



Na Vuku Makawa ni Qoli: Indigenous Fishing Knowledge (IFK) in Fiji and the Pacific

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The time-tested Indigenous fishing knowledge (IFK) of Fiji and the Pacific Islands is seriously threatened due to the commercialization of fishing, breakdown of traditional communal leadership and oral knowledge transmission systems, modern education, and the movement of the younger generations to urban areas for work and/or study. Consequently, IFK, which has been orally transmitted for generations, has either been lost, not learned by the current generation, or remains undocumented. This study focuses on the critical need to conserve and include IFK as a basis for assessing the conservation status of ecologically and culturally keystone fisheries species as a basis for planning site-specific management of marine and freshwater fisheries in Fiji and the Pacific Islands. The study reviews studies of the last two and a half centuries on IFK from Fiji and elsewhere in the small oceanic islands of the Pacific, as a basis for the conservation, documentation and intergenerational transfer of this knowledge as the foundation for sustainable fisheries management. The study also reviews: the nature and conservation status of IFK, itself; and the conservation status of species considered to be of particular ecological and cultural importance; reasons for the loss of species/taxa and associated knowledge and practices; and actions that can be taken to address this loss.

Keywords: indigenous fishing knowledge, fishing techniques, gender roles, knowledge transmission, marine fisheries, freshwater fisheries, Pacific Islands, conservation status

INTRODUCTION

Indigenous fishing knowledge (IFK) has been fundamental to environmental, cultural and livelihood sustainability of Pacific peoples for millennia. This time-depth inter-generationally transmitted oral knowledge is, however, seriously threatened, its loss being seen as a major threat to the sustainable management of marine and freshwater fisheries resources in Fiji and the Pacific Islands (McNeely and Pitt, 1985; Johannes and Yeeting, 2000; Foale, 2006; Thaman et al., 2017). Living on islands, Pacific peoples not only adapted to their isolated environments but also developed knowledge system of fishing, based on their interaction with the marine and freshwater environments, knowledge which has been continuously refined over the generations as individual local experiences and knowledge are blended with the ancestral fishing knowledge and passed to the next generation (Veitayaki, 2002).

The loss of IFK throughout the Pacific has sparked calls over the last two decades to document this Indigenous knowledge before it is lost (Peter, 2000; Atu, 2005; Coates, 2005; Blakeney, 2011; Nakashima et al., 2012). One of the earliest written records on IFK was by Captain James

Cook in 1769, when he described fishing and fishing gear of Tahiti (Cook, 1842; Mitchell, 1979; Novaczek et al., 2005). Since then, Western scholars have observed Indigenous fishing activities, and undertaken sporadic and sometimes systematic studies of IFK, fishing gear, and fishing events. Some of the early writings were at times trivial or inaccurate descriptions made from onboard vessels or in brief interactions with Pacific fishers (Boddam-Whetham, 1876; Nordhoff, 1930; Mitchell, 1979). While these initial observations were conducted through a Western lens, observers universally acknowledged the wealth and depth of IFK (Johannes, 1981; D'Arcy, 2006).

In 1930, Charles Nordhoff, an American journalist and author, wrote an extensive account of offshore fishing in Tahiti and challenged more'suitable' writers to study in detail the rich knowledge of indigenous fishing (Nordhoff, 1930; Hind, 2015). Nordhoff's challenge for IFK documentation was accepted through records of participatory observations, translations of Indigenous fishers' narratives, and oral histories of marine and freshwater resources and their use, applied scientific techniques, and IFK gender role studies. Many authors identified key species of pivotal cultural and ecological importance to Indigenous fishing communities (Johannes and Yeeting, 2000; Johannes et al., 2000; Veitayaki, 2002; Kronen and Vunisea, 2007; Thaman et al., 2017). Ecological keystone species have been variously defined as: species whose contribution to an environment is disproportionately larger than its population (Paine, 1969). Cultural keystone species (CSK) instead shape cultural identities and are key for acquisition of resource outside a territory (Garibaldi and Turner, 2004). Both types of keystone species vary over temporal and geographic scales, but cultural keystone species also vary over social scales. Ecological keystone species include top predators, high-trophic level herbivores, benthic cleaners and decomposers and aquatic plants, such as algae/seaweed and seagrasses, in both marine and freshwater environments (Terborgh, 1986; Power et al., 1996). Cultural keystone species include totems, chiefly foods, dietary staples, herbal plants and species of both high commercial, and subsistence importance or value (Bell et al., 1994; Charlton et al., 2016; Rabbitt et al., 2019).

Pacific IFK was transmitted orally and used by island fishers both for conservation and exploitation (Carrier, 1982; Ruddle et al., 1992; Lieber, 1994; Aburto et al., 2015). This review examines on how Pacific Island fishers perceive, exploit and protect their ecological and cultural keystone species by using IFK. It then explores ways in which IFK of the Pacific Islands has co-evolved with modern scientific knowledge (MSK) to build relevant synergies between IFK and MSK for informed community-based management and protection of the rich, but highly threatened marine and freshwater fisheries resources of the Pacific Islands. Three broad themes are explored here under which sub-topics are discussed: (1) comparisons between IFK and MSK and their generation and epistemologies, (2) threats globalization brings to IFK, and (3) how IFK can be used and supported to foster marine and freshwater conservation.

MATERIALS AND METHODS

This systematic review uses an explanatory social science study approach to analyze the three broad themes being explored for IFK in the Pacific Islands. The following questions were used to guide the literature review:

1. What are the characteristics and depth of marine and freshwater fisheries IFK in Fiji and the Pacific Islands and the state of IFK and the conservation of ecological keystone and culturally very important species?
2. What ecological, cultural and economic factors influence marine and freshwater IFK in Fiji and the Pacific Islands?
3. What are the drivers of the loss and/or enrichment of IFK and of taxa considered to describe keystone species?
4. What can be done locally and in collaboration with outside agencies, to protect or enrich marine and freshwater IFK in the Pacific Islands in the face of global environmental, social and economic changes.

The questions were answered in two phases. The first phase was to review literature available on a more global scale, which focused on traditional knowledge, indigenous fishing and other related themes. These sources were used to reflect the studies which have been conducted in this field and how the studies can be used in the Pacific Islands. The second phase involved separating the Pacific Island IFK literature from the global literature and narrowing it down to answer the questions and also the themes that are being explored. The documented IFK which was reviewed for the Pacific began in the 1700's with Captain James Cook's voyages, and include some of the up-to-date studies of Pacific Islands fisheries, such as the late Robert Johannes' classic study *Words of the Lagoon* (1981), an in-depth chronicle of the IFK of Palau; Hooper et al.'s work with Tokelau elders, *Echoes at Fishermen's Rock, a traditional Tokelau Fishing* (2012); Thaman, Balawa, and Fong's 2014 case study of the return of marine biodiversity to Vanua Navakavu, Fiji; and Thaman's IFK and MSK integration study *Te ika o Tuvalu mo Tokelau - Fishes of Tuvalu and Tokelau* (2015).

Data Sources

The literature for the content was found through an online search on SCOPUS, Web of Science, the University of the South Pacific Databases and Google Scholar, using key words (Indigenous fishing, traditional knowledge, keystone species, freshwater fisheries knowledge, local ecological knowledge) to identify the articles of relevance to the literature review. In addition, research was undertaken at the University of the South Pacific and the Fiji National Archives libraries. Furthermore, oral archives in the form of video documentaries were also reviewed from YouTube and TED Talks. The information collected was in English, Fijian, French, and German. The French and German information were translated through Google Translator and cross-checked with French and German-speaking colleagues. The literature used include peer-reviewed papers, books, reports and gray literature (theses). The outputs were saved as PDF files and the references were recorded on Zotero. The following Pacific

Islands are the focus of this review: Cook Islands, Federated States of Micronesia (Kosrae and Yap), Fiji, French Polynesia (Society Islands included Tahiti, Tuamotus and Marquesas), Kiribati (included Caroline Islands), Marshall Islands, New Caledonia, Niue, Palau, Papua New Guinea, Rapa Nui, Samoa, Solomon Islands, Tonga, Tokelau, Tuvalu, and Vanuatu (**Figure 1**). The IFK from Hawaii, New Zealand and Australia were excluded in this review because they have a wealth of information already systematically documented and discussed as compared to those of the aforementioned Pacific Islands.

IFK incorporates many terms which are used interchangeably depending on the context and sources. These include: traditional (ecological/environmental) knowledge (TK/TEK), local ecological knowledge (LEK), Indigenous and local knowledge (ILK), fisher knowledge (FK), Indigenous ecological knowledge (IEK), Indigenous skills, folk knowledge and ethnological science (Kunatuba, 1983; Berkes, 1993; Aswani and Hamilton, 2004; Veitayaki, 2005; Hamilton and Potuku, 2007; Rasalato et al., 2010; Hamilton et al., 2012; Thaman et al., 2013, 2014). Pacific Islanders of Fiji and other small Pacific islands prefer the term Indigenous in place of native, ethnic and landowners and, for this reason, we used IFK to indicate the knowledge that is unique to, and owned by, Indigenous fishers, both globally and in the Pacific.

Analysis

A total of 760 documents were identified through electronic, paper and oral archives and reviewed both for global and Pacific Island IFK. The documents were further narrowed to the Pacific using the following criteria: (1) Pacific Island centered research, (2) included Indigenous fishing or fisher knowledge, and (3) focused only on the selected islands from the Pacific (see PRISMA diagram in **Figure 2**). Once the duplicates were removed and other important yet unconnected research excluded, 459 documents were reviewed in-depth and only 148 were used as citations in this systematic review. The 148 documents cited in this paper are relevant for this systematic review because they gave concise examples to support arguments being discussed in line with the themes of the literature review.

RESULTS AND DISCUSSION

Comparisons Between IFK and MSK and Their Generation and Epistemologies

History of IFK Documentation

The review identified four waves of IFK documentation by both foreigners and Pacific Islanders from the 19 Pacific Island Countries and Territories (PICTs) covered in the study. These included: (1) personal observations; (2) taxonomic classifications; (3) ethnography and natural history, and (4) synergies between IFK and MSK (**Figure 3**). The four documentation waves are grouped according to the writers documenting the knowledge and the observation and the type of information they noted. The first wave of documentation (1769–1889), consisted of the writings by sailors, explorers, Western naturalist, and missionaries in the form of letters, journals and anecdotes describing fishing on the islands they visited (Hawkesworth,

1773; Murray, 1827; Bennett, 1831; Lucatt, 1851; Seemann, 1862; Pritchard, 1866; Boddam-Whetham, 1876).

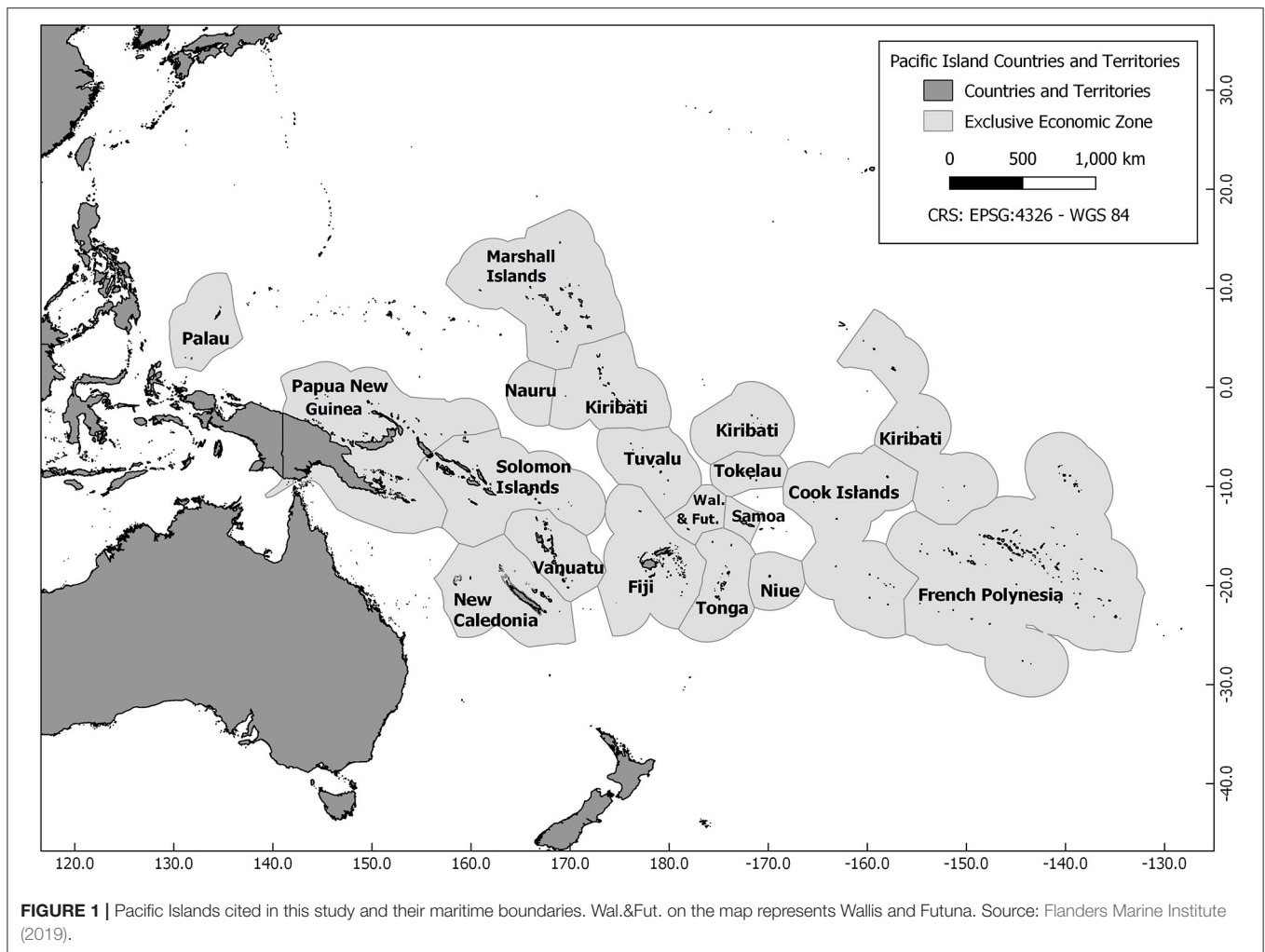
The second wave (1889–1909) features taxonomic classification and descriptions of marine and freshwater species and detailed descriptions of target species important to fishing communities (such as finfish, turtles, shellfish, and other invertebrates). Also included are the fishing techniques observed such as the communal fish drives and the use of plant as fish poison and stupeficient (Gardiner, 1898; Lambert, 1900; Woodworth, 1903; Anonymous, 1904).

Wave three (1910–1959) focused on details of fishing methods and gears, those who fish (groups or individuals), the target species and when they fish (time of day, diurnal movement, lunar or solar cycles, and seasonality), where they fish (locality), and why they fish (fishing for subsistence or other reasons). Also covered in this category are reports of how the fishing is done (gear, methods, and techniques; Ariki-tara and Smith, 1920; Nordhoff, 1930; Legand, 1950; Phillippis, 1953; Birket-Smith, 1956; Catala, 1957; McCoy, 1974).

The fourth and current wave (1960 – present day) delivers systematic documentation, investigation and the marriage and/or comparison of IFK with MSK, which acknowledge the local people's in-depth understanding and knowledge of their environment and resources. These reports offer better use and management approaches for the overexploited resources, and document the fast-eroding IFK of the islands (Johannes, 1981; Calamia, 1999; Johannes and Yeeting, 2000; Johannes et al., 2000; Aswani and Hamilton, 2004; Veitayaki, 2008; Hamilton et al., 2012; Thaman et al., 2017).

Characteristics of IFK in the Marine and Freshwater Fisheries of Pacific Islands

Pacific Islanders rely heavily on their marine and freshwater fisheries resources as among their main sources of protein and income (Johannes, 1981, 1987; Lieber, 1994; Rabbitt et al., 2019). Pacific Island fishing grounds can be classified into three categories; (i) inland—including rivers, streams, lakes, and ponds; (ii) nearshore—intertidal flats, mangrove areas, estuarine habitats, seagrass beds, lagoons, and reef areas, and (iii) offshore - the deep sea (outer reef areas and open ocean; Dalzell et al., 1991; Gillett, 2011; Quinn, 2011). Fishing location influences the type of gear and/or bait used during fishing and the type of resource harvested. Before fishers go out fishing, they take into account the geographic and environmental factors which can influence their catch (Johannes, 1981; Kunatuba, 1983; Veitayaki, 2002). Subsistence fisheries' in the Pacific Islands primarily target finfish, bivalves, gastropod and cephalopod mollusks, crustaceans, other invertebrates, mammals (whales, dolphins, and dugongs), and marine and freshwater plants, especially seaweeds (macroalgae) (**Supplementary Table 1**). Some of these species are potentially keystone species because their contribution to the Pacific Islands' fishing communities is disproportionately larger than the species abundance and sometimes, are most sought-after because of their value or their relative abundance. High value species are amongst the most exploited species in the Pacific Islands due to poverty and the need for cash, which leads to overfishing and

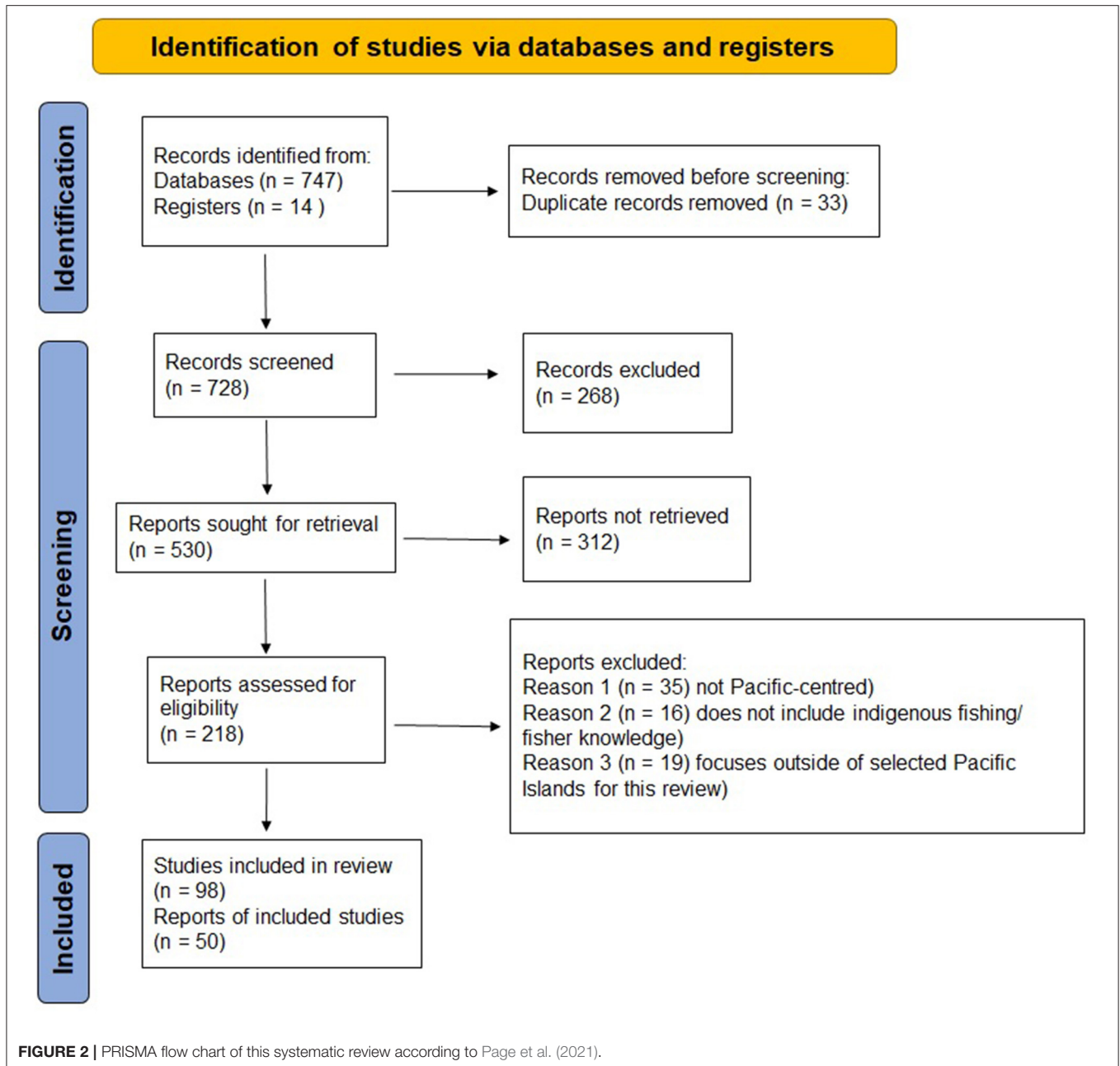


unsustainable use of marine and freshwater fisheries resources (Thaman, 2002; Mangubhai et al., 2016).

Indigenous fishers developed their own traditional taxonomic classification systems for marine and freshwater resources spanning thousands of years of daily in-the-field contact and experiences with their environment (Des Rochers, 1992; Johannes et al., 2000; D'Arcy, 2006). These local classification systems, which have been preserved over millennia through intergenerational exchange in local Pacific languages, are under serious threat with the loss of local language and the overdependence on urban education by the younger generations (Thaman, 2002; Hooper, 2005). Local classification systems have taxonomic/nomenclatural systems in place for most of these organisms or groups of organisms, and their life histories, seasonality, morphology or color of certain species, including multiple names for different growth stages (Kennedy, 1929; Morgan, 1999; Takekawa, 2000; Thaman et al., 2008). Species are commonly differentiated according to their value to the fishing communities. Important species under the same taxonomic designation are identified through local taxonomy to the species level, such as the smooth tailed trevally (*Selaroides leptolepis*) or

the purse eyed scad (*Selar crumenophthalmus*) (Foale, 1998). In Tonga, hawksbill turtles (*Eretmochelys imbricata*) are referred to as **fonu koloa**, and green turtles (*Chelonia mydas*) as **tu'a'uli**; although, turtles are also named according to their sex, size and color. For example, male turtles are called **ika ta'ane** or **hulemui**, the female immature turtles are called **tu'apolata**, **tu'akuia**, **aleifua** or **tufonu**, depending on their size and color (Pritchard, 1981; Havea and MacKay, 2009). In some places, species of low economic importance or use are commonly classed together under the generic name; for example, all damselfishes (Pomacentridae) are referred to as **guru** in Vanua Navakavu, Fiji, despite the fact that one species of gregory (*Stegastes* sp.) is the fish totem (**i cavuti**) of one of the chiefly clans (Thaman et al., 2008). In Fiji, Tokelau, Tuvalu and most of Polynesia, **ika**, **i'a** or a close cognate is a generic term used for finfishes (Ono and Addison, 2009; Thaman, 2016).

In Palau, the milkfish (*Chanos chanos*) is called **chaol** when small and found in brackish mangrove ponds, and when it matures and moves to the reef to live on the sandy bottoms, it is called **mesekelelat** (Johannes, 1981). In Vanua Navakavu, Fiji, Thaman et al. (2008) reported that the spotted herring



(*Herklouthichthys quadrimaculatus*) is called **daniva** when it is small, and **vaya** when it is larger; similarly, batfishes (*Platax* spp.) are called **laca** when small and **bati bulukovu** when of adult size (Thaman et al., 2008). In Tuvalu, the oilfish (*Ruvettus pretiosus*) is named according to its color; for example, the **palu malau** is described as deep pink merging into white, while the **palu kuakua** is iridescent-blue on its back and has a silvery white belly (Kennedy, 1929). Locals along three of Fiji's largest rivers, namely Ba, Dreketi and Rewa, refer to small-size sharks as **bulubulu**, while baby sharks are called **mata bulubulu**. The general term for sharks in Fiji is **qio** (Rasalato et al., 2010). Sometimes, species are identified according to their shape; for example, the guitarfish

(*Rhynchobatus* sp.) is called **qio uluvai**, which literally translates into a shark (**qio**) with a ray (**vai**) head (**ulu**) (Thaman et al., 2008). On Fanalei in the Solomon Islands, Indigenous fishers can identify species of dolphins according to their teeth (Takekawa, 2000).

Throughout the Pacific, there is a two-fold conservation ethic, which at times co-exists in a single community—one where some fishers are aware of their resource limitations, and the other, where the fishers believe their resources to be inexhaustible. This 2-fold conservation ethics co-existence is discussed by Sabetian and Foale (2006b), where their survey results from Milne Bay, PNG, showed one fisher believed

1 st Wave	2 nd Wave	3 rd Wave	4 th Wave
Personal observations	Taxonomic classifications	Ethnography and Natural History	IFK & WSK
120 years	20 years	50 years	60 years
1769	1889	1909	1959
<p>Observers: Sailors, explorers, Western naturalists, missionaries</p> <p>Type of information recorded: Sporadic descriptions of fishing from the Pacific</p> <p>Documents: Letters and journal entries</p>	<p>Observers: Naturalists and taxonomists</p> <p>Type of information recorded: Detailed scientific descriptions (including scientific names) of all marine and freshwater resources from the islands</p> <p>Documents: Detailed journal entries and field notes. Natural museum entries</p>	<p>Observers: Missionaries, explorers, naturalists and archaeologists</p> <p>Type of information recorded: Detailed descriptions of Pacific Island fishing and IFK</p> <p>Documents: Field notes converted to academic journal articles</p>	<p>Observers: Local and Western scientists, historians</p> <p>Type of information recorded: Systematic investigation and/or marriage of IFK and MSK</p> <p>Documents: Academic journal articles, books</p>
			2021

FIGURE 3 | Progression of the four waves of indigenous fisher knowledge documentation in Fiji and other Pacific Islands.

sharks, finfish and sea cucumbers were limited, while the rest of the fishers believed their resources were inexhaustible. Some authors used customary management systems in the Pacific to discuss the conservation ethics of the Pacific. Customary management systems which existed in the Pacific include: no fishing during spawning, mating seasons and after the death of a chief; restrictions on access to some fishing areas, size to be taken and who can consume certain marine resources; freeing some of the catch; and observing marine tenure systems and requirements (Johannes, 1978; Ruddle et al., 1992; Aburto et al., 2015). These measures were used in places where the fishers regard their resources limited and also to accumulate resources for a future feast (Polunin, 1984; Foale et al., 2011). Gear restrictions were not part of traditional management systems because the traditional gear developed by the island fishers such as the fish gorges were created to allow the people to catch only what they needed (Toganivalu and Beauclerc, 1917; Johannes, 1978). According to Foale et al. (2011), customary management systems in Melanesia existed for managing social relationships instead of sustainable food security, their argument challenging the generalization about the presence of customary management systems in the Pacific as a tool for sustainable fisheries as presented by Johannes (1978). In contrast, where fishers believed their resources unlimited, exploitation was widespread as they used their IFK to locate and harvest resources without restraint. In Tikopia, Solomon Islands, fishers use various methods to capture fish, regardless of the unsustainability of the method, because unlike land, the sea was not owned by anyone (Firth, 1965). A similar unsustainable scenario was reported in Tokelau, where turtle

fishing season coincided with the turtle mating season because fishers preferred to capture sea turtles in pairs (Ono and Addison, 2009).

Small traditional markets offered little commercial incentive for fishing of commercially valuable taxa, while colonization and the more recent commercialization of nearshore fisheries resources in the Pacific (1870–1970's), ushered in the introduction of a monetary economy, modern fishing legislations and practices, and the breakdown of traditional authority. Collectively, this contributed to the collapse of the pre-colonial traditional management systems and led to overfishing in many areas (Johannes, 1978; Aburto et al., 2015). The “traditional management system pause,” saw the early post-colonial heavy exploitation of high value resources/products such as bêche-de-mer, pearl oysters, gastropods (tritons, turban shells, and conch shells), whales, shark fins, and tortoise shell. These changes led to the overexploitation of these resources in some areas and the reduced species population sizes across the Pacific Islands (Kunatuba, 1983; Mangubhai et al., 2016; Jino et al., 2018). Such a trend led to the associated loss of time-depth fishing and taxonomic knowledge among younger generations who were no longer familiar with the names and associated taxonomies of extirpated species (Thaman et al., 2013, 2014). After experiencing heavy losses in marine and freshwater biodiversity, traditional management systems as well as modern management interventions, which include size limits, gear bans and the implementation of no fishing zones (Johannes, 1978, 2002; Sabetian and Foale, 2006a; Solomona and Vuki, 2012; Aburto et al., 2015) increasingly have been employed in many Pacific Islands.

Threats Globalization Brings to IFK Temporal, Generational and Gender Roles

Elder fishers believed that “everything has its own time” (Hickey, 2006, p. 14), therefore the fishing methods they used corresponded with the seasons, weather, diurnal, lunar and tidal cycles, as well as the surface conditions. Such knowledge was traditionally acquired from the elders and personal observations and experiences, and was shared in the community through in-the-field or on-the-water experience (Nordhoff, 1930; Groves, 1936; Turbott, 1950; Johannes, 1981; Aswani and Hamilton, 2004; Herdrich and Armstrong, 2008; Veitayaki, 2008). In Pacific Island communities, the oral transmission of IFK between generations was from the elder generation (knowledge bearers) to younger generations (knowledge receivers). IFK in the Pacific is guarded in some countries and is only shared orally with a selected few (Resture, 2001; Foale, 2006; Lefale, 2010). Knowledge on sidereal calendars, lunar calendars and natural phenomena, such as the fruiting of particular plants or swarming of insects or fish larvae, is tightly guarded by elders who feared their knowledge would be lost or shared with the unworthy (Johannes, 1981; Takeda and Mad, 1996; Mondragón, 2004; Hooper et al., 2012). During fishing activities, older fishers, who are highly skilled and knowledgeable with strong leadership qualities, were in charge and responsible for designating roles to the younger fishers (Lieber, 1994; Herdrich and Armstrong, 2008; Ono and Addison, 2009). Older fishers also shared knowledge, advised or demonstrated techniques with the younger fishers while fishing, thus transmitting their knowledge through hands-on, in-the-field experiences. Keeping IFK and fishing skills alive comes down to the individuals who receive the knowledge and are taught the skills, and their interest in keeping the practices alive (Balick, 2009).

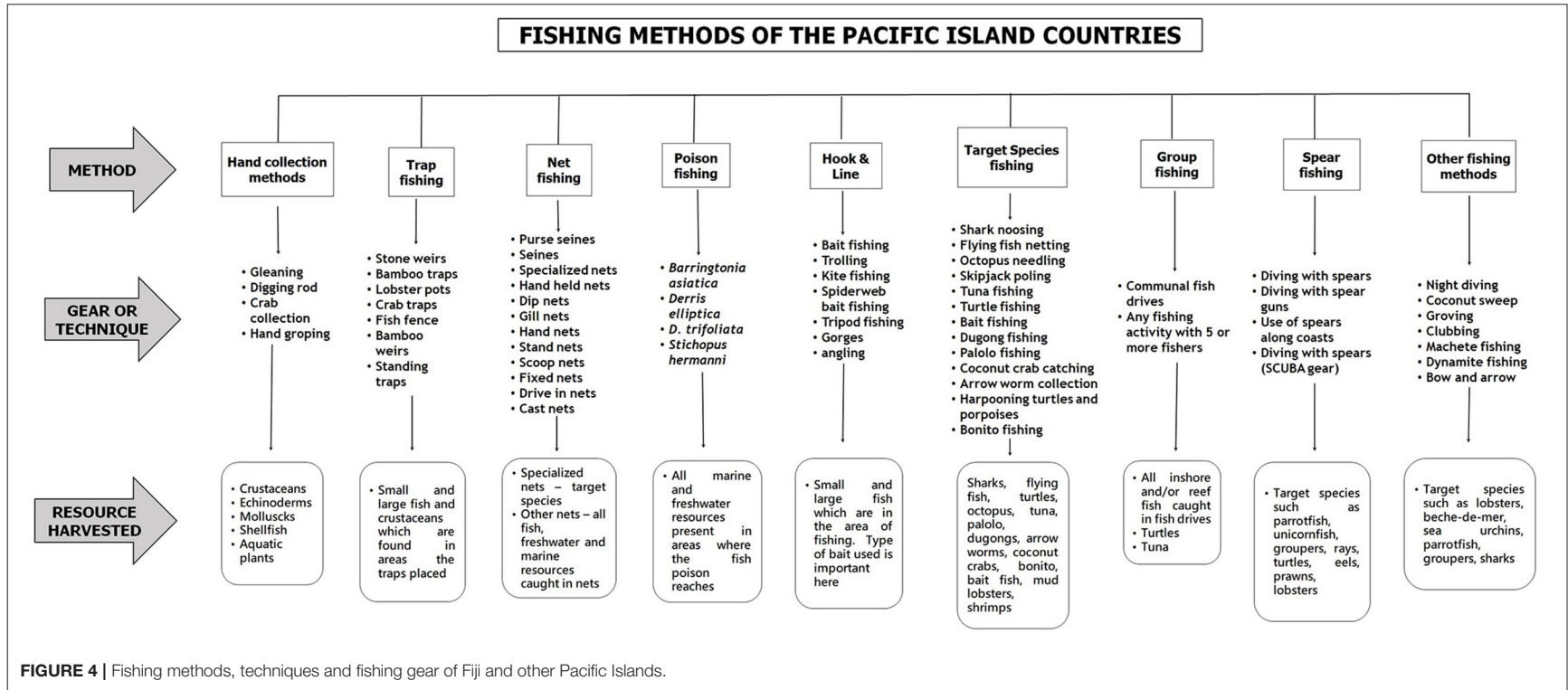
Early documentation describes men, women and children all playing important roles in fishing and being involved in different aspects of fishing and engaged in fishing activities (Boddam-Whetham, 1876; Aitken, 1930; Matthews, 1991a; Malm, 2009a; Rabbitt et al., 2019). According to ethnologists, men at the time of early contact usually fished offshore, while women and children fished closer to the shore, commonly gleaning along the coasts at low tide. In addition to accessible resources, women and children were kept closer to the villages during pre-contact period for their protection from raiding and warfare (Carrier, 1982), and in some instances, like in Tonga and Niue, due to a superstitious belief that the sea was a jealous woman who would not give up her resources if another woman was on the fishing boat out at sea (Ryan, 1981; Benguigui, 1988; Malm, 2009b). Some ethnologists even refer to women’s fishing as a recreational and bonding activity for younger and older women (O’Brien et al., 1984) until the 1990s (Matthews, 1991b; Des Rochers, 1992; Malm, 2009a; Hooper et al., 2012; Rabbitt et al., 2019). While this may have been true for the areas they observed, it does not fit all the Pacific Islands. For example, in Kosrae and Papua New Guinea, men preferred to go to the forests to farm while the women went out fishing (Carrier, 1982; Abraham and Lambeth, 2001). In parts of Fiji (such as Gau Island and in the Lau group), Samoa, and Wallis and Futuna, women were/are the main fishers, contributing the greatest commercial and subsistence catch, often in the form

of shellfish or smaller fish for household consumption (Vuki et al., 1992; Tiraa-Passfield, 1996; Levine and Sauafea-Le’au, 2013).

Decision making in most areas is still dominated by men, especially when setting up taboo areas, fishing restrictions and protected areas, where fishing is banned or managed in areas where most subsistence resources is caught, commonly by women. As a result of this style of decision making and the “culture of silence” in the Pacific, where women and children are not included in decision making, fishing activities of the women, children and the elderly, who usually have access to the nearby shallow fishing areas (Johannes, 2002; Vunisea, 2016) would lose their fishing location. In many communities, men went fishing and brought their catch back, after which the women were responsible for post-harvest activities such as cleaning, marketing, processing or cooking the catch on behalf of their families (Toganivalu and Beauclerc, 1915). Again, there are places where things have changed. For example, men of Arorangi village in Rarotonga, Cook Islands, used to go out on canoes for trolling, fishing with nets, hand lining and spearing, while women collected delicacies within the reef. Today, fishing in this village has changed as women have taken up the fishing methods which only the men of the village used to do because of the modernization of fishing technology and tools (Solomona and Vuki, 2012).

Fishing Technology, Methods and Techniques

Indigenous Pacific Island fishing technology reflected the intimate understanding of the aquatic food resources and their environments (Veitayaki, 2005). This is evident from the various ingenious traditional fishing methods and techniques reported throughout the Pacific that testifies to the people’s in-depth understanding of their natural world and how it works. This knowledge allowed the people to efficiently manipulate the environment and the species they have (Brewster, 1922; Johannes, 1981; Mokoroa, 1981; Herdrich and Armstrong, 2008; Buga and Vuki, 2012; Basily and Vuki, 2014). Von Brandt globally described 16 fishing methods (Gabriel and Brandt, 2005) while the FAO International Standard Statistical Classification of Fishing Gear ISSCFG Rev. 1, 2013 classifies fishing gear into 12 classes. The Von Brandt’s fishing methods were grouped according to the gear used, while the ISSCFG gear was classified according to their structure (Gabriel and Brandt, 2005; FAO, 2016). Traditional Pacific Island fishing methods are classified into nine categories, similar to Von Brandt, according to the gear used (**Figure 4**). The main fishing methods are: (1) hand collection or reef gleaning, (2) net fishing, (3) spear fishing, (4) hook and line, (5) group fishing, (6) fish poisoning, (7) trap fishing, (8) specialized targeted-species fishing, and (9) other fishing methods. Some of the methods described by Von Brandt were not used in traditional fishing in the Pacific. While some of the methods involve the use of more than one type of gear, overlap in the classification occurs here, and although methods remain similar throughout the Pacific, the actual techniques for catching or handpicking resources varies across the Pacific for both freshwater and marine areas. Early writers described fishing technology and gear, which made use of plants, shells and bones,



as hooks, lures, bait or fish poisons (Toganivalu and Beauclerc, 1917; Kennedy, 1929; Nordhoff, 1930; Turbott, 1950; Davidson et al., 1998), with fishing boats, poles, canoes and sails made from native trees and plants. Alexander (1902) described fishing gear from all across the Pacific, along with the methods through which they were employed. Deane (1910) described women from Fiji making nets by using natural materials made of coconut fiber which was sewn together using the wing bone of the long-tailed fruit bat (*Notopteris macdonaldii*) as a needle and **yaka** wood (*Dacrydium nidulum*) for the net handles.

Many of the fishing techniques have become redundant with the introduction of more efficient fishing gear. For example, in the Marovo Lagoon in the Solomon Islands, teams of fishers traditionally used to carry pole and lines with pearl shells or turtle shell lures to catch tuna in the open sea, which is today replaced by trolling for tuna from an outboard motor vessel and using commercially-made lures or steel hooks (Hviding, 1996). In Sukiki Village on Guadalcanal in the Solomon Islands, where resources were limited, fishers developed fishing gear made of woven spider web, and fishing lines with termites attached to the end of vines to catch drummer fish (Atu, 2005). This traditional fishing gear has been replaced by fishing nets and spears, which inevitably has led to the loss of a cultural heritage. Traditional canoes, which used to be constructed by fishers from native trees, are replaced by motorized outboard fiberglass, aluminum or marine plywood boats, which allow fishers to travel further afield from their traditional fishing areas. Torches made from burning coconut fronds for night fishing are today replaced by battery-powered torches, which can either be used from a boat or taken underwater by a diver (Mokoroa, 1981; Abraham and Lambeth, 2001). Moreover, in Fiji, the fishing gear used to capture sea turtles changed as they interacted with their Tongan neighbors who introduced more efficient turtle capture methods (Tippett, 1968).

Baits used for fishing are also important, and often kept secret by fishers. Baits used spanned from small fishes (e.g., silversides, herrings, sprats, goatfishes, mackerels and mullets), to invertebrates (e.g., crustaceans, such as hermit crabs, fiddler crabs and other live crab; gastropods, such as cowries), and plants (such as seaweeds and coconut meat; Dye, 1983; Abraham and Lambeth, 2001; Vunisea, 2004; Thaman, 2016). Some baits were specifically used to passively attract a particular target species; for example, cowries and pearls were used as lures to attract octopuses, while bonito finfish and coconut meat were used to attract coconut crabs (*Birgus latro*).

Group or communal fishing where the community is involved in fish drives or leaf sweeps is common across the Pacific Islands. This method requires long hours of preparation of coconut fronds or other plants to make the ropes or leaf-sweep nets, and usually requires commitment from an entire fishing community, with the exclusion of pregnant women and of those community members who broke the taboos set before the fishing activity (Veitayaki, 1990; Vunisea, 2004). On Ponam Island in Papua New Guinea, fishing crews gather in silence and get help from community members to load the canoes with their fishing gear. Once the fishing crews go out to the designated fishing area, the rest of the community goes back to the beach to wait for the crew,

who upon returning with their net catch, pass the nets to young men, boys or girls who will carry the fish catch to the shore. The catch is then taken to the house of the man who controlled the fishing expedition, and there the men, women and children gut and cook the fish that will later be served by the women to the fishermen (Carrier, 1982). Some fishing methods involve only the men or women. In Lakeba, in Fiji, women perform a traditional fishing method known as **vonu** where a group of four women go out into the lagoon and set up their reef markers at low tide, glean and set up a temporary trap during high tide, and then finally enclose the fish in their trap at low tide and catch them (Kronen, 2002a). On Ahamb Island in Vanuatu, at least five males go out on turtle drives, which are done during full moon during the highest spring tide, performed by the men diving into the water to capture the turtles (Obed and Vuki, 2014).

In some cases, fishing techniques used were named after the target species. For example, “shark noosing” is the name of a technique used in most Polynesian Countries, where the sharks are attracted using a rattle and bait, then are caught by a noose slipped between the gills and the dorsal fin. The catch is then hauled into the boat and killed (Vaea and Straatmans, 1954; Johannes, 1981; Dye, 1983; Veitayaki, 1990). Flying fish netting, called **fai isave** in Vaitupu, Tuvalu, is where flying fish are caught in a special dip net called **tae** (Turbott, 1950). Hand collection methods or gleaning involve complicated methods and a keen eye where the fisher is able to identify where the target species is hiding; for example, feet are used to feel resources like ark clams (*Anadara* spp.) hiding in the marine muddy bottoms (Abraham and Lambeth, 2001). This is commonly done along tidal flats and in the mangrove areas during low tide, and is predominantly done by women, children and older fishers who cannot travel far to fish. Some traditional fishing practices are environmentally destructive, such as plant-based fish poisons, (e.g., derris root, a source of rotenone), which are used to stun and stupefy fishes, also kills or negatively affects other organisms in the fishing area, including corals, and fish drives often damage coral growth as many people trample on them (Barrau, 1955; Basily and Vuki, 2014).

Environmental factors (**Table 1**) strongly influence the technology fishers use, and this in turn affects the type of fishing activity. IFK’s dynamic nature allows the knowledge bearer to receive orally-passed knowledge and hands-on skills, are enriched with their own personal fishing experiences and observations, which are in turn passed on to succeeding generations (Akimichi, 1978; Berkes, 1993). Octopus fishing was done by women on Rapa Nui, who wade into the sea at night during low tide (Ayres, 1979). The women conduct the fishing at night time, given the appropriate phase of the Moon and armed with spears and buckets or baskets. In most places, the flowering of specific plants signify abundance or aggregation of resources, such as the flowering of **gasau** (Pacific Island silvergrass, *Miscanthus floridus*), which signifies reef fish abundance in Fiji and is the “month” or season of **Vula i Gasau** in the traditional Fijian calendar (Veitayaki, 2002), the flowering of the same plant signifying the aggregation of gravid reef fishes in Vanuatu (Hickey, 2006). In the Solomon Islands, fishers correlated the moon phases with

TABLE 1 | Environmental factors, which influence indigenous fishing decisions on the type of gear, fishing methods and techniques which they use on a given fishing expedition, in Fiji and other Pacific Islands.

Country	Environmental factors	References
Fiji	Wind, tidal movement, daily weather conditions, yam season, local environment conditions	Kunatuba, 1983; Veitayaki, 2002
Kiribati	Lunar cycle, wind, tidal movement	Tebano and Tabe, 1993; Lieber, 1994; Takeda and Mad, 1996
New Caledonia	Current movement, flowering or fruit bearing of selected trees, lunar cycle	Teulière, 1988
Papua New Guinea	Eddies, currents, driftwood, lunar cycles, seasonal periods	Groves, 1936; Carrier, 1982; Hamilton et al., 2005
Samoa, Cook Islands	Lunar cycle, tidal movement, wind movement (speed and direction)	Mokoroa, 1981; Kramer, 1994; Herdrich and Armstrong, 2008; Solomona and Vuki, 2012; Levine and Sauafea-Le'au, 2013
Solomon Islands	Lunar cycle; wind patterns; flowering, shedding and the re-growth of leaves of certain plants, wind and tidal movement, wet and dry seasons	Akimichi, 1978; Gina-Whewell, 1992; Takekawa, 2000; Atu, 2005; Sabetian and Foale, 2006a
Tokelau	Lunar cycle	Ono and Addison, 2009
Tonga	Tidal movement	Vaea and Straatmans, 1954; Kronen, 2002b
Tuvalu	Celestial movements, lunar cycle, tidal movement	Kennedy, 1929; Turbott, 1950
Vanuatu	Solar cycle, lunar cycle, wind, tidal patterns, cold and warm seasons, yam planting season	Mondragón, 2004; Hickey, 2006

spawning aggregations of three grouper species (Hamilton et al., 2012); and in the Caroline Islands and Kiribati in Micronesia, fishers believed that an overcast sky and light rain during the day signaled good conditions for cast netting (Takeda and Mad, 1996).

Indigenous fishing culture also extends to seabirds, which are important indicators for environmental conditions suitable for fishing, and show where schools of fish are present. In Tahiti, a **tautai** (lead fisherman) determines when albacore tuna was catchable by the sighting of the swooping behavior of a species of sea tern (Nordhoff, 1930; Johannes and Hviding, 2000). Frigate birds, terns and noddies usually feed on baitfishes chased to the surface by tunas, mahimahi or other large fishes, with the presence of seabird feeding behavior being used by the fishers to locate fish aggregations (Kennedy, 1929). In addition, fishers also used their nets to catch some of the seabirds for their sustenance. Seabirds such as the sooty terns, red footed boobies, and frigate birds and their eggs, are important parts of cultural diets in Tongareva, Cook Islands (Passfield, 1997). Traditional sailors also use birds as guides to show them where land is located by observing the direction in which they fly in the daytime as birds fly out to sea in the mornings, and return to the land in the afternoons or early evenings (Lewis, 1972).

How IFK Can Be Used and Supported to Foster Marine and Freshwater Conservation?

Conservation Status of Marine and Freshwater IFK in the Pacific Islands

Collating the rich information provided by IFK across the Pacific is a mammoth task, and a difficult one because some facts are already forgotten, or are protectively guarded, or simply by now only vaguely remembered (Routledge and Routledge, 1917;

Johannes, 1981). In most of the Melanesia Countries, most of the fish names are never been written down, nor have they been included in any dictionary. To make things even more difficult, the Indigenous fish names are rarely associated with the corresponding scientific name. In addition, some fishing practices, ceremonial practices and beliefs passed down orally, are no longer practiced. For instance, in Samoa and Fiji, those going out to harvest palolo worms (*Palolo viridis*), would “style up” as if they are going to a party, and fish with fine clothes and home-made garlands made of strong scented flowers (Levine and Sauafea-Le'au, 2013, p. 400).

Nomenclatural systems in the Pacific Islands have also undergone severe intergenerational change and loss due to the lack of interest in learning and sharing them, lack of and reduced interaction with the elders, and an overemphasis on Western schooling. This change is evident in the loss of IFK such as the fish names, names of stars, moon phases and the characteristic features of seasons and periods that the older fishers used (Johannes, 1981; Allen et al., 2001; Furusawa, 2009; Horley, 2011; Thaman et al., 2017). In addition, the promotion of artisanal and commercial fishing in the beginning of the 1960's, made the IFK knowledge bearers regard their skills and knowledge inferior or devalued compared to the “new” (Western) knowledge (Horley, 2011; Thaman et al., 2013, 2014). This trend and perception echoes the urgent need for the documentation of IFK as a basis for building synergies with MSK (Thaman et al., 2013).

IFK can also be lost in translations, particularly when documented by non-native speakers or by an urbanized local person who does not understand the cultural, ecological and historical contexts of the knowledge; something that can be partially overcome using documentary videos and voice over recordings of elder fishers' interviews. Given the improved awareness on the value and loss of IFK, there has been a marked increase in the number of young scientists involved

in recording and applying the knowledge of their elders and incorporate these into fisheries management (Nakashima et al., 2012; Carlson, 2017). Creating new information, which can be used for improving and making effective local area management plans (Table 2) can be a welcomed development. Aswani et al. (2017) called for more studies into the dynamics of marine resource use in Fiji, Solomon Islands, and Vanuatu to increase the effectiveness of existing marine resource management programs. Golden et al. (2014) acknowledged the necessary integration of natural history and fisher knowledge as a basis for effective community-based management in Fiji. Hamilton et al. (2012) combined local knowledge of fish spawning aggregations with creel surveys to develop appropriate community-based management for three grouper species in Roviana Lagoon in the Solomon Islands. Finally, Thaman et al. (2017) collated a decade worth of indigenous local knowledge to assess overfishing, marine biodiversity loss and the success of marine conservation in Vanua Navakavu's locally managed marine area (LMMMA) in Fiji. One particularly successful example of IFK-MSK integration are the LMMAs in Fiji. These areas are set up using the traditional knowledge of fishers merged with modern science to better manage the fisheries resources at the grassroots level. A portion of the fishing grounds is usually set aside as a no-fishing zone to safeguard the future sustainability of fisheries resources (Tawake et al., 2001, 2004; Veitayaki et al., 2003). Today, the Fijian network is made up of over 400 LMMAs, which not only focus on management but also on raising awareness, informing policies, and sharing information at the national and international levels (Jupiter et al., 2014). The success of each area in the network is measured by the health of the ecosystem, habitats and species, along with the reduction of threats and the well-being of people who use the resources (Tawake and Tuivanuavou, 2004).

Limitations of IFK Documentation and IFK Threatened Status

Some two and a half centuries of documented (written, video recorded and voice recorded) IFK shows that, although the same locations are commonly revisited, thus adding to the time-depth IFK documentation of that site, this often isolates other equally important fishing communities whose IFK is location-specific and who need their own IFK blended with MSK. Moreover, in-depth documentation does not reflect how universally successful or unsuccessful conservation and management strategies are when communities are not involved. Another limitation is that information is commonly lost in translation of species' local names, which can be improved by including knowledgeable local groups as taxonomists and translators for IFK recording in Pacific communities. The documentation of culturally very important species and keystone species in the Pacific Islands and their significance is lacking, although it is very important for policy makers who formulate policies that will affect access to the cultural keystone species by those communities that value them. There should be initiatives to promote community-based studies on cultural keystone marine and freshwater resources, and associated IFK in all Pacific Island communities to strengthen and enrich appropriate MSK. Customary fisheries management

systems that are complementary to the national management systems and can serve as examples of "best practice" that can be more universally applied should be publicized. Ironically, IFK in the Pacific Islands is seriously threatened by factors (Table 3), that are directly or indirectly related to the commercialization of fishing, breakdown of communal living and overemphasis on urban education. Some of the IFK now seriously threatened include nomenclature systems (endangered/extinct), traditional fishing gear making and use (rare), traditional fishing methods and techniques (endangered/extinct), knowledge of customary fishing calendars (endangered), and the knowledge of marine and freshwater species biology and behavior (rare). While these components of IFK are threatened, there is still time to protect the knowledge base along with the resources linked to the knowledge.

Threats to IFK and Recommendations of Its Conservation

Nomenclature systems are important because they include the knowledge of classifying important target species according their growth stages. More importantly, because of the fishers' daily contact with resources, nomenclature systems can help them identify the species that are being exploited at different life stages. This system is threatened with the loss of language and the elders' inability to pass on the knowledge to the next generation due to the distance created between the elders and the young generation as a consequence of urban education. Moreover, the commercialization of fisheries has influenced the fishers to focus on the commercialized species while excluding the knowledge of other equally important subsistence species and their local names. Nomenclature systems can be studied if protected and promoted through educational activities, which entices the younger generation in their urban schools to document their elders' fishing knowledge. This can be accomplished through special marine and freshwater documenting projects and the registration of local species names. Using visual media to document the elders during their storytelling and sharing of nomenclature systems is important because information would not be lost through translation.

Traditional gear use and traditional fishing-gear making skills are seriously threatened throughout the Pacific and have become redundant because introduced gear is more efficient, which makes it more attractive but damaging to the fisheries. Pacific fishing gear is both sustainable and unsustainable, which can be useful as we try to formulate contemporary fisheries management arrangements. Traditional fishing gear such as large mesh sized nets allow the younger and smaller species to escape and grow, which aids sustainability while other techniques such as the use of fish poisons kills both target and non-target species that threatens the fisheries and the environment. Some authors describe the knowledge and skill loss as a pity and hoped that the ingenuity of traditional fishing-gear making can be maintained in the community to assist us to improve some fishing gears to better suit the areas they are used for and help bring about more suitable and sustainable fishing gear.

Traditional fishing methods and techniques are either threatened, endangered or have disappeared in many areas of the Pacific because of the lack of interest in fishing among youths

TABLE 2 | Marriage of indigenous fisher knowledge and modern scientific knowledge: examples from literature on Fiji and other Pacific Islands Pacific Islands.

Study focus	Pacific Island	References
Ecology		
Historical ecology	FJ, KI, NI, SI	Loeb, 1926; Catala, 1957; Kunatuba, 1983; Ono and Addison, 2013; Thaman et al., 2017
Spawning aggregations	FJ, KI, PNG, SI	Johannes and Yeeting, 2000; Hamilton and Kama, 2004; Hamilton and Potuku, 2007; Fox et al., 2012; Hamilton et al., 2012
Fish aggregating behavior	PNG, SI	Johannes and Hviding, 2000; Hamilton and Kama, 2004; Hamilton and Potuku, 2007; Hamilton et al., 2012
Physical environment		
Tidal cycles and patterns	KI, TK	Johannes and Yeeting, 2000; Hooper et al., 2012
Lunar cycles	KI, PL, SI	Johannes, 1981; Takeda and Mad, 1996; Johannes and Yeeting, 2000; Johannes et al., 2000; Hamilton et al., 2012
Weather patterns for fishing	CI, NI, VA	Loeb, 1926; Mondragón, 2004; Carlson, 2017
Seasonal markers	FJ, PL, VA	Klee, 1976; Mondragón, 2004; Veitayaki, 2005;
Collaborative mapping	SI	Lauer and Aswani, 2009
Language and marine cognition		
Names for fish and marine invertebrates	FJ, FSM, PNG, SI, TA, TN	Aitken, 1930; Akimichi and Sakiyama, 1991; Foale, 1998; Morgan, 1999; Abraham and Lambeth, 2001; Thaman et al., 2008, 2017; Ross et al., 2011
Lexical categories for water ecological zones	SI	Lauer and Aswani, 2009
Season names	FJ, PL	Klee, 1976; Veitayaki, 2005
Resource management		
Management practices in coastal fisheries	RN, NR, SI	Johannes et al., 2000; Spennemann, 2002; Aswani and Hamilton, 2004; Aburto et al., 2015
Fish harvesting techniques and technologies	FSM	Abraham and Lambeth, 2001
Harvesting methods	FSM	Abraham and Lambeth, 2001
Community based resource management systems	CI, FJ, NC, PL, SA, SI, TK, TU, VA	Ruddle, 1994; Veitayaki, 1997; Johannes, 2002; Léopold et al., 2011; Hooper et al., 2012
Customary marine resource management	CI, EI, FJ, PNG, SI	Johannes, 1978; Tiraa-Passfield, 2006; Foale et al., 2011; Solomona and Vuki, 2012; Golden et al., 2014; Aburto et al., 2015

Table adapted from Thornton and Scheer (2012) and modified for the Pacific Islands.

Key: CI, Cook Islands; FJ, Fiji; FSM, Federated States of Micronesia; KI, Kiribati; NC, New Caledonia; NI, Niue; NR, Nauru; PL, Palau; PNG, Papua New Guinea; RN, Rapa Nui; SA, Samoa; SI, Solomon Islands; TK, Tokelau; TN, Tonga; TU, Tuvalu; VA, Vanuatu.

in both rural and urban areas, urban drift, modern education and the increasing availability of marine and freshwater fish products in urban markets. The three main types of fishers in the Pacific are subsistence fishers, artisanal commercial fishers and recreational fishers. Fishing is a means of daily sustenance in the islands so some fishers' traditional knowledge and techniques may still be intact. However, those that fish commercially, focus more on obtaining resources faster and more efficiently, therefore increasingly using more modern fishing techniques at the expense of traditional methods and knowledge. Traditional fishing methods and techniques in the Pacific are similar and reflect the unique environment and aquatic resources harvested in different places. Documenting these methods and techniques on paper and visually is important for the protection of these knowledge and skills. Fishers who use the plants to inform them of the fishing seasons are being confused as climate change is disrupting the natural flowering/fruited seasons of these plants. The customary fishing calendars can be updated to reflect present local conditions, which are changing. Passing this knowledge to the next generation must be made more interesting and organic

in ways that will involve people, particularly the children and youth, in all parts of the country.

Finally, the knowledge of marine and freshwater species' behavior is an important part of Pacific IFK because it informs fishers where to fish, how to fish and on fish abundance. This knowledge-base is rare, only retained by the most proficient fishers and elders as shown by Hooper et al. (2012), and is threatened because of the lack of interest in these fishing stories from majority of the younger generations. While IFK on species behavior is invaluable to Pacific fishers, proper documentation of this knowledge and its marriage with MSK can help in the protection of this knowledge. Examples of knowledge on fish behavior is documented by Hooper et al. (2012) from Tokelau and Johannes (1981) from Palau. Moreover, because the knowledge is localized, developing it further using scientific information may help incorporate this knowledge as a basis for localized policies and sustainable resource use management plans in the future. An example of this IFK and scientific knowledge marriage is shown by Hamilton et al. (2012) on grouper spawning season in Roviana Lagoon, where local knowledge was used

TABLE 3 | Summary of conservation status of marine and freshwater indigenous fisher knowledge (IFK) in Fiji and other Pacific Islands, drivers of loss and suggestions for conservation enrichment.

IFK	Status	Driver of loss	Suggestions for conservation enrichment
Nomenclature systems	EN, EX	<ul style="list-style-type: none"> - Loss of language usage - Distance from elders in fishing communities - Focus on commercialized species 	<ul style="list-style-type: none"> - Listen to elders' stories of fishing and species descriptions - Document elder fisher's species descriptions - School children projects to get local names of marine and freshwater resources from their elders
Traditional fishing gear	R	<ul style="list-style-type: none"> - Introduction of new and efficient fishing gear 	<ul style="list-style-type: none"> - Limit or ban on new fishing gear which does not allow species to escape. - Create awareness on traditional fishing gear making - Involve younger generation in making fishing gear
Traditional fishing methods and techniques	EN, EX	<ul style="list-style-type: none"> - Loss of interest in fishing - Urban drift - Availability of marine and freshwater resources in supermarkets and markets 	<ul style="list-style-type: none"> - Raise awareness on traditional methods and techniques - Document traditional fishing methods - Encourage research into IFK - Involve younger generations to use traditional fishing methods are used
Customary fishing calendars	EN	<ul style="list-style-type: none"> - Knowledge not passed to next generation - Climate change affecting seasonal markers such as flowering seasons 	<ul style="list-style-type: none"> - Promote IFK using modern communication methods - Document customary calendars and signs
Marine and freshwater resource biology and behavior	R	<ul style="list-style-type: none"> - Loss of interest in fishing 	<ul style="list-style-type: none"> - Documenting ILK on fishery biology and behavior - Support empirical research on ILK to highlight the science behind traditional knowledge

IFK status: EN, Endangered; EX, Extirpated; R, Rare.

to fill data gaps of science. Other examples are shown in Ruddle et al. (1992), Hamilton and Potuku (2007), Hamilton et al. (2012), Thaman et al. (2014) and Johannes and Neis (2007), which carefully collect, evaluate and validate IFK while respecting the cultural sensitivity and confidentiality of the knowledge. Additionally, temporal information older fishers have can identify species which are locally extinct, especially food fish which were heavily targeted during communal fishing, such as the bumphead parrotfish (*Bolbometapon muricatus*) from some Lau Islands, Fiji (Dulvy and Polunin, 2004; Haggan et al., 2007).

Several countries in the Pacific have recognized the loss of IFK as serious and have implemented initiatives to document their knowledge before it is entirely lost (Léopold et al., 2011; Hooper et al., 2012; Thornton and Scheer, 2012). Educational activities on fishing knowledge and skills aimed at bringing together the younger generation, and their elders can help reconstruct this broken bridge and help keeping IFK alive, meaningful and useful. Further exacerbating the loss of knowledge is the increasing use of widely available internet access, television and other modern media, which further isolates youth from older generations of fishers. Yet, these modern communication tools can also be used to document and disseminate IFK and relevant MSK, as a basis for building synergies in a rapidly changing, and increasingly threatened Pacific fishery. IFK is invaluable to the Pacific and even if it does not support MSK today, fishers throughout the Pacific will still use their IFK while fishing in their marine/freshwater environments.

Moreover, creating awareness on the value of IFK is one of the ways to counter its loss. This awareness needs to go both ways—for people in the communities to know and understand the knowledge and for those who wish to help communities in

their sustainability efforts, to understand the context of resource use. The reason this awareness is important when merged into resource management initiatives is because it creates a sense of ownership for the initiatives introduced into the community from outside, and it may guarantee that communities develop it further as they use their own IFK and resources to run the management initiative.

CONCLUSION

To protect their IFK, elder fishers across the Pacific are slowly opening up to allow the proper documenting of their IFK through questionnaires and in-depth interviews, voice-recorded interviews and video documentaries. Although an intergenerational gap remains between IFK holders and the younger generation, there is an urgent need to increase awareness on and engagement with the rich but rapidly disappearing traditional knowledge. Knowledgeable elders must be engaged to share their knowledge for documentation and the training of future generations; in particular, there is a need to involve local fishers in fisheries stock assessment and the planning and implementation of fisheries management plans, and in the establishment and monitoring of marine managed areas. Moreover, the applicability of IFK as a basis for marine conservation needs to be integrated into both the secondary and tertiary science and social science curricula, as one of the most effective ways of insuring the continued application of IFK to modern fisheries and conservation management, as well as conserving IFK for future generations of Pacific Islanders.

Widespread exploitation of Pacific resources stems from their knowledge of the resource base they are in daily contact with. Although customary management systems are in place and give communities the feeling of sustainable resource use, there is still a great need to create awareness about the limit of resources in many fishing communities. Understanding the limit of the resources coupled with the encouragement on the proper use of IFK can assist the fishing communities in the Pacific to better manage their already strained resource base.

While the Pacific IFK is threatened on a daily basis, records show that not all of the knowledge of fishers has been lost yet. The mammoth task of documenting IFK is slow and late, however, it has captured information such as the importance of particular species to a culture, the nomenclature systems in place for important species, different locations, conditions and gear that fishers use. Past and recent documentation highlights the need to use local scientists to help in the documentation of their own IFK. They understand the customs and the language, and they will also learn from their elders through their documentation of IFK. Moreover, the value of IFK is recognized today by many, and while work on its protection and documentation is ongoing, Pacific Island fishers are continuously interacting with their environment and adding on to their IFK knowledge base for the future generations' use.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/Supplementary Materials,

further inquiries can be directed to the corresponding author/s.

AUTHOR CONTRIBUTIONS

SK: conceptualization, data curation, formal analysis, methodology, investigation, visualization, writing—original draft, and writing—review and editing. RT: methodology, resources, supervision, validation, and writing—review and editing. JV and AB: writing—review and editing. SP: conceptualization, methodology, supervision, validation, and writing—review and editing. All authors contributed to the article and approved the submitted version.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fmars.2021.684303/full#supplementary-material>

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