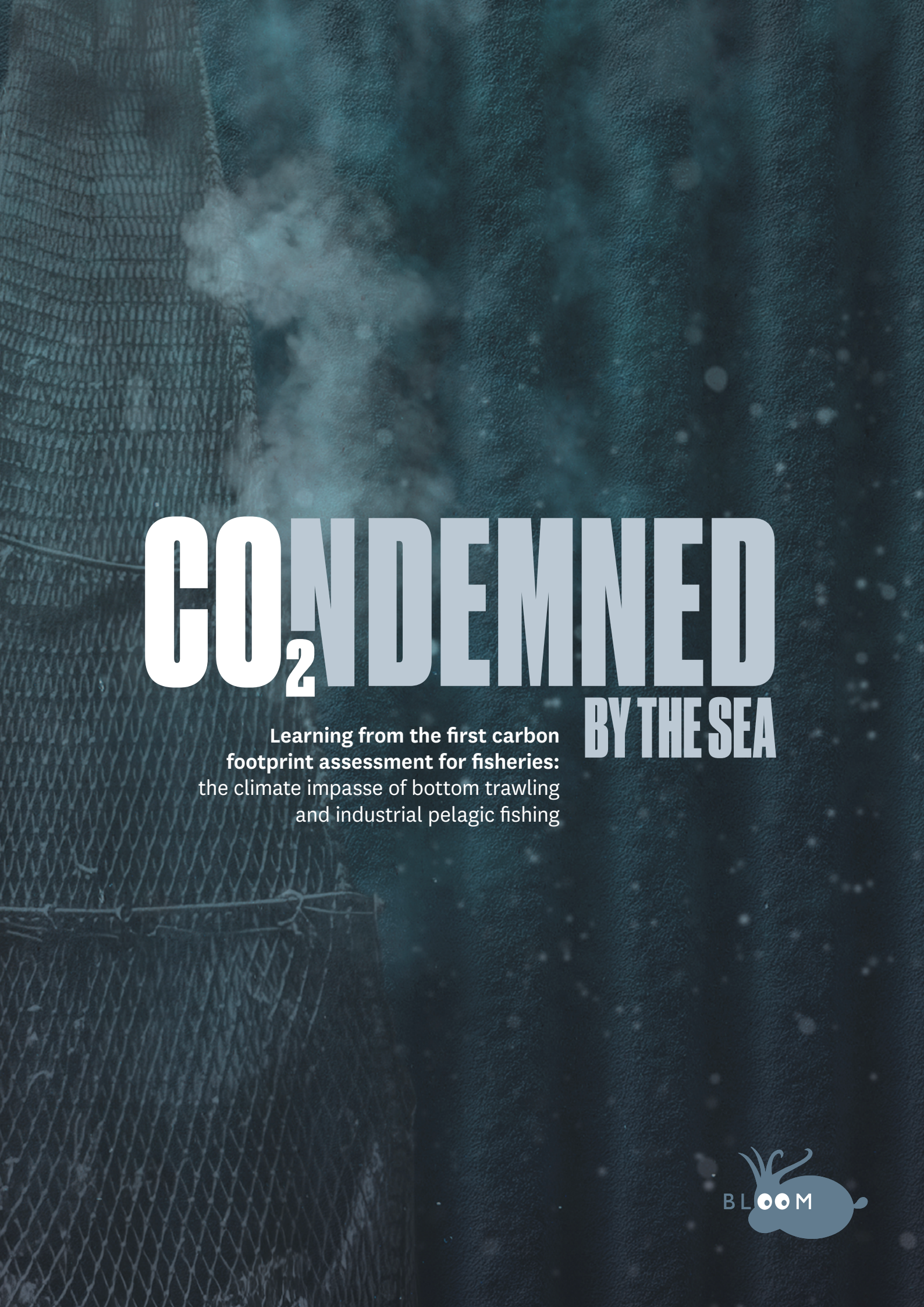


CO_2NDEMNED BY THE SEA

Learning from the first carbon footprint assessment for fisheries:
the climate impasse of bottom trawling and industrial pelagic fishing

BLOOM



Link to the scientic study:
https://bloomassociation.org/wp-content/uploads/2025/11/Bilan-des-emissions-carbone-de-la-peche-francaise-BLOOM-x-The-Shift-Project.pdf

This report, written by BLOOM, was produced using the results of the fishing industry's greenhouse gas emissions assessment carried out as part of a partnership between BLOOM and The Shift Project (the latter acting as a technical partner) on the social and ecological transition of fisheries.

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EVERYTHING YOU NEED TO KNOW IN 4 PAGES

In a first-of-its-kind initiative, BLOOM has unveiled the greenhouse gas emissions assessment, or "carbon footprint of French fishing," conducted with The Shift Project as technical partner. This current BLOOM report draws the main conclusions from that groundbreaking work. French fishing emits 1.1 million tons of CO_2 per year, equivalent to the chicken egg (laying) industry, and seven times more greenhouse gases (GHG) than the pulse industry (protein crops). This is also similar to the emissions from domestic air traffic in mainland France in 2023, estimated at 1.6 million tons of CO_2. This sector-wide result conceals significant heterogeneity: emissions fluctuate greatly depending on the techniques and fishing models used to land the fish, mollusks, and crustaceans that end up on our plates.

The first study to analyze the carbon footprint of French fishing fleets

This unique project required analyzing greenhouse gas emissions linked to the entire productive upstream sector (fishing operations) for the entire French fishing fleet in 2022: **fuel consumption, the manufacture and end of life of vessels and gear, the purchase of consumables, refrigerant gas leaks, electricity consumption, and the travel and food consumption of sailors.** With these factors considered, the carbon footprint of the fishing sector therefore excludes the processing and distribution of resources caught at sea. For the first time, **the quantities of CO_2 released as a result of seabed disturbance by fishing gear or that could not be stored due to the extraction of marine animals have been estimated as part of a carbon footprint assessment.** In doing so, the study goes beyond a purely energy-based approach, where only emissions related to energy consumption are assessed. With seven of the nine planetary boundaries already exceeded, it is crucial to take into account the impact of intensive fishing on the release of ocean carbon. The assessment of this data appears as the only reasonable and responsible option.

The results of the carbon assessment, which were reviewed by industry professionals and proofread by a dozen researchers, highlight **the responsibility of bottom trawling, as well as industrial models, in the French fleet's CO_2 emissions. One figure stands out: 39 trawlers (bottom and pelagic) and seiners (pelagic) over 40 meters in length, representing just 1% of the French fleet, account for 29% of the sector's GHG emissions.**

At a time when every tenth of a degree counts in ensuring the survival of our species and maintaining the habitability of the planet, the conclusion is simple: **we must urgently plan the transition of the fishing sector towards responsible practices and a fair economic model: one which is energy-efficient and which guarantees the integrity of ecosystems, providing jobs and high-quality fish.**

Bottom trawling condemned by its carbon footprint

The first finding of this study shows that trawling (trawlers and seiners of all sizes) is the fishing practice that generates the most emissions in the fleet. **73% of the French fishing fleet's GHG emissions (832 kt of CO_2e) come from trawling, even though trawlers represent only 14% of the fleet, 39% of jobs, and 62% of volumes, but also only 54% of the economic value landed (which also indicates that these vessels are not maximizing the value of their production).**

Bottom trawlers in particular are the worst offenders when it comes to carbon emissions, both in absolute and relative terms (i.e., in absolute volumes of emissions and when these are reported per kilogram caught). **At least 46% of CO_2 emissions from fishing come from 583 bottom trawlers (11% of the fleet).** This is equivalent to 530,000 tons of CO_2e, or the total emissions of the Cannes metropolitan area. When their emissions are measured per kilogram landed, this is 1.7 times more than vessels using traps, lines, and nets! Fuel consumption is the main source of emissions from bottom trawlers.

However, these vessels are also the ones that receive the most public subsidies. Fishing benefits from an exemption from tax on energy consumption, a measure initially designed to reduce CO_2 emissions in certain sectors, with only a few sectors excluded. In fact, this exemption mainly benefits those who consume the most fuel: bottom trawlers. Per kilogram caught, they receive on average three times more subsidies than fishing using traps, lines, and nets. This exemption, which also applies to aviation, dates back to 2003. It is dangerously ill-adapted to a world that has already warmed by 1.5 degrees compared to the pre-industrial era.

Analysis of existing literature on the impact of bottom trawlers indicates that they are also responsible for disrupting the sedimentary carbon cycle by dislodging carbon that has been stored, sometimes for thousands of years, in the seabed. **We have calculated the potential emissions from the carbon released by these bottom trawlers based on three assumptions from the literature: according to the most reliable estimate, these emissions would represent 8% of emissions from fishing, and up to 44% according to the least conservative estimate. Regardless of the scenario used, the disruption of the sedimentary carbon cycle would be the second largest source of emissions from the French fleet.**

While scientific debate continues regarding the exact level of emissions produced by these disturbances and their effects on the climate (which is why we prefer to address this issue separately in our assessment), the subject can no longer be ignored. The precautionary principle is the only reasonable course of action. Furthermore, there is scientific consensus on the lasting and potentially irreversible damage caused to the seabed by bottom trawling. **In France, the repeated passage of trawlers is responsible each year for the abrasion of bottoms covering an area equivalent to France, Belgium, and Switzerland combined, making trawling a major factor in the overall depletion of the ocean and its loss of biological productivity.** Replacing the most polluting, as well as environmentally and economically damaging fishing techniques is a social, economic, environmental, and climate imperative.

Finally, this work must be used to develop methodologies for accounting for carbon emissions. In the current official carbon footprint methodology, forests, grasslands, and agricultural land are rigorously monitored and accounted for, while "the use of marine funds or ecosystems" and the disturbances they endure through bottom fishing are not included.

Emitting more to catch more: the overwhelming impact of industrial trawlers and seiners on the sector's carbon footprint

The carbon footprint also highlights the huge gap between emissions from industrial vessels over 24 meters in length and those from the rest of the fleet. Ships over 24 meters account for 49% of emissions, even though they represent only 3.7% of the fleet. Conversely, smaller vessels (under 12 meters) using passive fishing gear (traps, lines, nets), which make up 73% of the French fleet, are responsible for 14% of the sector's emissions. As mentioned above, the devil is in the details: 39 trawlers (bottom and pelagic) and seiners (pelagic) over 40 meters long, representing 1% of the French fleet, emit 29% of the sector's GHG emissions! These vessels bring hundreds of tons of tropical tuna, caught far from our coasts, as well as "bluefish," pelagic species such as whiting, to the docks. The former will end up in cans, while the latter will be used in highly processed products such as surimi. Per sailor on board, industrial vessels over 40 meters long emit 7.5 times more than small coastal fishing vessels.

But how did we get to this point? The industrial production model means that ships, in order to fish in greater quantities and further afield, are equipped with machines to build a cold chain for storing catches (or even to process them on board), use increasingly larger nets, deploy devices to aggregate fish, sometimes use support vessels for the sole purpose of deploying even more traps to catch fish, and even fly crews to distant ports in Seychelles, Scotland, or Norway. **This industrial, production-oriented model inherently requires high energy consumption.** Like other extractive industries in which growth is primarily linked to dependence on fossil fuels, it is the same resource that has made industrial fishing financially successful and even economically dominant that now condemns it, alongside the depletion of natural resources. The striking power of industrial fisheries would not exist without fossil fuels. This model, inherited from the frantic race for productivity that began in the 1960s, has developed at the expense of small units using "passive" gear. In France, vessels over 24 meters (3.7% of the fleet) now account for 47% of catches. This is not only because they have the capacity, but above all because they have the opportunity. In short, they have more fishing rights. However, their model, based on machine power, destroys jobs and creates little added value. **Furthermore, by overfishing, their model disrupts the phenomenon of carbon storage by fish: 54% of the carbon that has not been stored through the natural death of fish is linked to the activity of industrial trawlers and pelagic seiners.**

While the ocean is being bled dry, it seems regressive to continue to tolerate a handful of ships emitting hundreds of thousands of tons of GHGs into the atmosphere and destroying our marine ecosystems, in order to offer highly processed seafood products manufactured at the cost of immense social destruction.

The energy transition will not solve all the problems in the sector

The work which we now present, which logically should have been supported and financed by the public authorities, enables us to move resolutely towards a truly sustainable transition in fishing.

As it stands, the French public authorities are lagging behind and appear to be completely out of touch on this issue, given that fishing is not included in France's *National Low-Carbon Strategy*. Despite this, the few measures mentioned by the French government with regard to decarbonization[1] point towards a **blissful, technological fix based solely on the pursuit of energy efficiency, without questioning an industrial model based on maximizing volumes for greater scale economies.** This objective is attractive to an industrial sector that has every interest in maintaining the status quo and its privileges, but is catastrophic from an environmental and socio-economic point of view. **Replacing current engines with others that consume less fossil fuel or adapting them to "alternative fuels"** such as hydrogen or biofuels, which are a pipe dream in the case of the former and pose potential land use problems in the case of the latter, **is not a sustainable solution.** Far from taking this reality into account, the *Strategic Contract for the French Maritime Fishing Industry* **emphasizes the development of highly efficient and competitive fishing,** aimed at **increasing the production of processed seafood products so that they are readily available on supermarket shelves.** In short, it is an irresponsible and unrealistic approach to fishing that **seeks to increase volume at any cost** and runs counter to environmental concerns and the wishes of citizens.

By advocating decarbonization through energy efficiency alone, public authorities are repeating the mistakes of the past, engaging in greenwashing and procrastination, when the fishing industry is now more than ever in dire need of ambitious and bold structural reform. The French authorities are bowing to the pressure to increase volume, a goal shared by industrialists who stand to gain from the status quo. This is happening despite the fact that solutions for truly sustainable fishing do exist.

The future of fishing depends on putting an end to industrial development and phasing out trawling (detrawling) from the fleet. Bottom trawls must be replaced by "passive" gear, which is less polluting, creates jobs, and has minimal impact on biodiversity, provided it is properly regulated. This begins with directly allocating part of the bottom trawl quotas to these more virtuous methods.

These social and climate justice measures are within reach: they are technically feasible but **politically blocked, as is the creation of genuine marine protected areas,** which would already be delivering ecological and socio-economic benefits if they had actually been implemented. **The obstacles created by a minority are therefore preventing us from accessing a sustainable world that would otherwise be within reach.**

1 Notably in the document "Status Report on the Energy Transition of Fishing Fleets and Aquaculture" (in French: “Etat des lieux de la transition énergétique des flottes de pêche et d’aquaculture”) published on 3 November 2025, on the website: https://www.mer.gouv.fr/etat-des-lieux-de-la-transition-energetique-des-flottes-de-peche-et-daquaculture-francaises

KEY FINDINGS

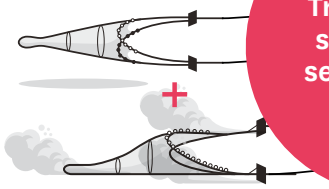
EMISSIONS PER FLEET

73%

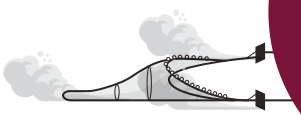
of GHG emissions from the French fishing fleet (832,000 tons of CO_2e) are emitted by vessels using trawls and seines, even though they represent only **14% of the fleet** (but account for 39% of jobs, 62% of volumes and 54% of economic value).

21%

of GHG emissions from the French fishing fleet (234,000 tons of CO_2e) are emitted by vessels using traps, lines, and nets of all sizes, even though they represent **77% of the fleet's** vessels (accounting for 51% of jobs, 18% of volumes, and 34% of economic value).



Trawlers and seiners: the sector's main emitters.



Trawlers are, in absolute and relative terms, the biggest emitters of greenhouse gases.

At least 46%

of GHG emissions from the fishing sector come from **bottom trawlers.** The 583 bottom trawlers and seine boats, which represent 11% of the fleet, emit 530,000 tons of CO_2e, equivalent to the total emissions of the Cannes metropolitan area (158,000 inhabitants)[2].

1.7 more

GHG emissions, that's what bottom trawling emits on average **per kilogram of seafood landed compared to passive gear (traps, lines and nets).** It also means **2.3 times more GHG emissions per euro landed** and even **4.6 times more per sailor** on board vessels.

7.5 less

GHG emissions per Full-Time Equivalent (FTE). This is what a small coastal vessel using traps, lines, or nets emits, compared to to an industrial vessel over 40 meters long.

An important criterion: industrial fishing, particularly tropical tuna fishing, is generally highly emissive. In general, the more industrialized a vessel is, the more energy it consumes.

At least 29%

of GHG emissions from the French fishing sector (328,000 tons of CO_2e) **are attributable to less than 1% of the fleet!** That is 39 trawlers or seiners measuring 40 to 90 meters, which represent 10% of jobs, 35% of volumes and 19% of the value of landings. These 39 vessels emitted almost as much as **16 cruise ships over 300 meters long[3]. Half of these vessels are seiners** that fish for tropical tuna in the Indian Ocean to make canned tuna...



2. Taking into account emissions from the transport, agriculture, tertiary, residential, waste, and industrial sectors. The total is 556,000 tons of CO_2e in 2021. https://cannespaysdelerins.fr/wp-content/uploads/2025/04/2_PCAET_1_Diagnostic_CACPL_OCR.pdf

3. An average of 20,641 tons of CO_2e per year. https://www.transportenvironment.org/uploads/files/Climate_Impacts_of_Shipping_Exemptions_Report_updated.pdf

KEY FINDINGS

EMISSION SOURCES

Fuel: the leading cause of emissions from the French fleet.



84%

of emissions (961,000 tons of CO_2e) come from fuel consumption by vessels (312 million liters of diesel), making it the largest source of emissions from fishing by far.

The disruption of the sedimentary carbon cycle could be the second largest source of CO_2 emissions from the French fleet.

DISTURBANCE OF THE SEDIMENTARY CARBON CYCLE COULD ACCOUNT FOR:



LOW ESTIMATE

8%

of emissions from fishing ($104,000$ tons of CO_2)

HIGH ESTIMATE

44%

of emissions from fishing ($883,000$ tons of CO_2)

KEY FINDINGS

EMISSIONS FROM THE SECTOR

Fishing is at least as polluting as the 'egg' sector.



1.1 million tons of CO_2e

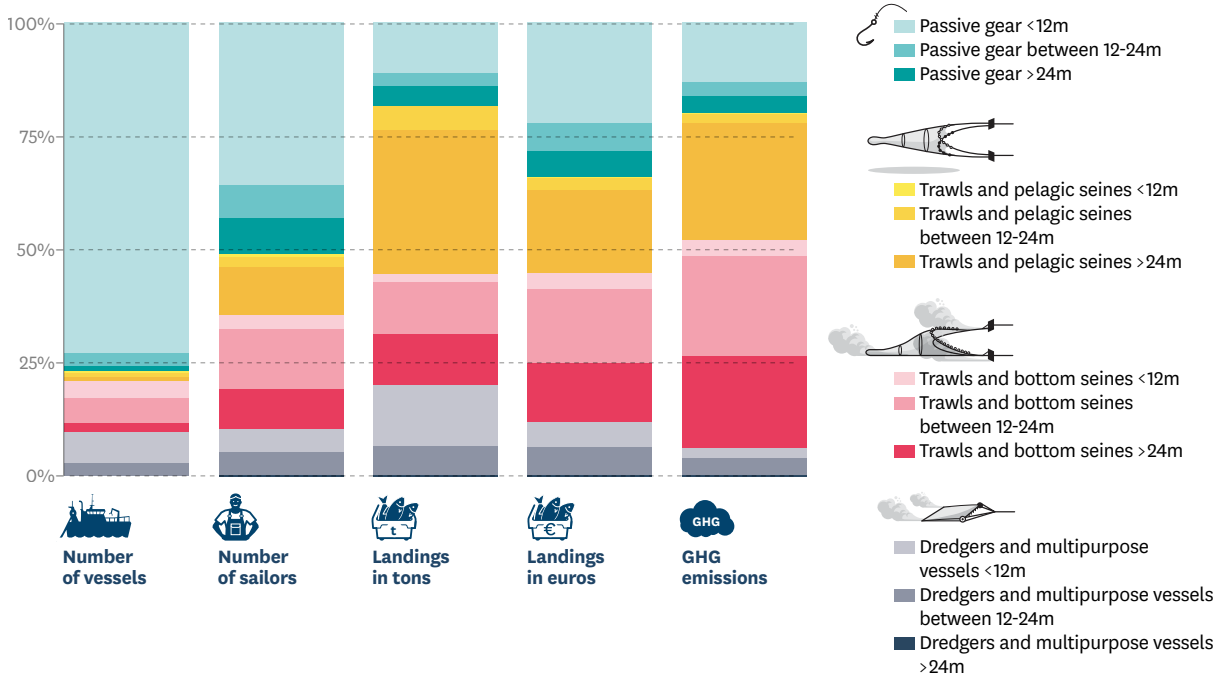
These are the emissions from French fishing, which lands 527,000 tons of seafood while employing 7,492 full-time equivalents (FTEs). The fish industry produces the same quantity of emissions as **the egg industry,** which supplies more eggs (nearly 900,000 tons)[4].

Compared to plant protein production sectors, this is **seven times higher than the emissions from the protein crop sector,** which produces 867,000 tons of chickpeas, lentils, broad beans etc. per year[5].

4. Floréal 2019. 1.1 $MtCO_2e$. Emissions also include the processing sector (0.23 $MtCO_2e$).
https://www.citepa.org/donnees-air-climat/donnees-gaz-a-effet-de-serre/floreal/ Egg industry, France AgriMer. https://www.franceagrimer.fr/node/2866
5. Floréal 2019. 0.162 $MtCO_2e$.. https://www.citepa.org/donnees-air-climat/donnees-gaz-a-effet-de-serre/floreal/ Protein crop sector, France AgriMer.
https://www.franceagrimer.fr/sites/default/files/rdd/documents/FICHE%20FILIERE%20PROTEAGINEUX_2.pdf

Comparison of GHG and socioeconomic data

Comparison of carbon emissions from the French fleet's 12 small-scale fleets in terms of number of vessels, FTEs on board, volumes landed, and the value they represent.



Graph 1: *Carbon emissions from the French fleet's 12 small-scale fleets based on the number of vessels, FTEs on board, volumes landed, and their value.*


“
A system generally goes on being itself, changing only slowly if at all, even with complete substitutions of its elements – as long as its interconnections and purposes remain intact.”
Donella Meadows

I. INTRODUCTION: BREAKING AWAY FROM A PRODUCTIVITY-FOCUSED APPROACH IN FAVOR OF LOW-CARBON FISHING AND A SOCIAL AND ECOLOGICAL TRANSITION OF THE SECTOR

This report by BLOOM reveals the full climate cost of trawling and the industrialization of the seas. It is based on the results of the first assessment of carbon emissions from fishing carried out by BLOOM and The Shift Project to account for all emissions from the French fishing fleet. For the first time in France, this work reveals how the energy consumption of ships and sailors, as well as the disruption of the ocean's biological carbon pump, are condemning the future of certain fishing practices and techniques.

Prior to this assessment, no study had been carried out that integrated all greenhouse gas emissions linked to the use and consumption of inputs, including incoming material flow, by ships and their crews (fuel, refrigerant gases and crew food) across the French fleet[6]. **In particular, potential CO_2 emissions linked to the disruption of processes related to carbon sequestration by the ocean were never accounted for.** The total amount of emissions released as a result of bottom trawling and dredging through the disturbance of marine sediments is a new topic in the literature. There are varying estimates, and even heated debates, about the scale of these emissions. Nevertheless, **experts agree that towed gear has an impact on the sedimentary carbon cycle**[7]. Lastly, examining emissions from fishing involves **looking at how each small-scale fleet contributes to these CO_2 emissions.** The main findings of this assessment are included and summarized in this report.

This work expands a fundamental debate on the future of the sector and its transition. Given the disruption of certain ocean carbon cycles and, above all, the environmental (particularly on biodiversity) and socio-economic impacts caused by bottom trawling and industrial models, it would be a mistake to view the transition through the prism of technological advancement and energy substitution. However, this seems to be the path that public authorities are taking, echoing the demands of industry players in the sector.

It is now clear and scientifically proven that years of industrialization of fisheries to bring in maximum quantities of fish, mollusks, and crustaceans have led to an unsustainable socio-economic and environmental situation. Since 1950, the total engine power of the French fishing fleet has increased sixfold[8]. The number of vessels has simultaneously fallen sharply from around 20,000 in

6 However, life cycle assessments have already been carried out, notably by ADEME as part of the Agriblayse project. This is the ICV Pêche study: https://entrepot.recherche.data.gouv.fr/dataset.xhtml?persistentId=doi:10.57745/ZYMKIC

7 Tiano, J., De Borger, E., Paradis, S., Bradshaw, C., Morys, C., Pusceddu, A., Ennas, C., Soetaert, K., Puig, P., Masqué, P., Sciberras, M., 2024. Global meta-analysis of demersal fishing impacts on organic carbon and associated biogeochemistry. Fish Fish. 25, 936–950. https://doi.org/10.1111/faf.12855

8 Mesnil, B. (2008). Public-aided crises in the French fishing sector. Ocean & Coastal Management, 51(10), 689-700. https://www.sciencedirect.com/science/article/pii/ S0964569108000720

1950 to 4,163 in 2020, and France has even lost more than 25,000 fishers between 1970 and 2020[9]. Fish populations fell sixfold in the Bay of Biscay and the Celtic Sea between 1950 and 2020[10]. 90% of marine predator biomass has disappeared since 1900[11]. According to Didier Gascuel, lecturer and researcher at the Institut Agro, member of the fisheries transition research group led by BLOOM, and member of the IFREMER scientific council, it is *as "if we were sending out boats out to sea to fish, then adding others to destroy part of the catch. It's as if* ***fishers worked part of the year to earn a living, then added extra days of work dedicated to destroying part of their income"***[12].

In September 2025, the seventh planetary boundary was exceeded. Precisely in relation to the ocean, it is now said to have reached a critical "acidification" threshold[13]. Our ocean, which is vital for fishing, is under threat. This is due to both commercial fishing and climate change[14]. Home to more than 80% of the known biodiversity on Earth, from planktonic microorganisms to large predators, the ocean plays a vital role in the Earth's ecoystem[15]. As **humanity's greatest climate ally, it absorbs 20 to 30% of our CO_2 emissions and more than 90% of the heat generated by our activities[16]. Through its ability to store and redistribute heat, moisture, and carbon, the ocean profoundly influences global climate patterns and is a key element in the global carbon cycle**[17]. This role is performed by two large complementary carbon pumps, **the physical pump and the biological pump** (→ see box on page 14).

Unfortunately, the consequences of anthropogenic global warming on the ocean (warming, acidification of waters, etc.) directly threaten the functioning of these two pumps, **altering their capacity to absorb and store carbon**[18;19]. In addition, multiple phenomena such as the migration of fish towards the poles and the deterioration of coral reefs are already underway[20].

9 Ibid.

10 Guénette, S., & Gascuel, D. (2012). Shifting baselines in European fisheries: the case of the Celtic Sea and Bay of Biscay. Ocean & Coastal Management, 70, 10-21. Actualisée en 2021 par Hernvann et Gascuel. https://hal.science/hal-00840405/

11 Christensen V, Guénette S, Heymans J, Walters C, Watson R, Zeller D, Pauly D, «Hundred-year decline of North Atlantic predatory fishes», 2003

12 Gascuel, D. (2023). La pêche écologie: Manifeste pour une pêche véritablement durable. Quae

13 Findlay, H. S., Feely, R. A., Jiang, L., Pelletier, G., & Bednaršek, N. (2025). Ocean acidification: another planetary boundary crossed. Global Change Biology, 31(6). https://doi.org/10.1111/gcb.70238
Potsdam Institute for Climate Impact Research. Planetary Health Check 2025.
https://www.planetaryhealthcheck.org/wp-content/uploads/PlanetaryHealthCheck2025.pdf

14 IPBES (2019): Summary for policymakers of the global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. S. Díaz, J. Settele, E. S. Brondízio E.S., H. T. Ngo, M. Guèze, J. Agard, A. Arneth, P. Balvanera, K. A. Brauman, S. H. M. Butchart, K. M. A. Chan, L. A. Garibaldi, K. Ichii, J. Liu, S. M. Subramanian, G. F. Midgley, P. Miloslavich, Z. Molnár, D. Obura, A. Pfaff, S. Polasky, A. Purvis, J. Razzaque, B. Reyers, R. Roy Chowdhury, Y. J. Shin, I. J. Visseren-Hamakers, K. J. Willis, and C. N. Zayas (eds.). IPBES secretariat, Bonn, Germany. 56 pages.

15 Costello, M. J., Coll, M., Danovaro, R., Halpin, P., Ojaveer, H., & Miloslavich, P. (2010). A Census of Marine Biodiversity Knowledge, Resources, and Future Challenges. PLoS ONE, 5(8), e12110. https://doi.org/10.1371/journal.pone.0012110

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17 IPCC, 2019. Summary for Policymakers. In: Pörtner, H.-O., Roberts, D.C., Masson-Delmotte, V., Zhai, P., Tignor, M., Poloczanska, E., Mintenbeck, K., Alegría, A., Nicolai, M., Okem, A., Petzold, J., Rama, B., Weyer, N.M. (Eds.), IPCC Special Report on the Ocean and Cryosphere in a Changing Climate, Cambridge University Press, Cambridge, UK, and New York, NY, USA, pp. 3-35. https://doi.org/10.1017/9781009157964.001

18 Gruber, N., Bakker, D. C. E., DeVries, T., Gregor, L., Hauck, J., Landschützer, P., McKinley, G. A., & Müller, J. D. (2023). Trends and variability in the ocean carbon sink. Nature Reviews Earth & Environment, 4(2), 119-134. https://doi.org/10.1038/s43017-022-00381-x

19 IPCC. (2021). Climate Change 2021: the Physical Science Basis, the Working Group I contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change (Chap. 5: Global Carbon Cycle and Other Biogeochemical Cycles and Feedbacks). Cambridge University Press.
https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_Chapter05.pdf

20 IPCC, 2019: Summary for Policymakers, IPCC Special Report on the Ocean and Cryosphere in a Changing Climate [edited by H.-O. Pörtner, D.C. Roberts, V. Masson-Delmotte, P. Zhai, M. Tignor, E. Poloczanska, K. Mintenbeck, M. Nicolai, A. Okem, J. Petzold, B. Rama, and N. M. Weyer], in press

Ocean carbon pumps:

Excess atmospheric CO_2 (caused by anthropogenic GHG emissions) creates an imbalance that causes carbon dioxide to dissolve in the ocean's surface waters 1**. This is the physical pump** (or solubility pump). It is dependent on the physical and chemical properties of water: atmospheric CO_2 dissolves more easily in cold waters at high latitudes, which, as it sinks to greater depths (via thermohaline circulation[21]) 2, carries this carbon away from the atmosphere for long periods before being re-emitted into the atmosphere in "upwelling"[22] zones and warm tropical waters 3. **This is the primary mechanism for long-term carbon sequestration in the ocean[23].**

There is also the biological pump; every year, phytoplankton captures huge amounts of CO_2 through photosynthesis[24] 4. Much of this CO_2, is quickly re-emitted into the atmosphere through respiration 5 but about 15% is exported to the depths, where a **fraction[25] is sequestered for long periods in sediments[26;27]** 6. This journey to the depths relies on **tooplankton, pelagic and mesopelagic fish,** through their vertical migrations 7 (movements between the seabed and the surface)[28], their excretions, or their death (marine carcasses)[29] 8. **Without the biological pump, the climate would have been 1.64°C warmer in the pre-industrial era.[30]**.

21 Also known as deep ocean circulation, this is the ocean circulation caused by differences in the density (mass per unit volume) of seawater, which gives rise to deep ocean currents. These differences in density are caused by differences in the temperature and salinity of water masses, hence the terms thermo (for temperature) and saline (for salinity).

22 A term referring to the rise of cold, deep water, rich in nutrients and dissolved CO_2, to the ocean surface. As the water warms, it releases CO_2 into the atmosphere.

23 Sarmiento, J. L., & Gruber, N. (2006). Ocean Biogeochemical Dynamics. Princeton University Press. https://doi.org/10.2307/j.ctt3fgxqx

24 Approximately 41.5 ± 9.0 GtC per year.
Doney, S. C., Mitchell, K. A., Henson, S. A., Cavan, E., DeVries, T., Gruber, N., Hauck, J., Mouw, C. B., Müller, J. D., & Primeau, F. W. (2024). Observational and Numerical Modeling Constraints on the Global Ocean Biological Carbon Pump. Global Biogeochemical Cycles, 38(7). https://doi.org/10.1029/2024gb008156

25 0.05%

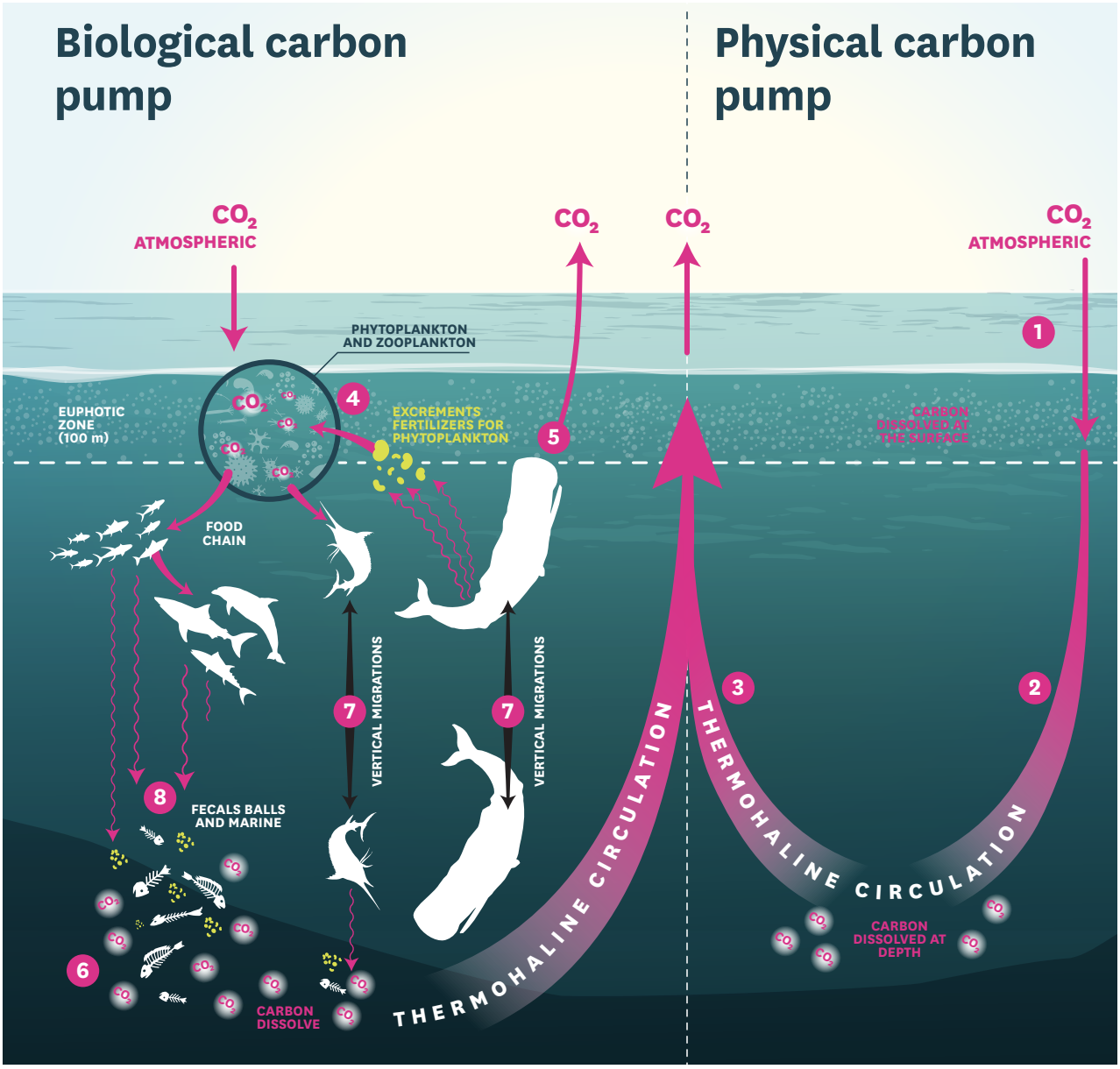
26 Marine sediments: solid particles from continental erosion, biological activity, chemical precipitation, or volcanic and atmospheric processes that settle and accumulate on the ocean floor. They form a dynamic interface between the water column and the oceanic crust, playing a central role in the biogeochemical cycles of carbon, nitrogen, phosphorus, and metals.
Hedges, J. I., & Keil, R. G. (1995). Sedimentary organic matter preservation: an assessment and speculative synthesis. Marine Chemistry, 49(2-3), 81–115. https://doi.org/10.1016/0304-4203(95)00008-F

27 Middelburg, J.J. (2019). Introduction. In: Marine Carbon Biogeochemistry . SpringerBriefs in Earth System Sciences. Springer, Cham. https://doi.org/10.1007/978-3-030-10822-9_1

28 Certain fish living on or near the seabed move to the surface at night to feed, then return to the depths during the day. In doing so, they capture carbon at the surface and store it at depth.

29 Nowicki, M., DeVries, T., & Siegel, D. A. (2022). Quantifying the Carbon Export and Sequestration Pathways of the Ocean's Biological Carbon Pump. Global Biogeochemical Cycles, 36(3). https://doi.org/10.1029/2021gb007083

30 Tjiputra, J. F., Couespel, D., & Sanders, R. (2025). Marine ecosystem role in setting up preindustrial and future climate. Nature Communications, 16(1). https://doi.org/10.1038/s41467-025-57371-y


Biological carbon pump
Physical carbon pump
CO_2 ATMOSPHERIC
CO_2
CO_2
CO_2 ATMOSPHERIC
PHYTOPLANKTON AND ZOOPLANKTON
EUPHOTIC ZONE (100 m)
4
EXCREMENTS FERTILIZERS FOR PHYTOPLANKTON
5
1
CARBON DISSOLVED AT THE SURFACE
FOOD CHAIN
7
VERTICAL MIGRATIONS
7
VERTICAL MIGRATIONS
3
2
8
FECALS BALLS AND MARINE
THERMOHALINE CIRCULATION
THERMOHALINE CIRCULATION
6
CARBON DISSOLVE
CARBON DISSOLVED AT DEPTH

In this context, logic dictates that our entire industry should evolve to minimize its impact on both the climate and the ocean, particularly fishing, which relies on this unique shared resource. Through the Paris Agreement in 2015, France committed to transforming its economy in order to limit global warming to 1.5°C[31]; a target that has already been missed and is now inevitably going to be exceeded[32]. By signing the Kunming-Montreal Agreement in 2023, France also committed to halting and reversing the collapse of biodiversity over the current decade[33].

However, there is nothing in current or announced public policies that suggests the beginning of a change in our fishing model. Worse still, public policy documents dealing with the future of the sector suggest that the fleet will continue to grow in size, with a focus on ever-greater performance and technological innovation. Fuel substitution, engine optimization, and hull optimization are all levers mentioned in the *2025 French National Strategic Sector Contract*, the *2024 French National Roadmap for the Decarbonization of the Maritime Sector* ou *the Status Report on the Energy Transition of Fishing Fleets*, which all push for greater energy efficiency without ever questioning the goal of catching as many fish as possible in the shortest amount of time, regardless of the environmental and human cost. **In short, the transition of the fishing industry is conceived above all as an "energy" and technological transition.** The problem is that this runs the risk of developing, in the name of decarbonization, highly-efficient vessels capable of tracking down every last fish, whilst ignoring the destruction of marine ecosystems and carbon sinks caused by bottom fishing gear.

This vision of the energy transition in fisheries based on technological innovation is at best, insufficient and, at worst, misleading. According to science historian Jean-Baptiste Fressoz, thinking about the energy transition in sectors other than energy "produces more procrastination than anything else"[34]. He shows us that energy substitutions in productive sectors are in fact merely accumulations: the spread of new technologies in no way guarantees the end of the use of old ones[35]. **According to another researcher, François Schneider, there is no guarantee that the environmental gains promised by technological progress will be realized, as they may be offset by a "rebound effect"**[36]: externalities linked to an increase in use or consumption as a result of this technological progress.

As it stands, it is vitally important to break with the logic that the most polluting and environmentally damaging vessels bring in the most catches, even though they receive a very large share of public funding.

31 Adopted in 2015, the Paris Agreement is an international treaty on climate change mitigation and adaptation that aims to keep the average global temperature rise below 2°C compared to pre-industrial levels, and preferably not exceeding +1.5°C.

32 https://www.lemonde.fr/planete/article/2025/06/19/limiter-le-rechauffement-climatique-a-1-5-c-est-desormais-inatteignable_6614266_3244.html

33 The Kunming-Montreal Global Biodiversity Framework is the strategic plan for the 2020s adopted at COP 15 on biodiversity in 2023. It succeeds the Aichi Targets for the 2010 decade. By signing the agreement, France has committed to ensuring that by 2030, at least 30% of land, inland waters, and coastal and marine areas (...) are protected. It must also restore 30% of its degraded ecosystems.

34 Fressoz J.B., 2024. “Sans transition une nouvelle histoire de l’énergie” (Without transition: a new history of energy), Seuil. Ibid

35 Ibid.

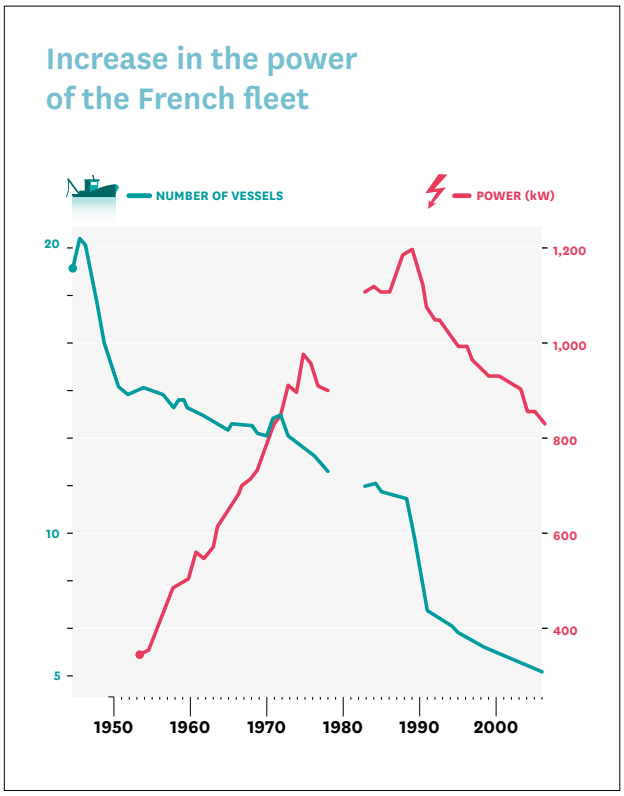
36 Schneider F., 2003. "L’effet rebond," The Ecologist No. 11, October 2003, Vol. 4, No. 3, p. 45

II. CONTEXT: IN JUST A FEW DECADES, THE FISHING INDUSTRY HAS BECOME ENERGY-INTENSIVE

In order to analyze CO_2 emissions from the fishing industry, we need to go back a few years and understand the unprecedented changes that have taken place in this sector since the late 1940s. At the end of World War II, French fishing underwent modernization, both to increase maritime power and to respond to the supply crisis[37]. **From 1950 onwards, fishing power increased dramatically as the industry became more industrialized[38], aided by the emergence of new technologies** (diesel engines, steel hulls, electronic equipment, on-board refrigeration and processing systems, etc.). Total engine power increased sixfold between 1950 and 1990[39]. As this development progressed, the number of vessels decreased[40], and fish catches skyrocketed. Europe reached peak production in 1974 (three million tons caught in 1950, compared to seven million in 1974)[41].

1983 marked a turning point with the introduction of the Common Fisheries Policy (CFP) to regulate fishing activities at the European Union level. This new EU regulation gradually replaced national legislation, creating an integrated European framework for the fishing industry. It was introduced to curb the decline in resources and reduce the number of vessels, while maintaining high productivity.

Although overall engine power has declined since 1996 (notably as a result of various revisions of the CFP)[42], the development of auxiliary equipment has significantly increased the fishing capacity of the European fleet. Electronic tools used to aid fishing (sonar, fish concentration devices, etc.) and navigation, as well as fish processing



37 Fabien Locher. «Reconstruire la pêche française. État, écologie et modernisation (1939-1958)». Le Mouvement social, 2022, 278 (1), pp.73-88. https://shs.hal.science/halshs-03925528/

38 Mesnil, B. (2008). Public-aided crises in the French fishing sector. Ocean & Coastal Management, 51(10), 689-700. https://doi.org/10.1016/j.ocecoaman.2008.07.009

39 Ibid.

40 See graph below in Mesnil, B. (2008). Public-aided crises in the French fishing sector. Ocean & Coastal Management, 51(10), 689-700. https://doi.org/10.1016/j.ocecoaman.2008.07.009

41 BLOOM processing based on FAO data.

42 The Common Fisheries Policy in figures. Basic statistical data — 2022 edition. https://op.europa.eu/fr/publication-detail/-/publication/c2f39f4a-29a2-11ed-975d-01aa75ed71a1

and preservation equipment, have made fishing extremely effective, thereby increasing the power of the fleet[43]. **In 2022, France ranked second among the most powerful fleets in the European Union, just behind Italy, even though it has almost half as many fishing vessels**[44].

This race for modernization has propelled the industrial fishing model and "towed gear", such as trawling, to the forefront of the European fishing industry. **However, it is this increase in fishing effort that has led to an unprecedented decline in fish biomass**[45], causing widespread **destabilization of the food web and ecosystem functioning**[46].

In order to catch the same volumes as before, the fishing effort had to increase, along with a greater reliance on more efficient vessels that exerted disproportionate pressure on ecosystems. While small-scale fishing is carried out on a human scale[47], industrial fishing has gradually evolved to catch, preserve, sometimes process on board, and then land tens, hundreds, or even thousands of tons of resources caught during long sea campaigns and destined for processing. At the same time, **consumption of prepared seafood products has skyrocketed:** in 1990, the French ate 4.2 times more than in 1960. **The decline in the market share of fresh produce has strengthened large-scale distribution:** while large and medium-sized stores in France accounted for 6% of seafood purchases in 1969, they accounted for 24% of sales in 1983[48] and 73% in 2023[49].

This model of production and consumption means that, in order to fish ever further and further afield, it is necessary to take machinery on board to **build a cold chain for storing catches (or even process them on board), use ever larger nets, deploy devices to aggregate fish**[50]**, sometimes use support vessels for the sole purpose of deploying even more fishing gear**[51]**, and even send crews by plane to distant ports in Seychelles, Scotland and Norway.** This model inherently requires a high consumption of energy.

In present-day France, we have reached a paradoxical situation where 60.7% of the fish caught by the French fleet in terms of weight (kilograms) comes from 8.5% of vessels, namely high-sea and industrial trawlers over 12 meters in length. However, their volumes represent only 47% of the total economic value of catches (in euros)[52]. At the other end of the spectrum, coastal fishing with passive gear (trap boats, longliners, and gillnetters under 12 meters) accounts for 74% of vessels, 11% of the French fleet's volume, but only 21% of the total economic value of catches[53]. In other words, industrial fishing catches huge volumes of low-value fish, unlike small-scale coastal fishing, which catches less but adds a higher value.

There is no doubt that the difference in catch volumes between these fleets is not so much a question of "capacity" as it is one of "opportunity." The allocation of quotas among vessels is always linked to fishing history, in other words: vessels that have fished more in the past are allocated larger quotas.

43 Communication from the Commission to the Council and the European Parliament on improving fishing capacity and effort indicators under the Common Fisheries Policy. Brussels, February 5, 2007. https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM%3A2007%3A0039%3AFIN%3AFR%3APDF

44 Agreste GraphAgri 2024. Pêche et aquaculutre. https://agreste.agriculture.gouv.fr/agreste-web/download/publication/publie/GraFra2024Chap7.1/GraphAgri2024_peche-maritime.pdf

45 Christensen, V., Guénette, S., Heymans, J. J., Walters, C. J., Watson, R., Zeller, D., & Pauly, D. (2003). Hundred-year decline of North Atlantic predatory fishes. Fish And Fisheries, 4(1), 1-24. https://doi.org/10.1046/j.1467-2979.2003.00103.x

46 Pauly, D., Christensen, V., Dalsgaard, J., Froese, R., & Torres, F. (1998). Fishing down marine food webs. Science, 279(5352), 860-863. https://doi.org/10.1126/science.279.5352.860

47 Human scale refers to fishing activities that are rich in human capital and integrated within a local ecosystem.

48 Michèle Bertrand, Consommation et lieux d'achat des produits alimentaires en 1991, INSEE Results Collection. https://www.bnsp.insee.fr/ark:/12148/bc6p06xwzqb/f1.pdf

49 Kantar 2023 data on seafood consumption.

50 These are known as Fish Aggregating Devices (FADs) in tuna fishing.

51 Vessels used to deploy new FADs, track them, and help locate schools of tuna.

52 STECF data (average between 2017 and 2021 in Quemper *et al.*, 2025).

53 Ibid.

III. CARBON FOOTPRINT OBJECTIVES AND METHODOLOGY

1. Objectives and scope of the carbon footprint of French fisheries

Carbon footprint assessments are used to comprehensively **quantify the sources of greenhouse gas (GHG) emissions from an activity** in order to better **understand their causes and identify areas for improvement.** It is one of many tools needed to decide on a policy for the social and ecological transition of fisheries. As shown by researchers from the Institut Agro and the French Natural History Museum, who are collaborating with BLOOM as part of the fisheries transition research group, it is also necessary to evaluate fisheries using multiple ecological, economic, and social indicators. This work was carried out for France in 2025[54].

The carbon footprint analysis examines emissions from French commercial fishing activities, from the construction of vessels and fishing gear to the landing of fish, which constitutes the "upstream" part of the sector. Emissions from the "downstream" part of the sector (i.e., emissions related to the entry of fish into the value chain until its consumption) and those related to the trade balance of French seafood products (emissions related to the consumption of imported products consumed by French residents, as well as those of exported products) are not included. Quantifying these emissions remains essential in the context of the social and ecological transition of the fishing industry and its supply chain, and in the evolution of consumption practices. To date, no such quantification exists.

Carbon emissions linked to fishing are by no means a new topic in the literature. However, until now, no carbon footprint assessment has been carried out for the French fleet as a whole[55].

54 Quemper F., Levrel H., Mouillard R., Gascuel D., 2025. Evaluation des performances environnementales, économiques et sociales des flottilles de pêche: Bilan France. Rapport du programme TransiPêche: Scénarios de transition écologique et sociale des pêches françaises. Les publications du Pôle halieutique, mer et littoral de L'Institut Agro n° 56

55 In France, environmental studies and life cycle assessments (LCAs) of seafood products exist and consider numerous emission sources, but they are not applied to the entire fleet. These studies have been used for the present exercise, particularly the one conducted by ADEME.

2. Classification of fleets to facilitate comparison

In order to compare emissions from different types of fishing, we used the classification of fishing fleets by Quemper *et al.* (2025). Each fleet is defined by: a main gear type (dredge, pelagic trawl and seine, bottom trawl and seine, passive gear) and a size class of vessel (coastal, less than 12 meters, offshore, between 12 to 24 meters and industrial, over 24 meters). This classification yields a total of twelve comparable fleets [56]. Passive gear includes traps, lines, and nets.

This organization has distinguished:

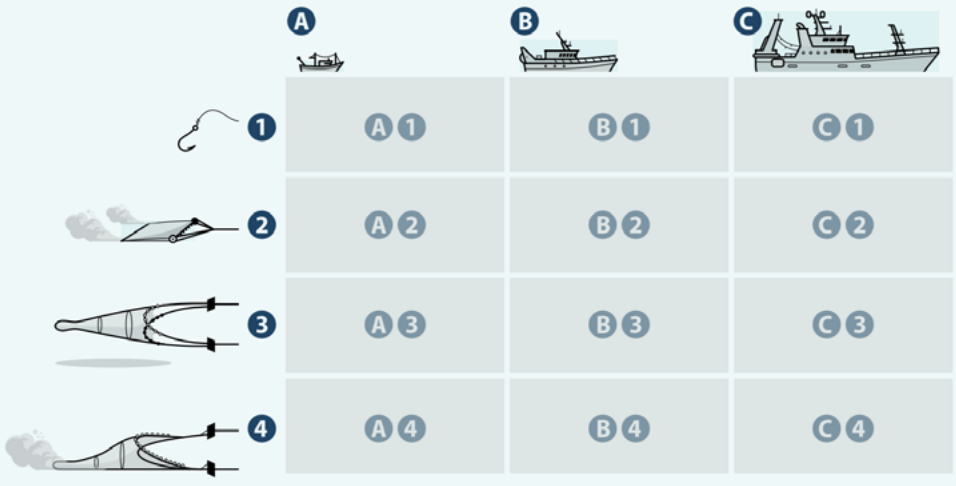
(This classification is used in the rest of this document)

4 major categories for fishing techniques

1. Passive gear (nets, lines and traps)
2. Dredgers and multipurpose vessels
3. Pelagic trawls and seines
4. Bottom trawls and seines

3 major categories for vessel size classes

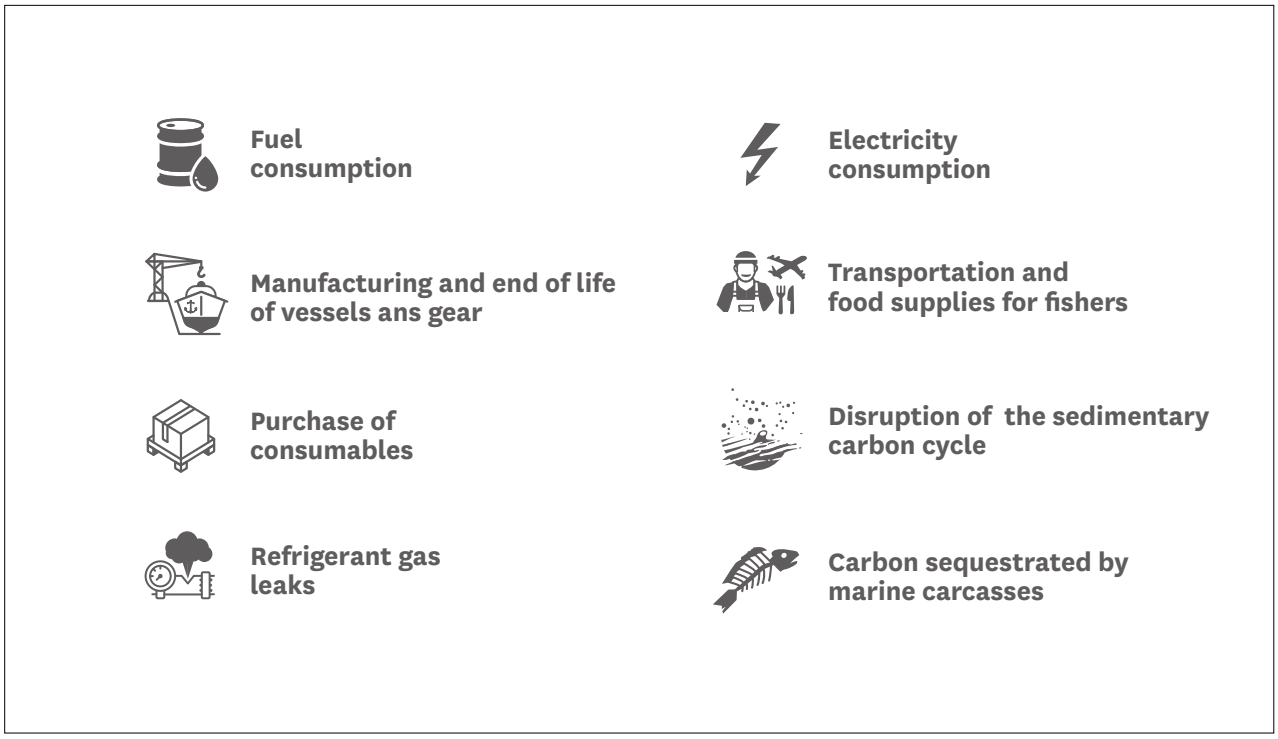
- A Coastal vessels (vessels from 0 to 12 meters)
- B High-sea vessels (vessels between 12 and 24 meters)
- C Industrial vessels (vessels over 24 meters)



56 Quemper F., Levrel H., Mouillard R., Gascuel D., 2025. valuation des performances environnementales, économiques et sociales des flottilles de pêche: Bilan France. Rapport du programme TransiPêche: Scénarios de transition écologique et sociale des pêches françaises. The publications of the Pôle halieutique, mer et littoral de L'Institut Agro n° 56

3. Summary of emission sources studied

The GHG emissions assessment[57] takes into account 10 emission sources. In this summary, and to make the results easier to read, we have grouped some of these sources, which are similar in nature, into eight categories (details of the groupings are provided in Appendix 3):



1 Fuel consumption

Whether for fishing, transit, dock activities, or all onboard needs, vessels consume a significant quantity of fuel.

2 Manufacturing and end of life of vessels ans gear

This emission category covers fishing vessels and all equipment on board, from manufacture to end of life (treatment as waste). This includes:

- **Vessel:** the materials used to construct the various parts of the vessel (hull, deck, cabins, electronic equipment, holds, etc.).
- **Fishing gear:** the materials used to make the fishing gear (nylon nets, panels, hooks and artificial bait, ropes, ballast, etc.).

57 See link to the carbon footprint on the inside cover of this report.

3 Purchase of consumables

Emissions linked to the manufacture and end-of-life treatment (as waste) of materials or products purchased annually for onboard maintenance or storage/packaging of fish (plastic crates, motor oils, paints, cardboard packaging, etc.).

4 Refrigerant gas leaks

Depending on the target species and the duration of sea trips, refrigeration systems of different types and sizes may be used on board vessels. Refrigeration requires the use of natural or synthetic gases, some of which have global warming potentials (GWP) that are vastly higher than those of carbon dioxide. For example: 1 kg of R410a gas leaking corresponds to 2,256 kg of CO_2[58]. Gas leaks, which we quantify here, escape from these refrigeration machines every year.

5 Electricity consumption

This item calculates emissions from electricity consumption from ice-making machines at docks. Other categories of electricity consumption at docks could not be quantified due to a lack of response from the port managers contacted.

6 Transportation and food supplies for fishers

These are GHG emissions linked to fishers' travel to port and their food consumption on board. Some French vessel crews have to travel to Seychelles, West Africa, or the north of the United Kingdom to embark. This is particularly the case for industrial fishing models operating far from the French coast (tropical tuna purse seine fishing and trawlers in the North Sea off the United Kingdom).

Two items related to the disruption of the biological carbon pump

The ocean is a **key** element in **the carbon cycle** on Earth and contains at least **40 times more carbon than the atmosphere**[59]. By exchanging approximately 160 gigatons of carbon (GtC) with the atmosphere each year, and absorbing slightly more than it releases, it represents a net sink of approximately **2.9 GtC/year**[60] which is modest compared to the volumes exchanged. **However, the ocean absorbs almost 30% of CO_2 emissions linked to human activities**[61].

However, the **submerged nature of the ocean symbolically reflects our profound lack of understanding of its ecological dynamics,** particularly with regard to **its role in the carbon cycle.** For example, in the current carbon footprint methodology [62] forests, grasslands, and agricultural land are rigorously monitored and accounted for in the official item[63] *"Land use and land-use change (LULUCF),"* **while "use of marine resources or ecosystems"** and the disturbances they undergo through bottom fishing **are not included.**

Many mechanisms that contribute to the ocean carbon cycle could be impacted by fishing (e.g., vertical movements of marine animals, fecal pellets, end-of-life carcasses, sedimentation, etc.). A group of researchers has shown that deep-sea demersal fish living in British and Irish waters store around 1 million tons of CO_2 each year through their vertical movements[64].

For the first time, our carbon footprint assessment takes into account two of these mechanisms: carbon sequestered by marine carcasses and carbon stored in sediments.

58 https://prod-basecarbonesolo.ademe-dri.fr/documentation/UPLOAD_DOC_FR/index.htm?prg.htm

59 Friedlingstein, P., O'Sullivan, M., Jones, M. W., Andrew, R. M., Gregor, L., Hauck, J., Quéré, C. L., Luijkx, I. T., Olsen, A., Peters, G. P., Peters, W., Pongratz, J., Schwingshackl, C., Sitch, S., Canadell, J. G., Ciais, P., Jackson, R. B., Alin, S. R., Alkama, R.,. . . Zheng, B. (2022). Global Carbon Budget 2022. Earth System Science Data, 14(11), 4811-4900. https://doi.org/10.5194/essd-14-4811-2022

60 Ibid.

61 Gruber, N., Clement, D., Carter, B. R., Feely, R. A., van Heuven, S., Hoppema, M., Ishii, M., Key, R. M., Kozyr, A., Lauvset, S. K., Lo Monaco, C., Mathis, J. T., Murata, A., Olsen, A., Perez, F. F., Sabine, C. L., Tanhua, T., & Wanninkhof, R. (2019). The oceanic sink for anthropogenic CO_2 from 1994 to 2007. Science, 363(6432), 1193–1199. https://doi.org/10.1126/science.aau5153

62 https://abc-transitionbascarbone.fr/wp-content/uploads/2022/03/bilan-carbone-v8-guide-methodologique-final.pdf
https://www.ecologie.gouv.fr/sites/default/files/documents/methodo_BEGES_decli_07.pdf

63 In the Bilan Carbone® (carbon footprint) methodology by ADEME, an emissions item corresponds to a homogeneous category of greenhouse gas (GHG) emission sources grouped according to their nature or origin (e.g., fuels, electricity, freight, purchases, travel, waste).

64 Trueman *et al.* (2014). Trophic interactions of fish communities at midwater depths enhance long-term carbon storage and benthic production on continental slopes. Proceedings of the Royal Society B: Biological Sciences 281(1787).

7 Carbon sequestrated by marine carcasses

Marine *biomass* plays an underestimated but crucial role in regulating the global carbon cycle, particularly through the contribution of large pelagic predators (such as tuna and sharks). By storing carbon in their tissues and exporting this carbon to the deep sea when they die (a phenomenon known as "sinkfall"), these species contribute to the long-term sequestration of ocean carbon. **By reducing this marine biomass each year, industrial fishing potentially prevents the sequestration of tens of millions of tons of carbon,** particularly by reducing the number of carcasses reaching the abyssal zones[65]. Protecting and restoring large fish populations is therefore not only a matter of biodiversity conservation, but also a potential strategy for continuing to store CO_2 sustainably. A study published in October 2025 even shows that, on a global scale, the sequestration potential of marine macrofauna is similar to that of mangrove restoration, with mangroves included among the most effective ecosystems for CO_2 sequestration[66;67].

Had they not been caught, a fraction of the fish would have died naturally and could have contributed to carbon storage (as explained above). It is this portion of unstored carbon that is quantified here, based on scientific research (notably Mariani *et al.*[68]).

It is important to remember that these processes are part of a complex food chain, where predatory interactions influence carbon circulation. This dynamic makes it difficult to establish a net balance of carbon losses or gains associated with the extraction of marine biomass. For example, overfishing of a large predator with high sequestration potential (living on the surface above the deep seabed and producing carcasses or fecal pellets that sink quickly) could paradoxically promote the proliferation of small prey species. By increasing their own biomass and biological activity, these species could in turn increase carbon sequestration through similar mechanisms or reduce it through increased respiration[69].

8 Disruption of the sedimentary carbon cycle

Marine sediments are an invisible treasure trove. Preserved from human destruction for millions of years, they have been able to accumulate immense quantities of carbon, among other things, via the biological pump. There is as much carbon in sediments as in all the terrestrial soils on the globe[70]. Approximately 87 gigatons of carbon are stored in the top five centimeters of marine sediments[71], equivalent to about three-quarters of the world's underground gas reserves[72]. **The seabed represents a valuable store of CO_2 that should be protected rather than left prey to bottom trawling.**

65 Mariani, G., Cheung, W. W. L., Lyet, A., Sala, E., Mayorga, J., Velez, L., Gaines, S. D., Dejean, T., Troussellier, M., & Mouillot, D. (2020b). Let more big fish sink: Fisheries prevent blue carbon sequestration—half in unprofitable areas. Science Advances, 6(44). https://doi.org/10.1126/sciadv.abb4848

66 Donato, D. C., Kauffman, J. B., Murdiyarso, D., Kurnianto, S., Stidham, M., & Kanninen, M. (2011). Mangroves among the most carbon-rich forests in the tropics. Nature Geoscience, 4(5), 293-297. https://doi.org/10.1038/ngeo1123

67 Mariani, G., Guiet, J., Bianchi, D., DeVries, T., Barrier, N., Troussellier, M., & Mouillot, D. (2025). The combined impact of fisheries and climate change on future carbon sequestration by oceanic macrofauna. Nature Communications, 16(1). https://doi.org/10.1038/s41467-025-64576-8

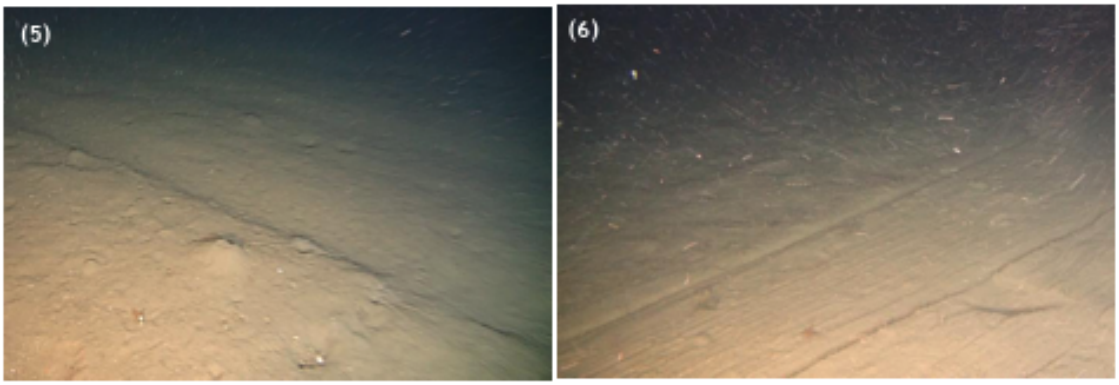
68 Ibid.

69 Stafford, R., Boakes, Z., Hall, A.E. *et al.* The Role of Predator Removal by Fishing on Ocean Carbon Dynamics. Anthr. Sci. 1, 204–210 (2022). https://doi.org/10.1007/s44177-021-00005-x

70 Friedlingstein, P., O'Sullivan, M., Jones, M. W., Andrew, R. M., Gregor, L., Hauck, J., Quéré, C. L., Luijkx, I. T., Olsen, A., Peters, G. P., Peters, W., Pongratz, J., Schwingshackl, C., Sitch, S., Canadell, J. G., Ciais, P., Jackson, R. B., Alin, S. R., Alkama, R.,. . . Zheng, B. (2022). Global Carbon Budget 2022. Earth System Science Data, 14(11), 4811-4900. https://doi.org/10.5194/essd-14-4811-2022

71 Lee, T. R., Wood, W. T., & Phrampus, B. J. (2019). A Machine Learning (kNN) Approach to Predicting Global Seafloor Total Organic Carbon. Global Biogeochemical Cycles, 33(1), 37-46. https://doi.org/10.1029/2018gb005992

72 Ibid 70.



Photos: *Deep trench caused by trawling (102 m deep) and narrow trawl marks (88 m deep). Source: setec énergie environnement, 2023 – Figure 6 of the Environmental Study Report using an ROV... SMW6 – March 2023.*



Photos: *Soft seabed*[73] *(consisting of sediments) and benthic ecosystems in the North Atlantic. Photo credit: Alain Pibot. Source: « Note de vulgarisation – Habitats Meublés », LIFE Marha / OFB, 2025.*



Photo: *Trawl marks on a soft seabed in the Gulf of Lion. Photo credit: Céline Labrune. Source: « Note de vulgarisation – Habitats Meublés », LIFE Marha / OFB, 2025.*

73 Soft seabeds are areas of the seafloor consisting of unconsolidated sediments (sand, mud, gravel, etc.), which are home to a rich biodiversity of species living on or in the sediment, and which play an essential role in the functioning and balance of marine ecosystems.

This sink is the result of a complex chain of **biogeochemical** processes involving dynamic interactions between marine life (production, consumption, degradation), the physical properties of the environment (currents, turbulence, deposition, burial, bioturbation[74]), and chemical reactions involving carbon in sediments (mineralization). Benthic invertebrates (sponges, bivalves, burrowing worms, etc.) are the engineers of this sink: they stabilize sediments, bury organic matter, and slow its degradation. These sedimentary ecosystems, despite remaining largely unseen, are essential for sustainable carbon storage.

However, the mechanisms described above are fragile and are greatly affected by bottom fishing activities.

Bottom trawling, which is used to dislodge species buried in or close to the seabed, resuspends some of the organic carbon stored in sediments, making it available again for remineralization (i.e., its transformation into dissolved CO_2), which can then be re-emitted into the atmosphere. Trawling also alters the structure and functioning of benthic communities (sometimes with conflicting consequences[75]), which, in addition to altering ecosystems, can reduce their capacity to store carbon sustainably in the long term[76]. Finally, the resuspension of sediments can also influence the activity of phytoplankton, which also sequesters carbon dioxide. For example, by increasing the water turbidity[77] (how cloudy it looks), this physical disturbance could, in certain areas, limit light penetration and locally reduce primary production (production of plant organic matter resulting from phytoplankton photosynthesis)[78]. Conversely, it could also release nutrients previously buried in sediments into the water column and promote primary production[79].

The model developed by Zhang *et al.* (2024)[80], the most recent and robust to date, analyzes the impacts of trawling on the various biogeochemical mechanisms of the benthic ecosystem in the North Sea. **It shows that trawling drastically reduces the accumulation of organic carbon in sediments.**

Furthermore, new research warns of the harmful consequences of seabed abrasion, which have previously been overlooked:

- Pyrite *(an iron sulfide mineral that is highly abundant in marine sediments) is believed to oxidize due to agitation by bottom trawls, releasing* CO_2[81];
- By agitating the seabed, trawling allows oxygen to penetrate deep layers of sediment, preventing a natural reaction that only occurs in the absence of oxygen and which would enable the ocean to increase its buffering capacity, i.e. its ability to absorb CO_2[82].

74 Refers to the physical and spatiotemporal rearrangement of sediments caused by the movement or activity (reworking of sedimentary material) of certain living organisms, known as bioturbators (worms and crustaceans).

75 Bottom trawling can, to a certain extent, temporarily limit carbon losses by burying a small portion of organic carbon in deeper layers of sediment, which are less exposed to degradation. In addition, the decline in benthic fauna caused by this practice reduces biological respiration and, consequently, associated CO_2 emissions. However, these effects remain minor compared to the scale of the disruption caused to carbon stocks and sequestration.

76 Epstein, G., Middelburg, J. J., Hawkins, J. P., Norris, C. R., & Roberts, C. M. (2022). The impact of mobile demersal fishing on carbon storage in seabed sediments. Global Change Biology, 28(9), 2875-2894. https://doi.org/10.1111/gcb.16105

77 Turbidity: a measure of the amount of suspended particles in water, which reduce its transparency. High turbidity limits light penetration, which can impair photosynthesis and primary productivity in aquatic ecosystems.

78 Tiano, J., De Borger, E., Paradis, S., Bradshaw, C., Morys, C., Pusceddu, A., Ennas, C., Soetaert, K., Puig, P., Masqué, P., & Sciberras, M. (2024). Global meta-analysis of demersal fishing impacts on organic carbon and associated biogeochemistry. Fish And Fisheries, 25(6), 936-950. https://doi.org/10.1111/faf.12855

79 De Madron, X. D., Ferré, B., Corre, G. L., Grenz, C., Conan, P., Pujo-Pay, M., Buscail, R., & Bodiot, O. (2005). Trawling-induced resuspension and dispersal of muddy sediments and dissolved elements in the Gulf of Lion (NW Mediterranean). Continental Shelf Research, 25(19-20), 2387-2409. https://doi.org/10.1016/j.csr.2005.08.002

80 Zhang, W., Porz, L., Yilmaz, R., Wallmann, K., Spiegel, T., Neumann, A., Holtappels, M., Kasten, S., Kuhlmann, J., Ziebarth, N., Taylor, B., Ho-Hagemann, H. T. M., Bockelmann, F., Daewel, U., Bernhardt, L., & Schrum, C. (2024). Long-term carbon storage in shelf sea sediments reduced by intensive bottom trawling. Nature Geoscience. https://doi.org/10.1038/s41561-024-01581-4

81 Kalapurakkal, S., *et al.* (2025). Sediment resuspension and its impact on carbon emissions from coastal ecosystems: The role of pyrite oxidation. Global Biogeochemical Cycles, 39(4), 567-582. https://www.nature.com/articles/s43247-025-02132-4

82 Van de Velde, S. J., Hylén, A., & Meysman, F. J. R. (2025). Ocean alkalinity destruction by anthropogenic seafloor disturbances generates a hidden CO_2 emission. Science Advances, 11(13). https://doi.org/10.1126/sciadv.adp9112

In order to estimate the carbon impact of sedimentary carbon disturbance by French fishing, the carbon footprint assessment was based on the two models currently available:

- **Atwood *et al.* (2024)**[83]: This model was one of the first to estimate emissions due solely to sediment resuspension. However, it does not take into account other mechanisms affected by trawling (bioturbating organisms, additional carbon burial, etc.). It is also based on incomplete satellite data (AIS) and a carbon degradation rate parameter (a constant named k) the value of which is subject to controversy (probably overestimated). In the carbon footprint assessment, this model was applied to the French fleet of bottom trawlers and dredgers using two carbon degradation rate values that were more conservative than the one initially used in the model; namely reduced by one and two orders of magnitude (10 and 100 times slower than the reaction speed in the initial model), as suggested in the critiques[84].

- **Zhang & Porz (2024)**[85]: This model is described by several experts as the most robust to date. It assesses the overall impact of bottom trawling (but not dredging) on the sedimentary carbon cycle, and therefore on the various benthic mechanisms (with sometimes conflicting carbon implications) disrupted by bottom abrasion. It is currently limited to the North Sea and was not possible to implement directly on the French trawling area due to its technical complexity. It was therefore used indirectly to produce an order of magnitude based on the spatial footprint of French trawling.

To account for methodological uncertainties, three estimates were produced based on the two previous models:

1. **Hypothesis 1 – Atwood *et al.* (2024) with k/100:** the most conservative approach, which uses a carbon reaction rate in sediments that is 100 times slower than the initial model.

2. **Hypothesis 2 - Zhang *et al.* (2024):** the intermediate approach: the model results were extrapolated to the French fleet and its fishing areas. The approach is based solely on characteristics specific to the North Sea (although these are quite similar to the rest of the trawled waters in the Northeast Atlantic).

3. **Hypothesis 3 – Atwood *et al.* (2024) with k/10:** the least conservative approach: based on a carbon reaction rate in sediments that is 10 times slower than in the initial model.

Due to the lack of maturity of research on this subject and the significant variability in the orders of magnitude currently available, we have chosen not to include it in the official items of this assessment or in the overall figures presented in the "Results" section. These emissions items will be dealt with separately.

Outside the scope of the carbon footprint: supply chain, consumption, and trade balance

As mentioned above, this carbon footprint does not include emissions linked to the fish processing and marketing sector, nor those linked to exports. Furthermore, it does not include emissions linked to the consumption of imported fish consumed in France.

83 Atwood, T.B., Romanou, A., DeVries, T., Lerner, P.E., Mayorga, J.S., Bradley, D., Cabral, R.B., Schmidt, G.A., Sala, E., 2024. Atmospheric CO_2 emissions and ocean acidification from bottom-trawling. Front. Mar. Sci. 10:1125137. https://doi.org/10.3389/fmars.2023.1125137

84 Hiddink, J. G., Van de Velde, S. J., McConnaughey, R. A., De Borger, E., Tiano, J., Kaiser, M. J., Sweetman, A. K., & Sciberras, M. (2023). Quantifying the carbon benefits of ending bottom trawling. Nature, 617(7960), E1-E2. https://doi.org/10.1038/s41586-023-06014-7

85 Zhang, W., Porz, L., Yilmaz, R., *et al.*, 2024. Long-term carbon storage in shelf sea sediments reduced by intensive bottom trawling. Nat. Geosci. 17, 1268–1276. https://doi.org/10.1038/s41561-024-01581-4

IV. RESULTS

The results below do not include emissions related to the disruption of the sedimentary carbon cycle. Given the different approaches and estimates on this subject, these are treated separately, after the results below.

1. Fuel consumption plays a key role in the carbon footprint

French commercial fishing emits at least 1.1 million tons of CO_2e for approximately 527,000 tons[86] of seafood caught. This is equivalent to the emissions produced by 444,000 combustion engine cars in one year[87]. In total, emissions from the fishing industry are equivalent to those from the egg-laying industry, which produces around 14.4 billion eggs per year[88] (almost 900,000 tons). If we compare these emissions to those of the plant protein production sector, the fishing industry emits seven times more than the protein crop sector[89] which supplies 867,000 tons of chickpeas, lentils, broad beans, etc. annually[90]. This is also similar to the emissions from domestic air traffic in mainland France in 2023, estimated at 1.6 million tons of CO_2.

84% of the fleet's emissions (960,800 tons of CO_2e) come from fuel consumption by ships (used for travel and all activities on board), making it by far the largest source of emissions from the fleet.

The rest of the emissions from this activity are linked (from highest to lowest emissions) to the life cycle of ships and onboard equipment[91] (95,800 tons of CO_2e, or 8%), refrigerant gas leaks (31,200 tons of CO_2e, or 3%), marine carcasses (23,200 tons of CO_2e, or 2%), the travel and food consumption of fishers (14,500 tons of CO_2e, or 1.3%), the purchase of consumables (12,200 tons of CO_2e, or 1%), and finally electricity consumption (600 tons of CO_2e, or 0.05%).

If we had included sediment disturbance in these results, which is treated separately due to the novelty of studies on the subject and the resulting uncertainties, this emission source would be the second largest in the sector, with potential emissions of 104,000 to 883,000 tons of CO_2e, or 8% to 44% of the sector's emissions (see section on *Sediment disturbance: a ticking time bomb?*).

86 485,000 tons if laminaria algae are excluded.

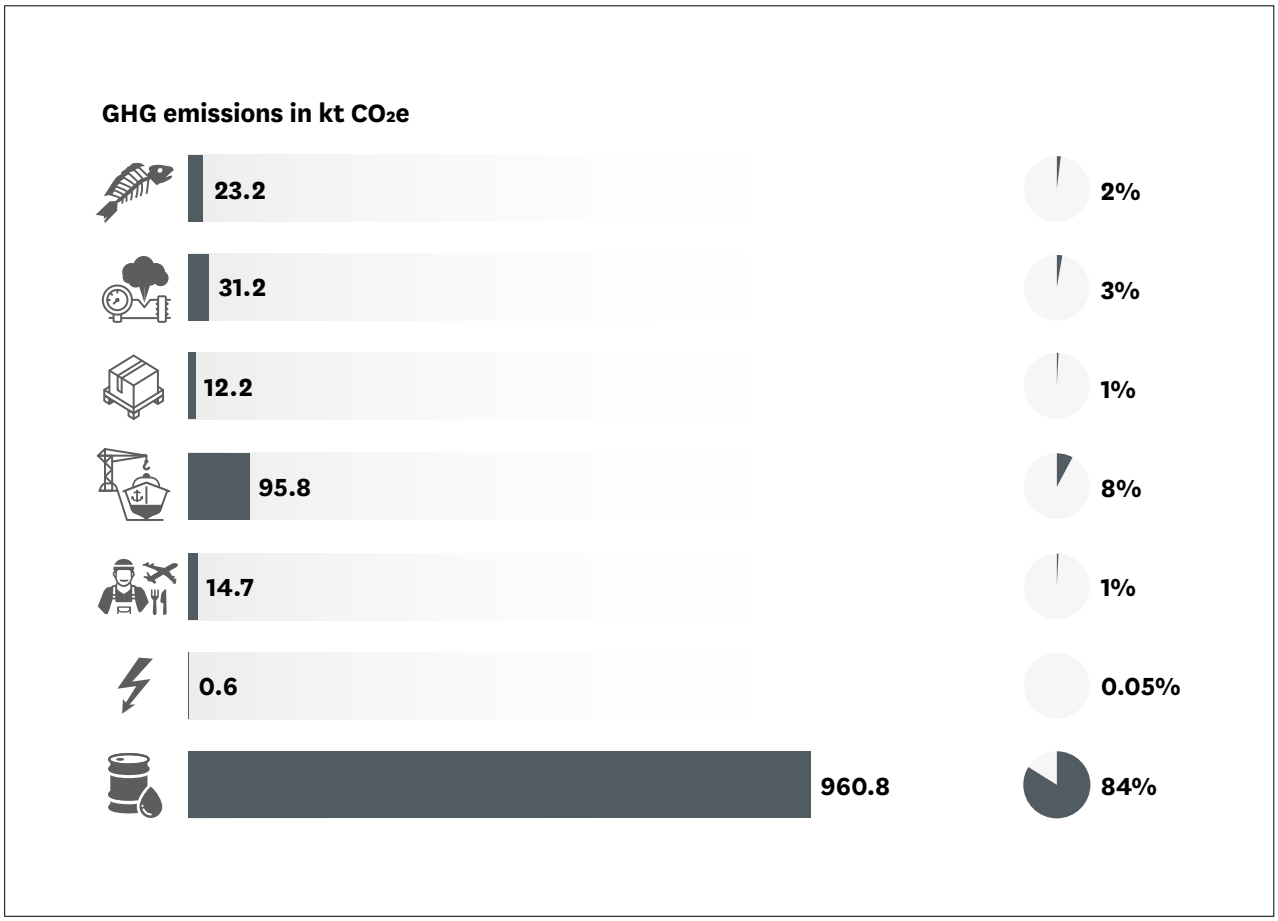
87 Calculations based on data from the Base Empreinte (ADEME) and an average distance of 10,000 km per year per car.

88 2019 emissions (the most recent available outside the COVID context) from Floréal, CITEPA. 1.1 $MtCO_2e$. Emissions also include the processing sector (0.23 $MtCO_2e$). https://www.citepa.org/donnees-air-climat/donnees-gaz-a-effet-de-serre/floreal/ Egg sector, France AgriMer. https://www.franceagrimer.fr/node/2866

89 Floréal data, 2019. In the Floréal inventory, soybeans are included in the oilseed sector (oils) and we are unable to extract GHG emissions from the available data.

90 Floréal 2019. 0.162 $MtCO_2e$. https://www.citepa.org/donnees-air-climat/donnees-gaz-a-effet-de-serre/floreal/
Protein crop sector, France AgriMer.
https://www.franceagrimer.fr/sites/default/files/rdd/documents/FICHE%20FILIERE%20PROTEAGINEUX_2.pdf

91 Manufacturing and end-of-life.



Graph 3: *Breakdown of GHG emissions from French fishing by different emission sources.*

2. The limitations of a productivity-based approach

Note – *The results per kg of landed/consumable product below correspond to* ***indicative average values for the "carbon performance" of small-scale fleets***[92].

A traditional approach: emissions per kg landed…

In relation to what it extracts, French fishing emits an average of 2.2 $kgCO_2e$ per kilogram of seafood landed. These emissions can vary significantly from one fleet to another: from 0.4 $kgCO_2e$ per kg landed for dredgers less than 12 meters long, to 4.3 $kgCO_2e$ per kg landed for trawlers less than 24 meters long[93] (graph 4).

Going one step further: emissions per kg of consumable product

These emissions can be compared to those from other sources of animal protein **by relating the emissions from fishing fleets to the quantities of consumable products from their landings,** i.e., once the heads, entrails, bones, or shells have been removed. In French fisheries, an average of **4.2 $kgCO_2e$** is emitted per kilogram of consumable seafood, which is slightly more than the emissions associated with chicken meat production (3.7 $kgCO_2$[94]). This average obviously masks a great deal of heterogeneity: consumable seafood from dredgers less than 12m long emits **0.5 $kgCO_2e$**[95] per kg of consumable flesh (for the same reasons mentioned above), **while, at the other end of the scale, this figure is around 10 $kgCO_2e$ for bottom trawlers.**

Across all emission categories, **the vessels with the highest emissions per kilogram landed are trawlers and bottom seiners,** followed by passive gear and then pelagic trawlers and seiners[96]. **The dredger and multi-purpose fleet has the lowest emissions per kilogram landed. The lower footprint of dredgers can be explained by their operating mode (fishing in defined and identified areas for a limited time, without fuel being used to search for resources).** Furthermore, this apparent performance is based on very high volumes of biomass landed, only a small proportion of which is consumable: the weight of the shell therefore tends to "dilute" the carbon intensity per kg landed. This consideration is essential when interpreting the performance of dredgers.

Dredges aside, **pelagic trawls and seines have the best "energy performance."** However, if we look solely at emissions linked to fishing activity (fuel, refrigerant gases, electricity and travel by fishers), industrial pelagic trawlers and seiners emit almost as much per kilogram landed as passive gear less than 12 meters long, which puts the argument that industrial vessels are "more efficient" than passive gear into perspective.

92 They are not of the same nature as the carbon footprint associated with a specific product that a Life Cycle Assessment alone can produce (such as Agribalyse, for example). See dedicated box in the methodological report.

93 Indicators that do not take into account the disruption of the sedimentary carbon cycle, and are therefore underestimated for bottom trawls.

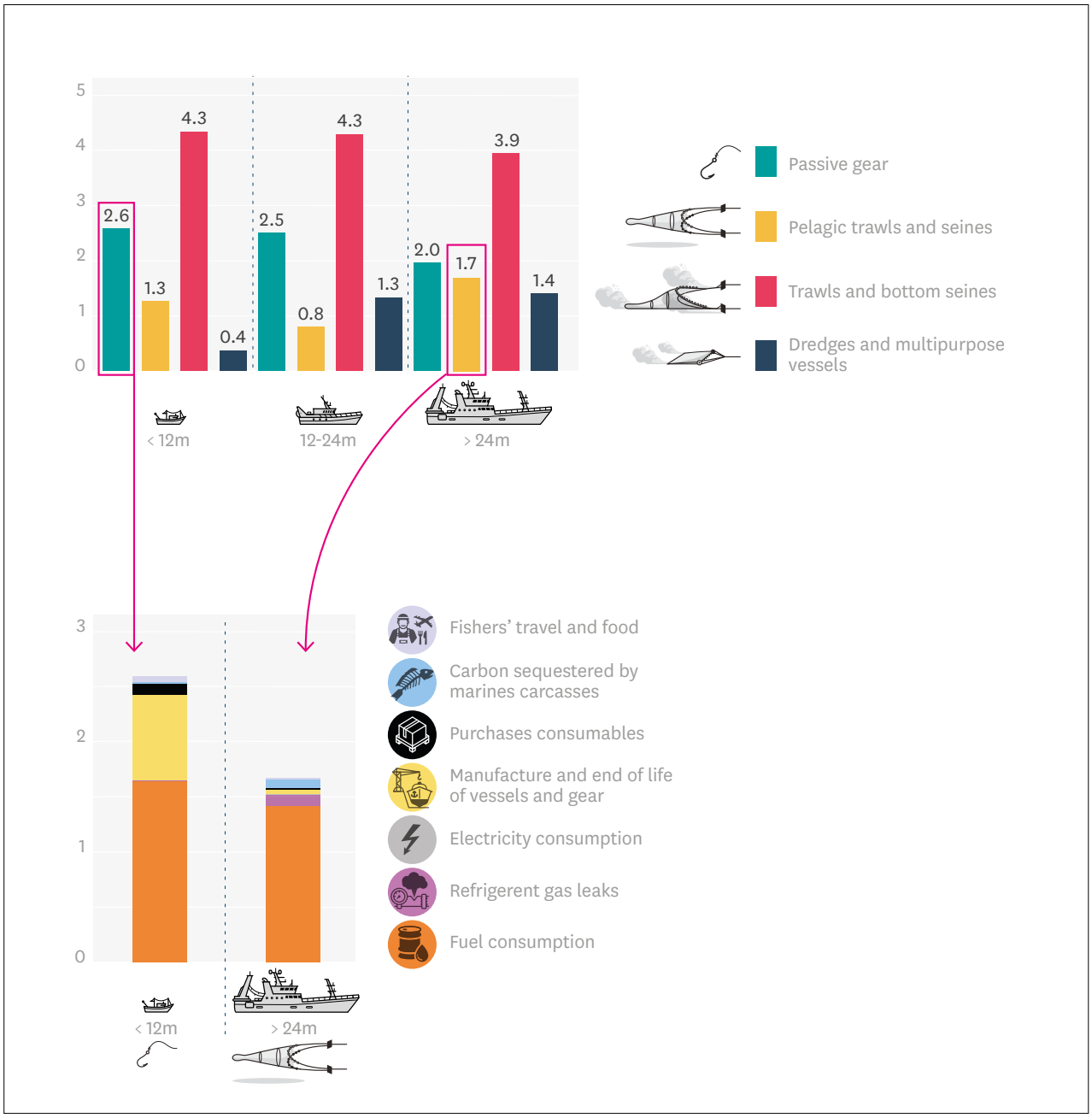
94 81.7% * 4.56 $kgCO_2e$ (Agriculture stage only) https://agribalyse.ademe.fr/app/aliments/36003#Poulet,_viande,_crue

95 This strong performance is particularly influenced by the significant presence of algae in their landings (for which the conversion factor is 100%), especially those of small vessels.

96 Pelagic trawlers use a trawl net (a cone-shaped net that is dragged through the water column) through the school of fish. It is typically used for mackerel, herring, or blue whiting. Pelagic seines, used by seiners, are vertical nets deployed around the school. They are typically used for tuna. .

In other words, **industrial pelagic trawlers may be more "efficient" in terms of capturing a large volume in a limited time, but this difference in efficiency disappears when we take into account the total consumption required for this type of fishing.** These factors include: long distances traveled to reach fishing grounds, significant energy requirements to keep the catch cold on board, accommodation and logistics associated with sailors, or long-distance travel for crews, etc.

If we disregard the end of life of ships and gear (which does not depend on fishing practices but on shipyards and is by nature more difficult to offset when compared to volumes), emissions per kilo landed by industrial fishers are systematically higher than those of coastal fishers. The focus in Figure 4 illustrates this phenomenon.



Graph 4: *GHG emissions per kg landed for the 12 small-scale fleets, with a focus on vessels under 12 meters using passive gear and pelagic trawlers and seiners over 24 meters.*

...reveals nothing about the socio-ecological impacts of fisheries

While it may be "useful" in a productivity-based approach to relate GHG emissions to fish catch volumes in order to compare the relative carbon footprints of different fleets (passive gear, bottom trawls, pelagic trawls, etc.), **this approach reveals nothing about the "social utility" of the activity** (i.e., what the catch contributes to society) **or even the harmful impact of certain vessels** on biodiversity and habitats, or on the local economy. Numerous investigations[97] and even films[98] have accordingly documented the impact of European trawlers and seiners on local populations in order to offer mass-produced farmed or processed products for European markets. Scientific literature (Quemper *et al.*, 2025) shows that pelagic fleets over 12 meters in length are responsible for half of the landings from overexploited stocks. **However, a key finding from the research is that the most effective lever for reducing fishing effort (and therefore fuel consumption per ton caught) is to actually improve the ecological status of stocks**[99;100]. Healthy stocks allow the same quantity to be caught while emitting less[101].

A comprehensive analysis of the sustainability of fisheries must incorporate these energy indicators alongside broader ecological, social, and economic criteria.

We therefore propose an alternative and complementary approach, namely looking at GHG emissions relative to jobs in the sector (full-time equivalent or FTE). According to this approach, fishing emits an average of **152 tons of CO_2e** per FTE (in comparison, emissions are around 124 tCO_2e per FTE for the cereal sector and 229 tCO_2e for the livestock sector (excluding cattle))[102]. Here too, this average conceals significant heterogeneity between fleets. One FTE on board a trawler or pelagic seiner less than 12 meters long represents approximately **42 tCO_2e** compared to approximately **355 tCO_2e** when the vessel is over 24 meters long. This approach reveals that industrial fleets engaged in pelagic or bottom trawling generate emissions per job that are completely disproportionate compared to passive gear and coastal fisheries. When examining bottom trawlers over 24 meters, **per sailor per year,** an average of **344 tCO_2e** is emitted, equivalent to **the annual carbon footprint of 35 French citizens**[103]. In terms of employees on board, **a trawler over 40 meters is 7.5 times more polluting than a coastal vessel using traps, nets, or lines,** without even taking emissions linked to sediment disturbance into account.

97 The issue of the social utility and local impact of fishing methods has been a recurring topic of discussion. In a study released in September 2025, the independent journalism platform Follow The Money took Senegalese sardinella fishing as an example. Whilst once smoked and consumed by local populations, it is now used to feed European farmed fish, particularly on Dutch farms. The problem is that the increasing use of fresh fish in Senegal for this purpose is leading to a loss of income for the local population and a rise in food prices.

98 See, for example, the documentary "Razzia sur l'Atlantique" (Raid on the Atlantic), written and directed by Nicolas Van Ingen, 2023.

99 Kristofersson, D., Gunnlaugsson, S., Valtysson, H., Kristofersson, D., Gunnlaugsson, S., & Valtysson, H. (2021). Factors affecting greenhouse gas emissions in fisheries: evidence from Iceland's demersal fisheries. ICES Journal Of Marine Science, 78(7), 2385-2394. https://doi.org/10.1093/icesjms/fsab109

100 Ziegler, F., & Hornborg, S. (2013). Stock size matters more than vessel size: The fuel efficiency of Swedish demersal trawl fisheries 2002–2010. Marine Policy, 44, 72-81. https://doi.org/10.1016/j.marpol.2013.06.015

101 By traveling a smaller distance and carrying out fewer trawl hauls.

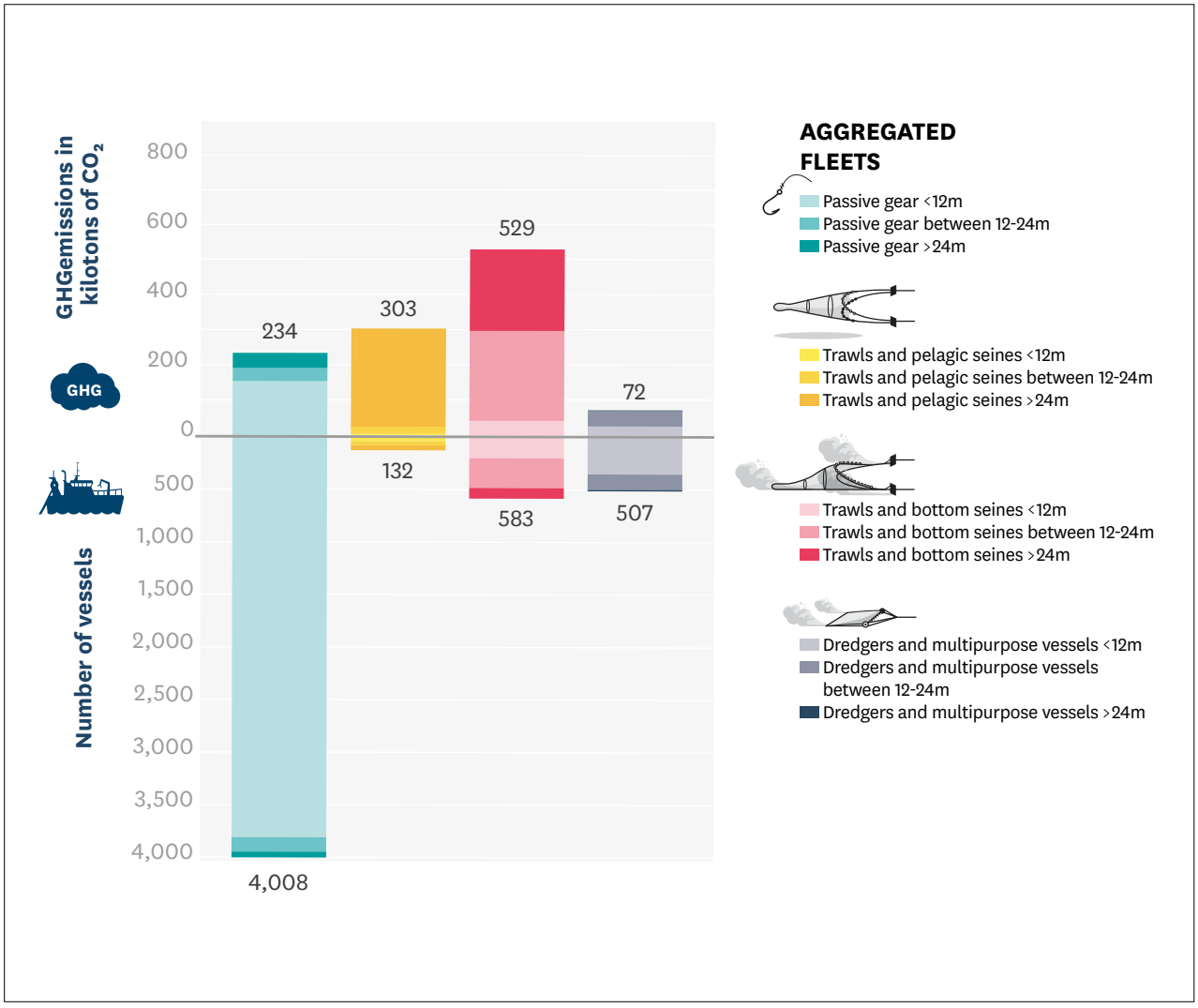
102 Average calculations based on CITEPA, INSEE, and Agreste data from 2020.
https://www.citepa.org/donnees-air-climat/donnees-gaz-a-effet-de-serre/floreal/
https://www.insee.fr/fr/statistiques/7728861?sommaire=7728903&#tableau-figure2
https://www.bnsp.insee.fr/ark%3A/12148/bc6p07dgqfp.pdf

103 The carbon footprint of a French person is rounded to 10 tons of CO_2e per year. This includes all needs related to housing, heating, food, and transportation.
https://www.statistiques.developpement-durable.gouv.fr/lempreinte-carbone-de-la-france-de-1995-2022

3. Bottom trawling, trawlers, and industrial pelagic seiners condemned

The initial comparisons presented above therefore clearly suggest that **the fishing industry as a whole cannot be used as a basis for understanding the dynamics behind these emissions. There is no single type of fishing, but rather a variety of techniques, practices, and scales that make up different fisheries.**

In order to better understand where these GHG emissions come from, it is necessary to analyze them at the fleet level (see categorization by Quemper *et al.* (2025)[104] in the method) by looking at fishing gear as well as vessel size.



Graph 5: *Comparison of the number of vessels and GHG emissions for each fleet.*

104 QUEMPER Florian, LEVREL Harold, MOUILLARD Romain, GASCUEL Didier. 2025. Evaluation des performances environnementales, économiques et sociales des flottilles de pêche: Bilan France. Rapport du programme TransiPêche: Scénarios de transition écologique et sociale des pêches françaises. Publications from the Pôle halieutique, mer et littoral de L'Institut Agro n° 56.

This graph alone summarizes **the structural imbalance in the responsibility of different fleets for emissions in the sector.**

With around 435 vessels, which represent **8.3% of the French fishing fleet, three fleets are among the top three in terms of emissions from French fishing. Deep-sea bottom trawlers (12-24 meters) and industrial trawlers (> 24 meters) for bottom and pelagic fishing are responsible for 67% of the sector's emissions** (they account for 54% of landings by weight and 48% by value). This is without even taking into account the potential CO_2 emissions linked to sediment disturbance caused by bottom trawling, which is treated separately. The emissions from these fleets are mainly due to their high consumption of fossil fuels, refrigerant gas leaks on board, and the fact that their crews sometimes travel by plane.

In contrast, coastal fishing (less than 12 meters) using fixed gear, which accounts for 73% of the French fleet (and represents 11% of landings by weight and 22% by value), **is responsible for only 14% of the sector's emissions, even though it is, comparatively speaking, the most socially, economically, and ecologically virtuous segment**[105].

Dredging, regardless of vessel size, contributes little to emissions in the sector. Although it accounts for 10% of vessels, 20% of landings by weight, and 12% by value, dredgers are responsible for only 6% of emissions. Nevertheless, due to its operating method (described above), dredging is comparable to a form of intensive underwater "monoculture" on a circumscribed area that is effectively "sacrificed" from an environmental point of view, due to the highly destructive nature of dredging on the seabed[106].

The weight of each source of GHG emissions varies from one fleet to another. However, fuel consumption remains the main source of emissions for fleets overall. One notable exception is coastal fleets using passive fishing gear, for which the life cycle phase of vessels (construction, maintenance, and end of life) accounts for a more significant share of their carbon footprint (30%). This is due to the fact the that impacts associated with construction for these small production units are less offset than for larger or more intensively used vessels, which increases their relative weight in the overall footprint.

Bottom trawling is the most polluting practice in both absolute and relative terms



In terms of the main fishing gear used, bottom trawlers are the biggest polluters. Although they represent only 11% of the fleet, 24% of landings and 25% of jobs in the sector, bottom trawlers and seiners of all sizes are responsible for at least 46% of the carbon footprint of French fisheries. **Bottom trawlers and seiners over 12 meters in length account for 43% of total emissions alone, without counting the potentially considerable impact they may have on sediments.** By dragging heavy weighted nets along the seabed, bottom trawlers require a huge amount of fossil fuel, making trawling a completely unprofitable fishing method, even with the tax exemption on energy products (excise duty on petroleum products in France, formerly known as TICPE). Without this tax exemption, the fleet would not be able to stay afloat (see box below).

105 QUEMPER Florian, LEVREL Harold, MOUILLARD Romain, GASCUEL Didier. 2025. Evaluation des performances environnementales, économiques et sociales des flottilles de pêche: Bilan France. Rapport du programme TransiPêche: Scénarios de transition écologique et sociale des pêches françaises. Publications from the Pôle halieutique, mer et littoral de L'Institut Agro n° 56.

106 Hiddink JG., Jennings S., Sciberrasa M., Szosteka C., Hughes C., Ellis N., Rijnsdorp A., McConnaughey R., Mazor T., Hilborng R., Collieh J., Pitcher C., Amorosoi R., Parma A., Suuronenj P., and Kaiser M. Global analysis of depletion and recovery of seabed biota after bottom trawling disturbance. Proceedings of the National Academy of Sciences, July 2017. DOI: 10.1073/pnas.1618858114

Fleets practicing trawling or bottom seine fishing also produce the highest emissions when compared to the volume of fish caught, the economic value of their catches, or the number of jobs on board. Compared to passive fishing gear, these fleets emit:

- 1.7 times more GHGs per kg of fish landed
- 2.3 times more GHG emissions per euro landed
- 4.6 times more GHG per sailor on board.

After **fuel,** the second largest source of emissions from trawlers and bottom seiners is linked to the **manufacture of the vessel and fishing gear** (6.3%). This is followed by **refrigerant gas leaks,** which mainly occur on large vessels (1.8%)

Bottom trawling: a destructive practice kept afloat by public subsidies

Beyond CO_2 emissions, research conducted by scientists at the French Natural History Museum and the Institut Agro shows that ***"deep-sea and industrial bottom trawling has a significant environmental impact, particularly in terms of juvenile catches, seabed abrasion, and CO_2 emissions. For every 1,000 tons produced by nature, these vessels generate around three times fewer jobs and three times less added value than coastal vessels using passive fishing gear."***

Despite all these drawbacks, trawls and bottom seines are artificially maintained thanks to the subsidies they receive. In general, fishing vessels receive operating subsidies (notably to reduce their operating costs) and benefit from an exemption from domestic tax on energy consumption (excise duty on petroleum products, formerly known as TICPE). Trawlers and seiners, which consume the most fuel, are in fact the ones that benefit most from this exemption. **According to Quemper *et al.* 2025, *"Trawlers and bottom seines benefit greatly from these subsidies, even though they are the most impactful fishing vessels."***

For example, "1 kg of harvested resources is subsidized at a rate of 40-to-80-euro cents for trawl and bottom seine fleets in the Atlantic, and up to €1.60 for bottom trawlers in the Mediterranean." In comparison, "passive gear is subsidized at a rate of 20-to-50-euro cents per kg landed, which is 2 to 4 times less"[107].

Worse still, according to their research, *"a comparison between the subsidies received and the gross operating surplus of the fleets clearly shows that some are only profitable thanks to public aid. This is the case for the vast majority of industrial pelagic trawlers and seiners (except Mediterranean tuna seiners) as well as industrial and deep-sea demersal trawlers and seiners."*[108] Some industrial trawler companies, such as Scapêche (owned by Intermarché), are even running a chronic deficit despite this tax exemption[109].

They conclude, *"It is worth questioning the social and environmental benefits of subsidies. Indeed, they seem to reward fleets that generate the highest environmental costs, whether in terms of biodiversity or climate, but also those that create the least jobs and wealth in France*[110]*."*

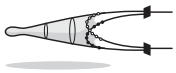
107 QUEMPER Florian, LEVREL Harold, MOUILLARD Romain, GASCUEL Didier. 2025. Evaluation des performances environnementales, économiques et sociales des flottilles de pêche: Bilan France. Rapport du programme TransiPêche: Scénarios de transition écologique et sociale des pêches françaises. Publications from the Pôle halieutique, mer et littoral de L'Institut Agro n° 56. 6.

108 Ibid.

109 According to the Pappers website, Scapêche's net result has been negative every year since 2018. In recent years, the figures were recorded as -7.45 million in 2021, -€9.14 billion in 2022, -€2.57 million in 2023, and -€10.9 million in 2024.

110 Ibid.

Pelagic trawlers and industrial tuna seiners are energy-intensive due to their fuel-intensive design and infrastructure



Industrial fishing vessels (over 24 meters) account for at least 49% of emissions for 3.7% of the French fleet. Three-quarters of these vessels are trawlers and seiners.

Among them, the fleet of industrial pelagic trawlers and seiners emits the most GHG per vessel. A single one of these vessels emits an average of 5,800 tCO_2e[111], equivalent to the annual footprint of around 580 French citizens[112]. This is 6.4 times more than a similar-sized fishing vessel using passive gear. **Within this fleet, the 39 largest vessels (between 40 and 90 meters in length) account for 29% of emissions.**

Focus on 20 problematic vessels: tropical tuna seiners

Of these 39 vessels, 20 are tropical tuna seiners averaging 80 meters in length. These vessels target skipjack tuna[113] or yellowfin tuna in the Indian Ocean and West African waters, which are found in Petit Navire and Saupiquet canned tuna, among others, and which BLOOM has revealed to be widely contaminated with mercury[114].

These 20 vessels alone account for 20% of the French fleet's emissions. These vessels use **"purse seine" nets that can measure up to 2,000 meters long and 300 meters deep**[115] (equivalent to 60 hectares, or the average size of a farm in France[116]). In one year, these 20 vessels emit around 210,000 tons of CO_2e through their fuel consumption, equivalent to 80,000 combustion engine cars[117]. **In order to freeze several hundred tons of tuna per day, they use large refrigeration systems on board, leaking up to one ton of refrigerant gas per ship per year[118]. Some of these gases warm the climate much more than CO_2[119]. For example, one kilogram of leaked R410a gas has a global warming potential equivalent to 2,256 kg of CO_2[120].** Across 20 ships, these leaks release the equivalent of approximately 13,000 tons of CO_2e per year and constitute their second largest source of emissions.

Furthermore, this tropical tuna fishing model uses fish aggregating devices (FADs). FADs are high-tech floating and drifting rafts that exploit the natural tendency of tuna species to gather under floating objects. To deploy and retrieve them, these industrial giants use six additional support vessels, which sometimes travel from the Mediterranean for one season[121].

111 Please note that this is an average. This figure can vary greatly between a 25-meter vessel and an 80-meter vessel

112 Ibid 103.

113 Also known as 'bonite'

114 https://bloomassociation.org/wp-content/uploads/2024/12/rapport-Mercure-EN.pdf

115 https://www.iccat.int/Documents/SCRS/Manual/CH3/CHAP%203_1_1_PS_ENG.pdf

116 https://agreste.agriculture.gouv.fr/agreste-web/download/publication/publie/Pri2213/Primeur%202022-13_RA2020_%20VersionDéfinitive.pdf

117 Ibid 87.

118 DG Environnement for European Comission, 2007. Winfried Schwarz and Jan-Martin Rhiemeier https://climate.ec.europa.eu/system/files/2016-11/2_maritime_rail_aircraft_en.pdf

119 Other gases (such as carbon dioxide or ammonia), used in particular for freezing, have very limited or no impact on the climate.

120 https://prod-basecarbonesolo.ademe-dri.fr/documentation/UPLOAD_DOC_FR/index.htm?prg.htm

121 Example of the Jean Louis Raphaël 2 vessel: https://globalfishingwatch.org/map/vessel/9f03ca61d-d959-2902-aacb-405ca352b79d?vDi=public-global-vessel-identity%3Av3.0&vIs=selfReportedInfo&vSRi=9f03ca61d-d959-2902-aacb-405ca352b79d&start=2017-03-04T05%3A59%3A13Z&end=2025-09-13T23%3A59%3A15Z&latitude=8.4912696361075128&longitude=21.139050483703618&zoom=2.3472700834991028&vE[0]=fishing&vE[1]=encounter&vE[2]=port_visit

These 20 seiners account for half of the emissions linked to marine carcasses from the entire French fishing fleet. By fishing tuna at such high volumes, **these vessels are preventing 11,000 tons of carbon from being sequestered by the ocean.**

The final absurdity of this fishing model lies in the fact that crews often fly to join their vessels in the Indian Ocean or West African waters. A round trip for a sailor between Paris and Mahé (Seychelles) represents approximately 2.8 tons of CO_2e. **Over the course of a year, a sailor working on a tropical tuna seiner emits on average 17 times more GHG to get to their workplace than a small-scale artisanal fisher.**

In addition, our report "From Heaven to Hell"[122] published in May 2024 shows that purse seine fishing combined with the use of FADs by Europeans in the Indian Ocean leads to **high volumes of bycatch of particularly endangered species,** which are discarded by the thousands. The footprint of these vessels is very high compared to a traditional and selective fishing technique used by coastal communities in the Maldives: **pole and line fishing. For the same amount of fish caught, this coastal fishing creates up to 30 times more jobs than purse seine fishing, while also emitting three times less.**

Apart from tropical tuna seiners, emissions from the pelagic trawler fleet over 24 meters in length are divided between **three pelagic trawlers between 81 and 90 meters in length**[123] **each emitting approximately 8,800 tCO_2e per year.** Of this:

- **68%** comes from fuel consumed **while dragging huge nets through the water column** (18,100 tons of CO_2e in total for the three vessels) and
- **23%** comes from **refrigerant gases** leaking from the enormous freezing/refrigeration infrastructure on board (6,000 tons of CO_2e in total for the three vessels).

Focusing on emissions from industrial vessels opens up a fundamental debate that was established earlier: that of energy efficiency. If we compare the total emissions of pelagic trawlers over 40 meters in length to the volumes they catch, these vessels could be seen as energy efficiency experts, **capable of using the least amount of fuel possible to catch the maximum amount of fish**[124]. In fact, their emissions per kilo landed are better than those of pelagic trawlers under 40 meters. This is not necessarily the case for pelagic seiners, whose relative emissions increase as the length of the vessels increases.

122 https://bloomassociation.org/wp-content/uploads/2024/05/From-heaven-to-hell.pdf

123 For example, the Joseph Roty 2, a French pelagic freezer trawler producing surimi base from blue whiting, measures 90.56 m (Source: EU Fleet Register).

124 With all sizes combined, pelagic trawls and seines (representing less than 2.7% of the fleet) account for 37.6% of the volumes caught (STECF annual average between 2017 and 2021, in Quemper et al 2025).

Ultimately, this volume-based approach is problematic in that it allows a single vessel to bring in hundreds of tons of fish per day, disregarding the health of marine populations, the quality of the fish caught, and therefore its value. On average over the period 2017-2021, 32% of overexploited fish were caught by trawlers and pelagic seiners over 24 meters in length, even though these vessels represent less than 1% of the French fleet![125] These large industrial pelagic vessels catch tuna for canning or "blue fish" such as blue whiting, which is mainly found in processed products (such as surimi).

These vessels generate very little added value. According to Quemper et al (2025), in the Atlantic, pelagic trawlers over 24 meters in length generate 10 times less added value than coastal vessels using passive gear. According to the researchers, "This is largely due to the market value of the species targeted by these fleets, but also to their operating costs and the quality of the products caught with the different types of gear"[126].

Furthermore, the carbon footprint reveals that **this fishing model disrupts the carbon storage process by fish: 54% of the carbon that has not been stored through the natural death of fish is linked to the activity of industrial pelagic trawlers and seiners.**

In conclusion, **this interpretation of emissions based on volume landed hides other realities: can we be satisfied with a ship that, under the pretext of energy efficiency, catches in one day what a small coastal fisher would catch in a lifetime?** In October 2025, the ICES (International Council for the Exploration of the Sea) recommended a 70% reduction in catches (and therefore quotas) of North-East Atlantic mackerel for 2026[127]. The immense pressure exerted by industrial fleets on certain populations has justly been denounced by many, including the president of the Normandy Regional Fisheries Committee[128]. The intense targeting of fish populations, such as mackerel, is condemning the entire profession, particularly coastal vessels, which are disadvantaged by a quota allocation system based on historical fishing records (where the more a vessel has fished in the past, the more quotas it receives).

This is not the fishing model we want.

125 QUEMPER Florian, LEVREL Harold, MOUILLARD Romain, GASCUEL Didier. 2025. Evaluation des performances environnementales, économiques et sociales des flottilles de pêche: Bilan France. Rapport du programme TransiPêche: Scénarios de transition écologique et sociale des pêches françaises. Les publications du Pôle halieutique, mer et littoral de L'Institut Agro n° 56, 185 p.

126 Ibid.

127 https://ices-taf.shinyapps.io/advicexplorer/?assessmentkey=21166&assessmentcomponent=NA

128 In a Facebook post on October 20 and in comments on his own post, Dimitri Rogoff, president of the Normandy Regional Fisheries Committee, denounced the impact of pelagic freezer vessels and asked, "Does industrial production have a future?"

4. Sediment disturbance: A ticking time bomb?

Every year in France, more than **664,000 km² of seabed is abraded** by towed gear (trawlers and bottom seines: 630,035 km²; dredgers: 34,265 km²)[129]. This is an **area larger than that of mainland France (551,695 km²).**

Studies show that a single passage of a bottom trawl systematically kills between 20 to 50% of the invertebrates present in the trawled area[130]. **By scraping, tearing and crushing marine fauna and flora, this technique transforms complex ecosystems into biological deserts.** Even on sandy-muddy bottoms, several studies show that bottom trawling destroys microscopic animals that live buried in the sediment (such as mollusks, crustaceans, and worms) and contribute to the bioturbation of sedimentary material (mixing of sediment by invertebrates) and water filtration. At the base of food chains, this fauna plays an essential role in the functioning of marine ecosystems, and more specifically for all groundfish[131]. Bottom trawling is therefore a key factor in the overall depletion of the ocean and its loss of productivity.

By scraping up sediments, trawling gear also disrupts the sedimentary carbon cycle. The processes involved (from physical disturbance of the sediment to the possible re-emission of dissolved carbon) are numerous, closely intertwined, and interact with other components of ocean carbon pumps. Although research on this topic remains at a preliminary stage and the orders of magnitude involved are not yet well understood, it is clear that trawling has a significant impact on the carbon cycle. Although research on this topic is still in its early stages and there is no consensus on the magnitude of potential CO_2 re-emissions to the atmosphere, several recent models offer initial quantitative estimates of these emissions.

According to the three estimates made (see methodology), the disruption of the sedimentary carbon cycle would be the second largest source of emissions from the fishing industry in France.

1. **Hypothesis 1 - Atwood *et al.*, (2024) - with k/100, most conservative approach:**
   0.10 million tons of CO_2e (8.4% of total emissions)
2. **Hypothesis 2 - Zhang *et al.*, (2024), intermediate approach:**
   0.44 million tons of CO_2e (28.1% of total emissions)
3. **Hypothesis 3 - Atwood *et al.*, (2024) - with k/10, least conservative approach:**
   0.88 million tons of CO_2e (43.7% of total emissions).

According to these hypotheses, **bottom trawlers, *despite being seven times less numerous than passive gear,*** would emit overall:

→ **2.7 times** more CO_2 emissions than passive gear (hypothesis 1)
→ **4.2 times** more CO_2 emissions than passive gear (hypothesis 2)
→ **6 times** more CO_2 emissions than passive gear (hypothesis 3).

Based on these assumptions, bottom trawling would be responsible for:

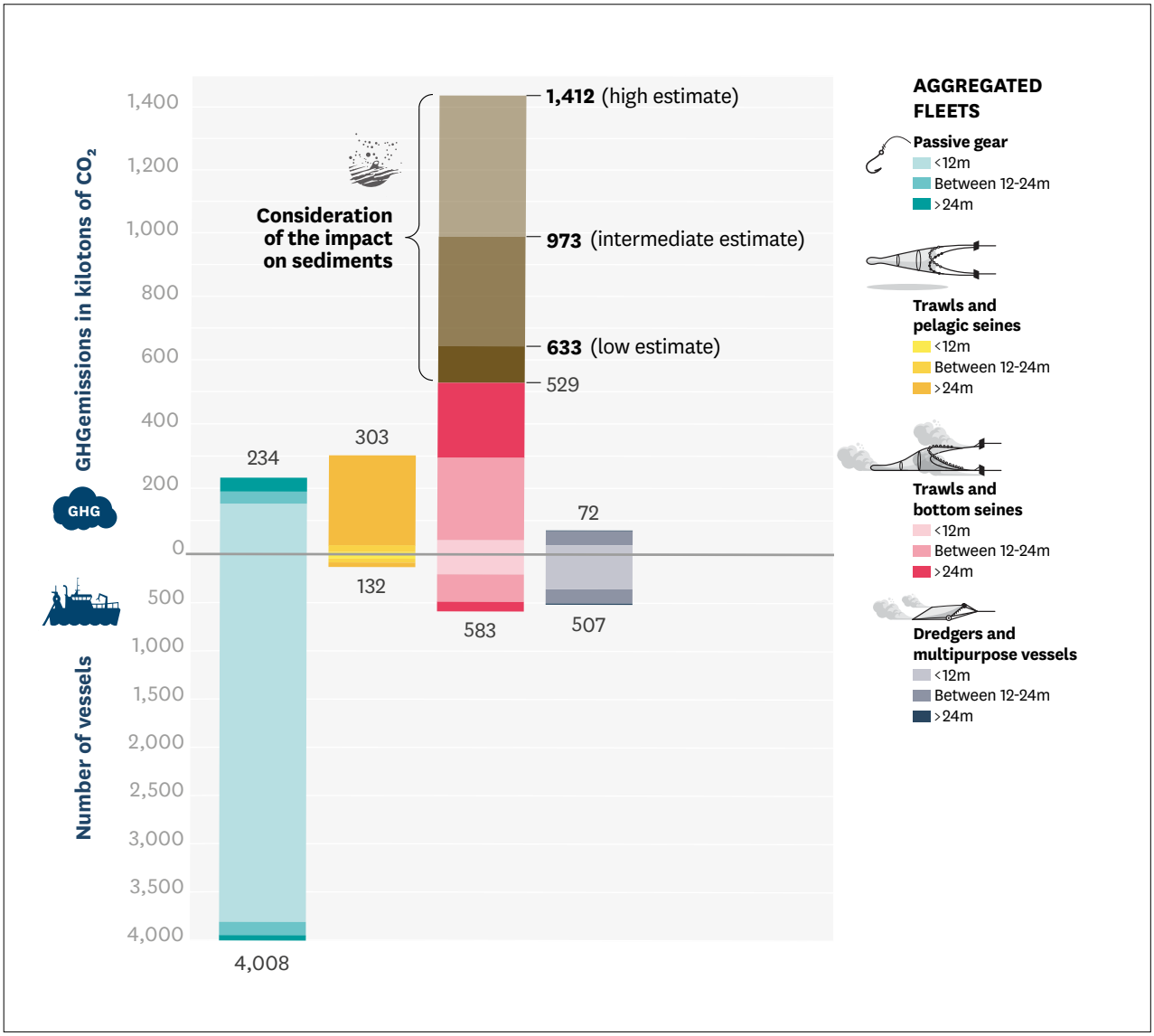
→ **51%** of the sector's emissions (hypothesis 1)
→ **61%** of emissions in the sector (hypothesis 2)
→ **70%** of emissions in the sector (hypothesis 3).

129 Quemper F., Levrel H., Mouillard R., Gascuel D., 2025. Evaluation des performances environnementales, économiques et sociales des flottilles de pêche: Bilan France. Rapport du programme TransiPêche: Scénarios de transition écologique et sociale des pêches françaises. Les publications du Pôle halieutique, mer et littoral de L'Institut Agro n° 56

130 Collie J., Hiddink J., Van Kooten T., Rijnsdorp A., Kaiser M., Jennings S., Hilborn R., Indirect effects of bottom fishing on the productivity of marine fish, Fish and Fisheries, October 2016 https://doi.org/10.1111/faf.12193

131 Based on several studies (Collie *et al.* 1997, 2005, Pitcher *et al.* 2000, Duplisea *et al.* 2002, Olsgard *et al.* 2008, Hinz *et al.* 2009, Pusceddu *et al.* 2014, Hiddink *et al.* 2019), Ocean Care's report The Trawl Supremacy shows that bottom trawling reduces the biomass and diversity of benthic invertebrate species, including on sandy-muddy bottoms.

In the model developed by Atwood *et al.* (hypotheses 1 and 3), dredgers account for 1% of sediment-related emissions. They are less involved in this phenomenon of sediment disturbance as their spatial footprint is much smaller than that of bottom trawls. This is because dredgers are smaller and repeatedly sweep limited areas over a short period of time, unlike trawlers. Hypothesis 2 only considers emissions from bottom trawlers.



Graph 6: *Comparison of GHG emissions from the four fishing techniques (all sizes combined) based on estimates of emissions linked to the disruption of the sedimentary carbon cycle*

Despite the uncertainties and limitations of existing models, the message is clear: these emissions can no longer be ignored.

Despite existing models on the subject, such as those by Atwood *et al.* (2024) and Zhang *et al.* (2024), many, such as the French Fishing Ship-Owners' Union (Union des Armateurs à la Pêche de France (UAPF))[132], faced with the uncertainty of orders of magnitude and the difficulty of modeling these impacts on a large scale, decide to perpetuate the status quo by defending bottom trawling, even in spite of all its proven drawbacks (fuel consumption, seabed abrasion, overfishing, etc.).

Although experts agree that towed gear has an impact on the sedimentary carbon cycle, opinions differ on the extent of this impact, with estimates varying by several orders of magnitude. In view of the results presented for the French fleet, which are based solely on the literature currently available, it is imperative to apply the precautionary principle by protecting sedimentary carbon stocks, pending the emergence of a consensus.

The precautionary principle, according to Principle 15 of the Rio Declaration, consists of taking proportionate measures in response to a plausible risk of serious harm, even in the absence of scientific certainty, in order to prevent potentially irreversible effects on the environment, health, or climate[133].

This principle is enshrined in Articles 2 and 4 of the Common Fisheries Policy[134] and in recitals 6 and 10[135] (preliminary part of a legal text). According to this approach, *"the absence of adequate scientific information should not justify postponing or failing to take management measures to conserve target species, associated or dependent species and non-target species and their environment"*. European Union Member States must therefore follow this principle.

132 Post by Jérôme Jourdain, Deputy Secretary General of the UAPF, on LinkedIn. April 2025.

133 Definition based on Principle 15 of the Rio Declaration on Environment and Development (1992). https://www.un.org/french/events/rio92/rio-fp.htm

134 https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX%3A32013R1380

135 Recital 10 states, among other things, that the sustainable exploitation of marine biological resources should be based on the precautionary approach.

V. RETHINKING THE TRANSITION OF FISHERIES: DECARBONIZING, MINIMIZING IMPACTS ON LIVING ORGANISMS, AND CHANGING THE SOCIO-ECONOMIC MODEL

1. The "technological fix": The wrong path taken by advocates of industrial fishing

These results provide us with information on several key points: firstly, **bottom trawling is not only the most fuel-intensive technique, but it is also the main cause of disruption to the sedimentary carbon cycle due to fishing.** Secondly, in terms of vessel size, industrial fishing vessels are, in absolute terms, major CO_2 emitters due to their highly intensive use of machinery and equipment. **These fishing models (such as that used for tropical tuna fishing) are not compatible with France's commitments to restore 30% of degraded ecosystems.**

Ultimately, these findings, much like all the literature on the impacts of trawling and industrial fishing, lead us to an inevitable conclusion: the transition of fisheries **cannot be based solely on energy efficiency criteria without questioning the sector's production model.** Reducing fuel consumption emissions by improving vessel performance **cannot justify perpetuating a system** based on **short-term profitability, where trawlers and seiners exert immense pressure on marine ecosystems.**

Planning for the future of the fishing industry: A blind spot in public policy

In light of the goal of Net Zero by 2050, **France is seriously far behind in planning for the decarbonization of the fishing industry and even further in planning for its social and ecological transition**[136]. France's National Low-Carbon Strategy (SNBC), a reference document on the decarbonization of the economy, mentions fishing only once within its 191 pages. In the section entitled "Supporting the evolution of fleets for all modes of transport," the document merely states that it is necessary to "define transition trajectories for maritime fleets," particularly for fishing.

136 "Like all signatory states to the Paris Agreement, concluded in December 2015 at the end of the 21st Conference of the Parties (COP), France has committed to achieving carbon neutrality by 2050, i.e., finding a balance between GHG emissions and the offsetting provided by carbon sinks (natural or artificial reservoirs that absorb carbon)." Source: https://www.vie-publique.fr/eclairage/19383-snbc-ppe-pnacc-la-politique-climatique-de-la-france#:~:text=stock.adobe.com-,Neutralit%C3%A9%20carbone%2C%20adaptation...,France%20face%20au%20changement%20climatique&text=La%20France%20a%20adopt%C3%A9%20une,Pacte%20vert%20pour%20l'Europe.

Alternative fuels and ship modernization: Buzzwords for policymakers

Among the few sectoral public policy documents that mention the future of the fishing industry, there are three that are particularly noteworthy.

1

The Strategic Contract for the French Maritime Fishing Industry[137] published in 2025 by Emmanuel Macron, sets out **the principles for a highly competitive fishing industry capable of offering maximum volumes of seafood products on a readily available basis, without the need to question practices and equipment.** Far from aiming for carbon neutrality and minimizing impacts on biodiversity, it **aims to develop new innovative methods capable of making fishing highly competitive**[138].

In line with this document, on 19 September 2025, **Olivier Le Nézet, the President of the National Committee for Maritime Fisheries and Marine Farming (CNPMEM)**[139]**, announced that €12 million of the €700 million promised by the wind tax and announced via the Strategic Sector Contract would be allocated to the modernization of vessels, particularly to "the energy efficiency of vessels."** According to Le Monde, "the aid could, for example, be used to finance a project to improve the hydrodynamics of ship hulls" or "install a better fish preservation system on board (...) such as ice-making machines"[140].

2

The French National Roadmap for the Decarbonization of the Maritime Sector[141] published by the French Ministry of the Sea in November 2024, in which fishing is mentioned intermittently. This document targets certain fishing vessels (only those with a tonnage greater than 400/500 GT[142], i.e., those with a length of more than 35/40 m), container ships, gas carriers, ferries, and offshore services. Beyond the fact that it only very partially concerns fishing vessels, this decarbonization roadmap, which is **almost exclusively technological-fix-based**[143] focuses on **"energy efficiency" and "alternative fuels." The document mentions technological levers** (reducing ship drag, improving propulsion efficiency, biofuels, electrofuels, onboard CO_2 capture, hybridization and electrification of ships, etc.[144]) and **twice mentions fuel efficiency as a lever, which is considered solely from the perspective of sailing speed and ship design.**

For example, the document highlights three "concept ships," including a hydrogen-powered fishing vessel.



Hydrogen-powered fishing vessel (Credit: Mauric)

137 https://www.comite-peches.fr/contrat-strategique-de-filiere-2025/

138 The contract mentions as a lever: "Increasing innovation and the development of fishing gear with less impact on ecosystems, in particular through dedicated calls for projects under the EMFF and funding via the FFP."

139 https://www.mediapart.fr/journal/ecologie/040224/olivier-le-nezet-pecheur-de-petits-fours-la-barre-du-lobby-francais-de-la-peche

140 To modernize French fishing, €12 million will be released thanks to the wind power tax. https://www.lemonde.fr/planete/article/2025/09/19/pour-moderniser-la-peche-francaise-12-millions-d-euros-vont-etre-debloques-grace-a-la-taxe-eolienne_6641855_3244.html

141 https://www.mer.gouv.fr/la-decarbonation-de-la-filiere-maritime

142 Gross ton (Universal Measurement System). 1 UMS = 2.832 m3. This is one of the methods used to measure a ship's carrying capacity.

143 "Technnological fix": reliance on technology to solve a problem often created by earlier technologies. According to this concept, all problems can be solved by better and newer technologies.

144 See Appendix 4 of the *Roadmap for Decarbonization of the Maritime Sector.*

However, **regardless of its form (fuel cell, liquid, or e-fuel), hydrogen requires space, safety, storage, and pressure, and is dependent on low-carbon electricity, which is already scarce.** In 2018, the International Energy Agency (IEA) estimated that only 0.1% of global hydrogen production came from electrolysis[145], which is currently the only production option that guarantees emission-free, or "green," hydrogen. At this stage, the use of green hydrogen in fishing is still a pipe dream.

3

Status Report on the Energy Transition of Fishing Fleets and its technical report, published on 3 November 2025, by the French Ministry of the Sea[146], follow the same logic. The assessment evaluates GHG emissions associated with fuel only and proposes reduction scenarios based exclusively on improvements in the energy efficiency of vessels when they are replaced. There is no consideration for restructuring the fleet. **Among the levers mentioned are the use of hydrogen, hybridization (diesel-electric) of engines, and the use of biofuels.**[147] The *Status Report* highlights a dozen projects, the vast majority of which involve 20- to 25-meter trawlers, as well as a 60-meter longliner with hybrid engines.

In the face of the climate emergency, one question stands out: **why waste time and money trying to save destructive fishing methods, such as trawling, that are doomed to failure, when we could be organizing the implementation of the most effective recommendations: namely by replacing fleets that are particularly unprofitable, insatiable in their consumption of fuel, and destructive to marine life?**

2. Passive gear: The key to energy-efficient fishing with less impact on ecosystems

In decarbonization scenarios, the *Status Report on the Energy Transition of Fishing Fleets* shows gains of between 5% and 30% thanks to the renewal of fishing fleets. **As the French fleet becomes increasingly outdated, the renewal of vessels should not be a simple operation to update the most polluting vessels with the latest "environmentally friendly" technology, but rather an opportunity to change the model** so that fishing is virtuous across all indicators, including: overfishing, juvenile fishing, CO_2 emissions, and seabed abrasion, whilst creating wealth and jobs.

In this sense, several systemic levers must be explored: protecting and improving the state of marine animal populations and ecosystems to reduce fishing effort or replacing bottom trawlers with vessels using passive gear (traps, longlines, gillnets), which are significantly less energy-intensive and more respectful of ecosystems[148].

145 IEA, Global Hydrogen Review 2023, page 64

146 https://www.mer.gouv.fr/etat-des-lieux-de-la-transition-energetique-des-flottes-de-peche-et-daquaculture-francaises

147 https://www.transportenvironment.org/articles/imo-fuelling-deforestation

148 Bastardie, F. *et al.* (2022). Reducing the Fuel Use Intensity of Fisheries: Through Efficient Fishing Techniques and Recovered Fish Stocks. Frontiers in Marine Science, 9. https://doi.org/10.3389/fmars.2022.817335

Indeed, research conducted by scientists at the Institut Agro and the French Natural History Museum, as well as members of the BLOOM-led research group on fisheries transition, highlights the social, economic, and environmental limitations of trawling, whereas fishing methods using passive gear perform comparatively well across all aspects. According to their research, trawlers and seiners are the worst offenders in terms of overfishing: 88% of overexploited resources come from these fleets... even though they account for only 60% of catches (including 36% for bottom trawlers over 12 meters alone)[149]. Bottom trawlers are responsible for around 90% of seabed abrasion. Furthermore, the larger the vessels, the less added value and jobs they create, which is particularly the case for large pelagic trawlers. In addition, the profitability of trawling depends on public subsidies. At the other end of the spectrum, small-scale coastal fishing accounts for three-quarters of the French fleet and creates two to three times more added value than trawling, whilst having close to no impact on the seabed[150]. In all respects (carbon emissions, impacts on biodiversity, and socio-economic criteria) **the phasing out of trawling, starting with bottom trawlers, is an absolute necessity.**

Initial estimates show that **replacing all bottom trawlers under 40 meters with new vessels using passive gear would reduce the fleet's fuel-related emissions by 53%, compared to only 38% if all these trawlers were replaced by similar but modernized vessels**[151]. The difference between these two scenarios would, in fact, be even greater if we included the "hidden" emissions associated with the destruction of the sedimentary carbon sink.

Replacing bottom trawls with passive gear is not a pipe dream, unlike other technological approaches.

> **Technically, it is possible for passive gear to capture most of the volumes fished by bottom trawls[152]. 85% of the volumes caught by bottom trawlers less than 40 meters long could be transferred to passive gear (on vessels of equivalent size).**
>
> **39% are easily, and even directly, transferable, meaning that a simple transfer of quotas to fisheries using passive gear that catch the same species as trawlers would make it possible to begin reducing trawling[153].**

At a time when scientists are showing us that it is possible to fish differently, the phasing out of trawling remains absent from public policy strategies. Insisting on renewing the fleet by rebuilding bottom trawlers amounts to impeding an improvement in the sector's carbon transition for another 30 to 40 years, even though credible solutions exist. Fleet renewal that includes replacing trawls with passive gear is not only a major climate strategy, but also a social opportunity to boost employment in a sector in crisis. This can all be done by reducing the destructive impact of trawling on marine life, the seabed, and the sedimentary carbon cycle.

149 Particularly stocks of cod, haddock, sardines, and whiting.

150 QUEMPER Florian, LEVREL Harold, MOUILLARD Romain, GASCUEL Didier. 2025. Evaluation des performances environnementales, économiques et sociales des flottilles de pêche: Bilan France. Rapport du programme TransiPêche: Scénarios de transition écologique et sociale des pêches françaises. The publications of the Pôle halieutique, mer et littoral de L'Institut Agro n° 56, p. 185

151 V. Deschamps, R. Mouillard. (2025) Renewing the French fleet: financial burden or opportunity for a sustainable transition? Conference of the European Association of Fisheries Economists 24th-26th June 2025, Rome

152 MOUILLARD Romain et GASCUEL Didier, 2025 - Estimation des captures de la senne et du chalut démersal transférables aux arts dormants, Note d'avancement du Programme TransiPêche: Scénarios de transition écologique et sociale des pêches françaises. Doc minéo de L'Institut Agro, p. 10

153 Ibid.

3. Levers for action towards truly sustainable fishing

As well as replacing bottom trawlers with passive gear, other systemic levers must be explored to ensure ambitious structural reform of the fishing industry. **These measures focus on the spatial reorganization of fisheries, the equitable distribution of quotas, and the protection of ecosystems and juveniles.** The latter is absolutely essential. According to biologist Daniel Pauly[154]: *"we must fish less if we want to fish better."* Allowing fish to grow older and spawn would reduce the overall fishing effort of fleets by catching fewer but larger individuals.

The table below presents various levers that should be at the heart of a truly sustainable fishing model, also known as an "ecofishery"[155].

Levers	Description
Protect juveniles to rebuild population abundance and the resilience of ecosystems	This lever aims to enforce minimum catch sizes for juveniles and young fish so that the fleet catches fewer fish, but older and therefore larger ones, to maintain constant volumes. This lever is essential to ensure stock reproduction and reduce fishing effort[156].
Implement truly protected marine areas	According to the International Union for Conservation of Nature (IUCN), a marine area can only be considered "protected" if it prohibits all industrial activities and infrastructure, including industrial fishing[157]. To date, only 0.03% of France's maritime area meets this definition[158], whereas scientific recommendations recommend that 30% of our waters be reserved for small-scale coastal fishing, with 10% being exempt from fishing. In the absence of human pressure, the biomass of fish populations in marine reserves is on average six times greater than in unprotected waters[159] and results in an increase in the abundance, size, and diversity of fish species[160].

154 Daniel Pauly, a specialist in marine resources, is the author of more than 500 scientific publications and some 30 books. He has also developed the world's largest database on biodiversity: fishbase.org, as well as "searoundus.org," which maps fishing catches across all oceans, and was the first to develop a global vision of fishery resources. He received the International Cosmos Prize, the equivalent of the Nobel Prize in ecology, in 2005.
Source: https://www.lemonde.fr/planete/article/2009/03/03/rencontre-avec-daniel-pauly-expert-mondial-de-la-peche_1162580_3244.html

155 Gascuel, D. (2023). La pêche écologie: Manifeste pour une pêche véritablement durable. Quae.

156 GASCUEL Didier. Ecological fishing: Manifesto for truly sustainable fishing. Quae. 2023

157 IUCN. (2016). IUCN resolutions, recommendations and other decisions. 106pp. https://portals.iucn.org/library/sites/library/files/documents/IUCN-WCC-6th-005.pdf

158 Claudet, J., Loiseau, C., & Pebayle, A. (2021). Critical gaps in the protection of the second largest exclusive economic zone in the world. Marine Policy, 124, 104379. https://doi.org/10.1016/j.marpol.2020.104379

159 Sala, E., & Giakoumi, S. (2017). No-take marine reserves are the most effective protected areas in the ocean. ICES Journal of Marine Science. https://academic.oup. Com/icesjms/article/75/3/1166/4098821

160 Grorud-Colvert, K., and al. (2021). The MPA Guide: A framework to achieve global goals for the ocean. Science, 373(6551), eabfo861. https://www.science.org/ doi/10.1126/science.abfo861

 **Exclude industrial vessels from the coastal zone (12 nautical miles)**	Industrial vessels (over 24 meters) are designed for offshore fishing. However, many vessels operate within the first 12 miles, competing with small-scale fishing using traps, lines, and nets. This situation weakens coastal fishing and ultimately the local economy (jobs at the docks, fish markets, fishmongers, etc.). This measure, supported by many fishers was adopted, for example, in the Normandy White Paper for the reform of the CFP[161] in June 2025. In Brittany, the regional council opposed it[162]. Coastal waters are also nursery areas for fish.
 **Replacing bottom trawls with more virtuous gear and reallocating quotas for greater social justice**	This involves transferring quotas from bottom trawlers of less than 40 meters for vessels using passive gear (transfers to vessels of the same size). In short, to gradually replace bottom trawls with traps, lines, and nets. This measure goes hand in hand with the reallocation of fishing quotas to fishers using passive gear. It is part of a strategy to reduce trawling by the French fleet and to put an end to industrial development.
Ending financing for fossil fuels 	To date, the Energy Taxation Directive grants exemption from energy consumption tax for the aviation and maritime sectors, including fishing. This exemption effectively benefits the vessels that consume the most fuel. It falls within the OECD category public subsidies and amounts to financing fossil fuels. This "encouragement" to consume fossil fuels is not compatible with the fight against climate change. On the contrary, avenues must be explored to finance support for the sector's transition towards an ecofishery.

161 https://www.ceser.normandie.fr/sites/default/files/2025-06/5_Avis_Proposition%20de%20livre%20blanc%20de%20la%20Ndie%20sur%20la%20r%C3%A9forme%20de%20la%20PCP.pdf

162 See our news item on this subject (in French): https://bloomassociation.org/conseil-regional-de-bretagne-voeu-25-metres/

CONCLUSION

When every tenth of a degree counts, fishing, like all French manufacturing and industrial sectors, must become carbon neutral. As we have seen, the sector emits as much as the egg-laying industry, despite producing half as many tons in volume.

However, the evidence is clear. Today, a handful of ships are responsible for the majority of emissions. **29% of the sector's GHG emissions are due to just 39 ships over 40 meters long.** Their model is based on one simple objective: to catch as many fish as possible in record time. Going forward, only one question remains: do we want to continue to tolerate a handful of vessels emitting hundreds of thousands of tons of GHGs into the atmosphere in order to provide us with highly processed seafood products caught at the cost of immense destruction? Or do we want to promote and support low-carbon artisanal fishing by offering fresh, local, seasonal, and high-quality fish?

It is clear that not all fishing methods are equal. **Regardless of the size of the vessels, towed gear, particularly trawls and seines, account for three-quarters of the French fleet's GHG emissions.**

Responsible for almost half of the sector's emissions alone, the bottom trawl fleet is problematic. In addition to being excessively fuel-intensive, bottom trawlers contribute to disrupting the sedimentary carbon cycle. **In the face of the climate emergency, the lack of certainty about the impact of this disruption on the climate should not be used as an excuse for maintaining the status quo. The precautionary approach must take precedence.**

A transition is needed, but not just any transition. **Behind the concept of energy transition, ideas of technology-based solutions are flourishing in the name of technological progress and green growth, championing the principle of innovation without questioning the principle of the race for volume, which is destroying life with the heavy use of fuel.**

The ecological transition does not exclude innovation, but it should not be viewed solely through the prism of technology. Innovation should also be viewed from a social and ecological perspective. Rather than investing in the development of hydrogen and hydrodynamic hulls, we should innovate with ambitious public policies for training fishers in sustainable practices, subsidize employment on board rather than fossil fuel consumption, and prioritize the replacement of old trawlers with new vessels equipped with fuel-efficient passive fishing gear. Finally, we must make full use of ecosystem protection tools and have the courage to implement truly protected marine areas. **We possess the opportunity to radically rethink and innovate our relationship with the ocean, whilst remembering that the environmental foundation of the French Constitution affirms that *"Natural resources and equilibriums have conditioned the emergence of mankind; The future and very existence of mankind are inextricably linked with its natural environment"*[163].**

163 Constitution of France, 2004 Charter for the Environment. https://www.conseil-constitutionnel.fr/le-bloc-de-constitutionnalite/charte-de-l-environnement-de-2004

APPENDICES

Appendix 1. Glossary[164]

Passive and towed gear: Fishing gear is classified into two main categories: passive gear and towed gear. Towed gear is dragged along the seabed or in open water to capture the desired species. Passive gear is set in place, hence the term. Target species are caught in this gear, which acts like a trap.

Caskets: Also known as "traps", they consist of a rigid structure covered with netting and an opening, called a funnel. The funnel (there may be several) is positioned so that the animal can enter the casket but will find it very difficult to get out. Traps are set in lines, meaning that they are connected to each other and weighted so that they rest securely on the seabed. A trap vessel can set several hundred traps.

Trawl: A trawl is a cone-shaped net dragged along the seabed (bottom or demersal trawl) or through the water column (pelagic trawl) by one or two vessels. In order to maximize the opening of the trawl, it is possible to use "panels," "poles," or even tow the net with two vessels. The trawl is also weighted. Trawling encompasses several specific fishing techniques, making a "trawling" family.

Benthic species: Species that move along the bottom, or are fixed to the bottom, or buried. Flatfish, monkfish, and shellfish are benthic species.

Demersal species: Highly mobile species that move above the bottom and depend on it for food. These species include cod, pout, and hake.

Pelagic species: Species that live near the surface or between the surface and the bottom. Herring, sardines, anchovies, mackerel, and tuna are pelagic fish.

Net: There is a wide variety of active and passive nets. In this document, the word "net" is used to refer to passive nets (gillnets, trammel nets, set nets). The net is made up of meshes forming a vertical rectangular curtain deployed by the fishing boat in which the fish are caught by their gills. Trammel nets consist of three layers called panels[165].

GHG: Greenhouse gases

GtC: Gigatons of carbon. One gigaton is equivalent to one billion tons.

Line: Lines are very simple fishing gear, consisting of one or more hooks attached to the end of a line. This technique allows for the capture of high-quality fish, which are brought aboard the vessel alive. There are two types of line fishing: rod fishing and longline fishing. The first uses rods that are operated manually or mechanically, to which lines and baited hooks are attached. The second involves attaching several baited hooks along a main line.

GWP: Global warming potential

PPM: Parts per million, a fraction equal to 10-6, or one millionth.

Seine: Seines are rectangular nets used on the surface to encircle schools of fish. Purse seines can exceed one kilometer in length and 100 to 200 meters in height. At the end of the encirclement, to prevent the fish from escaping through the bottom, the net is closed at the bottom using a cable called a purse line. The enclosed pocket is then gradually reduced in size so that the catch can be removed using a special scoop net called a brail net.

$kgCO_2e$: Kilogram of carbon dioxide equivalent. This is the reference unit used to express the impact of a gas on the climate.

tCO_2e: Ton of carbon dioxide equivalent.

164 Sources for definitions of species and fishing gear: Ifremer

165 Species guide https://www.guidedesespeces.org/fr

Appendix 2. Fleet structure and socio-economic indicators

Vessels	Coastal	Deep-sea	Industrial	
	3,814	147	47	4,008
	352	153	2	507
	37	47	48	132
	196	288	99	583
	4,399	635	196	5,230

Table 1: *Table showing the distribution of French vessels in 2022 by fleet (STECF).P).*

Vessels	Coastal	Deep-sea	Industrial	
	2,701	528	588	3,817
	369	379	16	764
	62	172	785	1,019
	227	991	673	1,891
	3,359	2,070	2,063	7,492

Table 2: *Table showing the distribution of jobs in 2022 by fleet (STECF)*

Vessels	Coastal	Deep-sea	Industrial	
	59,687	15,140	21,670	96,496
	70,718	33,843	944	105,505
	2,056	27,279	167,366	196,701
	9,311	59,820	59,643	128,774
	141,772	136,082	249,623	527,477

Table 3: *Table showing the distribution of volumes landed by French vessels in 2022 by fleet (STECF).*

Vessels	Coastal	Deep-sea	Industrial	
	309,841,510	85,581,593	77,354,598	472,777,701
	74,820,989	85,762,455	2,803,506	163,386,950
	4,809,432	36,882,237	254,800,611	296,492,280
	46,269,047	227,549,417	181,396,011	455,214,475
	435,740,977	435,775,703	516,354,726	1,387,871,406

Table 4: *Table showing the distribution of landing values (€) by French vessels in 2022 by fleet (STECF).*

Appendix 3. Correspondence table of emission sources

Emissions category	Emission sources in the carbon footprint	Emission sources analyzed in the carbon footprint	Items aggregated in this summary
Direct emissions	Fixed and mobile combustion sources	Fuel consumption	Fuel consumption
	Fugitive emissions	Refrigerant gas leaks	Refrigerant gas leaks
	Disruption of carbon sinks	Sedimentary carbon disruption	Sedimentary carbon disruption
		Marine carcasses	Marine carcasses
Indirect energy-related emissions	Electricity consumption	Electricity consumption	Electricity consumption
Indirect emissions	Fixed assets	Shipbuilding and end-of-life	Manufacture and end-of-life of ships and vessels
		Shipbuilding and end-of-life	
	Purchases of goods	Purchases of consumables	Purchases of consumables
		Food for fishers	Travel and food for fishers
	Travel	Travel by fishers	



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