**Aquatic Foods for Nourishing Nations**

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**Introduction (300 words)**

Our oceans and inland waterbodies are a vital source of nutritious food for billions of people around the world. Increasingly, aquatic foods are being recognized as an important component of nutritious diets, however, the debate is severely restricted by the narrow focus on fin fish and a lack of data on and understanding of the vast, diverse range of aquatic foods and their untapped potential in meeting the nutritional needs of the many,

very different population groups, in particular the poor and vulnerable. This paper begins with a comprehensive documentation of the vast range of different aquatic foods, presenting the most current data on nutrient composition—the foundation without which, the nutritional and health benefits of aquatic foods cannot be fully assessed. Thereafter, the benefits of these aquatic foods, not only on their own but also together with other foods on the plate will be exemplified through case studies of selected population groups. These case studies demonstrate how aquatic foods can transform diets to being more nutritious and thereby contribute to tackling escalating global public health challenges. This paper will provide the breadth of evidence which policy makers and development stakeholders, at global and national level, can draw upon for directing policies and investments in research and interventions to ensure making full use of the vast potential of aquatic foods in meeting the Sustainable Development Goals (SDGs), in particular to achieve food and nutrition security and end malnutrition in all its forms by 2030.

**Main text**

**I. *Aquatic foods on the plate for diverse, nutritious, sustainable diets* (1000 words)**

Aquatic foods are defined as the breadth of aquatic organisms used as food, including finfish, shellfish (e.g. shrimp), molluscs (e.g. oyster), aquatic plants (e.g. watercress), algae (e.g. seaweed), and other aquatic animals like snails, sea cucumbers, and aquatic mammals and insects. We will next describe the diversity, quantity and nutritional quality of aquatic foods produced and consumed and how these vary across geographies and population groups. The EAT-Lancet Commission (EL) Summary Report (2019) outlined a path to a healthy and sustainable diet, yet failed to adequately highlight and integrate the critical role of aquatic foods to the future of human health and planetary health. We will briefly discuss the multi-fold benefits of aquatic foods to planetary health, drawing on the most current epidemiological evidence (e.g., Bernstein et al 2019; Zhao et al, 2015; Ezzati and Riboli, 2013; Lim et al 2012; Rimm and Mozaffarian 2006). Aquatic foods contribute multiple micronutrients with high bioavailability, and enhance the bioavailability of crucial nutrients in plant-based food sources (and diverse plate combinations). We will lean on some of the epidemiological evidence linking aquatic foods consumption to health outcomes in section I (e.g., birth outcome, breast milk composition (Fiorella et al 2018), child growth (Skau et al 2015, Sigh et al 2018), development, cognition (Rangel-Huerta and Gil 2018), school performance, and work performance), and discuss some of the innovative interventions that have been developed to link these food systems to human health and well-being. We will highlight contributions to vulnerable population groups, e.g., in the first 1000 days of life (perhaps also refugees and displaced populations (from coasts and inland water bodies). Aquatic foods tend to have minimal loss to cleaning and plate waste, especially for small fish. We will also discuss the social, cultural, and environmental benefits of aquatic foods, drawing on literature from life-cycle assessments and other relevant studies.

**II. *Nutrient composition and contribution of aquatic foods to estimated average requirements* (1500 words)**

In this section, we will collate the most comprehensive database detailing the macro- and micro-nutrient composition profiles of aquatic foods—the Aquatic Foods Composition Database (AFCD). The AFCD will comprise more than 30 nutrients, inclusive of minerals, vitamins, fatty acids, and macronutrients. Food composition databases from the USDA and FAO, and individual food composition tables from Australia, New Zealand, Pacific Islands, Korea, India, Bangladesh, West Africa, Canada, and Hawaii (among others) will be integrated into a coherent global database of aquatic foods (finfish, shellfish, molluscs, cephalopods, and aquatic plants and animals) to cover all segments of inland and marine foods.

In addition to these national and regional tables, we will integrate data on small indigenous species (Thilsted and Fiorella) that includes more than 500 species from Bangladesh, Cambodia, and Myanmar. Lastly, we will systematically review the literature harnessing machine learning techniques to comprehensively scope disparate databases for nutrient composition information. In partnership with Jaron Porciello, we will develop a machine learning approach to gleaning data from the published, peer-reviewed literature, similar to the process adopted by Ceres2030.

Each of these components will become the baseline of AFCD, allowing for future versions to dynamically update this original database. The creation of this comprehensive and coherent database (to live on a dynamic website that can be added to over time) will elevate the importance of diverse aquatic foods as more than a source of protein; because for many, it is an irreplaceable source of micronutrients and essential fatty acids. In addition, to ensure a comprehensive and cohesive Blue Food Assessment, the AFCD will be invaluable in shaping the narratives in the themes of economics, smallholder production, environment, so that due value is given to the diversity and relative importance of different aquatic foods consumed, traded and produced in different geographies. We envision this living on an openly accessible, permanent website (e.g., Scientific Data, Harvard Dataverse, Github, R Shiny App, etc.) where future versions can be updated by the authorship group.

**III. *The important and varying paths of aquatic foods to nourish nations* (1500 words)**

In this section, we will calculate the nutrients supplied to the human population by aquatic foods consumption by country, comparing this to overall nutrient supply of current diets, and comparing to thresholds of estimated average requirements (EARs) to determine the dependency of certain nations on aquatic foods. This will involve the use of a series of databases to make these calculations:

1) Starting with the Global Expanded Nutrient Supply (GENuS; Smith et al. 2015) database, we will calculate the total food system nutrient supply at national levels, and disaggregate nutrient supplies per capita for 23 different nutrients to 32 different age-sex groups. This examination of current dietary nutrient supplies will offer insight into the nutritional vulnerability of various nations, and particular age-sex groups at sub-national levels.

2) Aquatic foods in the GENuS database currently include the following categories: i) demersal fish; ii) pelagic fish; iii) fish oils; iv) crustaceans; v) cephalopods; vi) other marine fish; vii) freshwater fish; and viii) aquatic animals. To increase the resolution of these categories, we will assume that the volumes of consumption in these categories stay the same, however, we will assign species to these categories with dietary intake data from other sources such as the Illuminating Hidden Harvests (IHH) project, Household Income and Expenditure Surveys (HIES) and the World Bank Living Standards Measurement Study (LSMS) household surveys in order to have a better representation of the diversity of aquatic foods within current diets.

3) By using the individual species identities of consumption presented within the databases, species can be mapped onto their respective nutrient composition profiles and update the total food system nutrient supplies for 23 different nutrients to 32 different age-sex groups for every country.

4) Looking at the proportional composition of aquatic foods to overall nutrient supply by age-sex group and nation, and the existing overall total nutrient supply and its relation to EAR thresholds, we can examine the vulnerability of certain nations and sub-groups within nations.

5) Changes in consumption to aquatic foods could arise from any number of factors. We will model an increase in aquatic foods consumption (TBD; potentially using the case of fisheries management improvements drawing on Free et al. 2020; or increases in aquaculture production drawing on official statistics) to explore potential impacts to health in both undernourished nations and overnourished nations. In undernourished nations, we will estimate the change in nutrient supply to overall diets from the additionality of aquatic foods consumption to evaluate the proportion of the population newly averting nutritional deficiencies, using EARs as a threshold. In overnourished nations, we will estimate the change in the number of servings of aquatic foods in the diet to estimate the proportion of the population attaining 1 serving of seafood per week. In this setting, we will model increases in the servings of seafood as a substitution from dietary saturated fats (SFs) for polyunsaturated fatty acids (PUFAs) drawing on Wang et al. (2016) and Zhao et al. (2016) to estimate the health impacts of these dietary changes on the incidence of total mortality, cardiovascular disease mortality, cancer mortality, and neurodegenerative disease mortality. Those accruing above a 5% substitution of SFs for PUFAs will not attain increasingly more health benefits.

6) Lastly, we can convert the changes in incidence of nutritional deficiencies and various forms of mortality to estimate the burden of disease associated with changes in access to aquatic foods, including an economic assessment of health impact.

**IV. *Case Studies***

After this global analysis, we will select a variety of countries to illuminate the conditions under which aquatic foods consumption can meet nutritional needs in various ecological, economic, and socio-cultural contexts. These country contexts will include low-, middle-, and high-income countries to distinguish between the functions of aquatic foods as ‘irreplaceable' vs ‘desirable.’ Fish-dependent countries (e.g. some small islands – Kiribati, Maldives, gleaning in Solomon Islands; low middle-income countries with deltas (Bangladesh); vast inland water bodies (Kenya, DRC, Brazil, Cambodia); China). These typologies will enable us to develop demand profiles for aquatic foods, based on nutritional needs e.g. age, sex, current diets. We will add cultural competency to this section by delving into the preparation of dishes, combinations of dishes on the plate, social/religious/other constraints, etc. We will also discuss issues affecting access to aquatic foods, describing, e.g., seasonality; household composition, geography/proximity to water bodies; economics; knowledge. The typologies and case studies selected will illustrate context-specific examples of the benefits of accessible and well-liked specific aquatic foods for population groups who stand to benefit from the unique value of aquatic foods as a source of multiple, highly bioavailable micronutrients which are currently low/missing in the diets; e.g., seaweed in the diets of pregnant women in Solomon Islands and dried small silver fish in complementary foods of young children in the Lake Victoria region. This will build on results of trials already conducted, strengthened with the new data from the AFCD, thereby, for the first time, being able to fully demonstrate the nutritional and health benefits of diverse aquatic foods.

Our research products will illuminate:

1) national-level vulnerabilities. This would lead to policies and investments for sustainable fisheries management, enhancing aquaculture, or trade regulations, to produce more aquatic foods in certain countries; or to build regional trade networks to have products flow to those in need;

2) age-sex profile vulnerabilities. This would lead to policies and investments of including aquatic foods in the diets of those most vulnerable (e.g., pregnant and lactating women, young children, elderly, refugees)

3) the conditions under which consumption of aquatic foods are most likely to meet nutritional needs.

**Conclusion**

In this section, we will distill main messages from the prior sections, and focus on solutions that integrate aquatic foods into sustainable, nutritious diets.

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