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VIEWPOINT

Maximizing cardiovascular benefits of fish consumption within the One Health approach: Should current recommendations be revised?

Annalisa Giosuè [a,*], Gabriele Riccardi [a], Marta Antonelli [b]

[a] Department of Clinical Medicine and Surgery, "Federico II" University, Naples, Italy
[b] Division Impacts on Agriculture, Forests and Ecosystem Services (IAFES), Foundation Euro- Mediterranean Center on Climate Change (CMCC), Viterbo, Italy

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Abstract *Aims:* Current dietary recommendations on fish consumption for cardiovascular disease (CVD) prevention put somewhat vague emphasis on fatty fish, mainly driven by evidence on the cardioprotective effects of n−3 PUFAs. Recent data on the consumption of different types of fish in relation to hard cardiovascular endpoints suggests that fatty but not lean fish can contribute to CVD prevention. This considered, we aimed at evaluating, by an environmental perspective, fish consumption limited to the fatty type – in appropriate amounts for optimizing CVD prevention – within the European context.
Data synthesis: Starting from the current average intake of total fish by the European population (i.e., 2 servings/week of fatty plus lean fish), we show that the shift towards the consumption of 2 servings/week of solely fatty fish – appropriate for optimizing CVD prevention – would allow a 32% saving of greenhouse gas (GHG) emissions related to fish consumption. This is due to the lower environmental impact of fatty fish globally considered, compared to lean fish. However, since the carbon footprint of different fatty fish species can vary significantly – with small blue fish (e.g., anchovies, sardines, herrings) in the lowest range, we estimated that GHG emissions due to fish consumption in Europe could be reduced by 82% by focusing on small blue fish consumption.
Conclusions: Consumption of 2 servings/week of small blue fish could represent a feasible and effective choice among the functional dietary strategies available to achieve the maximal benefits for human and environmental health.

1. Current evidence-based recommendations on fish consumption for cardiovascular health

Fish consumption has long been advocated as beneficial for the prevention of cardiovascular disease (CVD), which still represents the leading cause of death and disability worldwide [1]. Over time, a number of meta-analyses of prospective cohort studies has consistently shown that habitual fish consumption is associated with a significant reduction of cardiovascular events, and, in particular, of fatal and non-fatal coronary heart disease (CHD) [2], which accounts for the great majority of total CVD. This evidence has supported the most authoritative dietary guidelines worldwide to encourage the consumption of fish for the

* Corresponding author. Via S. Pansini 5, 80131 Naples, Italy.
E-mail address: annalisa.giosue@unina.it (A. Giosuè).

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prevention of CVD/CHD [3–5]. In clinical practice, the recommended amount of fish to consume is 2–3 servings per week in a heart-healthy dietary pattern [6], with the suggestion that higher intakes can provide additional cardiovascular benefits particularly when fish replaces other animal protein sources unfavorably related to CHD risk, such as red and processed meat. However, it is of note that according to the available evidence, the favorable association between habitual fish consumption and CHD risk is not confirmed when fish intake exceeds 4 servings per week [7]. Current dietary guidelines provide also advice on fish preparation – since the consumption of fried forms is not associated with health benefits – while for the preferential type of fish to eat, they put somewhat vague emphasis on fatty fish, mainly driven by evidence supporting the beneficial effects of n–3 PUFAs in fish rather than of fatty fish consumption *per se*.

2. New insights on fish consumption for cardiovascular disease prevention: the role of fatty fish

In 2022 a meta-analysis of 19 prospective studies [8] investigated for the first time the relationship between fish consumption and CHD as well as all-cause mortality, distinguishing between fatty fish and lean fish: the results clearly show that only the habitual consumption of fatty but not lean fish is associated with a reduced risk of coronary events (–8%) and premature death for all causes. According to the available data, the amount of fatty fish that should be included in the weekly diet for heart-health advantages is 1–2 servings per week [9]; conversely, lean fish can contribute to the diet's variety but without providing further cardiovascular benefits at any intake.

The finding that the heart-health benefits of habitual fish consumption are driven by fatty fish could have relevant implications for the optimization of CVD prevention at the population level through a revised dietary recommendation focused on fatty fish intake (1–2 servings, equivalent to 150–300 g per week). Considering that current average intake of fish by the European population is around 2 servings per week [10], an increase of fish consumption up to 3 or even 4 servings per week, as currently recommended, is probably not easily reached by all individuals. The target of fatty fish intake here proposed according to recent evidence is not only more feasible, but also coherent with that identified by the EAT-Lancet Commission (28 g/day equivalent to about 1–2 servings/week) to achieve the adequate amount of n-3 PUFAs for CVD prevention in "the healthy reference diet from sustainable food systems" [11].

3. Environmental perspectives for sustainable fish consumption

Fish is also promoted, among protein-rich foods of animal origin, as a more sustainable alternative to red meat for environmental reasons [12]. However, to account for the so called "planetary health" [13], health and environmental reasons to backup dietary recommendations should be harmonized in order to ensure that the health benefits supporting encouraging fish consumption do not lead to further overexploitation of fisheries, with relevant ecological drawbacks. According to FAO [14], the percentage of stocks fished at biologically unsustainable levels has reached 35.4% in 2019 from 10% in 1974. At the same time, the consumption of aquatic animal foods has increased worldwide from 9.0 kg per capita/year in the early 1960s to exceed 20 kg in 2020 and a number of driving forces – such as population growth and economic development, coupled with urbanization and dietary preferences – are expected to increase the demand of animal products including aquatic food in the near future [15].

Remarkably, the environmental impacts of capture fisheries can differ markedly according to the fish type: for instance, bottom trawling causes massive habitat destruction and increases greenhouse gas (GHG) emissions – which are causally related to climate change – because of the additional energy required to drag the net across the sea floor; instead, small pelagic fisheries have a lower impact because fish are caught in dense schools and require relatively little fuel consumption [16,17].

Blue food production are generally underrepresented in environmental assessments and the impacts analyzed are often limited [18]. However, an analysis of GHG, nitrogen, phosphorus, freshwater and land stressors showed that while capture fisheries generate high GHG emissions, the catch of small pelagic fishes (such as sardines and mackerel, blue fishes belonging to the fatty type) are associated with lower emissions than all fed aquaculture; conversely, catching flatfish as well as crustaceans (all being lean fish) generates the highest GHG emissions [19] (Table 1).

In a previous work [10] we have estimated that, according to the median Carbon footprint of all fish types, the current fish consumption in the European region is linked with 1.49 kg CO_2 eq. emissions per week. The shift towards the consumption of 2 servings per week of solely fatty fish would allow reducing GHG emissions due to fish consumption by approximately 32% (Fig. 1). Remarkably, the environmental impact of fish consumption in terms of GHG emission can be further decreased by choosing among various fatty fish species those with a lower

Table 1 GHG emissions per kg of different fish types and species.

Fatty fish		Lean fish	
Fish specie	Carbon Footprint (kg CO_2eq./kg)	Fish specie	Carbon Footprint (kg CO_2eq./kg)
Anchovy	0.82	Cod	3.08
Sardine	0.90	Sea bass	3.60
Pilchard	1.10	Sole	5.40
Herring	1.24	Octopus	5.80
Carp	1.76	Flatfish	6.41
Mackerel	1.80	Squid	6.91
Salmon	3.37	Prawns/Shrimps	7.04
Tuna	3.68	Rhombus	8.41
Eel	3.88	Lobster	20.25

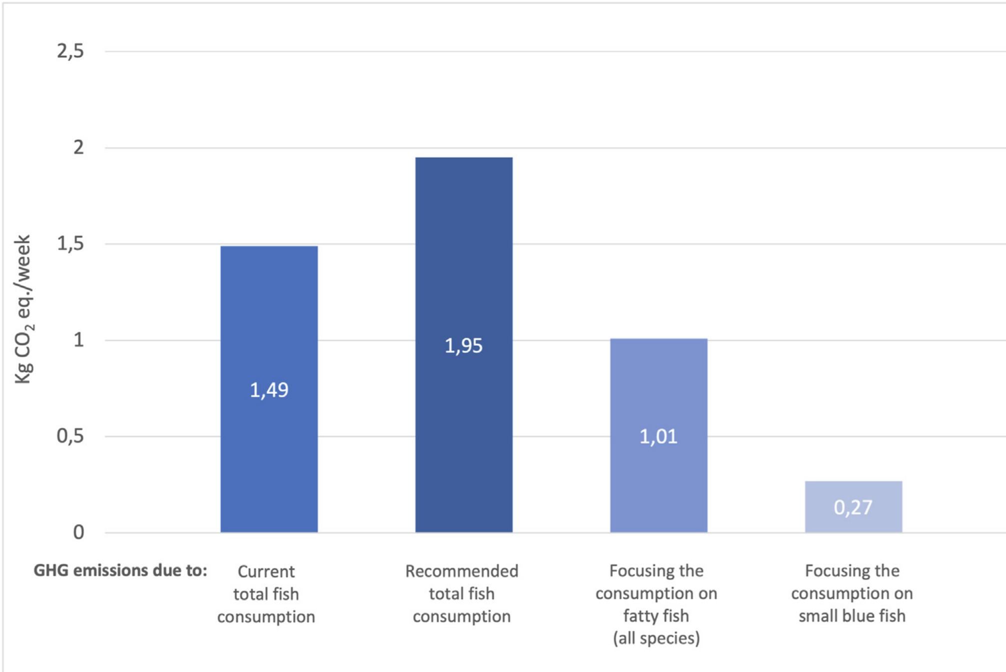

Figure 1 (Title): Impact of fish consumption on GHG emissions in Europe according to different scenarios.

ecological impact. Indeed, GHG emissions can vary consistently among different fatty fish species, with small blue fish (e.g., anchovies, sardines, herrings) having a much limited environmental impact compared to salmon and tuna (Table 1) [20]. Therefore, if the European population would replace current fish intake (2 servings per week) mainly based on species with a high ecological impact (like tuna and salmon) with that of sardines, mackerel, and other small blue fish, there would be around 80% reduction in GHG emissions due to fish consumption (Fig. 1).

4. Fish consumption within the 'one health' approach to food

Consumption of 1–2 servings per week of the appropriate types of fatty fish with the shortest lifecycle (e.g. sardines, mackerel, herring, etc.) can be adequate for the optimization of CVD/CHD prevention [8] and can have a significant beneficial impact on the environment if it replaces similar amounts of lean fish [16].

Moreover, it has been shown that replacing meat with certain typologies of sustainably sourced seafood can reduce the carbon footprint of diets, while being more nutritious than chicken, beef and pork [21]; this applies particularly to wild-caught, surface-dwelling fish (such as anchovies and mackerel). Indeed, considering the overall GHG emissions linked to the European weekly diet, a reduction of as much as 25% could be achieved by consuming the abovementioned more sustainable species of fatty fish in place of 2 servings of total fish and 2 servings of red meat, which is associated with an increased CVD risk and a huge ecological impact. Small blue fishes are also the cheapest nutritious fish in low- and middle-income countries [22].

This kind of discernments is pivotal, since the species of fish that Westerners are eating in increasing amounts have stocks that are already under high pressure (i.e. yellowfin tuna, the basis of the very popular "tuna-fish sandwich" or, more in general, "steak fishes" high on the food chain) [23]. These seafood species are also most likely to bioconcentrate mercury and persistent organic pollutants (i.e. dioxins and polychlorinated biphenyls), posing a potential risk for human health due to their association with impaired neurological, reproductive, and immunological functions [24,25]. Even though a comprehensive meta-analysis [26] concluded that any risk associated with fish consumption is unlikely to offset the benefits of increased omega-3 PUFAs intake at the recommended amounts of consumption, it is advised to limit the intakes of certain types of fatty fish (like tuna) in the diets of pregnant women and children, in order to minimize exposure to methylmercury [27,28].

Altogether, appropriate food behaviors are strictly dependent on proper information and deep consciousness of the consumers about what type of fish should be promoted for consumption, especially in high income countries. Global demand of fish has doubled since the start of the twenty-first century and there will be another near-doubling by the middle of the century [29]. At the same time, cardiovascular events are projected to increase – despite being largely preventable by appropriate dietary choices and lifestyle [30] – in parallel with food-related GHG emissions, if dietary modifications at the population level will not take place.

Within this scenario, it is mandatory to reconsider dietary recommendations on fish consumption taking into account its multifaceted sustainability aspects in terms of human and environmental health. Consumption of 2 servings per week of small blue fish can be a feasible and effective choice within the dietary strategy based on a "One Health" approach to optimize the health of human beings, animals and ecosystems.

Author contributions

A.G., M.A. and G.R. conceptualized the outline of the viewpoint. A.G. and M.A. curated data on the environmental impact of fish consumption. A.G. curated the data, validated the results and carried out the data visualization. A.G., G.R. and M.A. wrote the original draft of the manuscript. G.R. reviewed manuscript. A.G. edited the manuscript. All authors reviewed and approved the final manuscript. A.G. accepts full responsibility as guarantor of the work, conduct of the study, access to the data, and controlling the decision to publish.

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Declaration of competing interest

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