**Aquatic Foods for Nourishing Nations**

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***Introduction* (300 words)**

The Sustainable Development Goals (SDGs) prioritize achieving food and nutrition security and ending malnutrition as global priorities. Integrated, nutrition-sensitive food systems that can lead to the adoption of sustainable, healthy diets are recognized as a key pathway to achieving these global challenges. Within this framework, the contribution of aquatic foods has been overlooked and undervalued. This paper will demonstrate that aquatic foods have vast potential to contribute to solutions to achieving the SDGs, through presenting up-to-date evidence on the nutritional contribution of aquatic foods within diets for nourishing nations.

**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; Rim 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 sequelae in section I (e.g., child growth, development, cognition (IQ) (Hibbeln et al 2006; 2019), 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 aquatic foods as more than a source of protein; because for many, it is an irreplaceable source of micronutrients. We envision this living on an openly accessible, permanent website (i.e., 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 expand the resolution and diversity of aquatic foods within current diets, we populated these categories with improved dietary intake data from the Hidden Harvests project.

3) By using the individual species identities of consumption presented within the Hidden Harvests database, we can map these species 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 to perturbations in the consumption of aquatic foods and the potential nutrient contribution to avoiding undernutrition.

5) Looking at potential changes in aquatic food supply, we can estimate the change in incidence of cardiovascular disease events based on established dose-response relationships of relative risk of these dietary behaviors.

6) Lastly, we can convert the changes in nutrition and changes in disease outcomes 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 typologies of the importance of aquatic foods consumption 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; geography/proximity to water bodies; economics; knowledge.

Our research products will illuminate:

1) national-level vulnerabilities. This would lead to policies that could enhance aquaculture, or trade regulations, to keep ro 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 of including aquatic foods in the diets of those most vulnerable (ie pregnant and lactating women, small children, etc.)

References:

We will need to do new research on each of the case study countries to ground-truth ways in which aquatic foods can deliver nutrition, reviewing literature on taste preferences, price elasticities, social/economic/cultural barriers to consumption, etc.

**IV. *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. We will highlight a [case study from Cambodia](https://gcgh.grandchallenges.org/grant/high-quality-fish-powder-new-cambodian-ready-use-food) that uses fish products for treating malnutrition, school lunch programs in Alaska that integrate traditional foods like salmon, and the use of aquatic foods in humanitarian emergency situations (see reference list below).

References:

Efficacy studies in Bangladesh, Cambodia and Kenya on small fish on child growth: Shakuntala

Literature review required – also ‘grey’ literature’ on projects (e.g. school feeding done by World Food Programme)

IHME (The Institute for Health Metrics and Evaluation) team