CO2/t]
Seafood from aquaculture	*3,000-15,000*
Poultry	*2,000-6,000*
Pork	*4,000-11,000*
Beef	*9,000-42,000*
Mutton and lamb	*10,000-150,000*

Source: modified and adapted from Nijdam, et al. (2012)

Energy Audit in Fisheries: Mediterranean and Black Sea (DecarbonyT outcomes)



Relationships length overall (LOA) vs. hourly fuel consumption (hFC)

Main conclusions. Gear innovations to enhance energy efficiency

- **Rewarding best practices** and redirecting fuel subsidies to encourage the development of energy-saving gear
- Developing **acceptable technology** and creating incentives (*win-win situations*)
- **Objectives** being **achievable** and realistic
- **Adequate training** and technical assistance
- Making industries part of the solution (***proactive mode***)
- No realistic **alternatives available to trawling** for capturing certain species

Optimizing fuel efficiency in fisheries: balancing innovation and performance

- Significant fuel savings (10-20%) can be achieved quickly by improving net design and material or enhancing otterboard hydrodynamics.
- Replicating the catching performance of a fishing gear that has been refined over years by experts and fishers is particularly challenging within a short 10-day timeframe (5 standard, 5 experimental).
- Effective gear modifications require iterative testing, adaptation, and feedback to align efficiency gains with catch consistency.
- This process necessitates industry involvement from the proposal phase to ensure practical adoption and refinement.
- With *DecarbonyT*, we have sent a clear message to the industry: current fishing gears can be improved, and the payback time for fuel-saving modifications is relatively short.

DecarbonyT

DECARBONISATION OF THE FISHING FLEET IN THE MEDITERRANEAN AND BLACK SEA

Thank you for your attention

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Specific contract No. 7
Decarbonisation of the fishing fleet in the Mediterranean and Black Sea (*DecarbonyT*)

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