Aquat. Living Resour. 2025, 38, 13

https://doi.org/10.1051/alr/2025009

Aquatic Living Resources
Available online at:
www.alr-journal.org

Special Issue - Dynamics of small-scale fishery social-ecological systems: interdisciplinary insights from Madagascar

RESEARCH ARTICLE

OPEN ACCESS

Mapping place names for small-scale fisheries evaluation

Roddy M. Randriatsara[1,*], Faustinato Behivoke[1], Frédéric Ramahatratra[1], Jamal Mahafina[1], Thomas Lamy[2] and Marc Léopold[3]

[1] Institut Halieutique et des Sciences Marines (IH.SM), University of Toliara, Toliara, Madagascar
[2] UMR MARBEC, University of Montpellier, CNRS, Ifremer, IRD, France
[3] UMR ENTROPIE (IRD, University of Reunion, University of New Caledonia, Ifremer), c/o IUEM, Plouzané, France

Received 20 June 2024 / Accepted 23 June 2025

Handling Editor: Anthony Charles

Abstract – Fishers' spatial knowledge encompasses a diverse array of social, ecological, technical, experiential, and learning knowledge derived from local environmental and sociocultural contexts. In this study, we used a transdisciplinary framework to shed light on place names of fishing grounds in the context of small-scale fisheries through a case study in Madagascar. First, we jointly monitored fishing boat trajectories based on GPS tracking and recorded the vernacular names of fishing sites in a coral reef fishery from May 2018 to April 2019. This data was processed through spatial analysis to assess the dimensions of each named fishing site. A focus group discussion was conducted with fishers to determine the literal meanings of the toponyms (place names) in the local language. A total of 570 fishers (totaling 15,904 fishing trips) using five gear types were surveyed in eight communities. We identified 397 fishing sites over about 250 km^2, 304 of which (76.6%) were mapped. Overall, 371 toponyms (93.4%) were interpreted and categorized based on geographical features ($n = 222$), biodiversity ($n = 86$), and maritime uses ($n = 63$). The dimensions of the fishing sites varied significantly from 0.01 to 11.7 km^2, following spatially-explicit fishing distribution patterns and the level of precision of the delimitation method. Most fishing locations (63.3% of the total fishing grounds) were associated with multiple place names, particularly in heavily-targeted areas, indicating that individual fishers typically have their own names for their fishing sites. This study demonstrates that recording boat movements and vernacular toponyms simultaneously throughout an extensive monitoring survey in a coral reef fishery, effectively captured the rich and varied individual fishers' conceptualizations of the coastal and nearshore marine environment. Our findings suggest that named fishing sites may be used as local spatial reference units with known precision and accuracy, which is relevant for addressing spatial data limitations in small-scale fisheries and incorporating fishers' knowledge in collaborative fisheries science.

Keywords: Fishers' knowledge research / GPS tracking / local ecological knowledge / Madagascar / marine territory / participatory mapping / toponym / traditional fishing / transdisciplinary research / Vezo ethnic group

1 Introduction

To date, coastal fishing activities have been closely linked to the spatial dimension of the marine environment and resources. Fishers' knowledge develops through repeated social ecological interactions within marine environments, influenced by access conditions, resource ecology, and cultural tradition that shape their fishing practices (Smith et al., 2016). Individual motivations to fish and associated learning experience relate to the search for food resources, commercial goals, and/or social cultural practices, including use rights (Young et al., 2016; Camacho and Steneck, 2017). Territory use rights for fisheries refer to designated areas where access to resources is regulated and restricted to specific communities, so as to limit fishing pressure for their own benefits, support resource sustainability, and manage or prevent conflicts (Lester et al., 2017).

Fishers' spatial knowledge encompasses a range of social, ecological, technical, experiential, and learning knowledge that emerges from both the local environmental and social cultural context. Particularly vernacular place names (also known as toponyms) carry a comprehensive cultural meaning

*Corresponding author: randriatsararoddymichel@gmail.com

that results from a combination of social, geographical, and ecological characteristics and knowledge of the environment (Valkó et al., 2023). Altogether, they are part of a geographical mental representation of users' spatial knowledge, which is valuable information for resource management. Place names provide interesting information on the spatial distribution of the community's preferences and priorities in terms of use of the environment (Ottino-Garanger and Ottino-Garanger, 2017; Kobryn et al., 2018). They convey one's sense of place, i.e., one's emotional attachment to a specific geographical site and environment, which motivates cooperative efforts, improves social cohesion within one's community, differentiates between user groups, or establish territories and boundaries to regulate access to resources (Manzo and Perkins, 2006; McCall Howard, 2019). Understanding variations in the sense of place among communities and the relationship between users and place names opens up new opportunities in socio-ecological and fishers' knowledge research (Stedman, 2016; Rajala et al., 2020).

Diverse survey methods have been commonly used to document fishing areas and place names in coastal fisheries, including participatory mapping. Participatory mapping is a collaborative approach that engages local communities in creating, collecting, and analyzing ethnographically derived geographical data (e.g., Calamia, 1999). It enables people to share their local knowledge, experience, and perspectives to create maps that reflect the realities of their environment. Provided that the risk of sharing this spatial information with outsiders such as researchers or other local users is limited, participatory mapping provides a valuable perspective on the spatial distribution of place names, e.g., revealing local fishing preferences and practices, social markers of marine tenure, and how coastal communities delimit marine territories based on their knowledge (Kimani and Obura, 2004; Aswani, 2017). However, because of individual differences in sense of place (Quinn et al., 2019), fishers' knowledge varies within these communities although the latter own some form of collective knowledge, which generates inconsistency and imprecision of the boundaries of the named areas according to the participants to the mapping exercise. Mapping approaches should give consideration for the inherent heterogeneity of knowledge among fishers by considering large, representative samples of fishers (Grati et al., 2022), which is rarely accounted for in fishers' spatial knowledge research. This highlights the need for developing quantitative methods to systematically capture and explore the diversity of fishers' spatial knowledge on a large scale, thereby providing generalizable insights across different social and ecological contexts (Stedman, 2016).

Spatially-explicit methods using boat tracking instruments (e.g., vessel monitoring systems) have developed for extensive monitoring of fishers' movements (Jennings and Lee, 2012) in order to accurately assess the distribution of fishing gear use (Mills et al., 2007), including in coastal small-scale fisheries (Torres-Irineo et al., 2021). GPS tracking data (i.e., a sequence of latitude and longitude coordinates of boats at set intervals) have the potential to provide accurate spatial data on fishing activities per trip, including routes to fishing sites and gear usage (Alvard et al., 2015). This information helps characterize the spatial distribution of fishing pressure and associated catches, which is crucial for the management of small-scale fisheries and ecology research (McCluskey and Lewison, 2008). Nevertheless spatial data availability remains a recurrent bottleneck in the context of small-scale fisheries, where boats generally lack positioning technologies such as Vessel Monitoring System (VMS) or Automatic Identification System (AIS). To date, intensive map-based fisher interviews have represented an alternative to such technological limitation to gather representative spatially-explicit information on fishing effort through the use of geographical information systems (Léopold et al., 2014). However, as acknowledged by these authors, such surveys capture the overall spatial distribution of fishers' behavior at sea over long time periods (typically one year), while asking the fishers to specify their fishing area per trip would allow the characterization of fishery spatial patterns more accurately. Linking spatial monitoring of fishers' movements and local qualitative knowledge about fishing practices while accounting for confidentiality issues and the risk to fishers of sharing such spatial information (e.g., confidential fishing sites, conflict areas) therefore seems promising in this respect.

The objective of this study was to determine the spatial and qualitative characteristics of named fishing sites using GPS tracking of fishing boats. As a proof of concept, boat movements and vernacular names of fishing sites (i.e., fishing toponyms or place names) were recorded simultaneously as part of an extensive monitoring survey conducted in a coral reef fishery operated by traditional fishing communities in Madagascar. The boundaries of named fishing sites were determined as the smallest geographical units for conceptualizing the seascape (Smith et al., 2016), and the toponyms were categorized based on their literal meanings. The results revealed that fishing was associated with rich, individual fishers' mental maps of the coastal and nearshore marine area and how fishers spatialize their activities, perceive the marine environment, and conceptualize its spatial dimensions. We discuss fishers' conceptualization of the marine environment in the study area, along with the implications and perspectives for generalizing this participatory and analytical framework for monitoring and managing small-scale fisheries as a contribution to sustainability research.

2 Methods

2.1 Study area

The study area was located close to the urban center of Toliara, the primary population hub of southwestern Madagascar (approximately 330,000 inhabitants), which drives intense coastal fishing activity in the bay of Toliara (Fig. 1A). Fishers live in 12 urban and rural villages, which have a total population of about 36,000 inhabitants. In 2017, 892 traditional sailing pirogues (2–7 m in length) were operated by about 2,000 fishers who targeted reef fishes using traditional Vezo sailing pirogues and five main fishing gear types (Ranaivomanana et al., 2023): gillnet, handline, speargun, mosquito net trawl, and beach seine (Figs. 1B, 1C). Fishing also included reef gleaning for benthic invertebrates and was mainly for sale at the urban markets. Most fishers belong to the Vezo ethnic group (meaning "to paddle"), which refers to all those who live alongside the southwest coast of Madagascar and define their identity through fishing practice (e.g., paddling and sailing the pirogue) (Astuti 1995). They derive their livelihood

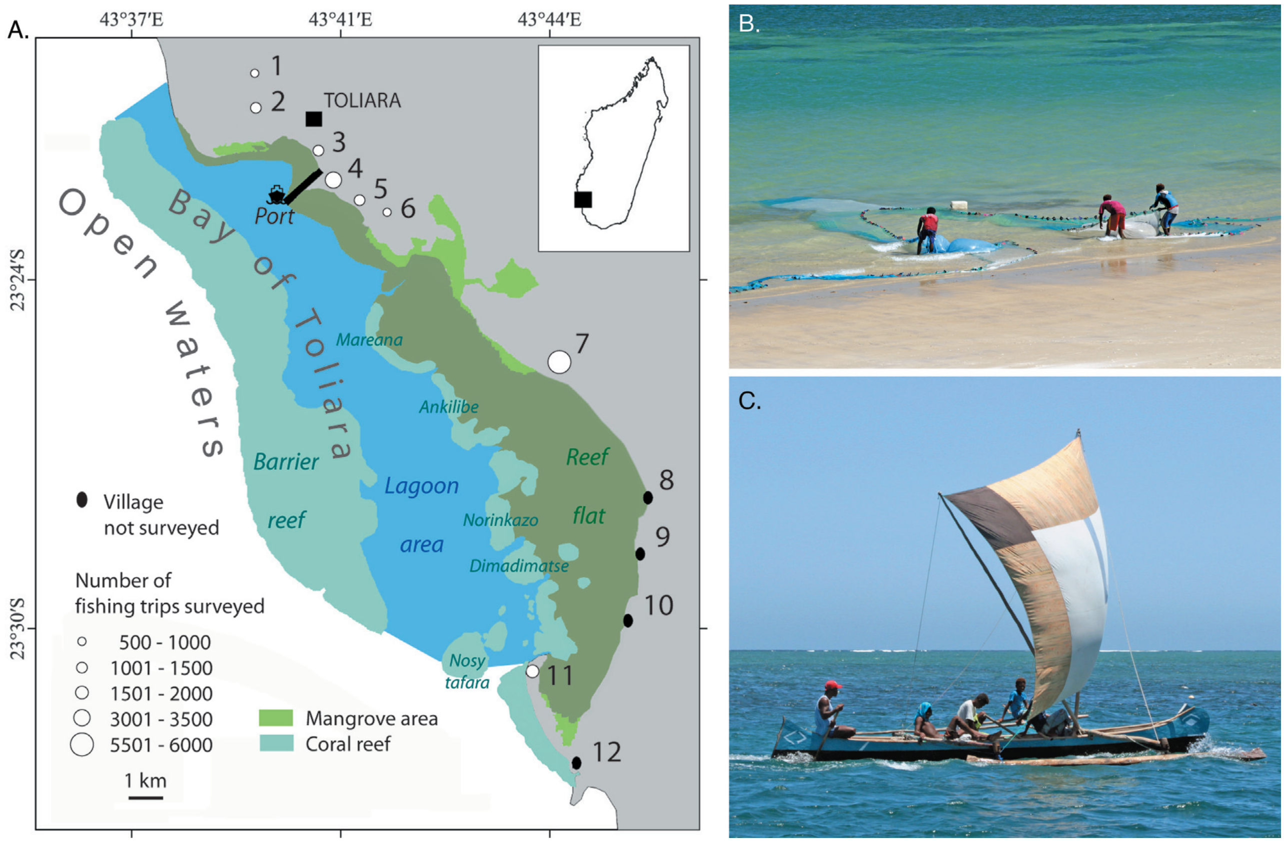

Fig. 1. Study area in the bay of Toliara (36.5 km coastal stretch), South-West Madagascar (A). Geomorphological reef units are represented as distinct colors. The commonly-known local names of internal reefs are indicated. Numbers correspond to the villages with Ambohitsabo (1), Besakoa (2), Mahavatsy 2 (3), Ankiembe-bas (4), Mahavatsy 1 (5), Ankiembe-haut (6), Ankilibe (7), Namakia (8), Antsifotse (9), Antanandreviky (10), Sarodrano (11), and Ambanilia (12). White dots refer to the villages surveyed. Fishers pulling a beach seine (B). A Vezo traditional sailing pirogue set up for fishing (C).

solely or mainly from coastal fishing. This population has diverse origins and includes other ethnic groups such as the *Masikoro* and *Mahafaly* from the southwest of Madagascar, the *Sakalava* from the west, the Bara form the east, and the *Antandroy* from the south, as well as African populations arrived over the last centuries, who gradually 'became Vezo people' by learning and performing the Vezo's interactions with the sea (Fauroux and Koto, 1993; Veriza et al., 2018).

The bay of Toliara (157 km^2) comprises multiple geomorphological reef units (Fig. 1): intertidal terrace, shallow lagoon (<10 m deep), pass, coral bank, internal reef, external reef, and reef slope (Andréfouët et al., 2013). The outer reefs consist of the Toliara great barrier reef (18 km long and 1-3 km wide) and the *Nosy Tafara* reef opposite to the village of Sarodrano. Three internal reefs (*Beloza, Dimadimatsy,* and *Norinkazo*) and two coral banks (*Ankilibe* and *Mareana*) are distributed in the lagoon area (Laroche and Ramananarivo, 1995).

2.2 Data collection

Fishing data was collected in the main fishing villages, namely, Ambohitsabo, Besakoa, Mahavatsy 2, Ankiembe-bas, Mahavatsy 1, Ankiembe-haut, Ankilibe, and Sarodrano (Fig. 1). A total of 100 boats were sampled monthly from May 2018 to April 2019. The sample was proportionally distributed among villages and gear types (Tab. 1). For a 25-to-35-day period (30 days on average), the voluntary fishers equipped their boat with a GPS tracker during each fishing trip. They were given a logbook and recorded the local name of the fishing site(s) visited at each trip when they returned from sea using Vezo geographical vocabulary, since this dialect is widespread throughout coastal areas in Southwestern Madagascar (Tab. 1). The objective of the survey was explained to them and oral consent was obtained for using this data. Each month the fishers surveyed were replaced according to availability of other fishers of the same village and using the same gear type (e.g., fishers were monitored over 1–3 months during the survey period), which resulted in a quasi-random sampling design. A total of 570 fishers (63.9% of the total) were sampled, corresponding to 25 to 159 fishers per village (4 to 28% of total fishers per village) and 75 to 222 fishers per gear type (13 to 38%) (Tab. 1).

Following the fishery monitoring survey, a focus group discussion (FGD) was carried out in 2022 to ascribe a translation or an interpretation of the equivalent term of the local names of the fishing sites in official Malagasy. This literal meaning of local names was expected to reflect the social, cultural, geographical, practical, or emotional significance of the fishing sites, revealing the symbolic relationships between the Vezo fishers and the marine environment. A preliminary

Table 1. Fishing data collected across gear types and villages in the study area. Number of fishing boats (percent of the number of boats sampled within brackets), number of fishing trips monitored, and number of toponyms (named fishing sites) by the five fishing gear types in each village studied. Village numbers correspond to Ambohitsabo (1), Besakoa (2), Mahavatsy 2 (3), Ankiembe-bas (4), Mahavatsy 1 (5), Ankiembe-haut (6), Ankilibe (7), and Sarodrano (11).

Gear types		Villages								Total
		1	2	3	4	5	6	7	11	
Gillnet	Boats	–	13 (69%)	15 (0%)	89 (52%)	52 (54%)	28 (78%)	104 (66%)	57 (84%)	358 (62%)
	Trips surveyed	–	208	6	1139	844	424	1945	1198	5764
	Toponyms	–	25	3	59	89	52	92	111	261
Handline	Boats	11 (82%)	18 (89%)	17 (65%)	10 (70%)	11 (91%)	39 (54%)	21 (76%)	15 (87%)	142 (72%)
	Trips surveyed	250	327	247	379	158	438	607	402	2808
	Toponyms	48	49	47	13	43	54	47	52	204
Speargun	Boats	25 (64%)	49 (61%)	28 (75%)	12 (75%)	8 (25%)	2 (0%)	6 (100%)	3 (67%)	133 (65%)
	Trips surveyed	434	499	422	321	75	–	325	35	2111
	Toponyms	37	47	43	29	33	–	18	19	140
Mosquito net trawl	Boats	–	–	–	21 (90%)	–	–	108 (59%)	2 (50%)	131 (64%)
	Trips surveyed	–	–	–	684	–	–	2576	52	3312
	Toponyms	–	–	–	48	–	–	44	7	85
Beach seine	Boats	–	1 (0%)	44 (77%)	70 (44%)	5 (60%)	1 (0%)	4 (100%)	3 (100%)	128 (59%)
	Trips surveyed	–	–	767	807	79	–	165	91	1909
	Toponyms	–	–	70	41	35	–	30	14	130
Total	Boats	36 (69%)	81 (68%)	104 (63%)	202 (55%)	76 (56%)	70 (61%)	243 (65%)	80 (84%)	892 (64%)
	Trips surveyed	684	1034	1442	3330	1156	862	5618	1778	15904
	Toponyms	62	64	98	97	102	77	127	125	397

Table 2. Distribution of fishers and focus group discussions (FGD) in the fishing villages studied in the Bay of Toliara. "*" refers to the villages where the FGD occurred.

Groups	Villages	Number of FGDs	Number of fishers	
			Per FGD	Total
1	1. Ambohitsabo*	1	5	5
	2. Besakoa			
2	3. Mahavatsy 2	4	3	12
	4. Ankiembe-bas*			
	5. Mahavatsy 1			
	6. Ankiembe-haut			
3	7. Ankilibe*	4	4	16
4	11. Sarodrano*	2	5	10
	Total	11		43

analysis of boat tracking data was conducted to reduce the implementation costs of this qualitative survey. The villages sharing common fishing grounds were grouped. The survey was conducted in four out of the eight villages (Ambohitsabo, Ankiembe bas, Ankilibe, and Sarodrano), in which 1–4 FGD (3-5 fishers each) were conducted (Tab. 2), based on the assumption that the fishers interviewed would know the literal meaning of all or most toponyms recorded in their village or group of villages. In each FGD, the fishers were selected among those who participated to the fishery survey. They retained the literal meaning of the toponyms by consensus.

2.3 Data analysis

The spatial characteristics and names of fishing sites were analyzed in each village separately, considering the village community as the unit of analysis of spatial uses (Manzo and Perkins, 2006). The frequency of use of fishing sites among fishers within each village was estimated from the logbook data. Because fishing gear types may target distinct marine areas due to technological limitations (e.g., depth limits, sea substrate), the fishing site corresponding to each local name was delimited by gear type. Indeed, beach seine and mosquito net trawl were generally used in shallow waters and over soft bottom, making it easier for fishers to pull the net (Herinirina et al., 2023), while gillnet, speargun, and handline were rather practiced in other, more diverse reef habitats.

The GPS boat trajectories were first processed to predict the fishing positions and non-fishing positions (e.g., during travel to/from fishing sites) during each fishing trip using Behivoke et al's (2021) method. The fishing site (i.e., the group of all fishing positions) of each trip were related to the local name(s) reported for that trip in the fisher's logbook. The trips for which more than one fishing site was declared were discarded in order to avoid localization errors. The fishers visited two or more fishing sites during 388 trips (2.4% of the total), consequently those sites were not considered in the mapping process.

The density of GPS fishing positions associated with each named fishing site was then mapped onto a 100-m square grid

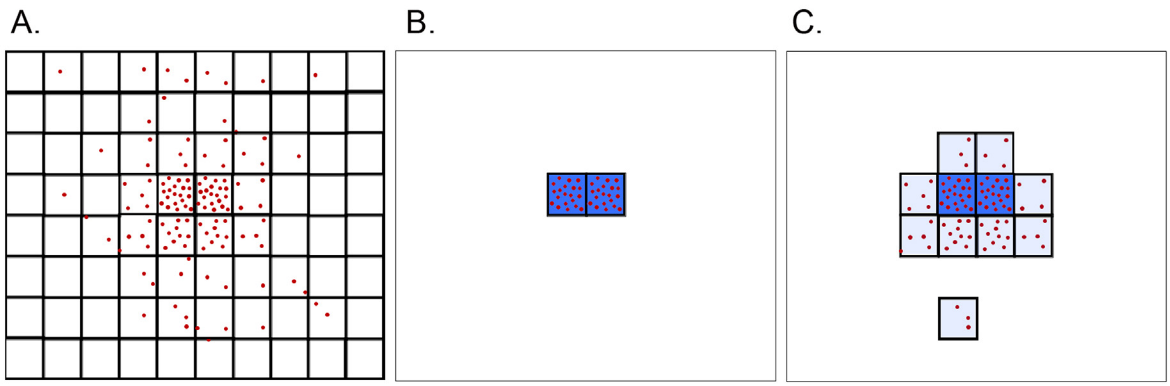

Fig. 2. Mapping procedure used for delimiting fishing sites. Spatial distribution of all GPS-fishing positions for a given fishing site (A). Definition of the conservative (B) and comprehensive (C) delimitations of that fishing site, containing 50% and 90% of all fishing positions, respectively.

using a geographical information system (GIS). The 10% GPS fishing positions of the least-frequently visited 1-ha cells were considered as spatial outliers due to potential spatial approximations or errors (e.g., fishers may have used the same toponym to identify fishing spots distinct from that named fishing site for not disclosing exact fishing places) and subsequently not incorporated in the spatial analysis as a precaution for avoiding spatial bias in map representations. In order to estimate the spatial precision vs. fuzziness of the boundaries of the named fishing sites, we quantified space use within these sites and defined their boundaries using two delimitation thresholds (50% and 90% of all GPS fishing positions). For each delimitation threshold, cells were aggregated starting with that with the highest fishing position density and then going downwards, which resulted in fishing sites being composed of cells tied or scattered spatially (Fig. 2). Following that definition, the 50% and 90% thresholds designated the conservative and comprehensive boundaries of the corresponding named fishing site, respectively. The respective boundaries and area of the conservative and comprehensive delimitations of the fishing sites were estimated in each village and compared through an one-way analysis of variance (ANOVA). The overall fishing grounds of each village were then combined and mapped using each delimitation threshold. To assess whether fishing sites were referred to by different names across and within villages (i.e., an indication of spatial overlapping among named fishing sites), the number of toponyms used in each cell was finally mapped at the scale of the Bay and within each village using the comprehensive delimitation of the fishing sites.

Following previous studies (Wynveen et al., 2012; Wynveen and Kyle, 2015), to interpret how fishers conceptualize the spatial dimensions of the environment, the toponyms were categorized by the researchers in three themes based on the FGD data: i) geographical characteristics of the landscape and the seascape, ii) uses of marine resources and areas including socio-cultural and fishing practises, and iii) biodiversity (fauna species names) (Tab. 3). To investigate whether the toponyms were individual or collective spatial knowledge of the marine environment, the frequency of use of named fishing sites among fishers was calculated for each thematic category. To assess whether our participatory survey captured all fishing toponyms in the study area, we built the accumulation curve of the number of named fishing sites as a function of the number of surveyed fishers using a sample-based rarefaction method. The accumulation curve showed that the number of named fishing sites accumulated and eventually reached a plateau with the increase of sample size (i.e., number of fishers surveyed), indicating that more than 80% of the fishing toponyms in the area was captured by the survey (Fig. 3).

Data was integrated into a PostgreSQL/PostGIS database, which allowed for efficient storage and spatial analysis of the GPS dataset. All analyses were carried out using R software version 4.3.3 and the following packages: DBI (Wickham et al., 2023) and RPostgreSQL (Conway et al., 2024) to handle online database, sf (Hijmans et al., 2023), and vegan (function specaccum) (Oksanen et al., 2024) to perform spatial and rarefaction analysis.

3 Results

3.1 Local names of fishing sites

A total of 15,904 fishing trips were monitored, corresponding to 65 to 127 trips per village, 1 to 103 trips per fisher (27 trips per fisher on average), and 84 to 261 trips per gear type (Tab. 1). A very high diversity of fishing toponyms ($n = 397$) was recorded during the survey. Among them, 371 toponyms (93.4%) were translated during the focus group discussion. The remaining 6.6% were unaccounted for because those fishers who participated in the FGD were unwilling to disclose and did not know their literal meaning. The data (fishing toponyms and their respective category, sub-category, and literal meaning) and related documentations that support the findings of this study are openly available in DataSuds repository (IRD, France) at https://doi.org/10.23708/G7IH98. Data reuse is granted under CC-BY license.

About three quarters of the fishers used the three thematic categories (Tab. 3). All the fishers used sites assigned to visual geographical characteristics at sea or alongside the coastline, particularly those meaning related to underwater and above water environments (79 and 66 sites, respectively, that were visited by 522 (91.6%) and 451 (79.1%) fishers, respectively).

Table 3. Thematic categories of named fishing sites (toponyms) in the study area. Literal meanings were categorized by the authors into three main themes and 13 sub-categories. For each of them, the number of fishing sites and the corresponding number of visiting fishers (percent of all fishers surveyed within brackets) are indicated. The dataset of the fishing toponyms and their meaning is available at https://doi.org/10.23708/G7IH98.

Category	Sub-category	Number of toponyms	Number of fishers (%)	
Geographical characteristics	Above water seascape	66	451	(79.1%)
	Underwater seascape	79	522	(91.6%)
	Littoral landscape	22	201	(35.3%)
	Vicinity of villages	31	185	(32.5%)
	Buildings and constructions	24	380	(66.7%)
	Sub-total	222	570	(100.0%)
Maritime uses	Socio-cultural activity	17	118	(20.7%)
	Navigation	10	29	(5.1%)
	Fisher's name	15	86	(15.1%)
	Fishing practice	13	157	(27.5%)
	Fishing effects	8	254	(44.6%)
	Sub-total	63	407	(71.4%)
Biodiversity	Fish name	63	382	(67.0%)
	Invertebrate name	16	177	(31.1%)
	Name of flagship species	7	151	(26.5%)
	Sub-total	86	458	(80.4%)
	Total	371	570	(100.0%)

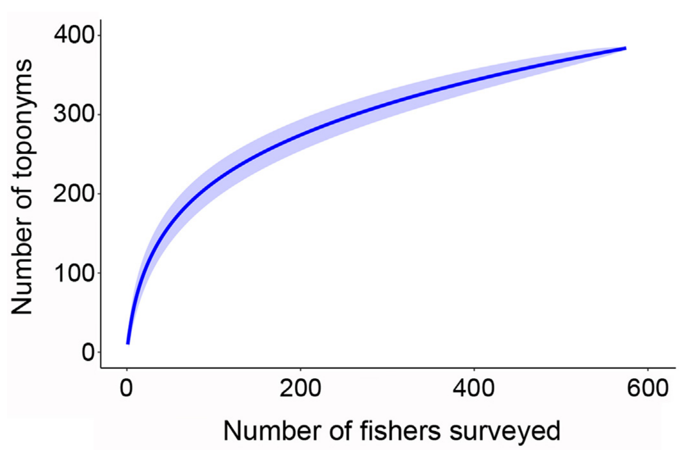

Fig. 3. Accumulation curve of named fishing sites (toponyms or place names) according to the number of fishers surveyed.

This indicated that fishers' geography at sea was shaped by how they visually perceived remarkable small to large coastal landmarks and seamarks in the bay of Toliara. The majority of toponyms ($n = 222$, 55.9% of total) referred to this thematic category. For example, the site of *Ambato be* being named for the presence of a large coral block (*am* meaning "at" or "near", *b-vato* meaning "coral block", and *be* meaning "large" or "big" in the Vezo language). Various landmarks were also frequently used according to coastal landscape ($n = 22$) and proximity to a village ($n = 31$) or remarkable buildings and constructions ($n = 24$). For example, *Andaboy* designated the area near the lighthouse of the bay close to the commercial harbor of Toliara (*an* meaning "at" or "near", *d-laboy* meaning lighthouse). *Celtel* designated an area near the cell phone network antenna owned by that telecommunication in Madagascar). *Melody* designated an area near the hotel of that name, located South of the Ankilibe village. A fishing site called *Antsakoa* was located close to a tree species called *sakoa* (*Poupartia caffra*, family of Anacardiaceae). Similarly, a fishing site called *Ambanitana* was close to a village (*Ambany* meaning "near" or "close to" and *Tana* meaning "village" or "home"). This appellation was recorded in several villages (Ankiembe-bas, Mahavatse-1, Ankiembe-haut, Ankilibe, and Sarodrano).

Toponyms also regularly referred to biodiversity ($n = 87$, 21.9% of total), a theme used by most fishers (80.7%) to define at least one of their fishing sites (Tab. 3). Specifically, most of those names ($n = 63$) referred to fish abundance or size, such as *Beakio* and *Andamatra* which designated areas where sharks and fish of the Scombridae family, respectively, were perceived as remarkable. These sites were visited by 382 fishers (67.0%), which indicated the fishers' primary targets were likely finfish. This was further supported by the finding

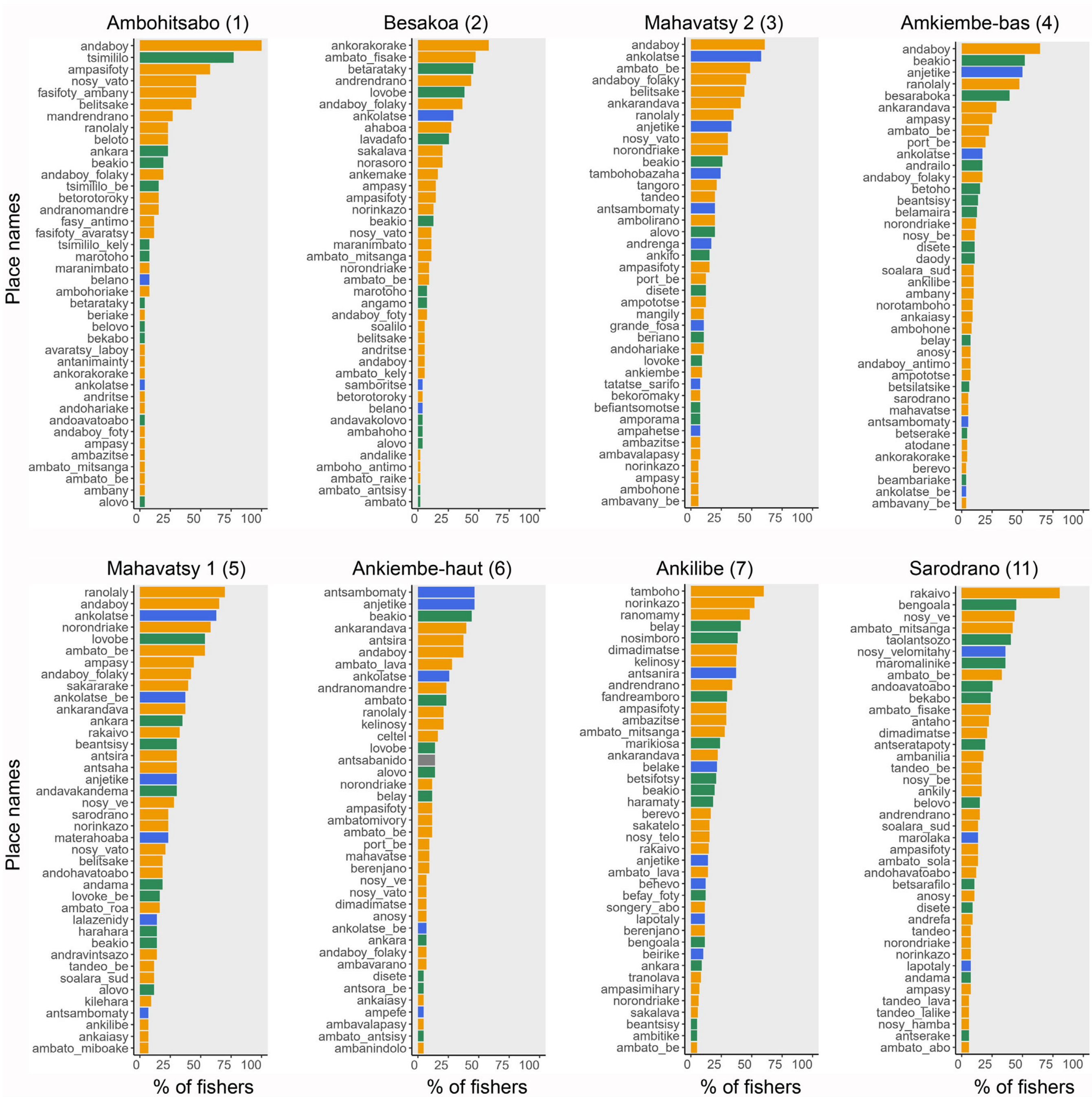

Fig. 4. Names and frequency of use (% of fishers per village) of fishing sites. The thematic meanings ascribed to names are shown as distinct colors with geographical characteristics (orange), maritime uses (blue), and biodiversity (green). Only the first 40 most-used fishing sites in each village are shown.

that other marine resources or flagship species were less frequently mentioned in the toponyms. The other sites of the biodiversity category ($n = 23$) were indeed named after invertebrates such as shellfish, coral, sea urchins, and sponges (177 fishers, or 31.1%), as well as emblematic non-exploited species such as whales and birds (151 fishers, or 26.5%). For example, the site *Nosimboro* used to be an islet habitat to many birds likely present in search of food according to local fishers (*nosy* translates as "islet" and *mboro* or *voro* as "bird").

A small number of sites ($n = 63$, 15.9% of total) were named according to maritime uses, in particular if they were close to or within a navigation area (e.g., passes) or an area intended for the practice of specific fishing or socio-cultural activities. These sites were visited by 118 fishers (20.7%) who mentioned traditional or recent fishing and non-fishing practices that they had experienced or observed in marine areas (Tab. 3). For example, *Andala masiny* means a channel for speedboats (*andala* meaning "on the way" or "road" and *masiny* meaning "machine" or "motorboat"), *Ankinerake* is an area reserved for surfing (*an* means "on the" and *kinerake* is a surfing activity), a fishing site called *Ankolatse* is reputed to be dangerous for diving (where *holatse* means a wound or injury), *Fandroahambe* designates an area known collectively pulling back fish to gillnets (*fandroaha* meaning "fish herding" and *be* meaning "big", "many" or "together"), and *Antanifaly* designates a taboo area where fishing used to be banned in the past due to spiritual beliefs. Although a few place names designated areas where fishing used to be restricted, such traditional community rules were not enforced any more based on the FGD. Other examples for the navigation category included *Andalanaomby*, which refers to an area close to a cart track (where *andala* means "on the way or road" and *aomby* means "beef") and *andalantsambo*, that designates the area where boats passed on their way to or from the port of Toliara (*andala* means "on the way or road" and *t-sambo* means "ship" or "vessel"). Finally, a minority of sites ($n = 15$) were named after fishers' names who often visited these sites.

Similar patterns were found at the village level. In each village, most of the fishing toponyms were associated with geographical characteristics of the seascape and landscape, while names related to maritime uses and biodiversity were less represented (Fig. 4).

3.2 Uses and location of fishing sites

The 397 fishing sites were visited by a highly varying number of fishers (i.e., from 0.2% to 32.3% of the total) during the fishery survey period. The majority of the toponyms ($n = 226$, 56.6%) were cited by less than 1% of the fishers, including the 26 toponyms that were not translated through the focus group discussion, which showed that such spatial knowledge was generally used by a rather small, although varying, proportion of the fishers within the area. Similar patterns were found at the village level. A total of 64.8–77.4% and 86.3–91.9% of the fishing sites was cited by less than 10% and 25% of the fishers, respectively (Fig. 4). Only 26 fishing sites (6.5%) were visited by more than 10% of the fishers monitored, including *Andaboy* (which designates the area near the lighthouses of the bay close to the commercial harbor of Toliara), *Ankorakorake* (which refers to the cave-shaped area of the barrier reef, where where an means "in" or "on" and *k-horake* means "cave"), *Ranolaly* (which designates a large basin, where *rano* means "water" or "sea" and *laly* means "deep"), *Antsambomaty* (which designates a shipwreck, where *an* means "in" or "on", *t-sambo* means "ship" or "vessel", and *maty* means "dead", "off", or 'not working"), *Tamboho* (which designates a sandblasted area at low tide, where *tamboho* or *tambohy* means "sand"), *Rakaivo* or *Riakaivo* (which is another name for the Nosy Tafara reef (Fig. 1), where *riaky* means "sea", and *aivo* means "middle", "in", or "on"), *Tsimililo* (which designates an area rich in the fish locally-named *Tsimililo*), and *Ankolatse* (which designates an area that causes injuries, where *holatse* means "wound" or "injury").

We also noticed a significant variability in the number of fishing sites visited per fisher, which was an indication of the spatial distribution of the individual fishing pressure during the survey period. Each fisher visited at least one fishing site, and up to 27 at most, with an average of 10 fishing sites per fisher.

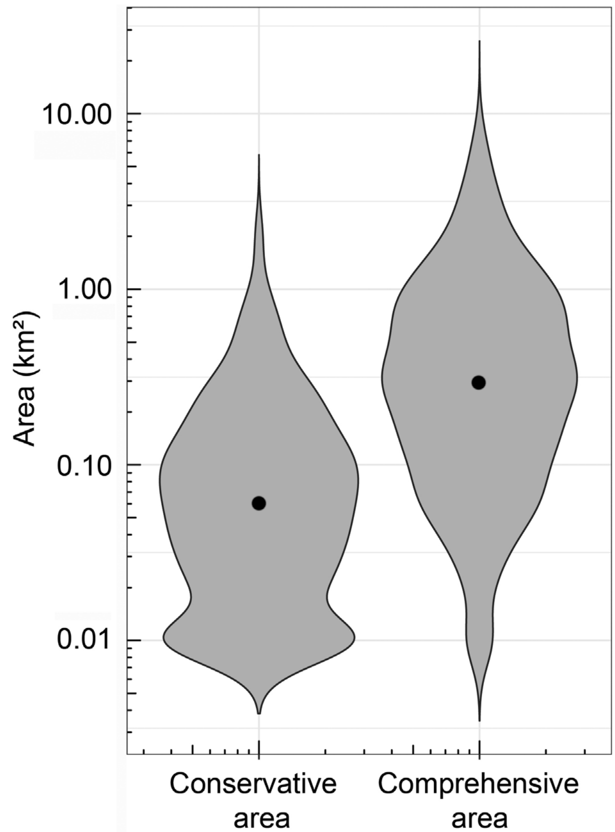

Fig. 5. Variation in the surface area of named fishing sites (log scale) according to the delimitation thresholds of fishing sites: 50% (conservative area) and 90% (comprehensive area) of all fishing positions recorded. Black dots refer to median values. See Methods and Figure 2 for details.

The sample showed that 74.9% of the fishers ($n = 427$) visited fewer than 13 fishing sites, while the bottom quarter visited fewer than six fishing sites.

A total of 7,988 fishing trips (50.2% of the total) were successfully tracked. They extended over about 250 km^2 both within the Bay of Toliara and in open waters. Among the 397 toponyms recorded, 304 (76.6%) were associated with positions at sea, which allowed for mapping the corresponding fishing sites. The spatial extent of the fishing sites significantly varied among them and according to the delimitation type: the conservative and comprehensive areas of the each fishing site at the village level covered 0.01 to 2.2 km^2 (0.13 km^2 on average) and 0.01 to 11.7 km^2 (0.65 km^2 on average), respectively (ANOVA, $p < 2e\text{-}16$; Fig. 5). On average, the conservative area represented 23.9% of the comprehensive area of named fishing sites. We did not observe any significant difference in surface area of individual fishing sites among the thematic meanings ascribed to toponyms.

The overall fishing grounds extended over 38 km^2 and 110 km^2 (15% and 44% of the total geographical coverage of the fishing trips recorded, respectively) based on the conservative and comprehensive delimitation areas of the fishing sites, respectively (Fig. 6I). In other words, almost half of the fishing ground extent was designated by locally-named

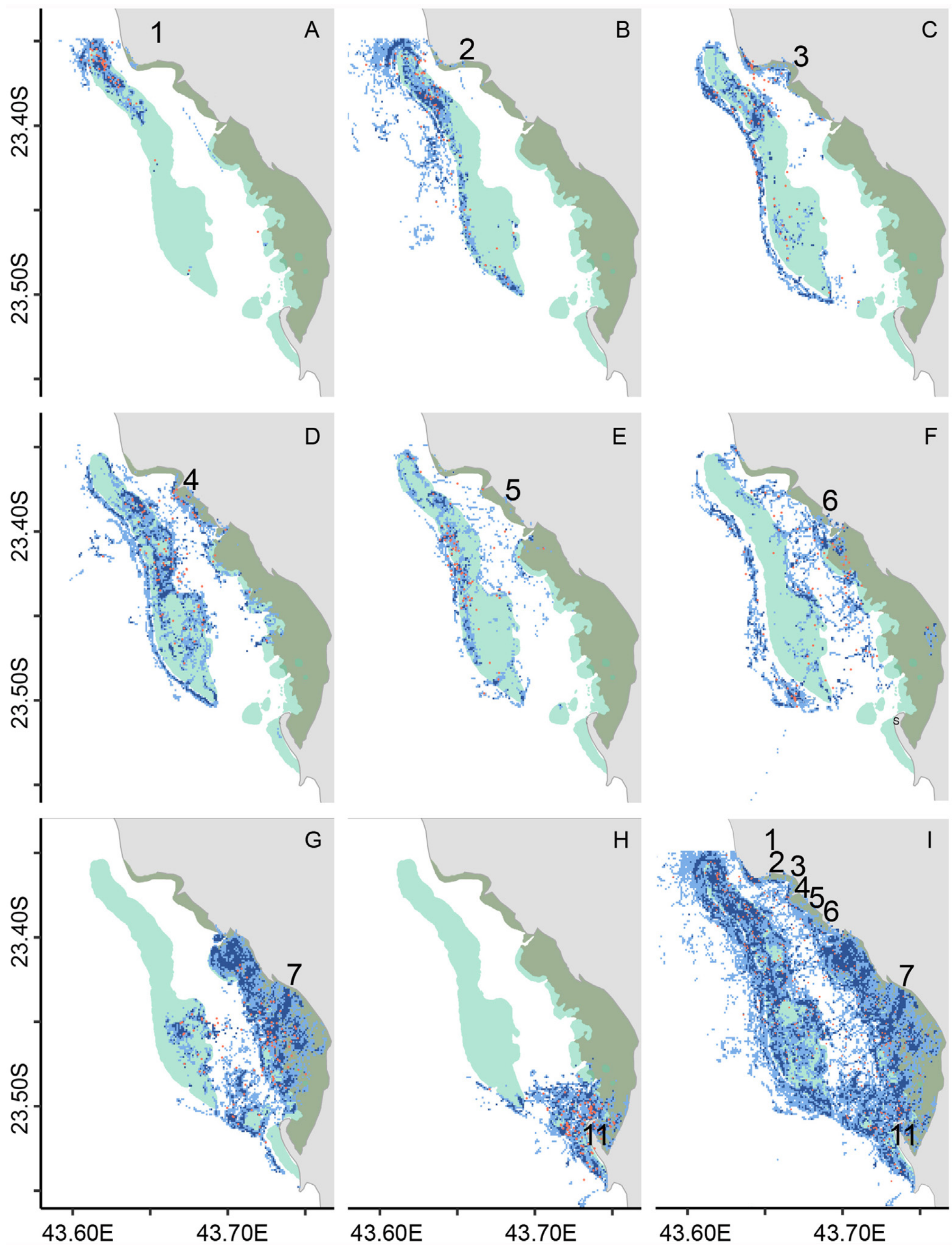

Fig. 6. Extent of the fishing grounds of each village (A-H) and all villages (I) according to the delimitation thresholds of fishing sites. Conservative (in deep blue) and comprehensive (in light blue) fishing areas gather 50% and 90% of all fishing positions recorded at each site, respectively. Village numbers correspond to Ambohitsabo (1), Besakoa (2), Mahavatsy 2 (3), Ankiembe-bas (4), Mahavatsy 1 (5), Ankiembe-haut (6), Ankilibe (7), and Sarodrano (11). See Methods and Figure 2 for details.

fishing sites while fishers used the same toponyms to identify more distant fishing spots that they visited occasionally. At the village level, the fishing grounds extended over 2.2-15.7 km^2 and 6.9-39.7 km^2 based on both delimitations of the fishing sites, respectively, and mostly overlapped in the Bay of Toliara (Fig. 6A-H). The territorial nature of fishing activities is presented in Behivoke et al. 's publication of this special issue by the Journal.

The density of distinct fishing toponyms strongly differed according to the geomorphological zones of the study area, as a result of the number of fishers that visited those sites and the presence of visual or symbolic spatial markers of the environment as described above (Fig. 6I). It was much higher within reef areas ($n = 242$, 5.05 site.km^{-2}, including 134 sites on the barrier reef and 108 sites on the intermediate reefs) compared with the lagoon area (42 sites, 0.74 site.km^{-2}) and the reef slope or intertidal terrace (27 sites, 0.33 sites.km^{-2}).

Overall most fishing locations (63.3% of the fishing area) were referred to through two or more (up to 34) names

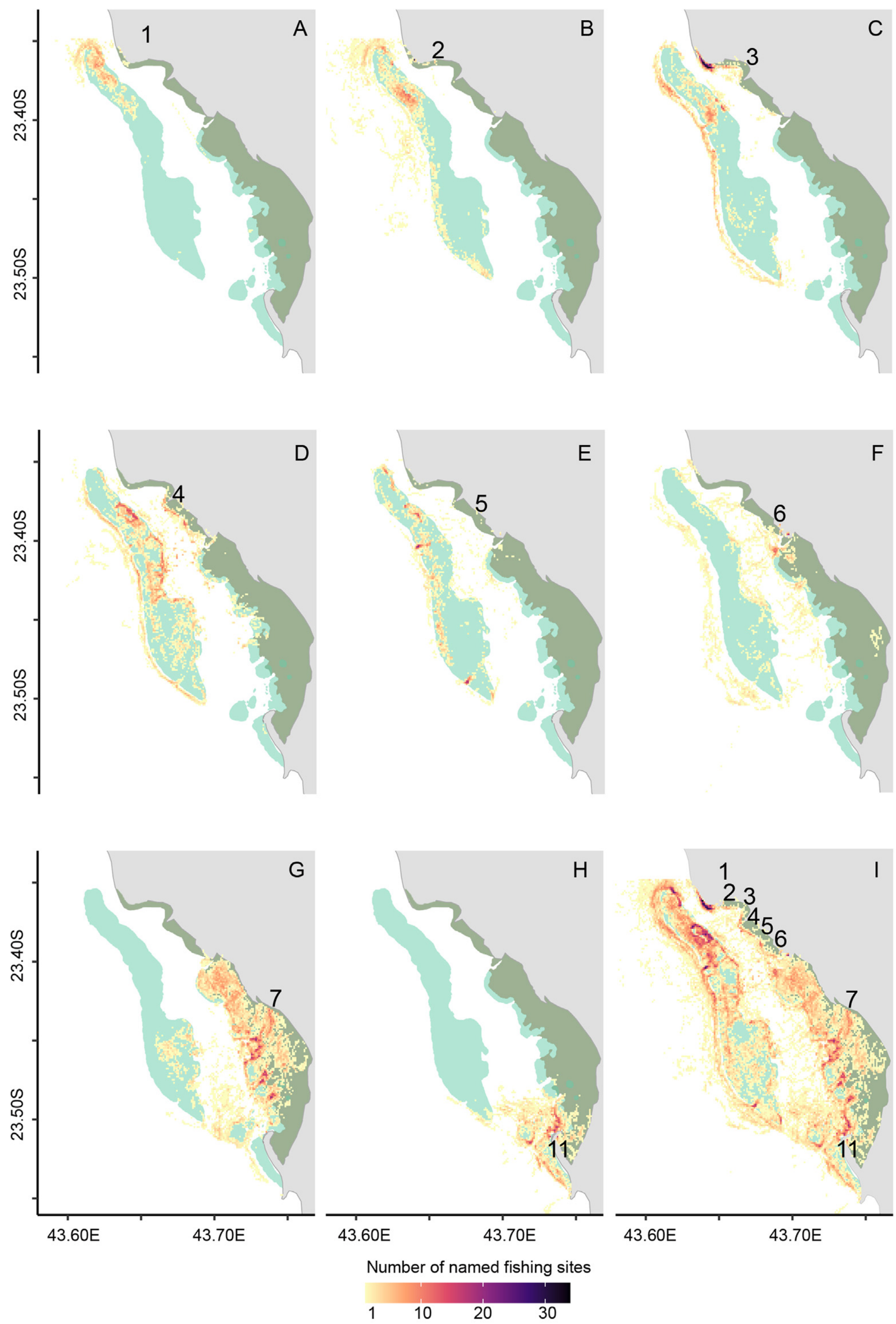

Fig. 7. Number of named fishing sites (toponyms) recorded at each 1-ha cell within each community fishing ground (A-H) and globally (I) in the study area. The comprehensive delimitation threshold (90%) of the fishing sites was used (see Methods for details). Village numbers correspond to Ambohitsabo (1), Besakoa (2), Mahavatsy 2 (3), Ankiembe-bas (4), Mahavatsy 1 (5), Ankiembe-haut (6), Ankilibe (7), and Sarodrano (11).

(Fig. 7I), which indicated that fishers usually used different toponyms to designate their respective fishing sites, consistently with the above finding that each toponym was generally used by one to few fishers only. Specifically, we generally recorded 2-5 toponyms and occasionally 6-10 toponyms at any fishing location (48.3% and 12.0% of the whole fishing grounds, respectively). This situation was common in the barrier reef in the northern part of the study area, close to the intermediate reefs, and on the shallow terrace alongside the coastline where fishing sites spread over large areas and/or were close to each other as described above. Such patterns were also observed at the village level. Indeed 24.7% to 60.1% of community fishing grounds were designated after two or more place names (Fig. 7A-H).

Fishers from different villages sometimes used the same place names to designate different fishing sites ($n = 12$) that shared similar geographical or geomorphological features. Example included *Ampasy* ("on sand"), *Ampasifoty* ("on white sand"), *Andranomandre* or *Andrendrano* ("in strong water current"), *Andrefa* ("westwards"), *Ankara* ("within a reef area"), *Ankaradava* ("within a long reef zone"), *Anosy* ("near a islet"), and *Ambavarano* ("within a water channel"). Conversely, variants of toponyms designated the same well-known landmarks regardless of the fisher's village of origin, e.g., *Andaboy* ("near the lighthouse"), *Andaboy mena* ("near the lighthouse with a red light"), *Andaboy foty* ("near the lighthouse with a white light"), and *Andaboy folaky* ("near the hidden lighthouse") all referred to the same area close to the commercial port of Toliara.

We also observed that the fine-scale difference in location of similarly-named fishing sites was sometimes linked to the type of fishing gear used within or across villages. Such toponyms designated areas that overlapped heterogeneous habitat and/or depth areas, therefore including distinct gear-specific fishing sites. For example, fishers from the villages Mahavatsy 2, Amkiembe-bas, and Sarodrano using handline/gillnet, speargun, and mosquito net trawl/beach seine, respectively, located the fishing site *Ambohone* near coral reef patches, in deeper waters, and close to the shoreline, respectively, while *Ambitiky* ("several", "many", or "rich") referred to different fishing sites rich in corals and/or fish targeted by gillnet, handline, and speargun fishers from the villages of Ankilibe and Sarodrano.

4 Discussion

4.1 Fishers' spatial knowledge of the marine environment

This participatory research is among the few studies that comprehensively and accurately locate, delimit, and attribute meaning to local fishing sites in coastal small-scale fisheries. We identified 397 fishing sites within a 250 km^2 area in southwestern Madagascar, highlighting local fishers' extensive spatial knowledge interwoven with geographical markers, maritime practices, and biodiversity. The diversity of individual knowledge bases, perceptions and conceptualization of marine areas was evidenced by the large number of named fishing sites recorded by participating fishers and derived from remarkable, mainly descriptive, visual or symbolic features.

An unexpected result was that fishers did not share a common spatial representation of the marine environment within the communities and study area. Most fishing place names were mentioned by only one or a small number of fishers, resulting in a high density and overlap of named fishing sites among fishers at village and study area levels, especially in the most heavily exploited zones. Fishers' mental geography of the marine environment highlighted the personal, sometimes intimate value of their relationship with the sea, from which they derive reference points for navigating and identifying target fishing areas. Our results align with previous research showing that coastal community inhabitants and fishers possess distinctive, very detailed geographical knowledge shaped by fishing traditions and individual practices, and used in conversations with peers through symbolic place names (McCall Howard, 2019). For instance, Smith et al. (2016) mapped about 400 place names within a 300-km^2 area in fishing communities in Newfoundland. In other studies of small-scale fisheries, named fishing sites were reported as juxtaposed, not-overlapping zones, which suggests that fishing site boundaries are unique, known, and consensually defined and used within small-scale fishing communities. For instance, Schafer and Reis (2008) mapped 124 juxtaposed place names over about 1,000 km^2 in the estuary of Patos lagoon in Brazil based on experienced fishers' knowledge in seven communities, while Ratsimbazafy et al. (2016) recorded 325 juxtaposed, named fishing sites over about 100-km^2 large fringing reefs in 13 communities in Southwest Madagascar. Conversely, our findings suggest that such mosaic-like patterns may be an oversimplified interpretation of community spatial knowledge that may not account for the heterogeneity of fishers' place names on topographic map representations.

The lack of GPS devices as individual fishing equipment in southwestern Madagascar, unlike in more advanced small-scale fisheries, likely promoted the use of alternative geolocation tools such as fishing toponyms, thereby contributing both to the diversity and confidentiality of these place names. Indeed fishers' focus on specific areas is driven by access to resources and expected fishing yield, supported by their extensive ecological knowledge on target species (McCall Howard, 2019). Following this perspective, we argue that between-fisher competition may explain why fishers' spatial knowledge was mostly composed of individual, utilitarian knowledge rather than collective knowledge in the low-technology small-scale fishery in our study area. Consistently with this interpretation, few place names at sea carried cultural or identity significance in our study area, contrasting with other studies (e.g., Triana et al., 2022). As a consequence we have not published the location of the named fishing sites for confidentiality reasons. Future social research would be useful to more deeply understand how fishers mentally represent their surroundings and share (or do not share) their spatial knowledge between generations and with other fishers of the Vezo or other ethnic groups from past and ongoing settlement, following the history of the fishery.

4.2 Using fishers' spatial knowledge in fisheries evaluation

This mixed-method study addresses spatial data limitations in the context of small-scale fisheries by using named fishing sites at village level as fine-scale spatial reference units with known precision and accuracy. The accurate location of the named fishing sites was characterized through an extensive GPS-based monitoring survey, which was used to reliably quantify their spatial dimensions through spatial analysis. We found that the size of named fishing sites varied by four orders of magnitude (i.e., from a 0.01 to a 10-km scale) according to fishers' conceptualization of the environment, consistently with other surveys of fishers' geographical knowledge such as those mentioned above. Additionally, the concept of conservative and comprehensive delimitations of fishing sites (i.e., following a spatial gradient in fishing distribution within a 1-ha cell grid; Fig. 2) was introduced in the spatial analysis to assess the precision *vs.* fuzziness of their boundaries, analogous to the ecological concept of home range (Pittman and McAlpine 2001). The comprehensive area delimitation of named fishing sites was on average four times larger than the conservative one and represented the more likely, although less precise, boundaries of these sites. This difference in precision arose because fishers used the same toponym to identify fishing spots at a distance one from another, which was likely driven by a number of factors including fishers' geographies and confidentiality issues as discussed above. Finally, the georeferenced fishing sites and their respective names were anonymized for confidentiality reasons and introduced in a fishery geographical information system (GIS) as spatial reference units. By recording fishing place names for each fishing trip as part of future regular fishery surveys, such a reference information system would therefore allow for the cost-effective spatialization of corresponding fishery-dependent data (e.g., fishing effort, catch). We recommend using the comprehensive threshold (i.e., 90% of GPS fishing positions attributed to each named fishing site) to delimitate the spatial reference units at the village level to achieve a more representative and accurate spatial allocation of associated fishery data.

When highly resolved spatial temporal data is not routinely achievable as is common in most small-scale fishery contexts (but see Tilley et al., 2020), our framework would enable a more detailed and reliable depiction of spatial temporal patterns of fishing activity distribution than currently available methods. To date, fishing location in small-scale fisheries have indeed usually been identified with limited *in situ* data through map-based survey methods (Léopold et al., 2014; Grati et al., 2022) or alternative socioeconomic, technological, and geographical proxies, balancing data acquisition costs, expected data accuracy, survey scale, and fishers' participation (Stewart et al., 2010; Thiault et al., 2017). The research framework is applicable in other geographic areas provided that boat tracking data and vernacular names can be recorded simultaneously through an extensive survey, with our proof-of-concept suggesting potential for further exploration of scalability. Two drawbacks need to be highlighted. First initialization and updating costs should be considered and scaled, particularly in developing fisheries. Creating the reference geodatabase of named fishing sites requires setting the conditions for building trust within and support of local fishing communities for sharing their spatial, partly confidential knowledge, financial capacity for baseline data collection among a large sample of fishers, and advanced academic education for processing spatial data. The latter condition may be facilitated by innovative computer tools and digital applications (e.g., Guitton and Mohamed, 2023; Tilley et al., 2024). Updating the reference fishery GIS would also be needed to detect whether the fishery expands spatially over time (seasons or years) and avoid potential misinterpretation of fishing effort allocation since new, unreferenced, place names will likely be used to designate new fishing areas. Second, the average spatial resolution of the toponyms achieved in our survey was 0.65 km^2 (standard deviation = 1.02) while the area effectively fished by small-scale fishers would be accurately estimated at much finer spatial resolution (e.g., 0.01 km^2 following Mendo et al.'s (2019) survey). Subsequently, our framework would likely overestimate the extent of the area fished during one fishing trip and capture the spatial patterns of fishing activities at 0.25- to 1-km^2 grid cell size, as a compromise between the costs and expected spatial precision of fishery surveys.

Leveraging fishers' knowledge holds promise for generating more accurate georeferenced information of resource use in those fisheries that lack boats' movements monitoring system, thereby facilitating informed decision-making processes through transdisciplinary research. By integrating small-scale fishers' knowledge of toponyms with scientific data on the fine-scale distribution of fishing effort, our transdisciplinary framework is a valuable contribution to the debate on knowledge pluralism (Tengö et al., 2014) and co-production (Norström et al., 2020; Cavaleri Gerhardinger et al., 2023) in sustainability research on small-scale fisheries. Indeed, despite considerable social science literature has established the relevance and legitimacy of fishers' knowledge for fishery management during the last two decades (e.g., Neis et al., 1999; Berkes et al., 2000; Johannes et al., 2000; Murray et al., 2005; Aswani and Lauer 2006; Murray et al., 2008; Aswani, 2017), persistent social and cultural barriers question the validity of such knowledge as compared to scientific knowledge (Soto 2006). To date, small-scale fishers' knowledge has generally been overlooked by mainstream fisheries science and not incorporated in the basis of resource evaluation and management (Hind, 2015). We argue that our framework addresses some of the methodological challenges of integrating fishers' spatial knowledge in fisheries science, by assessing how such knowledge may be gathered as part of fishery-dependent surveys and used to quantify fishing effort distribution at known spatial resolution, which is relevant to inform management at local level (McCluskey and Lewison, 2008; James, 2025). This study is expected to contribute to the growing effort for collaborative fishers' knowledge research as a way to address both evaluation and management challenges in small-scale fisheries (Stephenson et al., 2016). Future research should further explore the implications for generalizing the framework and evaluating its outputs, aiming to establish it as a standard part of monitoring and managing data-limited small-scale fisheries globally.

5 Conclusion

We developed a participatory research framework combining fishers' knowledge and high resolution spatial data on fishing sites as part of an extensive survey in a coral reef small-scale fishery in Madagascar. While fishing place names related to spatial patterns of resource harvest and access, they also revealed fishers' conceptualization of the marine environment. The geographical boundaries of fishing sites were mapped following a gradient-based approach for spatial use patterns, which proved relevant for using place names as local spatial reference units with known precision and accuracy. These findings underscore the potential of fishers' spatial knowledge in tackling spatial data limitations in the evaluation and management of small-scale fisheries.

Acknowledgments

This work was funded by the French institute for sustainable development (IRD) as part of the IH.SM–IRD research partnership (JEAI-ACOM), the MIKAROKA international research laboratory, and by the Laboratory of Excellence CORAIL, France (GEOFIA and MANJONO grants). We would like to express our sincere thanks to all those who, in any way, contributed to this work. We thank Jérôme Guitton for his help in data management. We thank the laboratory assistants for their invaluable help with data collection, particularly Duffarno, Tsipy Romano, and Jean-Jacques Marcelin. This work would not have been possible without our local assistants and the *fokontany* chiefs, who guided us and facilitated communication with the fishers. We would particularly like to thank the fishers who agreed to participate in the survey. We thank the three anonymous reviewers whose suggestions contributed to significantly improve the original manuscript and Emma Gibbons from Reef Doctor for her kind proofreading.

Data availability statement

The research data associated with this article are available in DataSuds repository (IRD, France), under the reference https://doi.org/10.23708/G7IH98.

References

Alvard M, Carlson D, McGaffey E. 2015. Using a partial sum method and GPS tracking data to identify area restricted search by artisanal fishers at moored fish aggregating devices in the commonwealth of dominica. *PLOS One* 10: e0115552.

Andréfouët S, Guillaume MMM, Delval A, Rasoamanendrika FMA, Blanchot J, Bruggemann JH. 2013. Fifty years of changes in reef flat habitats of the Grand Récif of Toliara (SW Madagascar) and the impact of gleaning. *Coral Reefs* 32: 757–768.

Astuti R. People of the Sea: Identity and Descent Among the Vezo of Madagascar, Cambridge University Press, 1995.

Aswani S. 2017. Customary management as TURFs: social challenges and opportunities. *Bull Mar Sci* 93: 3–12.

Aswani S, Lauer M. 2006. Incorporating fishermen's local knowledge and behavior into geographical information systems (GIS) for designing marine protected areas in Oceania. *Hum Organ* 65: 81–102.

Behivoke F, Etienne MP, Guitton J, Randriatsara RM, Ranaivoson E, Léopold M. 2021. Estimating fishing effort in small-scale fisheries using GPS tracking data and random forests. *Ecol Indic* 123: 107321.

Berkes F, Colding J, Folke C. 2000. Rediscovery of traditional ecological knowledge as adaptivemanagement. *Ecol Appl* 10: 1251–1262.

Calamia MA. 1999. A methodology for incorporating traditional ecological knowledge with geographic information systems for marine resource management in the Pacific. *SPC Tradit Mar Resource Manag Knowledge Inform Bull* 10: 2–12.

Camacho R, Steneck R. 2017. Creating a TURF from the bottom-up: Antigua's community-based coral reef no-take reserve. *Bull Mar Sci* 93: 217–232.

Cavaleri Gerhardinger L, Brodie Rudolph T, Gaill F, Mortyn G, Littley E, Vincent A, Firme Herbst D, Ziveri P, Jeanneau L, Laamanen M, Cavallé M, Marisca Gietzelt J, Glaser M, Chambon M, Jacquemont J, Ahmed Selim S, Brugere C, Brito C, Pereira LM, Colonese AC. 2023. Bridging shades of blue: co-constructing knowledge with the international panel for ocean sustainability. *Coast Manag* 51: 244–264.

Conway J, Eddelbuettel D, Nishiyama T, Prayaga SK, Tiffin N. 2024. RPostgreSQL: R Interface to the 'PostgreSQL' Database System (0.7-6).

Fauroux E, Koto B.1993. Les migrations Mahafales dans le processus de ruralisation de la ville de Toliara (Madagascar), in: V. Dupont, C. Guilmoto (Eds.), Mobilités spatiales et urbanisation: Asie, Afrique, Amérique. Cahiers des Sciences Humaines Vol. 29:547–564.

Grati F, Azzurro E, Scanu M, Tassetti AN, Bolognini L, Guicciardi S, Vitale S, Scannella D, Carbonara P, Dragičević B, Ikica Z, Palluqi A, Marčeta B, Ghmati H, Turki A, Cherif M, Bdioui M, Jarboui O, Benhadjhamida N, Mifsud J, Milone N, Ceriola L, Arneri E. 2022. Mapping small-scale fisheries through a coordinated participatory strategy. *Fish Fish* 23: 773–785.

Guitton J, Mohamed S. 2023. GPSMonitoring: A R package for small scale fisheries monitoring using GPS logger. *Softw Impacts* 17: 100573.

Herinirina PA, Bigot L, Frouin P, Volandrae HTE, Randriatsara RM, Behivoke F, Ranivoarivelo L, Léopold M. 2023. Seagrass macroinvertebrate bycatches support mosquito net trawl fishery in Madagascar. *Aquat Living Resour* 36: 18.

Hijmans RJ, Etten J, Sumner M, Cheng J, Baston D, Bevan 1A, Bivand R, Busetto L, Canty M, Fasoli B, Forrest D, Ghosh A, Golicher D, Gray J, Greenberg JA, Hiemstra P, Hingee K, Ilich A, Geosciences I, for MA, Wueest R. 2023. Geographic data analysis and modeling (3.6-26). [Computer software] https://cran.r-project.org/web/packages/raster/index.html

Hind EJ. 2015. A review of the past, the present, and the future of fishers' knowledge research: a challenge to established fisheries science. *ICES J Mar Sci* 72: 341–358.

James I. 2025. Participatory seascape mapping: a community-based approach to ocean governance and marine conservation. *Ocean Coast Manag* 261: 107531.

Jennings S, Lee J. 2012. Defining fishing grounds with vessel monitoring system data. *ICES J Mar Sci* 69: 51–63.

Johannes RE, Freeman MMR, Hamilton RJ. 2000. Ignore fishers' knowledge and miss the boat. *Fish Fish* 1: 257–271.

Kimani P, Obura D. 2004. Participatory mapping of terrestrial fishery resources in Kwale district, Kenya. *Western Indian Ocean J Mar Sci* 3: 209–220.

Kobryn HT, Brown G, Munro J, Moore SA. 2018. Cultural ecosystem values of the Kimberley coastline: an empirical analysis with implications for coastal and marine policy. *Ocean Coast Manag* 162: 71–84.

Laroche J, Ramananarivo N. 1995. A preliminary survey of the artisanal fishery on coral reefs of the Tulear Region (southwest Madagascar). *Coral Reefs* 14: 193–200.

Léopold M, Guillemot N, Rocklin D, Chen C. 2014. A framework for mapping small-scale coastal fisheries using fishers' knowledge. *ICES J Mar Sci* 71: 1781–1792.

Lester S, McDonald G, Clemence M, Dougherty D, Szuwalski C. 2017. Impacts of TURFs and marine reserves on fisheries and conservation goals: theory, empirical evidence, and modeling. *Bull Mar Sci* 93: 173–198.

Manzo LC, Perkins DD. 2006. Finding common ground: the importance of place attachment to community participation and planning. *J Plan Lit* 20: 335–350.

McCall Howard P. Working grounds, producing places and becoming at home at sea, in: T.K. King, G. Robinson (Eds.), At Home on the

Waves. Human habitation of the sea from the Mesolithic to today 2019, pp. 34–61.
McCluskey SM, Lewison RL. 2008. Quantifying fishing effort: a synthesis of current methods and their applications. *Fish Fish* 9: 188–200.
Mendo T, Smout S, Russo T, D'Andrea L, James M. 2019. Effect of temporal and spatial resolution on identification of fishing activities in small-scale fisheries using pots and traps. *ICES J Mar Sci* 76: 1601–1609.
Mills CM, Townsend SE, Jennings S, Eastwood PD, Houghton CA. 2007. Estimating high resolution trawl fishing effort from satellite-based vessel monitoring system data. *ICES J Mar Sci* 64: 248–255.
Murray G, Bavington D, Neis B. 2005. Local ecological knowledge, science, participation and fisheries governance in newfoundland and labrador: a complex, contested and changing relationship, in: T.S. Gray (Ed.), Participation in Fisheries Governance, Reviews: Methods and Technologies in Fish Biology and Fisheries. Springer: Netherlands, Dordrecht, pp. 269–290.
Murray G, Neis B, Palmer CT, Schneider DC. 2008. Mapping cod: fisheries science, fish harvesters' ecological knowledge and cod migrations in the Northern Gulf of St. Lawrence. *Hum Ecol* 36: 581–598.
Neis B, Schneider DC, Felt L, Haedrich RL, Fischer J, Hutchings JA. 1999. Fisheries assessment: what can be learned from interviewing resource users? *Can J Fish Aquat Sci* 56: 1949–1963.
Norström AV, Cvitanovic C, Löf MF, West S, Wyborn C, Balvanera P, Bednarek AT, Bennett EM, Biggs R, de Bremond A, Campbell BM, Canadell JG, Carpenter SR, Folke C, Fulton E.A., Gaffney O, Gelcich S, Jouffray JB, Leach M, Österblom H. 2020. Principles for knowledge co production in sustainability research. *Nat Sustain* 3: 182–190.
Oksanen J, Simpson GL, Blanchet FG, Kindt R, Legendre P, Minchin PR, O'Hara RB, Solymos P, Stevens MHH, Szoecs E, Wagner H, Barbour M, Bedward M, Bolker B, Borcard D, Carvalho G, Chirico M, Caceres MD, Durand S, Weedon J. 2024. Vegan: Community Ecology Package (2. 6-6. 1).
Ottino-Garanger P, Ottino-Garanger MN. 2017. Toponymie littorale aux îles Marquises, Fenua 'Enata/Henua 'Enana, Polynésie orientale (Polynésie française). *Revue d'ethnoécologie* 11.
Pittman SJ, McAlpine CA. 2001. Movements of marine fish and decapod crustaceans: process, theory and application, in: Advances in Marine Biology, Elsevier, pp. 205–294.
Quinn T, Bousquet F, Guerbois C. 2019. Changing places: the role of sense of place in perceptions of social, environmental and overdevelopment risks. *Glob Environ Change* 57: 101930.
Rajala K, Sorice MG, Thomas VA. 2020. The meaning(s) of place: Identifying the structure of sense of place across a social-ecological landscape. *People Nat* 2: 718–733.
Ranaivomanana HS, Jaquemet S, Ponton D, Behivoke F, Randriatsara RM, Mahafina J, Léopold M. 2023. Intense pressure on small and juvenile coral reef fishes threatens fishery production in Madagascar. *Fish Manag Ecol* 30: 494–506.
Ratsimbazafy HA, Oleson KLL, Roy R, Raberinary D, Harris A. 2016. Fishing site mapping using local knowledge provides accurate and satisfactory results: case study of Octopus fisheries in Madagascar. *Western Indian Ocean J Mar Sci* 15: 1–7.
Schafer AG, Reis EG. 2008. Artisanal fishing areas and traditional ecological knowledge: the case study of the artisanal fisheries of the Patos Lagoon estuary (Brazil). *Marine Policy* 32: 283–292.
Smith D, Woodrow M, Vodden K. 2016. A boat perspective: Local geographic knowledge of fish harvesters in Change Islands, Newfoundland. *J Cult Geogr* 33: 1–26.
Soto CG. 2006. Socio-Cultural Barriers to Applying Fishers' Knowledge in Fisheries Management: An Evaluation of Literature Cases. *Simon Fraser University (PhD), Burnaby, Canada*.
Stedman RC. 2016. Subjectivity and social-ecological systems: a rigidity trap (and sense of place as a way out). *Sustain Sci* 11: 891–901.
Stephenson RL, Paul S, Pastoors MA, Kraan M, Holm P, Wiber M, Mackinson S, Dankel DJ, Brooks K, Benson A. 2016. Integrating fishers' knowledge research in science and management. *ICES J Mar Sci* 73: 1459–1465.
Stewart KR, Lewison RL, Dunn DC, Bjorkland RH, Kelez S, Halpin PN, Crowder LB. 2010. Characterizing fishing effort and spatial extent of coastal fisheries. *PLOS One* 5: e14451.
Tengö M, Brondizio ES, Elmqvist T, Malmer P, Spierenburg M. 2014. Connecting diverse knowledge systems for enhanced ecosystem governance: the multiple evidence base approach. *Ambio* 43: 579–591.
Thiault L, Collin A, Chlous F, Gelcich S, Claudet J. 2017. Combining participatory and socioeconomic approaches to map fishing effort in small-scale fisheries. *PLOS One* 12: e0176862.
Tilley A, Dam Lam R, Lozano Lazo D, Dos Reis Lopes J, Freitas Da Costa D, De Fátima Belo M, Da Silva J, Da Cruz G, Rossignoli C. 2024. The impacts of digital transformation on fisheries policy and sustainability: lessons from Timor-Leste. *Environ Sci Policy* 153: 103684.
Tilley A, Dos Reis Lopes J, Wilkinson SP. 2020. PeskAAS: a near-real-time, open-source monitoring and analytics system for small-scale fisheries. *PLOS One* 15: e0234760.
Torres-Irineo E, Salas S, Euán-Ávila JI, Palomo LE, Quijano Quiñones DR, Coronado E, Joo R. 2021. Spatio-temporal determination of small-scale vessels' fishing grounds using a vessel monitoring system in the Southeastern Gulf of Mexico. *Front Mar Sci* 8: 643318.
Triana HW, Kustati M, Nelmawarni, Reflinaldi R. 2022. West coastal toponyms of Sumatra Insland: a corpus linguistics study. OKARA: Jurnal Bahasa dan Sastra 16 90–108.
Valkó O, Bede Á, Rádai Z, Deák B. 2023. 'Sense of place' and conservation: Toponym diversity helps to maintain vegetation naturalness. *People and Nature* 5: 1027–1033.
Veriza F, Chazan-Gillig S, Manjakahery B. 2018. Les Vezo du littoral sud-occidental de Madagascar: les oubliés de la terre ou les enfants adoptifs de la mer-mère. *J des Anthrop* 154–155: 261–283.
Wickham H, François R, Henry L, Müller K, Vaughan D. 2023. Dplyr: a grammar of data manipulation. R package version 1.1.4
Wynveen, C. J., Kyle, G. T., & Sutton, S. G. (2012). Natural area visitors' place meaning and place attachment ascribed to a marine setting. *J Environ Psychol*, 32: 287–296.
Wynveen CJ, Kyle GT. 2015. A place meaning scale for tropical marine settings. *Environ Manag*, 55: 128–142.
Young MAL, Foale S, Bellwood D. 2016. Why do fishers fish? A cross-cultural examination of the motivations for fishing. *Mar Policy* 66: 114–123.

Cite this article as: Randriatsara RM, Behivoke F, Ramahatratra F, Mahafina J, Lamy T, Léopold M. 2025. Mapping place names for small-scale fisheries evaluation. *Aquat. Living Resour.* 38. 13. https://doi.org/10.1051/alr/2025009