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Marine recreation with a purpose: an emerging form of marine citizen science in the Ocean Decade

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Amidst the growth of the marine technology and recreation sectors and heightened public environmental awareness, the opportunity for marine citizen science is extending to marine recreationalists. An unnoticed yet growing demand for purpose among marine recreationalists has translated into citizens recruiting scientists to integrate environmental data collection into recreational activities or events, named here "marine recreation with a purpose." As an example, GB Row Challenge is an annual ocean rowing competition circumnavigating Great Britain which recently integrated environmental monitoring as an inherent component of the event with the help of partner scientists and engineers. This bottom-up, integrated form of marine citizen science that is rooted in recreation, adventure or sports, has unique contributions to United Nations' Ocean Decade goals, such as encouraging ocean stewardship and normalizing citizen science and ocean literacy to audiences not usually exposed to this content. The public nature of these projects may also help overcome common barriers of citizen science with funding and technical support by private sources via sponsorships. To build the experiential, financial and technical capacities needed to enable marine recreation with a purpose at all scales, coordination between all forms of marine recreation-based citizen science is required. This could be realized through forming a dedicated coalition in existing citizen science associations and platforms. Marine recreation with a purpose is a growing trend of citizen science in the marine recreation sector and global coordination will amplify its impact as an essential contribution to the Ocean Decade.

KEYWORDS

marine citizen science, marine recreation, marine sports, purpose, GB Row Challenge, marine pollution, ocean literacy, Ocean Decade

1 Introduction

The terms citizen science (CS) describe the participation of members of the public in scientific research (Eitzel et al., 2017). Such participation exists on a spectrum, from isolated data collection or analysis to participatory engagement to setting the research agenda (Haklay, 2013). This different level of ownership from citizens over the processes of the research differentiates between bottom-up (more collaborative) and top-down (more managed by professional scientists) approaches (Wilderman et al., 2004). By opening aspects of research to the public, CS provides learning opportunities for non-scientists and increases the scope of the research that can be done (Bonney et al., 2009). The increased spatiotemporal coverage and reduced cost of CS data are especially crucial in hard-to-reach environments, such as the marine environment (Cigliano et al., 2015). Marine CS (MCS) has mostly followed a top-down approach, with projects initiated and managed within academia (Sandahl and Tøttrup, 2020).

Developments in the marine technology sector (Schwing, 2023) have broadened the options for MCS, traditionally based on manual data collection (e.g., Hidalgo-Ruz and Thiel, 2013; Agersnap et al., 2022). More robust, compact, affordable and autonomous sampling and sensing systems allow participation from any suitable platform. Simultaneously, the number of platforms at sea is increasing as marine recreation becomes more accessible and popular. In the UK in 2018, 17 million adults engaged in water sports, with 3.9 million of them engaging specifically in boating activities (Arkenford, 2019). The evolution in both sectors extends the opportunity for MCS to the marine recreation community (Lauro et al., 2014; Brewin et al., 2017). Research has started around adapting sensors and samplers to marine recreation activities, such as temperature sensors attached to a surfboard leash (Brewin et al., 2015), temperature and underwater acoustics sensors on kayaks (Griffiths et al., 2017), a lightweight manta trawl net for stand-up paddleboards (Camins et al., 2020), a portable CTD for scuba-divers (Sayer et al., 2021), or temperature and motion sensors built into surfboard fins (Bresnahan et al., 2022).

Popular and news media can shape public awareness of environmental issues (Henderson and Green, 2020; Males and Van Aelst, 2021). In recent years, the global spotlight on marine pollution has increased significantly (SAPEA, 2019; Walther et al., 2021). For marine recreationalists, this awareness is heightened by direct exposure to the marine environment and its degradation (Henderson and Green, 2020). Reflecting this, some marine recreationalists readily engage in environmental conservation, as part of which they participate in MCS. For example, seafarers can contribute light penetration depth data by using Secchi disks (Brewin et al., 2019; Kirby et al., 2021). Stand-up paddleboarders from the international group Surfrider Foundation have contributed nearshore microplastics pollution samples (De Haan et al., 2022) and sea surface temperature data (Bresnahan et al., 2017). Scuba-divers also can contribute observations of habitat, pollution and biodiversity to local projects (e.g., UK's Seasearch, https://www.seasearch.org.uk/; Spain's Observadores del Mar, https://www.observadoresdelmar.es/).

These top-down MCS projects are based on data crowdsourcing, in which marine recreationalists contribute at their convenience and without commitment. Here we discuss an alternative mode of engagement with CS which has been growing unnoticed in the marine recreation sector. This Perspective defines this trend and proposes why and how it should be promoted alongside traditional MCS.

2 Marine recreation with a purpose

2.1 A new mode of engagement with MCS in marine recreation communities

In recent years, a trend has emerged among marine recreationalists, which consists of initiating partnerships with research groups to integrate environmental data collection into their recreational activity. For example, Gewert et al. (2017) report that in 2014 two Swedish stand-up paddleboarders contacted them with the project of raising awareness of plastic pollution as they attempted to paddleboard across the Baltic Sea, and they wanted scientists to help them obtain useful data. This partnership resulted in the development of a specialized trawl net for the stand-up paddleboarders to take samples for microplastics analysis. In 2017, long-distance sailors started carrying and

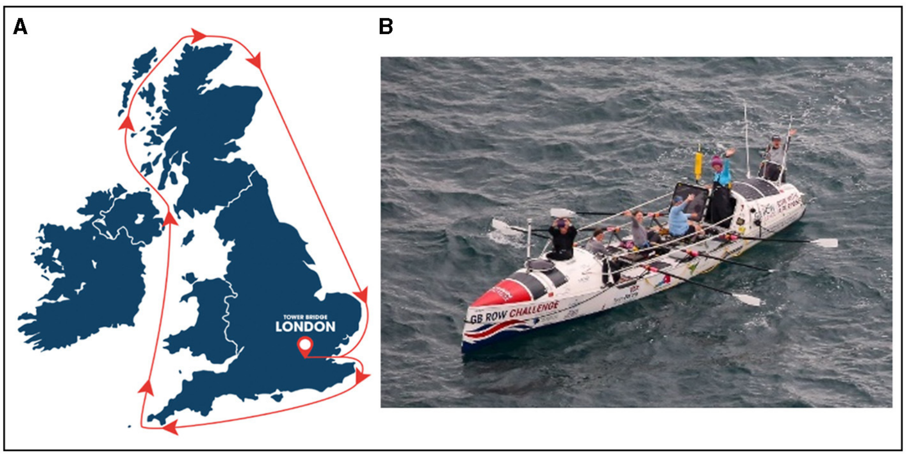

FIGURE 1
Marine recreation with a purpose example: GB Row Challenge's Row with a Purpose project **(A)** General route taken by crews on GB Row Challenge races, showing spatial coverage of the microplastics, environmental DNA, underwater acoustics, water temperature and salinity data collected. **(B)** A GB Row Challenge vessel with 2023 crew on board (scale: vessel is 10 m in length). Written permissions for the publication of identifiable images have been obtained.

operating tailored scientific equipment in transoceanic races to contribute to research on marine pollution and climate change, as part of the "Sailing meets Science" agreement with UNESCO and various marine scientific and engineering groups (Tanhua et al., 2020; Landschützer et al., 2023). Around the same time, the organizers of a high-profile transoceanic sailing race, The Ocean Race, launched their own science plan named "Racing with purpose" (https://www.theoceanrace.com/en/racing-with-purpose/science) which sees participating sailors collect data on pollution and climate as they go. Then in 2022, the Canadian team of the sailing championship SailGP, wanting to raise awareness on marine plastic pollution, commissioned the non-profit research group Ocean Wise to help design a bespoke scientific sampling plan (Landrini et al., 2023). The authors of this Perspective are involved in the first project of this kind for the endurance rowing sector. GB Row Challenge (GBRC) is an annual event launched in 2005 where teams of up to 6 rowers per boat attempt to row the 3,500 km-long circumnavigation of Great Britain, unsupported and uninterrupted (Figure 1A). In 2019, the organizers decided to integrate environmental data collection to the Challenge, to understand the state of marine environmental health, as captured by the project name, "Row with a Purpose" (https://www.gbrowchallenge.com/row-with-a-purpose). GBRC organizers own rowing vessels which participating teams typically hire for the Challenge and which could be modified to carry data collection equipment (Figure 1B). To this end they brought in scientists and engineers from academia and industry (University of Portsmouth, UK; Harwin; Porvair Filtration Group; NatureMetrics; RS Aqua), with financial support from philanthropic donations. They launched the resulting four-year research program in the 2022 GBRC edition, where participating rowing teams were trained to support the collection of data on microplastics, environmental DNA (eDNA), underwater sound, water temperature and salinity, via equipment made or modified in-house specifically for the project. Data from two complete circumnavigations (one team in 2022 and one team in 2023) are currently undergoing analysis, with dedicated publications to follow (Couceiro et al., 2023).

In all these instances, the impetus behind data collection has come from the marine recreation sector, with scientists providing technical support around relevant analytes, collection methods, data quality requirements, sample analysis and data interpretation. This demand for MCS goes beyond contributing to existing projects on an *ad-hoc* basis, as in classic MCS based on data crowdsourcing (Sandahl and Tøttrup, 2020). Instead, marine recreationalists seek a bespoke project, tailored to their activity or event, to be designed and in part carried out (e.g., data analysis) by the commissioned scientists. This bottom-up engagement with MCS reflects a growing need for purpose, ownership and personal action, leading them to modify the way they recreate. Furthermore, in these projects, the way data collection is embedded within the activity does not limit recreation, but rather complements it. Thus, this proactive, bottom-up integration of environmental research and collaboration with scientists forms the basis of a new mode of recreation: marine recreation with a purpose. This translates to a form of MCS that is initiated by citizens, where citizens retain a level of ownership over the research, and where scientists act as service providers (Wilderman et al., 2004).

2.2 Value to the Ocean Decade

The UN Ocean Decade, spanning from 2021 to 2030, is a global framework aiming to ensure the long-term health of ocean ecosystems and the benefits humanity derives from them, through scientific research and community ocean stewardship. Marine recreation with a purpose is a key contribution to the following Ocean Decade Challenges: expanding the Global Ocean Observing System (GOOS), addressing the pollution, biodiversity and climate change crises, democratizing access to ocean data and technology, and fostering a deeper connection between people and the natural environment (Bender et al., 2022).

The rationale for integrating CS into the marine recreation sector often emphasizes the potential for cost-effective spatiotemporal coverage and resolution (Lauro et al., 2014; Brewin et al., 2017). For example, the ongoing GBRC environmental data collection project has already yielded 2 years (2022–2023) of coherent datasets of pollution, climate change and biodiversity variables for the entire coastline of Great Britain (Couceiro et al., 2023). The project aims to yield coordinated datasets for the entire coastline of Great Britain for four consecutive years, and with continued funding, it could target more parameters and lengthen the time-series. Similarly, other marine recreation with a purpose projects have contributed marine pollution, biodiversity and climate data at various scales to the GOOS (Gewert et al., 2017; Tanhua et al., 2020; Landrini et al., 2023; Landschützer et al., 2023). Many other marine sports and recreation events and clubs exist worldwide, whose adoption of marine recreation with a purpose would greatly increase data coverage and resolution of many environmental variables (Brewin et al., 2017). Further, integrating data collection in marine recreation can also come with reductions in carbon footprint of research when working with human- or wind-powered activities (Camins et al., 2020), as well as engineering innovation due to novel constraints of marine recreation platforms and activities (low space and power, hydrodynamics; Bresnahan et al., 2022).

Marine recreation with a purpose specifically describes scientific research projects arising from the demand of sea-going citizens for integrating data collection in their recreational activity. Scientists meeting this demand as commissioned party allows for citizens to retain ownership of the project. For example, SailGP's Canadian sailing team commissioned Ocean Wise to help design a data collection plan specifically for marine plastic pollution (Landrini et al., 2023). This retention of agency over the process and outcomes of a multi-partner project is important in motivation and commitment (Light et al., 2013). Further, these more balanced leadership dynamics between scientists, citizens and other project partners encourage two-way communication with benefits in knowledge transfer and democratization of scientific concepts. Further, sharing responsibilities between partners in a MCS project improves overall productivity (Zhang et al., 2023).

Marine recreation events can generate publicity and attract wide audiences (Crespo Sogas et al., 2021). Complementing marine recreation with data collection in a way that allows the activity to retain its identity around leisure, adventure or sports, rather than limiting it to CS or conservation, allows marine recreation with a purpose projects to reach a much bigger audience than traditional MCS, promoting and normalizing ocean stewardship, ocean literacy and CS concepts. Simultaneously, the presence of environmental monitoring within a marine recreational activity can encourage environment-focused audiences to engage in the activity and experience the marine environment. The GBRC Row with a Purpose (Couceiro et al., 2023) editions in 2022 and 2023 have generated media interest across radio, television and newspapers, with interviews by rowers and scientists for national broadcasters, such as the BBC, Sky News, ITV and The Telegraph, as well as various local outlets, giving good visibility to the concept of marine recreation with a purpose, sports and science partnerships, and all partners.

Thus, beyond increasing spatiotemporal coverage and resolution of marine variables related to pollution, biodiversity and climate, marine recreation with a purpose can, through empowering citizens and normalizing environmental research, encourage a wider public to connect with both science and the marine environment, two key goals of the Ocean Decade.

2.3 Overcoming barriers of marine recreation-based MCS

Typical constraints that limit the scope of MCS with the marine recreation sector include a combination of lack of appropriate data collection equipment, lack of expertise, and lack of funding (Brewin et al., 2017). Different marine recreation platforms have different constraints of space, weight, power and hydrodynamics; different monitoring targets have their own data quality and spatiotemporal resolution requirements; and different users have different technical proficiencies (Brewin et al., 2017; Camins et al., 2020; Bresnahan et al., 2022; Couceiro et al., 2023; Landschützer et al., 2023). Sensor technology can offer low-cost, portability, autonomy, high data resolution and data integrity, and currently covers a wide spread of ocean parameters (Briciu-Burghina et al., 2023). However, some sensors remain expensive or bulky and sensor technology does not capture emerging variables. Sampling best targets those, but requires a robust data quality assurance plan, considering factors like sample contamination from non-specialist handling, and storage and preservation capabilities. Additionally, time and space are required for obtaining and storing samples, and subsequent sample processing can be expensive and time-consuming, requiring funds and creating a delay between sampling and results. Research around adapting either type of equipment to marine recreation platforms is still limited in terms of parameters, instruments and platforms (Gewert et al., 2017; Griffiths et al., 2017; Brewin et al., 2020; Camins et al., 2020; Tanhua et al., 2020; Sayer et al., 2021; Couceiro et al., 2023; Landrini et al., 2023; Landschützer et al., 2023). As such off-the-shelf equipment suitable for a project might be unavailable, leading to the need to design equipment in-house. This requires suitable expertise, such as in engineering (Bresnahan et al., 2017), as well as funds. So, in practice, the scope of the data that can be targeted in marine recreation-based MCS depends on the project's goals and the technical, experiential and financial capabilities available.

Participants in expedition- or competition-style marine recreation events often enter partnerships with private groups, in the form of sponsorships which can entail direct funding or in-kind donations of equipment, time or expertise, in exchange for visibility (Delpy et al., 1998). Marine recreation with a purpose that takes place in marine recreation events can therefore allow MCS to benefit from private sources of funding as well as traditional academic sources, and from partnerships with engineering or technology groups which can help with technical aspects of the project. The GBRC – Row with a Purpose project (Couceiro et al., 2023) has received funding from philanthropic donations and is partnered with several engineering and technology firms for a four-year period. This collaboration allowed for the design of equipment specifically tailored to the scientific, technical and user constraints. Equipment needed to minimize sample contamination and maximize data resolution and coverage, be portable, reliable and robust, and be simple to operate in harsh weather at sea. The monitoring targets included a range of variables (microplastics, eDNA, underwater acoustics, temperature, and salinity), and thus required a combination of sampling and sensing technology (Figure 2A). Two pump and filtration systems were designed specifically for the project: one for microplastics (Figure 2B), and one for eDNA (Figure 2C). These ran at pre-set times, only requiring filters to be changed, preserved (for eDNA) and stored daily by rowing teams. An off-the-shelf temperature and salinity sensor was fixed to the rudder (Figure 2D). A hydrophone was first fixed to the outside of the boat, but it was then integrated within the rudder to reduce noise (Figure 2C). Both of these sensors run autonomously, without input needed from rowing teams. Together, this suite of equipment is totally optimized for the GBRC project, vessels and users, with a plan for 3 boats to be outfitted for the 2024 edition.

Marine recreation with a purpose, through being a public-driven form of MCS, can exploit both private and public sources of funding as well as form partnerships with private groups, which can help overcome common barriers to MCS through expanding the project's pool of expertise and the scope of data collection.

3 Discussion

Marine recreation with a purpose describes emerging modes of both recreation and MCS, driven by citizens. A reflection of the growing need for purpose and adding value to recreation, as the various projects' name reflects, it represents the integration of environmental data collection into marine recreation as a result of a citizen-driven partnership between marine recreationalists, scientists and other parties (e.g., engineers).

Marine recreation with a purpose does not describe projects designed to crowdsource data from a large volume of volunteers (see Introduction), but rather it is complementary to this. Data collection is integrated within specific marine recreation activities or events, such as GBRC, sailing races, or individual expeditions (Gewert et al., 2017; Tanhua et al., 2020; Couceiro et al., 2023; Landrini et al., 2023; Landschützer et al., 2023). Therefore, their scope and the level of participation from citizens are limited to the context of the project. This limitation does not exclude that the structure and technology developed in marine recreation with a purpose projects be scaled up. In fact, it is expected that these projects inspire and enable more marine recreationalists to work

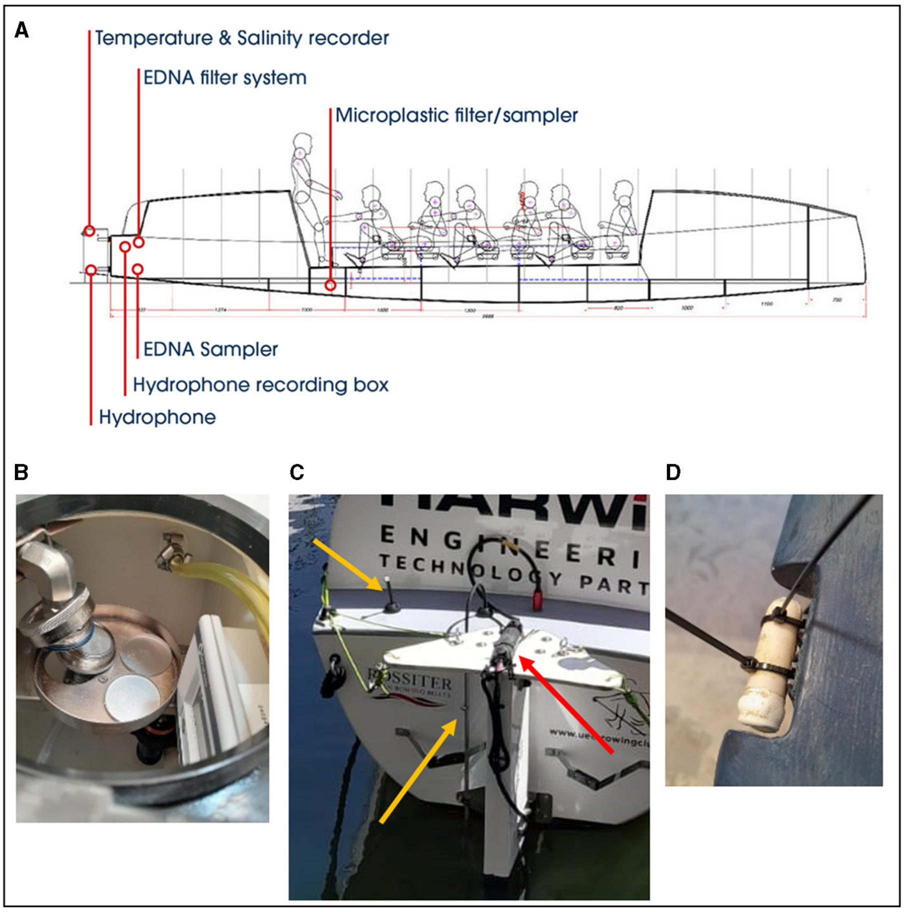

FIGURE 2
Monitoring equipment carried by GB Row Challenge vessels **(A)** Schematic representation of the location of monitoring equipment on board. Credits: GB Row Challenge. **(B)** The microplastics sampling system, custom-designed by project partners Harwin and Porvair Filtration Group, in one of the vessel's hatches. The clamp is open showing a stainless-steel filter on the filter stage ready to be stored in its metal case (scale: filter is 4.2 cm in diameter). **(C)** The stern of a GB Row Challenge vessel showing the visible parts of the eDNA *(left)* and acoustics (*right*) systems. The *yellow* arrows point to the eDNA sampling inlet and outlet with a filter attachment port. The peristaltic pump is inside the vessel. The system was designed by project partners Harwin, NatureMetrics and Porvair Filtration Group. The *red* arrow points to the cables linking the different parts of the integrated underwater acoustics system (Porpoise OB1 by RS Aqua, UK) with the sensor inside the rudder and the recorder board inside the vessel. **(D)** The temperature/salinity probe (DST CT Logger by Star-Oddi, Iceland; provided and fitted by RS Aqua) was attached to the rudder, subsequently with marine adhesive as well as cable ties (scale: probe is 5 cm in length).

with local research groups to integrate data collection in their recreational activities, even at smaller scales of recreation, from individuals to clubs and events. In the GBRC – Row with a Purpose project (Couceiro et al., 2023), the numbers of rowers engaging with data collection is limited to the number of rowers which participate in the Challenge. However, the fact that environmental data collection is a core part of the event sends a powerful message to all ocean rowers and ocean sports enthusiasts. Meanwhile, the monitoring equipment designs and expertise developed for this project can be used for other rowing groups or events, and even for different sea-going platforms.

The unique contributions of marine recreation with a purpose projects to Ocean Decade goals were highlighted, such as citizens' ocean stewardship empowerment as they retain ownership over the project, and normalization of environmental monitoring in marine recreation-focused audiences, which promote engagement with CS and the marine environment. It was also identified that the nature of some marine recreation with a purpose projects, such as GBRC, may help overcome typical barriers of citizen science around experiential, technical and financial capabilities. However, to effectively build the capacity to enable marine recreation with a purpose at all scales of recreation, and further advance community ocean stewardship in line with the Ocean Decade's goals, it becomes crucial to increase coordination between all forms of marine recreation-based MCS. This includes marine recreation with a purpose projects, research to adapt monitoring equipment for marine recreation platforms, and projects crowdsourcing data from marine recreationalists. The eu.Citizen.Science platform (Wagenknecht et al., 2021) features some marine recreation-based MCS projects, but none of the marine recreation with a purpose projects mentioned here. Adding these to the knowledge hub will increase exposure and understanding of this form of MCS. A further development might be to form a dedicated coalition (e.g., a Working Group or a Project) within a Citizen

Associations (e.g., ECSA, the North American CSA, ACSA, etc.). Such work could connect all types of marine recreation-based citizen science, develop synergies between projects, build a common agenda, share best practice, steer future projects, and catalyze impact.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding authors.

Author contributions

LF: Conceptualization, Investigation, Project administration, Visualization, Writing – original draft. AF: Conceptualization, Project administration, Supervision, Writing – review & editing, Resources. WL: Conceptualization, Writing – review & editing, Resources. AL: Supervision, Writing – review & editing. FC: Conceptualization, Writing – review & editing, Project administration, Resources, Supervision.

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Conflict of interest

WL is a founder and majority shareholder of GB Row Challenge Ltd.

The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

The author(s) declared that they were an editorial board member of Frontiers, at the time of submission. This had no impact on the peer review process and the final decision.

Publisher's note

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