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The Great Global Fish Count (GGFC): A Potential Project of the UN Ocean Decade

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ABSTRACT

The Great Global Fish Count (GGFC) is a community science project to count fish and then other forms of marine life in coastal and later all waters using loose DNA in seawater (marine eDNA) shed by all animals. The project would distribute small filtration devices to millions of people. The devices would enable participants to take water samples, filter the water, stably preserve the filter with the sediment containing DNA, and post the filters to qualified labs for eDNA analysis. Labs would analyze samples, identify species, and upload data to a project database including Web-based geographical information systems accessible to a mobile app. The collector of each sample would learn the species and quantities of DNA in their sample(s) and have access to information from all other samples. The totality of the data would open countless opportunities for analysts to discover patterns and trends. The project would begin by targeting fish species, because of their societal importance, public interest, availability of high-quality primers to grab relevant sequences, and richness of the DNA reference library of fish sequences. Later in the decade the project could expand to all vertebrates (including marine mammals), mollusks, crustaceans, and other taxa, perhaps adding one major group each year.

Vision and Potential Transformative Impact

The GGFC could measure the baseline and changes in the totality of the distribution and abundance of most known fish in the Anthropocene oceans, and potentially other taxa. The proposed scale of use of eDNA is unprecedented. The largest eDNA efforts so far involve a few hundred samples, while the GGFC would involve millions or tens of millions. The proposed scope, covering entire coastlines, basins, and the global ocean is also new.

The GGFC could greatly advance knowledge of impacts of fishing and aquaculture, urbanization of coast lines, pollution, offshore energy extraction, efforts to restore and protect habitat, climate change, and other factors. eDNA can illuminate the invasive, elusive, or endangered as well as the common.

The R&D component of the program would speed improvement and adoption of best practices. Enhanced adoption of marine genomic techniques could be a major outcome, as well as enhancement of marine genomic reference libraries. The number of people qualified for careers in marine 'omics should grow. The program would foster initiation of time-series. Entrepreneurial companies providing eDNA and other services in marine genomics should increase in number and scale. DNA results should become affordably available to large numbers of people for identification of presence of marine species in near real-time. The GGFC should also produce surprises about distributions and abundance.

Ultimately, smarter boundaries in space and time for marine protected areas could be an outcome, and identification of biodiversity hot spots and trouble spots. Detection and documentation of ecological recovery should become more reliable.

Realizable, With Connections to Existing U.S. Scientific Infrastructure, Technology Development, and Public–Private Partnerships

No U.S. or international networks yet exist for systematic advancement of marine eDNA. The program does not face a big problem of entrenched structures. The GGFC could create much of the national and global infrastructure for eDNA and marine genomics more broadly. It could lower costs and standardize practices.

The GGFC meshes with NOAA's Genomics Road Map, marine genomic and biodiversity initiatives of the Smithsonian Institution, and archival initiatives such as the Ocean Genome Legacy Project.

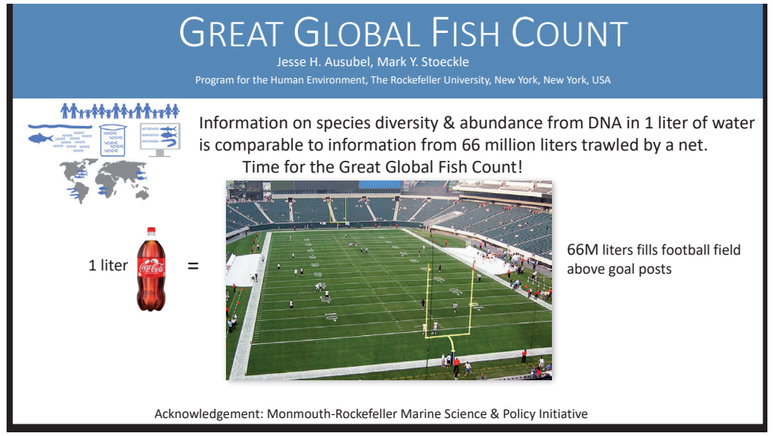
Within the U.S. government, most participants in the National Ocean Partnership Program should take an interest, including many parts of NOAA, the Office of Naval Research, National Science Foundation, and DOI's Bureau of Ocean Energy Management. State coastal and environmental agencies might have much to gain, for example, by enhancing survey efforts for salmon in the Northwest or cod in the Gulf of Maine.

Aquariums and natural history museums would have much to contribute and to gain from the success of the GGFC.

Scientific/Technological Sectors Engaged Outside of Traditional Ocean Sciences

The convergence of genomics with information technologies and geographical information systems makes the program newly feasible and available for global participation.

Suppliers of goods and services in the biotech industry such as New England Biolabs, Illumina, GeneWiz, and ThermoFisher/Applied



Biosystems would be valuable partners, as would companies making and operating drones, which could extend sampling, especially far from shore and in deep water. Shipping companies such as FedEx and UPS might provide useful services, as well as IT companies with cloud storage.

Cruise lines, resorts, and others involved in marine and coastal leisure industries might also welcome the program, to which they could contribute samples and with which they could entertain their guests.

An important ethical advantage of the program is that it does not require collection of living organism or stress animals.

Opportunities for International Participation and Collaboration

The United States and France, with far the largest Exclusive Economics Zones, must play leadership roles together with other nations combining strong competence and shoreline. Internationally, nongovernmental organizations, including POGO, SCOR, and SCAR (for Antarctica) could multiply success of the program by fostering eDNA science, standards and protocols, sampling, and big data analyses. In the North Atlantic ICES and in the Pacific PICES could use GGFC to develop eDNA standards for fisheries and other surveys. UN FAO (Fisheries Division) and other agencies could engage in capacity-building around GGFC and benefit from its findings, which should contribute to their reports on the State of Fisheries and Global Oceans and marine sections of IPCC and IPBES reports. Management of the GGFC would probably involve an international scientific steering committee as well as national or regional committees, and working groups concerned with technology development, standards and protocols, data science, engagement, and other themes.

Develops Global Capacity and Encourages the Development of the Next Generation of Ocean Scientists, Engineers and Technologists

Anyone with a cellphone should be able to benefit from the GGFC and its outcomes. People of all ages can make valuable collections and learn from their own samples. Recreational boaters and fishers would have wonderful opportunities. Adoption of the GGFC as a Decade Project at the 2022 Berlin conference would be an initial milestone. 2024 might be the year of the Great Count. A conference in 2025 would highlight important results and inspire continuing efforts. Overall, the GGFC should develop global capacity to sense and know the oceans and encourage new generations of ocean scientists and stewards.