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Inheriting wisdom: transfer of traditional, scientific, and ecological knowledge in fishing communities in Mexico

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The complementary use and transfer of empirical and scientific knowledge are essential for the holistic and sustainable management of fishing resources. To understand how both types of knowledge are transferred in fishing communities in three regions of Mexico, we conducted 120 in-depth interviews with young people, adults, and older adults who participated in various activities within fishing value networks. During the interviews, we identified who participated in transferring knowledge within communities, what lessons were passed on, what knowledge has been lost, and what scientific topics are known within the communities. We also investigated the sector's most used means of communication to further explore the transfer of scientific and technical knowledge and the fundamental roles of external actors in transferring knowledge within communities. The information was coded, categorized, and analyzed for each question. The interviewees valued the continuity of inheriting traditional knowledge, which included teaching practical skills, such as fishing techniques and navigation, and transmitting values, traditions, and ways of understanding and relating to the marine environment. The interviewees perceived knowledge transfer as a bidirectional exchange of knowledge, ideas, and practices among generations. Furthermore, they recognized the value of external actors with scientific and technical knowledge in promoting innovation and adapting to new challenges. The combination of knowledge and perspectives enriches fisheries management and marine environmental conservation. Promoting the transfer of traditional and scientific knowledge is fundamental to building a future where fishing and marine life coexist in harmony and prosperity. The responsibility of supporting this integration falls on fishing communities and external actors. Working together in this collaborative learning process is the key to achieving sustainable resource management and ensuring the continuity of this valuable tradition for future generations. In doing so, these communities' cultural and ecological richness can be preserved, ensuring a lasting balance between people and the sea.

KEYWORDS

conservation, new generations, exchange of knowledge, communication channels, small-scale fisheries

1 Introduction

Fishing is a principal global activity, providing 17% of animal protein to almost half of the world's population (FAO, 2020). It also generates significant employment and income and contributes to the socioeconomic development of coastal communities (FAO, 2020). Approximately 500 million people depend entirely or partially on small-scale marine fisheries, which produce a catch valued at USD 58 billion (Schuhbauer and Sumalia, 2016; FAO, 2018; FAO, Duke University, and World Fish, 2023). Fishing communities are instrumental in upholding the sustainability of marine resources, ensuring food security, and fostering economic development in coastal regions worldwide; this influence is especially pronounced within oceanic island nations and rural coastal communities across Asia, Africa, and Latin America (Bell et al., 2018; Salas et al., 2019; FAO, 2020; García-Lorenzo et al., 2021; March and Failler, 2022). As stewards of the oceans, these communities rely on marine resources for their livelihoods and actively contribute to their conservation and management (Fulton et al., 2019; Quintana and Basurto, 2021). As primary stakeholders, they possess invaluable traditional knowledge and expertise in marine resource management acquired through generations of interaction with the oceans. This local knowledge is often crucial for understanding ecosystem dynamics, migratory patterns, and sustainable fishing practices (Narchi et al., 2014; Narchi et al., 2024). However, these communities face continuous challenges from resource overexploitation, socioenvironmental change, and economic pressure. In this context, it is vital to promote agents of change in future generations and encourage knowledge transfer to ensure the future of these communities is sustainable and prosperous (Espinoza-Tenorio et al., 2022).

Small-scale fisher's knowledge determines how to access fishing resources, what environments are most suitable for their activities, how to interact with ecosystems, and how to conduct sustainable management (Berkes, 2013). Fishers have deep-rooted connections with their environments and deeply understand the natural world (Begossi et al., 2016; Garavito-Bermudez and Lundholm, 2017; Garavito-Bermudez, 2020a; Cisneros-Montemayor et al., 2020; Garavito-Bermudez and Boonstra, 2022). In addition, they hold fundamental knowledge of fishing techniques, capture areas, and tool-building and understand environmental dynamics from traditional knowledge passed down through the generations (Garavito-Bermudez, 2020b; Garavito-Bermudez and Boonstra, 2022; Ovung et al., 2022). This knowledge enables individuals to fully utilize their local environments, considering the ecological dynamics of their coasts and the natural resources available (Maharja et al., 2023).

Traditional ecological knowledge refers to the "cumulative body of knowledge and beliefs, transmitted culturally from generation to generation, of the relationships of living beings (including humans) with one another and with their environment" (Berkes, 1993). This knowledge includes language, naming and classification systems, resource-use practices, rituals, spirituality, and worldviews (Secretariat of the Convention on Biological Diversity, 2014). Scientific knowledge is established through methodical observation and experimentation conducted using a rigorous scientific method to explain observed events (Carey and Smith, 1993; Sells et al., 2018). This knowledge is transmitted among researchers through oral tradition and written technical language texts. These texts must be presented with precision and reproducibility to ensure the information can be analyzed and discussed in the context of refuted hypotheses (Nagel, 1961). In both cases, the information is a valuable resource necessary to solve problems, make decisions, and develop adaptive capabilities (Mazzocchi, 2006; Ogar et al., 2020).

A dialogue between traditional and scientific ecological knowledge holders can lead to new perspectives and help advance scientific research and effective management responses for coastal areas and natural resource use (International Council for Science, 2002). Therefore, researchers should try to understand traditional communities' cultures, concepts, customs, and regional rituals. This involves immersing themselves in community life, learning from traditional ecological knowledge held by community members, and sharing that knowledge with the scientific community (Patzlaff and Peixoto, 2009; Hurlbert et al., 2019; IUCN, 2022). To address the uncertainty and complexity surrounding current environmental problems and their possible solutions, scientific and traditional knowledge, specifically in decision-making, has to be incorporated (Wheeler and Root-Bernstein, 2020). To achieve this, both types of knowledge must be available, legitimized, and transmitted from generation to generation. However, within fishing communities and external actors' involvement, the processes and pathways through which information is transferred are insufficiently documented and may vary between communities and age groups. Specifically, when considering the dynamics, traditions, and processes unique to each community, the ways and means by which individuals perceive and transmit information can be influenced by various factors.

In studies focused on the transfer of cultural and traditional knowledge, four transfer types have been identified (Cavalli-Sforza and Feldman, 1981; Calvet-Mir et al., 2016): (1) vertical (parent to child), (2) oblique (one older generation to another), (3) horizontal (within the same generation), and (4) retroactive (younger generations to older generations). The transfer of scientific and technical knowledge can also occur by actors external to a community through various forms of media (Mattalia et al., 2020; Garavito-Bermudez, 2020a,b; Okui et al., 2021).

In Mexico, coastal communities are characterized by a long fishing tradition (Cisneros-Montemayor and Cisneros-Mata, 2018). Throughout their history, fishers have faced both favorable and challenging fishing and climatic conditions and diverse sociocultural, political, and economic contexts (Álvarez et al., 2018; Cisneros-Montemayor and Cisneros-Mata, 2018; Delgado-Ramírez et al., 2023). Thus, through the generations, fishers have generated and transmitted knowledge that has allowed them to respond to these challenges to ensure the continuity of their fishing cultures and livelihoods.

Limited research has been conducted on transmitting traditional and scientific fishing knowledge among and to community members (e.g., Young et al., 2016; Garavito-Bermudez, 2020a; Garavito-Bermudez and Boonstra, 2022). Here, we aim to answer how traditional and scientific fishing knowledge is transferred by identifying what is transferred, what has been lost, and what conservation and sustainability issues have been identified in communities. We investigated which media are most used by the small-scale fishing sector to obtain scientific and technical knowledge. Furthermore, we explored the extent to which external actors transfer knowledge within communities.

2 Materials and methods

The interviewees were selected using non-probabilistic methods by adapting and combining chain reference techniques, such as snowballing, directed sampling, and purposive sampling. These systematic methods consist of selecting a specific population within

the target group to recruit an adequate number of interviewees with the qualities and knowledge necessary to provide information on the topic of interest (Watters and Biernacki, 1989; Salganik and Heckathorn, 2004; Etikan et al., 2016).

We identified and selected a local community member to create a sampling recruitment network through the chain referral method. The first interviewees had previously collaborated with the authors and other external groups (e.g., conservation and fisheries governmental agencies, universities, and non-governmental organizations) that share scientific knowledge on different topics. This community member, called a "locator," helped introduce the research team and explain the general idea of the research project to encourage participation. Each interviewer was introduced to the community or fishing cooperative leaders via a formal letter issued by Comunidad y Biodiversidad, A.C. which explained the purpose of the research and formally requested permission to spend time in the community and interview people.

2.1 Interviews

Between 2019 and 2020, we conducted 120 interviews in the communities of Isla Natividad, Ensenada, and Bahía Tortugas on the Pacific coast of Baja California (55 interviews); Punta Chueca (an Indigenous community; 44 interviews) in the Gulf of California; and Cozumel, Punta Allen, Chetumal, and Punta Herrero in the Mexican Caribbean region (21 interviews; Figure 1). The interview process was conducted using a mixed questionnaire divided into two sections (Supplementary material 1). Section I employed closed questions to characterize the interviewees. Section II used semi-structured questions to identify the types of traditional and scientific ecological knowledge transferred within communities. We also asked about who participates in these transfers, what topics related to fisheries, ecology, and conservation are most well-known in communities, and what media the sector most uses to learn about these topics. To apply for the interview, a date (day, time, and place) was set with the interviewee. The interviews were conducted in person and lasted between 30 and 75 min. The ethical standards of informed participation established in the Code of Ethics of the International Society of Ethnobiology (ISE 2006) were respected. Participation in the study was voluntary, and interviewees had complete freedom to refuse to answer specific questions, refuse to participate, or end their participation at any time without needing to provide a reason and without facing any sanctions or consequences. The process should be executed in a formal and clear manner, ensuring that all questions posed by the interviewees are thoroughly addressed.

2.2 Data analysis

Data collected during the interviews were captured and analyzed in Excel (Microsoft, Redmond, United States) and SankeyMATIC (Bogart, 2018). Excel was used to analyze quantitative and categorical variables. The responses from the interviews were categorized and analyzed using SankeyMATIC to create flow diagrams that show the topics discussed and how the interviewees learned about them. The analysis was divided into three age groups: youth (18–29 years), adults (30–59 years), and elders (60+ years).

To protect the participants' identities, a structured approach was used for data coding and categorization. Each participant was given a unique code based on their gender (M for man or W for woman), their community of origin (represented by two letters), and an individual identifier (a sequential number for men and women). This coding system ensured confidentiality while allowing for organized data analysis (Supplementary material 2).

In terms of reliability and validity, all participants provided informed consent and agreed to the privacy policy regarding their personal information. The coding system was consistently applied across all participants, ensuring reliability in data handling. Using these codes did not compromise the accuracy of the responses, preserving the validity of the data by maintaining alignment between participants' identities and their input during the interviews. Thirty-two topics were selected to investigate how scientific and technical knowledge is transferred in coastal communities (Supplementary material 3). The topics were chosen from the Leadership Program designed by COBI (Fernandez-Rivera Melo et al., 2022). Fernandez-Rivera Melo et al. (2022) conducted semi-structured interviews with fishers ($n = 38$) and people from organizations and institutions outside the

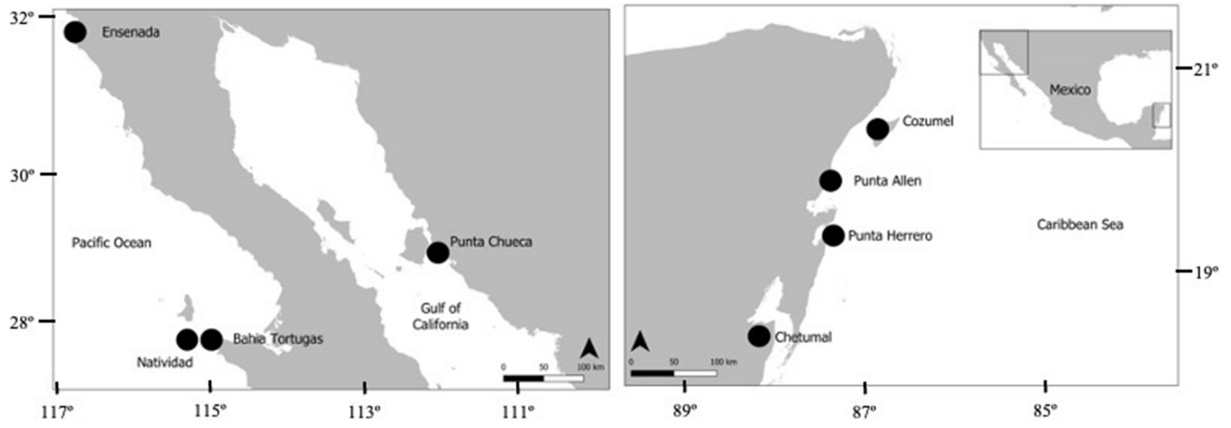

FIGURE 1
Locations of communities where the interviews were conducted.

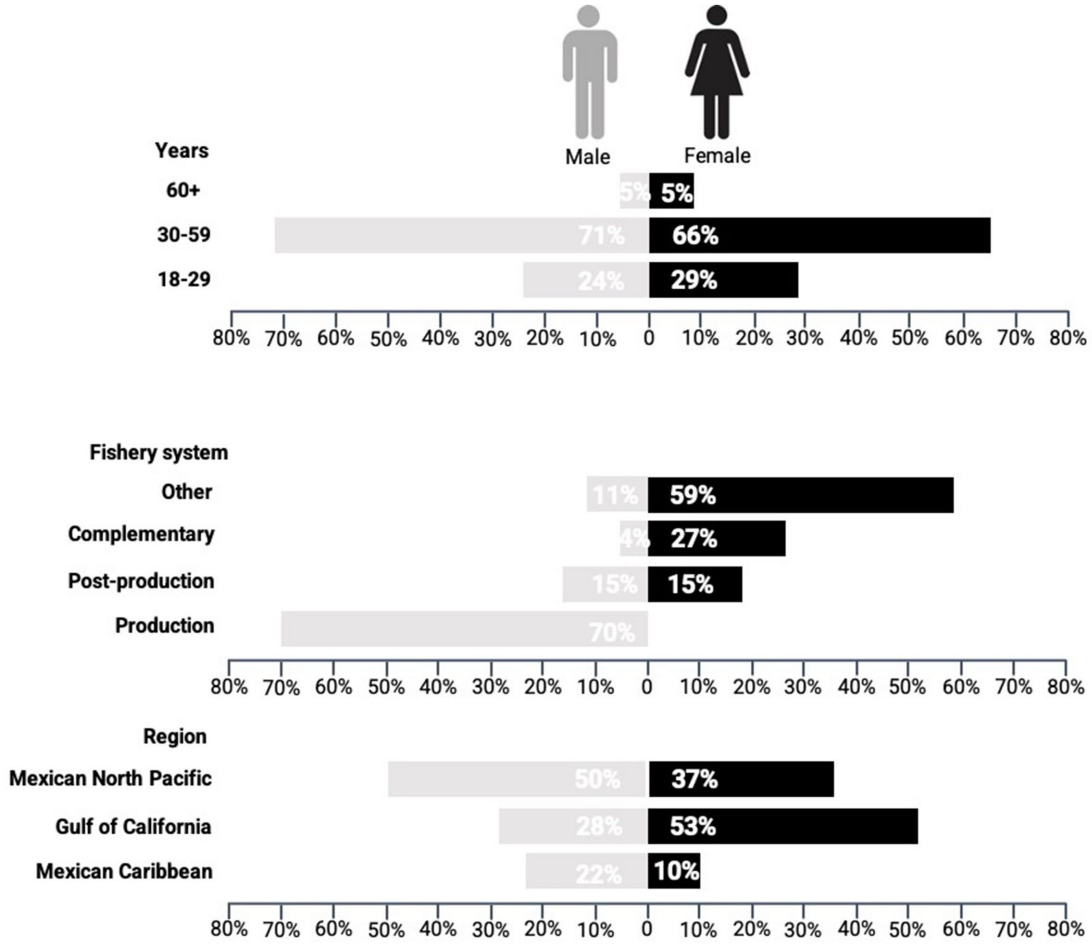

FIGURE 2
Institutions or organizations that transferred scientific knowledge in the communities of this study.

communities with experience in fishing, conservation, and gender issues ($n = 21$). The group of external participants included 13 representatives of civil society organizations (CSOs), six government institutions, and two academic institutions. Finally, it is important to note that because the study was conducted in communities where the authors work, any reference to Comunidad y Biodiversidad, A.C. in the interviews was excluded from the analysis.

3 Results

We interviewed 79 men and 41 women in communities across three regions of Mexico (Figure 2). The interviewees' ages ranged from 17 to 75 years. Young people between the ages of 17 and 29 years constituted 26% of the interviewees (19 M and 12 W), 69% were adults between the ages of 30 and 59 years (56 M and 27 W), and 5% were older adults of 60 years or older (4 M and 2 W). The interviewees conducted various activities related to the fishing value network and within their communities. In all, 46% participated in production (55 M), 15% in post-production (12 M and 6 W), 12% in complementary activities (3 M and 11 W), and 28% were not identified as part of the value network (Figure 2).

3.1 Who and what is transferred from traditional knowledge?

Traditional knowledge was mainly transferred by parents (vertical transfer 36%), people close to the family nucleus (grandparents, uncles, and aunts) and elders (oblique transfer 36%), siblings, cousins, spouses, and peers (horizontal transfer 28%; Figure 3, Table 1). All interviewees acquired traditional ecological knowledge by observing or talking with family members and colleagues. None of the interviewees mentioned the transfer of knowledge from younger generations (retroactive transfer).

According to the interviewees, the themes that were transferred between generations focused on areas related to fishing, including (1) fishing techniques (the sets of methods, tools, and procedures used by fishers to catch fish), (2) fishing gear (the types of hooks, nets, traps, and diving equipment), (3) key fishing areas (fishing zones and seasons), (4) navigation (routes, knowledge of positions, landmarks, and star movements to orientation), (5) oceanographic processes (winds, waves, currents, storms, and their relationships to the presence of species and the ability of fishers to navigate safely), (6) management tools (closed seasons, minimum catch sizes, and no-take fishing zones), (7) fishing gear and vessel construction and

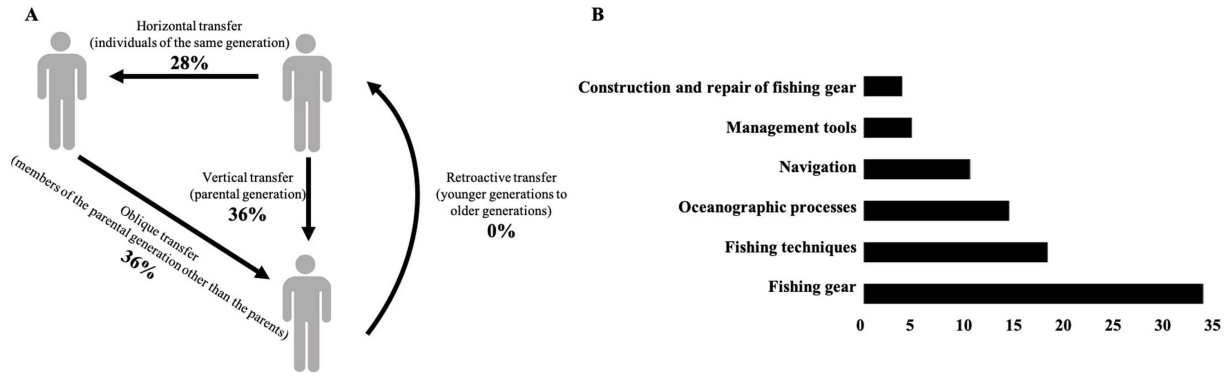

FIGURE 3
Modes in which knowledge is transferred (A) in the three study regions and percentage of times the transferred themes were mentioned (B).

repair, and (8) the importance of fishing activities as a socioeconomic means of life.

3.2 The loss and preservation of traditional knowledge

Of the total number of people interviewed, 58% considered that traditional ecological knowledge had been lost. In this case, it could include the lost knowledge of celestial navigation, marking fishing sites using landmarks, such as hills or natural formations, or using ancient fishing techniques. In contrast, around 37% of the respondents believed that fishing knowledge had not been lost. They pointed out that new knowledge has been acquired, and technology has reinforced certain practices, such as the proper care and management of different species. The remaining 5% were unsure whether fishing knowledge had been lost. Of those who believed fishing knowledge had been lost, 10% attributed this loss to the influence of technology and the disconnection between generations. Among the reasons mentioned for the loss, it was notable that younger generations have faced different social, economic, and development conditions than previous generations, leading to a loss of knowledge related to camaraderie, cooperation, and the common good, as has been reported by Espinoza-Tenorio et al. (2022). A reduction in knowledge of the natural cycles of species and their environments, such as species distributions and abundance, and their importance for sustainable resource management was also noted. Finally, 5% of adults mentioned that more fishers are now only interested in making money, which has decreased passion and care for fishing as a livelihood.

It is crucial to note that all the interviewees emphasized the importance of passing down their knowledge to the next generation. They expressed their willingness to share their expertise on fishing techniques, traditional fishing gear, resource conservation, sustainable fishing practices, and the potential risks of working at sea to prevent physical injury. Furthermore, 20% of the interviewees emphasized the importance of cooperativism. Two adults mentioned that sharing positive and negative experiences is essential for preparing younger generations for the challenges they will face while fishing.

From the interviews, we found that 83% of adults and older adults believed young people could transfer knowledge to them. In this regard, one of the most frequently mentioned topics was the use of technology. Indeed, 56% of adults and older adults highlighted that they could learn about using the internet, email, computers, and navigation equipment (e.g., GPS and echo sounders) from young people. Furthermore, 20% mentioned that young people hold knowledge of fishing techniques and gear for previously unexploited species in their communities and would like to learn from them, and 17% believed young people could teach them about conservation and sustainable resource use. Finally, 7% indicated young people have nothing to teach them.

3.3 Knowledge of conservation and sustainability issues

Of the 32 topics consulted (Table 1), 80% of interviewees had seen, heard, or read about global warming (96%), gender equality (88%), El Niño Southern Oscillation (ENSO) effects (88%), protected natural areas (92%), and marine reserves (83%) (Figure 4). However, little was known about 14 topics, which were mentioned by less than 50% of interviewees. These topics included payments for ecosystem services (21%), ecosystem services (28%), trophic networks (28%), ocean acidification (30%), functional species (30%), maximum sustainable yield (33%), ecosystem-based management (33%), citizen science (34%), oceanographic processes (35%), ecological connectivity (35%), resilience (40%), vulnerability (40%), and adaptation (40%) (Figure 4).

3.4 Communication channels used to learn about fishing, conservation, and gender issues

The interviewees used various media forms to learn about conservation and sustainable fishing, including audiovisual media (39%), radio (22%), digital media (18%), and printed media (21%) (Figure 5).

Young people preferred digital media, followed by print and audiovisual media. Adults tended to prefer print media, followed by

TABLE 1 Examples of the answers to the applied questions.

How did you learn this knowledge?
PBM3 "Listening at family gatherings…"
PBH6 "The oldest and most experienced members taught us how to work and how to be determined to meet catch quotas, speaking of their experiences and showing us in practice."
GCH7 "Through daily life, one's experiences in the fishing camps, and through older people…"
GCM10 "Since we were children, we saw the old fishers, my dad and uncles, go to sea every day, and we listened to them…"
MCM3 "I learned from my grandparents and parents…."
MCH10 "…. older fishers who demonstrate and explain the reasons for the instruments under various situations…"
Do you believe that knowledge of fishing has been lost? Why?
PBH2 "…due to technology and changes in thinking, new generations mock what is traditional…"
PBH9 "Because young people no longer know the same things, young people no longer approach older people…"
GCH2 "Because older people no longer fish together with younger people…the internet is now used on cell phones [to find out about] the weather."
MCH11 "Not everyone appreciates the value of this activity, especially those in the younger generations…"
MCM4 "In our family, fishing was no longer carried out… Communities do not respect traditional fishing seasons…"
Which scientific topics do you already know?
PBH12 "the topics about El Niño due to the mortality of resources in the region… marine reserves to preserve species, and gender equality to involve women a little more in the work…"
PBH20 "Impacts of temperature and oxygen changes, ocean acidification… It helped us understand why abalone died and understand species displacements…"
GCH5 "Through fisheries monitoring and comprehensive monitoring, I learned different methods for working with each species for its conservation…"
PBM4 "learn about citizen science…. I have learned a lot from the sea. Now, I am interested in topics related to caring and protecting. I know now how vulnerable we are and how important it is to take care of fisheries resources…"
MCH8 "Gender equality, because we actively work for gender equality in cooperatives… Vulnerable species, having a greater interest in protecting these species…"
PBH29 "I learned about the decline in fisheries…. because we depend on the sea, and when we see problems in fisheries, socially and economically, the cooperative has to adapt. This means teaching new generations how and why to do things differently…"
Do you believe external stakeholders should share their research findings with the community?
PBH14 "They (external actors) should continue to inform us of actions to take to look after the environment that sustains us…."

digital and audiovisual media. Lastly, older adults did not use digital media. Instead, they preferred print and audiovisual media (Figure 5). Among the options for print media, brochures (69%), posters (36%), and newspapers (33%) were the most popular. In the digital sphere, YouTube (37%), websites (28%), email (21%), and Facebook (20%) were the most frequently used. Of the options for audiovisual media, documentaries (64%) were most frequently mentioned by the interviewees (Figure 5).

3.5 Knowledge transfer from external sources

Interviewees mentioned various organizations and institutions that shared information on conservation and sustainable fishing within the communities. CSOs were mentioned most frequently (83%), followed by government institutions (65%), fishing cooperatives (40%), academic institutions (30%), and companies (4%) (Figure 6).

In total, 24 CSOs (excluding Comunidad y Biodiversidad, A.C.) were mentioned, including Ocean Revolution (21%), Grupo de Ecología y Conservación de Islas (18%), Prescott College (14%), and Smartfish (11%). In addition, 14 academic institutions were mentioned, such as Universidad Autónoma de Baja California (UABC, 29%), Stanford University (26%), Centro de Investigación Científica y de Educación Superior de Ensenada (CICESE, 16%), and Universidad Autónoma de Baja California Sur (UABCS, 12%). Eighteen government institutions were mentioned, with Comisión Nacional de Áreas Naturales Protegidas (CONANP) 38%, followed by Comisión Nacional de Acuacultura y Pesca (CONAPESCA, 12%), Instituto Nacional de los Pueblos Indígenas (INPI, 14%), and the Instituto Mexicano de Investigación para la Pesca y Acuacultura (IMIPAS, 11%). Sixteen groups and organizations in the fishing sector were mentioned, including the fishing cooperatives *Buzos y Pescadores de la Baja California* (27%), *Federación Regional de Sociedades Cooperativas Pesqueras* (FEDECOOP, 17%), and *Producción Pesquera Ensenada* (14%). Lastly, only people from northwestern communities mentioned companies that share knowledge with communities. Some companies mentioned were *Exportadora de Sal S.A.*, *Ecosturismo Kujimá*, Ocean Garden, and PADI (Supplementary material 4).

4 Discussion

Transferring traditional and scientific ecological knowledge is essential for sociocultural and human development. This dynamic process helps preserve cultural heritage, allows people to adapt to local and global change, and improves the quality of life within communities.

Various studies have been developed at the global level to understand how traditional ecological knowledge is transferred, who transfers it, what topics are transferred, and what knowledge is lost between generations. However, these have mainly been conducted in Indigenous communities and have focused on traditional botanical knowledge (Saynes-Vasquez et al., 2016; Kitolelei et al., 2021; Narváez-Elizondo et al., 2021; Okui et al., 2021; Akhmar et al., 2023; Teshome et al., 2023). Nevertheless, few studies have been conducted on fisheries and knowledge transfer in non-indigenous fishing communities (Garavito-Bermudez, 2020a,b; Garavito-Bermudez and Boonstra, 2022). This study constitutes the first approach to evaluating the transfer of traditional ecological knowledge in small-scale fishing communities in Mexico.

The results show that knowledge transfer occurred in the three regions through only three of the four modes described by Calvet-Mir et al. (2016): (1) vertical transfer, (2) oblique transfer, and (3) horizontal transfer. Traditional ecological knowledge that was transferred encompassed fishing techniques and the use of gear, the

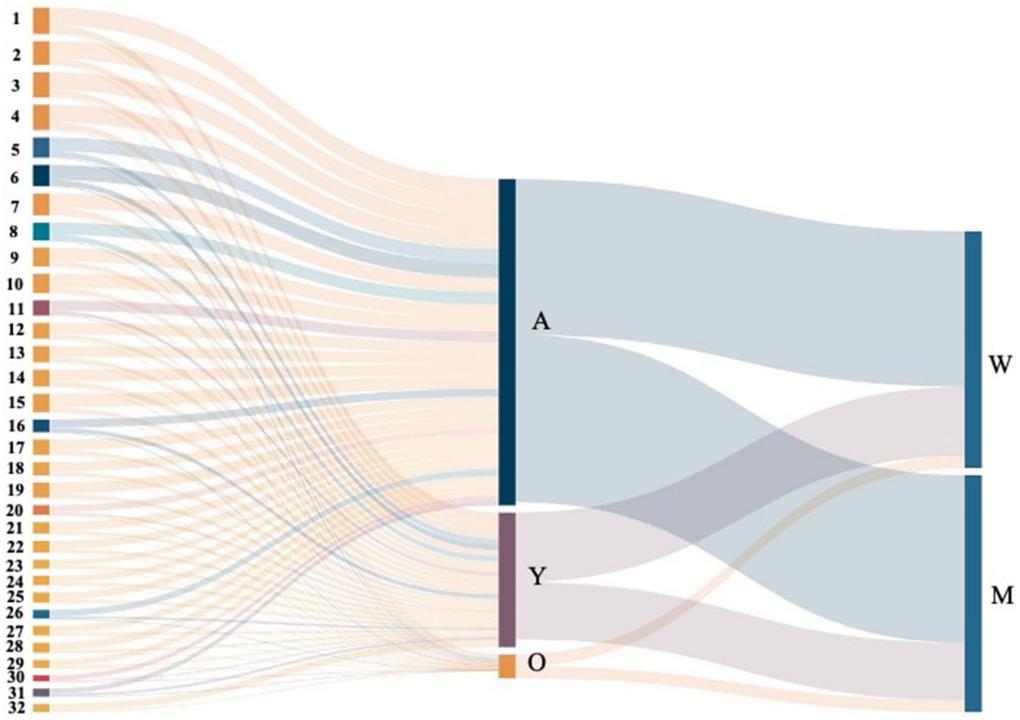

FIGURE 4
Topics mentioned by the interviewees. Men (M), Women (W); Older adults (O), Adults (A), and Young people (Y). Topics: (1) global warming, (2) protected natural areas, (3) gender equality, (4) El Niño effects, (5) marine reserves, (6) decision-making, (7) vulnerable species, (8) fishery certifications and ecolabels, (9) participation in resource management, (10) fishing refuge zones, (11) fishery improvement projects, (12) ecological fishery knowledge, (13) fishery management tools, (14) larval distributions and recruitment, (15) resource variability, (16) impacts of temperature and oxygen on fisheries, (17) criteria for certification standards, (18) gender roles, (19) vulnerability, (20) adaptation, (21) resilience fishery sector, (22) science communication, (23) ecological connectivity, (24) oceanographic processes, (25) citizen science, (26) ecosystem-based management, (27) maximum sustainable yield, (28) functional species, (29) ocean acidification, (30) trophic networks, (31) ecosystem services, (32) payments for ecosystem services.

construction and repair of fishing gear, species cycles, and navigation. None of the interviewees mentioned transferred knowledge from the youth. However, 20% of the adults expressed interest in learning about technological issues and new fisheries resources from young people (retroactively transferred).

A principal element that was transferred within communities was fishing as a profession. All interviewees declared that they had inherited this occupation from close relatives (vertical transmission) (Table 1). This transfer of the fishing profession has been documented in other fishing communities, and it is conducted by direct relatives, including grandfathers, grandmothers, fathers, mothers, uncles, aunts, or older siblings (Garavito-Bermudez, 2020a).

Other studies on the transmission of traditional knowledge have observed a tendency for it to diminish or disappear over successive generations (Tang and Gavin, 2016; Aswani et al., 2018). This topic was brought up as a concern of adults and older adults, specifically the loss of the ability to navigate without instrumentation, the loss of ancestral fishing techniques, and the loss of an understanding of the relationships between oceanographic processes and biological species cycles (Table 1). The adult interviewees attributed knowledge loss to two reasons: high dependence on technology for navigation and disconnection between generations, as young people live *full-time connected* to cell phones or the internet and no longer acquire the knowledge of older people.

Knowledge is crucial for making informed decisions, personal development, empowerment, and professionalization within the fishing sector. It enables individuals to grow and tackle challenges that arise locally and globally. Knowledge transfer is essential for generating, maintaining, and updating current knowledge. In the three studied regions, knowledge transfer took place between community members and external actors who possessed scientific and technical knowledge. In addition, interviewees used audiovisual, printed, and digital media to access knowledge of interest. The studies have suggested that the knowledge acquired throughout a person's life comes from a mixture of experiences and the diverse ways information is transferred over time (Aunger, 2000; Soldati and Albuquerque, 2016; Reyes-García et al., 2019).

Knowledge transfer is fundamental to the professionalization of people dedicated to fishing. The exchange of knowledge on selective fishing techniques, fishing gear, maneuvers, navigation, oceanographic processes, biological cycles, and fishery management tools notably contributes to preserving biodiversity and ensuring resource availability in the long term (Table 1). In addition, professionalization results in improved skills and technical knowledge, which translates into greater efficiency, allowing people in the sector to improve their performance, reduce environmental impacts, and limit waste. Training in occupational safety and techniques to prevent accidents and reduce risk at sea is also essential to professionalization, as it helps protect the lives and well-being of fishers so that they conduct their work safely.

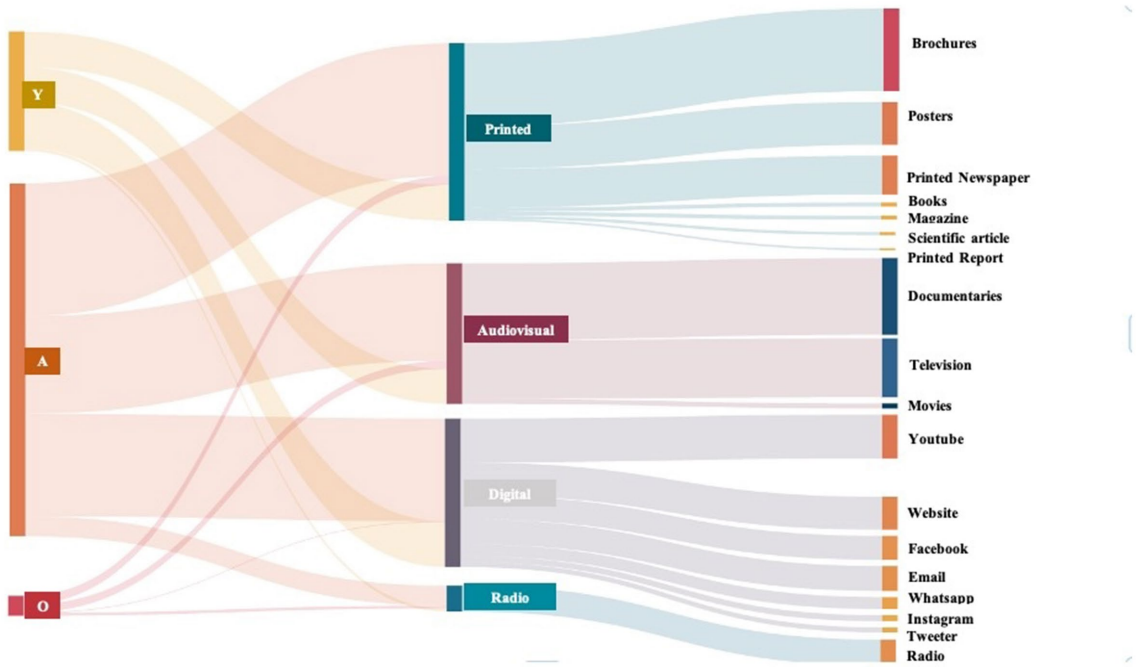

FIGURE 5
Communication channels used by the interviewees to learn about topics of interest in their communities. Older adults (O), Adults (A), and Young people (Y).

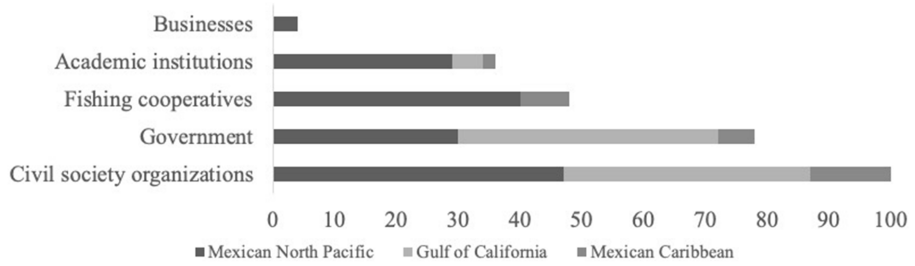

FIGURE 6
Profiles of the interviewees.

Furthermore, fishers can comply with regulations and contribute to marine conservation by being better informed about fishing regulations and laws.

Professionalization also opens opportunities for adopting new technologies and innovative approaches in fisheries. Fishers can learn about more efficient capture methods or the use of technology for navigation, how to face challenges, such as climate change, how to develop more secure administration, purchasing, and sales processes, and how to share decision-making information. Furthermore, professionalization elevates the status and recognition of fishers and their work in society, which encourages their work to be valued as vital for food security and the economies of many coastal communities.

People from various coastal communities in Mexico pointed out that institutions, organizations, researchers, and students come to their communities to conduct social, economic, or environmental studies. However, once information is collected, it is rarely returned to communities in the form of results. Instead, data tends to remain in theses and scientific articles, many of which are written in English and are difficult for local communities to access. Nonetheless, some governmental entities, CSOs, and academic actors have implemented social responsibility programs to return information to communities using different methods, such as face-to-face talks, workshops, brochures, reports, informative articles, posters, infographics, and videos that are distributed within communities and through social networks (e.g., Meza-Monge et al., 2015; Cuevas et al., 2021; CONAPESCA, 2022; CONANP, 2021; ECOSUR, 2022).

Promoting the dissemination of research results in communities by using the local language, organizing meetings to address concerns, and facilitating the expression of community opinions are responsibilities that agencies, researchers, and CSOs must assume. Likewise, identifying local perceptions regarding research and

developing a common language between communities and researchers are tasks researchers and CSOs must conduct. Furthermore, creating a dialogue network to share perceptions among residents, traditional communities, academic actors, and public managers is the responsibility of researchers, local actors, CSOs, and public managers (Mfutso-Bengo et al., 2008).

Returning project and research results to communities is a mutually beneficial practice for both communities and researchers (Hintz and Dean, 2020). This practice reinforces the importance of community participants' roles in citizen science. Moreover, it provides useful information for local decision-making, increases awareness of the effectiveness of research participation, and improves trust in the research and researchers (Fulton et al., 2019).

To ensure that the information generated by external actors is transferred to communities, it is important to tailor the material according to the age group and preferred means of receiving the information. The results show that young people tend to use digital media more (YouTube, websites, and Facebook), while adults prefer printed media (brochures and posters) and digital media (YouTube). In contrast, older adults prefer brochures, posters, and documentaries but need something digital.

5 Conclusion

In fishing communities, the continued transfer of traditional ecological, scientific, and technical knowledge through committed and trained agents of change who can address current and future challenges is vital. These agents must deeply understand the environmental, economic, and social problems that affect their communities and must be able to make informed and strategic decisions for the common good. These agents must transmit acquired knowledge, involve other fishers, and promote collective empowerment instead of only focusing on individual empowerment.

Training agents of change in future generations guarantees the continuity and renewal of fishing communities. As current generation agents retire, a new generation of leaders must emerge capable of effectively taking on leadership roles and addressing emerging challenges. To this end, knowledge transfer plays a vital role in the sustainability of fishing communities.

People in the communities in this study have accumulated traditional knowledge and practices over generations, which are fundamental to understanding marine ecosystems, climate patterns, species life cycles, and sustainable fishing practices. This ancestral knowledge is an invaluable treasure that provides a solid foundation for managing marine resources and conserving biodiversity properly. Combining traditional knowledge with scientific and technical knowledge is essential to addressing the complex challenges facing fishing communities and ensuring their future prosperity.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Author contributions

FF-R: Writing – original draft, Visualization, Investigation, Funding acquisition, Formal analysis, Conceptualization. JT: Writing – review & editing, Supervision, Resources, Methodology, Funding acquisition, Conceptualization. GC-G: Writing – review & editing, Methodology, Investigation, Data curation, Conceptualization. IA-C: Writing – review & editing, Data curation, Conceptualization. MV-C: Writing – original draft, Formal analysis. AE-T: Writing – review & editing, Visualization.

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Conflict of interest

The 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.

Publisher's note

Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/frsus.2024.1386259/full#supplementary-material

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