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Building local capacity for coral reef restoration: insights from two Caribbean MPAs

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ABSTRACT

Introduction: Coral reef restoration requires building local capacity and engaging stakeholders throughout planning and implementation to reduce conflicts and enhance ecological and socio-economic outcomes.
Objectives: To compare stakeholder perspectives on community engagement in coral reef restoration within the Seaflower Biosphere Reserve (Colombia) and Laughing Bird Caye National Park (Belize), and to develop tailored guidelines for effective engagement strategies.
Methods: We conducted a multiple-case study in the Seaflower Biosphere Reserve (Colombia) and Laughing Bird Caye National Park (Belize), collecting eight months of field data through interviews, surveys, and SWOT analyses, coding qualitative data and analyzing surveys with unpaired two-sample t-tests.
Results: The primary strategy for enhancing engagement in coral reef restoration was building local capacity, complemented by strategic planning, budgeting, and educational initiatives for youth. Respondents from Seaflower Biosphere expressed greater concern for coral declines, a stronger sense of reef identity, and felt personally affected by the issues. In contrast, residents of Laughing Bird Caye focused more on economic opportunities, community meetings, and passive educational approaches.
Conclusions: These guidelines provide a flexible framework for community engagement in coral reef restoration, emphasizing the importance of understanding socio-cultural and economic contexts, identifying key stakeholders, and fostering trusting, inclusive, and transparent relationships to empower communities and prioritize their active participation in restoration efforts.

Keywords: participatory research methods; interviews; SWOT analysis; qualitative analysis; Seaflower Biosphere Reserve; Laughing Bird Caye National Park.

RESUMEN

Desarrollo de la capacidad local para la restauración de arrecifes de coral: perspectivas de dos AMPs del Caribe

Introducción: La restauración de arrecifes de coral requiere fortalecer la capacidad local e involucrar a actores clave durante la planificación e implementación para reducir conflictos y potenciar los resultados ecológicos y socioeconómicos.

Objetivos: Comparar perspectivas de los actores sobre participación comunitaria en la restauración de arrecifes de coral en la Reserva de Biosfera Seaflower (Colombia) y el Parque Nacional Laughing Bird Caye (Belice), y elaborar lineamientos adaptados para el desarrollo de estrategias de participación efectivas.
Métodos: Se realizó un estudio de caso múltiple en la Reserva de la Biosfera Seaflower (Colombia) y el Parque Nacional Laughing Bird Caye (Belice), recopilando datos de campo durante ocho meses mediante entrevistas, encuestas y análisis FODA, codificando los datos cualitativos y analizando las encuestas mediante pruebas t de dos muestras independientes.
Resultados: La estrategia principal para fortalecer la participación en la restauración de arrecifes de coral fue el desarrollo de capacidades locales, complementada con planificación estratégica, elaboración de presupuestos e iniciativas educativas dirigidas a la juventud. Los encuestados de la Reserva de la Biosfera Seaflower expresaron mayor preocupación por el deterioro de los corales, un sentido más fuerte de identidad con el arrecife y se sintieron personalmente afectados por estos problemas. En contraste, los residentes de Laughing Bird Caye se enfocaron más en oportunidades económicas, reuniones comunitarias y enfoques educativos pasivos.
Conclusiones: Estos lineamientos ofrecen un marco flexible para la participación comunitaria en la restauración de arrecifes de coral, destacando la importancia de comprender los contextos socioeconómicos y culturales, identificar actores clave y fomentar relaciones de confianza, inclusivas y transparentes, para empoderar a las comunidades y priorizar su participación en los esfuerzos de restauración.

Palabras clave: métodos de investigación participativa; entrevistas; análisis FODA; análisis cualitativo; Reserva de la Biosfera Seaflower; Parque Nacional Laughing Bird Caye.

INTRODUCTION

The United Nations (UN) has placed a significant emphasis on 'rehabilitating our environment' by making it a central pillar of the 2030 Agenda for Sustainable Development (United Nations Environment Programme, 2021). To underscore the importance of this mission, the UN designated 2021–2030 as the UN Decade of Ecosystem Restoration. This global initiative aims to reverse the trends of ecosystem degradation, promote biodiversity recovery, and ensure the sustainable provision of ecosystem services, while also addressing the pressing issue of climate change.

Within this broader framework, the United Nations has recognized the urgent need to address the challenges facing coral reefs (United Nations Environment Assembly, 2019), which are some of the most biologically diverse and economically valuable ecosystems on our planet (Souter et al., 2021). The decline of coral reefs due to factors such as rising sea temperatures, ocean acidification, pollution, and overfishing has raised alarms in the scientific community and among environmentalists worldwide (Souter et al., 2021). The consequences of coral reef degradation are far-reaching, affecting marine biodiversity, food security, and livelihoods in many coastal communities. Recognizing the imperative need to restore and conserve these vital ecosystems, the UN adopted Resolution 4/13 during the 4th UN Environment Assembly in 2019 (United Nations Environment Assembly, 2019). This resolution specifically addresses the sustainable management of coral reefs and highlights the role of restoration in achieving biodiversity goals set forth by the UN Environment Assembly (United Nations Environment Assembly, 2019).

The challenges that coral reefs face have enhanced restoration efforts worldwide, motivating practitioners and researchers to engage actively in coral reef restoration. Coral reef restoration is "an active intervention aimed to assist the recovery of reef structure, function, and key reef species in the face of rising climate and anthropogenic pressures, promoting reef resilience and the sustainable delivery of reef ecosystem services" (Hein et al., 2021). Recent decades have witnessed the development of innovative approaches, such as coral propagation and planting, which has transformed restoration into a global initiative (Boström-Einarsson et al., 2020; Suggett et al., 2023). The global community has recognized the critical

importance of these efforts and has invested significantly in reef restoration. In the last 10 to 15 years, restoration practitioners reported that a total of USD 258 million has been spent to support coral reef restoration initiatives in 56 countries (Hein & Staub, 2021).

In parallel to these global efforts, the UN has recently introduced 'The Standards of Practice to guide ecosystem restoration,' a comprehensive framework that emphasizes the role of community engagement as a central component throughout all phases of ecosystem restoration projects (Nelson et al., 2024). These standards emphasize the role of local communities, including the unique role that local communities can contribute to ecosystem restoration (Nelson et al., 2024).

The significance of community engagement in conservation efforts has been highlighted by extensive scholarly research. Community engagement fosters enhanced environmental stewardship through collective action (Agrawal & Gibson, 1999; Ostrom, 1990) and strengthens the capacity to adapt to climate change (Ayers & Forsyth, 2009). As Stern (2000) pointed out, community engagement is recognized as a key driver for promoting conservation action, given that involving communities is crucial for managing environmental issues. Monroe (2003) emphasized the importance of engaging communities in environmental conservation, particularly in an era where resource scarcity and environmental degradation necessitate behavioral changes that favor conservation. With policies related to community engagement in natural resource management being implemented in nearly every country worldwide (Ojha et al., 2016), it is evident that community engagement has assumed a central role in shaping conservation and environmental management efforts.

Although the importance of engaging communities as partners in environmental conservation is widely recognized, it is equally important to acknowledge that communities differ and that these differences influence perspectives, needs, and motivations of community members. The failure to develop engagement strategies that address collective concerns and priorities is not likely to generate the type of community support needed for successful and long-lasting partnerships. While prior studies have highlighted the role of community engagement in marine conservation, comparatively few have applied a structured, comparative, and stakeholder and community driven approach to inform management and restoration practices across distinct Marine Protected Areas. In this context, this study provides a novel and applied contribution by integrating stakeholders and community perspectives from two Caribbean MPAs to generate management-relevant insights for coral reef restoration.

The objectives of this paper were to (1) evaluate similarities and differences in perspectives toward community engagement among different stakeholder groups in coral reef restoration programs in two Marine Protected Areas: the Seaflower Biosphere Reserve in Colombia and the Laughing Bird Caye National Park in Belize and (2) to use the information obtained to construct guidelines for developing successful community engagement strategies that can be tailored to meet the needs of different communities and directly support adaptive management and restoration planning in MPAs.

MATERIALS AND METHODS

Theoretical framework: we used Carter et al. (2022) ethical community engagement framework to guide this research and develop guidelines for engaging communities in coral reef restoration efforts, with a focus on principles 1 and 4 (Table 1). Principle 1 addresses the values of stakeholders and states that "a deep commitment to intrinsic values about people, their natural endowments and their agency is integral to inclusive (and effective) engagement." We chose to focus on this principle to incorporate inquiries about diverse engagement methods from the community perspective. We also focused on principle 4, which is an analytical approach to engagement methodologies that suggests "qualitative methods can be a useful technique for inclusive engagement."

Table 1
Ethical community engagement framework (Carter et al., 2022).

Principle	Statement
1	A deep commitment to intrinsic values about people, their natural endowments and their agency is integral to inclusive (and effective) engagement
2	An empathetic attitude along with specific interpersonal skills are essential to the engagement process
3	Situational awareness is paramount to building trust and achieving inclusion
4	In a research context, qualitative methods can be a useful technique for inclusive engagement
5	Participatory monitoring, evaluation, and learning enhance facilitators and communities' ability to reflect, collaborate, co-create, and adapt to situations
6	Without sufficiently deep commitment and ownership of engagement processes, initiatives are less likely to sustain over time

Study Areas: We selected two coral reef restoration efforts implemented within Marine Protected Areas (MPAs) in the Caribbean: the Seaflower Biosphere Reserve in Colombia and the Laughing Bird Caye National Park in Belize. These sites were chosen because both initiatives explicitly prioritize community engagement as a central component of coral reef restoration.

The Seaflower Biosphere Reserve, located in the western Caribbean, encompasses the San Andrés Archipelago and represents the largest MPA in the region. It is managed by the Corporation for the Sustainable Development of the Archipelago of San Andrés, Providencia, and Santa Catalina (CORALINA) under an integrated, multi-level management framework, with zoning developed collaboratively to promote ecosystem conservation, sustainable development, and equitable benefit-sharing (Taylor et al., 2013). Despite a local economy heavily dependent on tourism, the Seaflower MPA faces persistent challenges, including overfishing, coral reef degradation, and illegal fishing, which have prompted targeted efforts to engage local communities in coral reef restoration initiatives (Taylor et al., 2013).

Laughing Bird Caye National Park is a UNESCO World Heritage Site of high ecological and economic value, generating nearly USD 5 million annually through tourism (Nawaz et al., 2017). The park is managed by the Southern Environmental Association under a participatory management framework that integrates biodiversity conservation, sustainable tourism, and long-standing coral reef restoration efforts supported by active community involvement (Alicea, 2010). These initiatives are closely linked to the socio-economic dynamics of the Placencia Peninsula, where rapidly growing coastal communities depend heavily on marine resources and tourism, making local participation essential for the long-term success of conservation and restoration actions (Webb et al., 2024).

Participatory Research Tools: we conducted a multiple study case, which involves the analysis of a particular issue by examining a series of cases within a defined system (Creswell, 2007). We collected data over eight months of fieldwork across the two marine protected areas, which included in-depth semi-structured interviews with key stakeholders and restoration practitioners, a SWOT analysis (Leigh, 2009) with community members, and surveys of the broader community. A detailed description of each research method can be found in Uribe-Castañeda et al. 2024. Interviews with restoration practitioners and key stakeholders were conducted using snowball sampling until saturation and were complemented by a SWOT workshop and surveys designed to capture broader community perceptions, motivations, barriers, and desired participation in restoration activities. Qualitative data were transcribed, translated, and

coded through a multi-stage thematic analysis, using MAXQDA 2022 qualitative analysis software (Kuckartz & Rädiker, 2019) and compared community surveys responses using an unpaired two-sample t-test to assess differences in responses between the two communities (De Winter et al., 2016).

Research Permits: we obtained approval for this research from the Institutional Review Boards (IRBs) of the University of Florida, USA (IRB202100741); the University of Rosario, Colombia (Institutional Review Board CEI-UR 492-CS304); and the National Institute of Culture and History in Belize (ISCR/H/2/132). IRB approvals were obtained to ensure the protection of research participants' welfare and rights in accordance with federal and state laws, local policies, and ethical principles. All data collected from respondents were kept anonymous, de-identified, and confidential.

RESULTS

Interview data revealed that building local capacity was the strategy most frequently mentioned in both communities (Table 2). More than three-quarters of key stakeholders and restoration practitioners identified it as the primary action needed to enhance community engagement in coral reef restoration. The next most important component was strategic planning and budgeting, which the Seaflower Biosphere community ranked as a much higher priority than the creation and enforcement of new policies; in contrast, policy development and enforcement were considered of roughly equal importance at Laughing Bird Caye.

Surveys of the broader community in both study areas, revealed that the community believes in the importance of both community and individual responsibility in protecting coral reefs (Table 3). Both communities also indicated low levels of trust or confidence regarding the ability of environmental agencies to take care of the corals, the future of the corals, and whether current regulations are effective for protecting coral reefs (Table 3).

Three significant differences emerged between these two communities (Table 3). In the Seaflower Biosphere, respondents expressed a greater concern about coral reef declines and a greater sense of identity with the coral reefs. They also recognized that they would be personally affected (e.g., economically, quality of life, etc.) if local coral reefs declined. Conversely, in Laughing Bird Caye the community expressed less concern, a reduced sense of identity, and generally indicated that they did not feel they would be personally affected if the health of the coral reefs declined.

Surveys were also used to identify and prioritize strategies to promote community engagement. The top seven strategies represented 90 % of ideas put forward by both communities (Fig. 1). Educational strategies about coral reefs and why they are valuable were deemed to be highly important by both communities, especially for youth. Adult educational and informational strategies were varied

Table 2

Importance of strategies for community engagement strategies identified from interviews with key stakeholders and restoration practitioners from coral reef restoration programs at Laughing Bird Caye and Seaflower Biosphere Reserve. Values represent the percentage of total responses (n = number of total interview segments).

Overall strategy	Laughing Bird Caye Response (%), n = 283	Seaflower Biosphere Response (%), n = 237	Total (%)
Build local capacity	36.62	35.59	72.21
Strategic planning and budgeting	6.81	12.28	19.09
Policies creation and strengthening	6.58	2.14	8.71
Total	50.01	50.01	100.0

Values represent percent of total responses. n: number of total interview segments.

Table 3
Broad community perceptions about coral reefs were assessed on a 5-point Likert scale and analyzed using an unpaired t-test.

	Laughing Bird Caye, n = 60		Seaflower Biosphere, n = 60		Unpaired T test	
	Mean	SD	Mean	SD	T test	p
Community responsibility	4.28	0.64	4.47	0.83	1.35	0.18
Individual responsibility	4.10	0.66	4.32	0.81	1.61	0.11
Trust in organizations	3.65	0.80	3.35	1.20	1.61	0.11
Optimistic about future	3.67	0.86	3.40	1.12	1.46	0.15
Enough regulations	2.92	0.79	2.90	1.04	0.92	0.10
Concern	3.83	0.92	4.38	0.64	3.79	<0.01
Identity	4.00	0.82	4.47	0.70	3.34	<0.01
Personally affected	2.97	1.62	4.53	0.81	6.71	<0.01

Likert scale: 5 strongly agree - 1 strongly disagree; n: number of people surveyed.

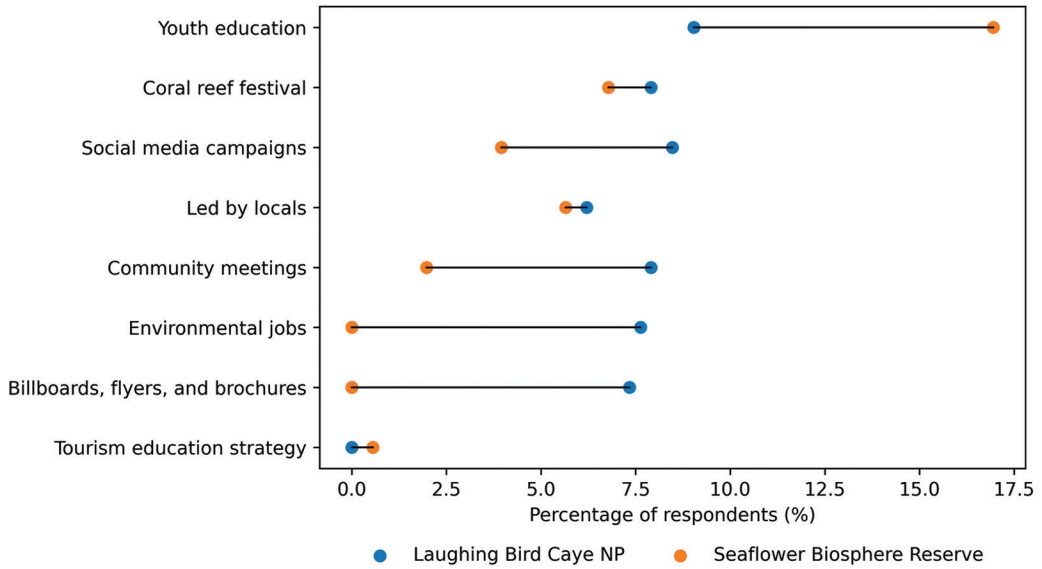

Fig. 1. Community engagement strategies for coral reef restoration between Laughing Bird Caye National Park (Belize) and the Seaflower Biosphere Reserve (Colombia). Points represent the percentage of survey respondents (n = 60 per site) selecting each strategy, with lines connecting values across sites to highlight differences.

and included suggestions such as social media campaigns, community meetings, and informational materials like billboards, flyers, and brochures. Educational programs that also created economic opportunities, such as the development of a coral reef festival and educational programs led by locals were suggested by both communities.

Community members from Laughing Bird Caye were much more interested in how coral reef restoration could contribute to jobs and indicated greater interest in community meetings and passive forms of education such as social media campaigns and printed information.

Fig. 2. presents the strategies identified during interviews with key stakeholders and

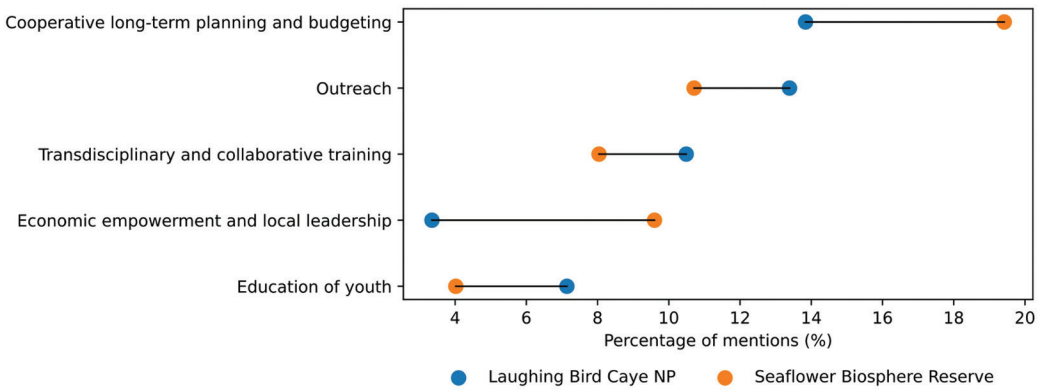

Fig. 2. Local capacity building strategies for coral reef restoration between the two MPAs. Points represent the percentage of times each strategy was mentioned by key stakeholders and restoration practitioners, with lines connecting values across sites to highlight differences.

restoration practitioners, whose perspectives on what was most important included, but ranked differently, priorities identified by the broader public. The most frequently mentioned strategy identified was the importance of developing long-term cooperative planning and budgeting among key stakeholders, particularly those in reef-related businesses and government. Enhancing and formulating outreach strategies was also recognized as important in both MPAs, with in-person meetings being the most cited outreach method, followed by social media campaigns. The results indicated that outreach campaigns should prioritize promoting behavioral change. Transdisciplinary knowledge exchange was noted in both study areas for its role in training and empowering practitioners and community members.

DISCUSSION

Our study reveals both similarities and differences in how local communities viewed coral reef restoration across the two study areas. Both interview and survey data highlight the central role of building local capacity as the primary strategy to enhance community engagement, identified by key stakeholders and practitioners in both areas. Similarly, broader community surveys indicate a shared recognition of the importance of community and individual responsibility in protecting coral reefs, despite low levels of trust in environmental agencies and skepticism regarding the effectiveness of current regulations. Educational initiatives, particularly those targeting youth, and outreach strategies such as community meetings, social media campaigns, and locally led programs were also consistently prioritized by both communities. These convergences suggest that, regardless of contextual differences, there is a common understanding across diverse Caribbean MPAs that empowering local stakeholders and fostering awareness are foundational components for successful coral reef conservation. In the Seaflower Biosphere, the community demonstrated a stronger personal connection to coral reefs, expressing greater concern for reef decline, recognizing its potential personal impacts, and viewing reefs as integral to their identity. In contrast, responses from the Laughing Bird Caye community reflected less concern about reef health or its impacts and greater interest in how coral reef restoration could contribute to local employment.

These findings provide insights into how both shared values and context-specific priorities can be leveraged to design locally adapted engagement strategies, with practical relevance not only for the studied MPAs but also for

similar coastal communities elsewhere (Barnes et al., 2019; McClanahan et al., 2015). Building on these insights, we develop guidelines for strengthening local capacity in coral reef restoration. These guidelines are designed to support both established and emerging programs, thereby enhancing the overall effectiveness of restoration efforts (Fig. 3).

The strategies in Fig. 3 reflect those in Fig. 2 but are organized on a scale from low to high levels of involvement to generate guidelines for building local capacity in coral reef restoration. These guidelines encompass five levels structured along a progressive continuum of engagement, each representing increasing influence over decision-making and greater local empowerment in coral reef restoration. The engagement process begins with raising awareness through outreach strategies, then progresses to education programs that include more structured and longer-term strategies. The third level involves collaborative and transdisciplinary training with focus on knowledge exchange. Well-trained and educated community members will be able to seek and create opportunities for cooperation among stakeholders, representing the fourth level of engagement. The final level culminates in individuals who are locally aware, educated, trained, capable of fostering cooperation, and empowered to lead restoration programs. Throughout this research, both communities identified fundamental human values underpinning these strategies: trust, respect, inclusion, and transparency. These values form the foundation of the guidelines and permeate all actions for building local capacity (Fig. 3). These findings encompass the ones identified in the Standard of Practice for Ecological Restoration, particularly Principle 2, which promotes inclusive governance, social fairness, and equity (FAO et al., 2021). Carter et al. (2019) further emphasize that situational awareness is critical for building trust and achieving inclusion. Our results align with these findings and extend them by providing insights derived from real-world case scenarios. The following sections further explain the five actions proposed in the guidelines for building local capacity in coral reef restoration.

Outreach: Effective outreach should aim to raise awareness and understanding of the

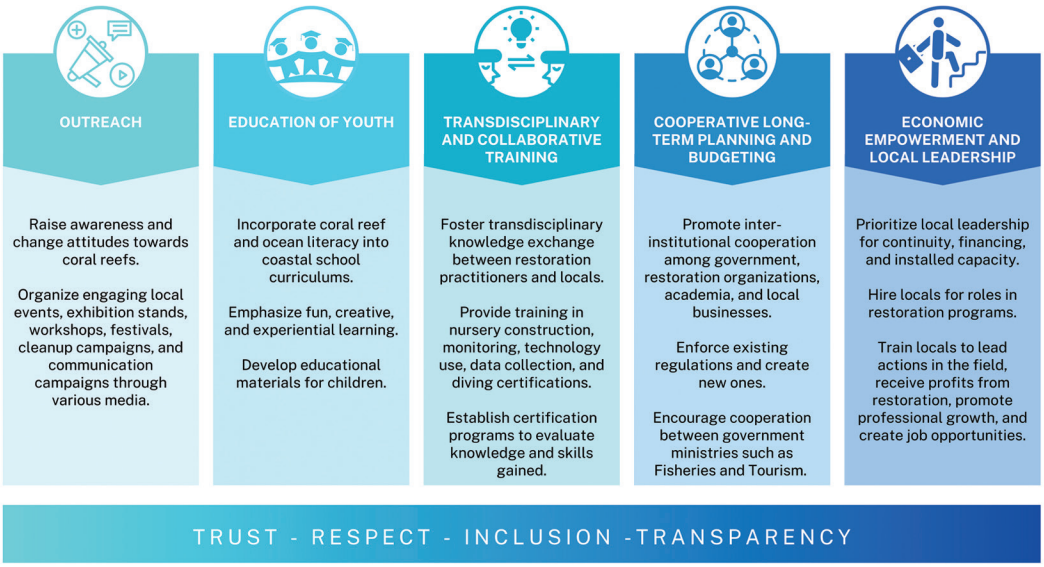

Fig. 3. Guidelines for building local capacity in coral reef restoration based on data collected through surveys, interviews, and SWOT analysis from the broad public, key stakeholders, and restoration practitioners associated with Seaflower Biosphere Reserve, Colombia, and Laughing Bird Caye National Park, Belize.

critical importance of coral reefs while promoting responsible environmental behavior (Rodríguez-Martínez & Ortiz, 1999). The necessity for outreach campaigns that foster behavior change is illustrated by the following quote: "*We need to start working on the minds of the people to achieve conservation outcomes. We must engage with psychology to change mindsets. To effect this change, a promoter is needed—an approach that resonates with people's self-satisfaction*" (Environmental Educator).

To achieve this, outreach strategies should be dynamic, engaging, creative, and rooted in experiential learning. These strategies could include a variety of activities suggested by community members, such as local coral reef festivals, workshops, face-to-face meetings, social media engagement, annual meetings, distributing informative materials, participating in clean-up campaigns, sharing conservation messages at community events, and creating innovative merchandise.

Research has shown that a deeper understanding of the coral reefs ecology, along with collaborative conservation efforts, plays a crucial role in preserving significant reef areas for future generations (Sebens, 1994). In this context, involving volunteers and citizen scientists in coral reef restoration represents a valuable strategy for enhancing the stewardship of natural resources (Hein et al., 2019). Citizen science programs are specifically designed to facilitate public participation in conservation, monitoring, and research efforts (Pocock et al., 2015).

Education of youth: Youth education represents a primary step towards building local capacity in coral reef restoration programs. This approach recognizes that children are a receptive demographic, eager to learn and capable of taking on future leadership roles in environmental practices. This strategy aligns with the United Nations' priorities in the Decade on Ecosystem Restoration (Nelson et al., 2024), which emphasizes educational initiatives aimed at shaping the values and actions of future generations. Grimmette (2014) found that students who participated in science camps exhibited a significant shift in their perception of the importance of nature to human well-being and became more inclined to support restoration efforts. Bai & Romanycia (2013) assert that children's education plays a crucial role in fostering behavior change towards more sustainable, caring, healthy, and regenerative human-nature relations.

While various organizations have initiated educational programs for children in both areas of study, these initiatives tend to be isolated, temporary, and limited in scope. The guidelines advocate for a continuous and structured approach to youth education, ensuring that it reaches children from diverse socio-cultural backgrounds. A key strategy to make education programs more inclusive and embedded in coastal communities could be to introduce an ocean literacy class into school curricula in regions where children live closely with coral reefs. The importance of including an ocean literacy course in school curricula as part of the education campaign is highlighted in the following quote: "*I believe environmental education could be formally integrated into the curriculum for schools. This is especially pertinent for high schools and could extend to primary schools as well*" (Restoration practitioner).

Transdisciplinary and Collaborative Training: This action focuses on knowledge exchange between restoration practitioners and local stakeholders. The integration of scientific, traditional, and community-based knowledge systems enhances understanding of the ecosystem and improves the effectiveness of restoration initiatives. This strategy aligns with Principle 6 of the Standard of Practice of Ecological Restoration (FAO et al., 2021), which states that "Ecosystem restoration incorporates all types of knowledge and promotes their exchange and integration throughout the process."

This research underscores the significance of formal certification training programs for community members engaged in restoration efforts. Restoration practitioners view certifications as an important step in their professional development, providing pathways to future

opportunities. This not only engages local communities in restoration activities but also equips community members with recognized qualifications that can advance their careers. Certification programs help establish and promote professional standards, ultimately benefiting public welfare (Nelson et al., 2017). However, a standardized certification process for coral restoration practitioners is currently lacking in most Caribbean countries where coral restoration efforts are underway. The following quote underscores the significance of certification programs: "*No other Caribbean nation has a Tour Guide Restoration Licensing Program. Their training is subsidized by grants, involving approximately 160 hours of class time. After completing the training, there are several sets of exams*" (Restoration Practitioner).

Cooperative long-term planning and budgeting: emphasize the essential role of sustained engagement and resource allocation for long-term success. Long-term planning and budgeting involve multiple stakeholders: government bodies, restoration organizations, academic institutions, community members, and local businesses. Local stakeholder involvement is crucial for biodiversity conservation, with success depending on governance and sociocultural contexts (Sterling et al., 2017).

Recognizing the role of local businesses in the economic benefits derived from coral reefs is fundamental. Communities in both areas highlight the need for businesses to contribute more to restoration efforts. Financial commitments from entities benefiting directly from the reefs could enhance resource allocation and local capacity. The necessity for sustained funding and alternative strategies independent of government cycles is reflected in a Decision Maker's quote: "*While it is crucial for the state to acknowledge that nature operates on a timescale beyond the annual, establishing strong ties with the private sector is also a good strategy, as they may not operate within these periodic cycles*". Innovative financing frameworks, such as the Global Fund for Coral Reefs (GFCR), offer alternatives to traditional grants, thereby reducing dependence on foundations and diversifying funding for reef restoration (Suggett et al., 2023). Political support is vital for successful long-term planning and budgeting. This requires developing cooperative relationships within government ministries, especially those related to fisheries and tourism, to better support coral reef restoration. Integrating isolated conservation programs into national strategies will promote increased protection and stricter enforcement of laws and regulations.

Economic empowerment and local leadership: Empowering locals to take on leadership roles fosters a sense of ownership and pride in restoration efforts. Local leadership enhances community-based conservation interventions (Salerno et al., 2021). The benefits of community-led conservation are encapsulated by a scientist who remarked: "*Definitely, get the community behind you. Make sure they're on board from the very start. If not, it's not going to work. Our reserve boundaries have expanded multiple times since its establishment, all sparked by the community recognizing the importance of our work and requesting further expansion*".

This action aims to reduce social inequalities and foster inclusive engagement. Such inclusivity aligns with insights from Hallett et al. (2023), emphasizing the need to address disparities in the restoration process. Hiring local professionals ensures that the restoration is authentically rooted in the community's context, values, and aspirations. Fostering local leadership and financial autonomy can create self-sustaining initiatives that enhance the social, economic, and environmental well-being of communities involved in coral reef restoration. Strategies must empower locals and increase their participation in monitoring, stewardship, and enforcement of natural resources, promoting equitable community engagement.

Conclusion: Guidelines for building local capacity in coral reef restoration (Fig. 3) were developed from research in two Caribbean marine protected areas with diverse cultures, low-income communities, and significant

ecological value. The guidelines were designed with an increasing level of engagement in mind, though they do not necessarily reflect the order in which actions should be taken. They were developed by evaluating perspectives and priorities among different stakeholder groups within each community, which enabled us to identify how these communities relate to the resource, how they wish to be engaged and empowered, the activities they want to participate in, their needs and desires, and how to prioritize these to build local capacity for restoration programs. Our research benefited from, and we recommend engagement of, diverse stakeholder groups.

The two communities expressed different perspectives on the importance of coral reef ecosystems, which is likely due to differences in environmental awareness and economic opportunities. Understanding the complex interactions between humans, ecological systems and the socio-cultural and economic characteristics of the region is crucial for engaging local support and ultimately for the success of coral reef restoration (Uribe-Castañeda et al., 2018). Despite these differences, many similarities emerged and the guidelines for building local capacity (Fig. 3) are flexible, allowing them to be tailored to local needs and desires. These guidelines can also be adapted to other geographic areas and presumably other restoration and conservation efforts, but doing so requires an understanding of community needs, developing programs that are flexible and adaptable to change, and establishing relationships built on trust, respect, inclusiveness, and transparency.

Ethical statement: The authors declare that they all agree with this publication and made significant contributions; that there is no conflict of interest of any kind; and that we followed all pertinent ethical and legal procedures and requirements. All financial sources are fully and clearly stated in the acknowledgments section. A signed document has been filed in the journal archives.

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REFERENCES

Alicea, E. (2010). Laughing Bird Caye National Park management plan 2011-2016: A component of Belize's World Heritage Site (NOAA Document No. 820). United States National Oceanic and Atmospheric Administration, Coral Reef Conservation Program. https://repository.library.noaa.gov/view/noaa/820/noaa_820_DS1.pdf

Agrawal, A., & Gibson, C. C. (1999). Enchantment and disenchantment: the role of community in natural resource conservation. *World Development*, *27*(4), 629–649. https://doi.org/10.1016/S0305-750X(98)00161-2

Ayers, J., & Forsyth, T. (2009). Community-based adaptation to climate change. *Environment: Science and Policy for Sustainable Development*, *51*(4), 22–31. https://doi.org/10.3200/ENV.51.4.22-31

Bai, H., & Romanycia, S. (2013). Learning from hermit crabs, mycelia, and banyan. In R. B. Stevenson, M. Brody, J. Dillon, & A. E. J. Wals (Eds.), *International handbook of research on environmental education* (pp. 101–107). Routledge.

Barnes, M. L., Bodin, Ö., McClanahan, T. R., Kittinger, J. N., Hoey, A. S., Gaoue, O. G., & Graham, N. A. J. (2019). Social-ecological alignment and ecological conditions in coral reefs. *Nature Communications*, *10*(1), 2039–10. https://doi.org/10.1038/s41467-019-09994-1

Boström-Einarsson, L., Babcock, R. C., Bayraktarov, E., Ceccarelli, D., Cook, N., Ferse, S. C. A., Hancock, B.,

Harrison, P., Hein, M., Shaver, E., Smith, A., Suggett, D., Stewart-Sinclair, P. J., Vardi, T., & McLeod, I. M. (2020). Coral restoration-A systematic review of current methods, successes, failures and future directions. *PloS One*, *15*(1), e0226631. https://doi.org/10.1371/journal.pone 0226631

Carter, L., Cosijn, M., Williams, L. J., Chakraborty, A., & Kar, S. (2022). Including marginalised voices in agricultural development processes using an ethical community engagement framework in West Bengal, India. *Sustainability Science*, *17*(2), 485–496. https://doi.org/10.1007/s11625-021-01055-1

Carter, L., Williams, L., & Cosijn, M. (2019). *The principles and practices of ethical community engagement: Resources to support engaging for impact* [Technical report]. Australian Centre for International Agricultural Research, Australian Government.

Creswell, J. W. (2007). *Qualitative inquiry and research design: Choosing among five approaches* (2nd Ed.). SAGE.

De Winter, J. C. F., Gosling, S. D., & Potter, J. (2016). Comparing the Pearson and Spearman correlation coefficients across distributions and sample sizes: A tutorial using simulations and empirical data. *Psychological Methods*, *21*(3), 273–290. https://doi.org/10.1037/met0000079

FAO, IUCN, CEM, & SER. (2021). *Principles for ecosystem restoration to guide the United Nations Decade 2021–2030*. [Manual]. Food and Agriculture Organization of the United Nations. https://openknowledge.fao.org/handle/20.500.14283/cb6591en

Grimmette, K. A. (2014). *The impacts of environmental education on youth and their environmental awareness* [Undergraduate thesis]. University of Nebraska–Lincoln, United States of America.

Hallett, L. M., Aoyama, L., Barabás, G., Gilbert, B., Larios, L., Shackelford, N., Werner, C. M., Godoy, O., Ladouceur, E. R., Lucero, J. E., Weiss-Lehman, C. P., Chase, J. M., Chu, C., Harpole, W, S., Mayfield, M. M., Faist, A. M., & Shoemaker, L. G. (2023). Restoration ecology through the lens of coexistence theory. *Trends in Ecology and Evolution*, *38*(11), 1085–1095. https://doi.org/10.1016/j.tree.2023.06.004

Hein, M. Y., Birtles, A., Willis, B. L., Gardiner, N., Beeden, R., & Marshall, N. A. (2019). Coral restoration: Socio-ecological perspectives of benefits and limitations. *Biological Conservation*, *229*, 14–25. https://doi.org/10.1016/j.biocon.2018.11.014

Hein, M. Y., & Staub, F. (2021). *Mapping the global funding landscape for coral reef restoration* [Technical report]. International Coral Reef Initiative (ICRI). icriforum.org

Hein, M. Y., Vardi, T., Shaver, E. C., Pioch, S., Boström-Einarsson, L., Ahmed, M., Grimsditch, G., & McLeod, I. M. (2021). Perspectives on the use of coral reef restoration as a strategy to support and improve reef ecosystem services. *Frontiers in Marine Science*, *8*, 618303. https://doi.org/10.3389/fmars.2021.618303

Kuckartz, U., & Rädiker, S. (2019). *Analyzing qualitative data with MAXQDA: Text, audio, and video*. Springer. https://doi.org/10.1007/978-3-030-15671-8

Leigh, D. (2009). SWOT analysis. In K. H. Silber, W. R. Foshay, R. Watkins, D. Leigh, J. L. Moseley, & J. C. Dessinger (Eds.), *Handbook of improving performance in the workplace* (Vol. 1–3, pp. 115–140). Pfeiffer. https://doi.org/10.1002/9780470592663.ch24

McClanahan, T. R., Graham, N. A. J., MacNeil, M. A., & Cinner, J. E. (2015). Biomass-based targets and the management of multispecies coral reef fisheries. *Conservation Biology*, *29*(2), 409–417. https://doi.org/10.1111/cobi.12430

Monroe, M. C. (2003). Two avenues for encouraging conservation behaviors. *Human Ecology Review*, *10*(2), 113–125.

Nawaz, S., Bood, N., & Shal, V. (2017). *Natural heritage, natural wealth: highlighting the economic benefits of the Belize Barrier Reef Reserve System World Heritage Site* [Technical Report]. World Wildlife Fund.

Nelson, C. R., Bowers, K., Lyndall, J. L., Munro, J., & Stanley, J. T. (2017). Professional certification in ecological restoration: improving the practice and the profession. *Restoration Ecology, 25*(1), 4–7. https://doi.org/10.1111/rec.12484

Nelson, C. R., Hallett, J. G., Romero Montoya, A. E., Andrade, A., Besacier, C., Boerger, V., Bouazza, K., Chazdon, R., Cohen-Shacham, E., Danano, D., Diederichsen, A., Fernandez, Y., Gann, G. D., Gonzales, E. K., Gruca, M., Guariguata, M. R., Gutierrez, V., Hancock, B., Innecken, P. … Weidlich, E. W. A. (2024). *Standards of practice to guide ecosystem restoration – A contribution to the United Nations Decade on Ecosystem Restoration 2021–2030* [Technical report]. Food and Agriculture Organization of the United Nations, Society for Ecological Restoration, & International Union for Conservation of Nature. https://doi.org/10.4060/cc9106en

Ojha, H. R., Ford, R., Keenan, R. J., Race, D., Carias Vega, D., Baral, H., & Sapkota, P. (2016). Delocalizing communities: Changing forms of community engagement in natural resources governance. *World Development, 87*, 274–290. https://doi.org/10.1016/j.worlddev.2016.06.017

Ostrom, E. (1990). *Governing the commons: The evolution of institutions for collective action.* Cambridge University. Press.

Pocock, M. J. O., Roy, H. E., Preston, C. D., & Roy, D. B. (2015). The biological records center: a pioneer of citizen science. *Biological Journal of the Linnean*

Society, *115*(3), 475–493. https://doi.org/10.1111/bij.12548

Rodríguez-Martínez, R., & Ortiz, L. M. (1999). Coral reef education in schools of Quintana Roo, Mexico. *Ocean & Coastal Management*, *42*(12), 1061–1068. https://doi.org/10.1016/S0964-5691(99)00061-7

Salerno, J., Andersson, K., Bailey, K. M., Hilton, T., Mwaviko, K. K., Simon, I. D., Bracebridge, C., Mangewa, L. J., Nicholas, A., Rutabanzibwa, H., & Hartter, J. (2021). More robust local governance suggests positive effects of long-term community conservation. *Conservation Science and Practice*, *3*(1), e297. https://doi.org/10.1111/csp2.297

Sebens, K. P. (1994). Biodiversity of coral reefs: what are we losing and why? *Integrative and Comparative Biology*, *34*(1), 115–133. https://doi.org/10.1093/icb/34.1.115

Souter, D., Planes, S., Wicquart, J., Logan, M., Obura, D., & Staub, F. (2021). *Status of coral reefs of the world: 2020 report* [Technical report]. Global Coral Reef Monitoring Network (GCRMN) and International Coral Reef Initiative (ICRI). https://doi.org/10.59387/WOTJ9184

Sterling, E. J., Betley, E., Sigouin, A., Gomez, A., Toomey, A., Cullman, G., Malone, C., Pekor, A., Arengo, F., Blair, M., Filardi, C., Landrigan, K., & Porzecanski, A. L. (2017). Assessing the evidence for stakeholder engagement in biodiversity conservation. *Biological Conservation*, *209*, 159–171. https://doi.org/10.1016/j.biocon.2017.02.008

Stern, P. C. (2000). New environmental theories: toward a coherent theory of environmentally significant behavior. *Journal of Social Issues*, *56*(3), 407–424. https://doi.org/10.1111/0022-4537.00175

Suggett, D. J., Edwards, M., Cotton, D., Hein, M., & Camp, E. F. (2023). An integrative framework for sustainable coral reef restoration. *One Earth (Cambridge, Mass.)*, *6*(6), 666–681. https://doi.org/10.1016/j.oneear.2023.05.007

Taylor, E., Baine, M., Killmer, A., & Howard, M. (2013). Seaflower marine protected area: governance for sustainable development. *Marine Policy*, *41*, 57–64. https://doi.org/10.1016/j.marpol.2012.12.023

United Nations Environment Assembly. (2019). *Report of the United Nations Environment Assembly of the United Nations Environment Programme. Fourth Session (Nairobi, 11–15 March 2019)*. General Assembly, Official Records (74th session, suppl. 25).

United Nations Environment Programme. (2021). *Becoming #GenerationRestoration: Ecosystem restoration for people, nature and climate* [Technical report]. UN Environmental Programme, & Food and Agriculture Organization of the United Nations.

Uribe-Castañeda, N., Morales, N., Loizzo, J., Patterson, J., & Main, M. (2024). Community engagement in coral reef restoration in the Seaflower MPA, Colombia. *Restoration Ecology*, *32*(8), e14268. https://doi.org/10.1111/rec.14268

Uribe-Castañeda, N., Newton, A., & Le Tissier, M. (2018). Coral reef socio-ecological systems analysis & restoration. *Sustainability*, *10*(12), 4490. https://doi.org/10.3390/su10124490

Webb, W. A., Wells, E. C., Prouty, C., Zarger, R., & Trotz, M. (2024). Ethics and ambiguity in wastewater development on the Placencia Peninsula, Belize. *Annals of Anthropological Practice*, *48*(1), 130–145. https://doi.org/10.1111/napa.12215