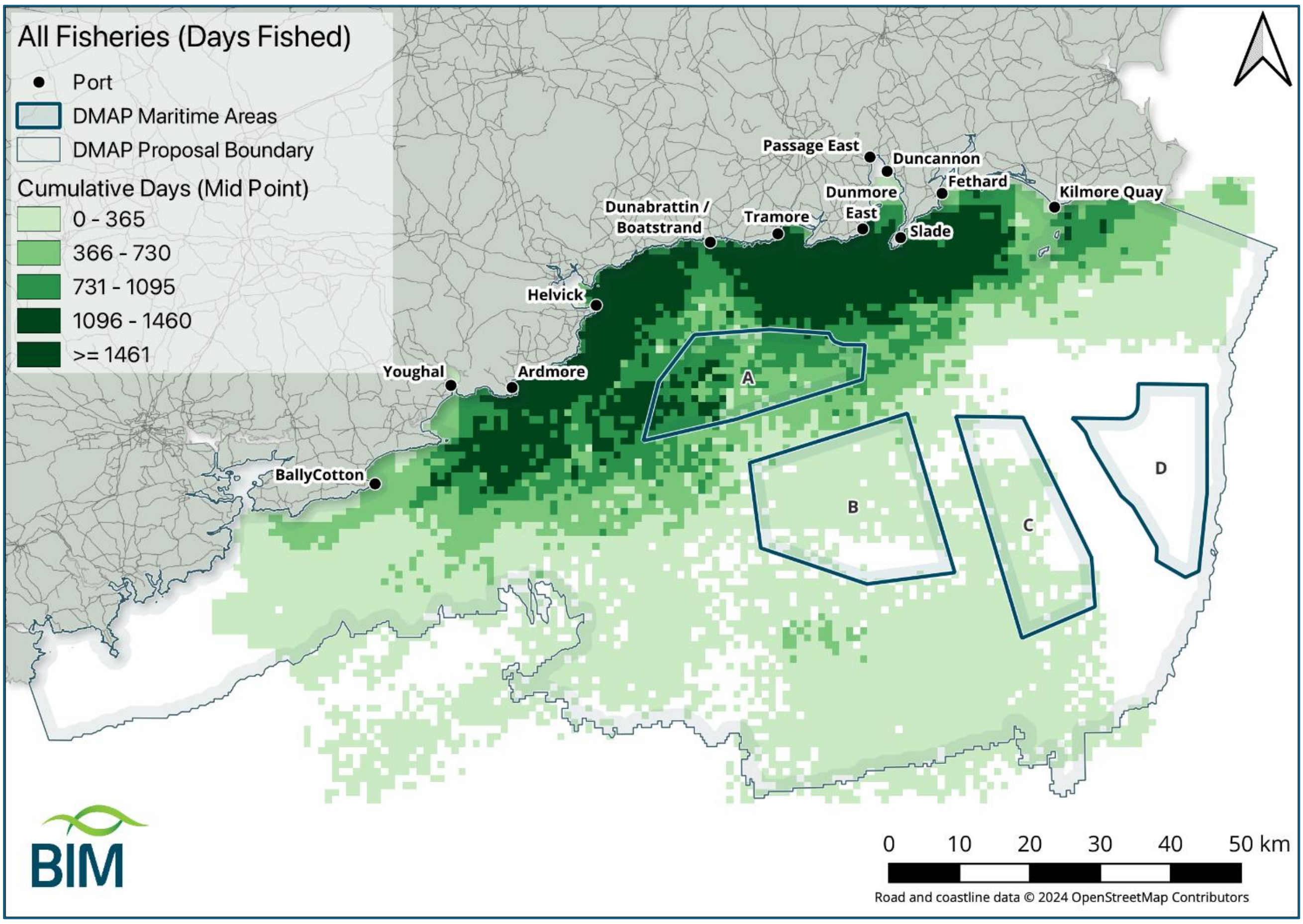
Participatory mapping of small fishing vessel activities for marine spatial planning



Marine Spatial Planning Report **January 2025**

Participatory mapping of small fishing vessel activities for marine spatial planning

Elizabeth Tray[1], Jonny Huck[2], John Hickey[1], Sean Daly[1], Ronan Cosgrove[1]
[1]Bord Iascaigh Mhara (BIM), Regional offices in Galway, Wexford and Cork, Ireland
[2]Lune Geographic Ltd., 49 Bridgeside, Carnforth, Lancashire, LA5 9LF.

Email: Elizabeth.Tray@bim.ie

Key Findings

- We successfully developed a new fisheries participatory mapping approach to address data gaps for under 12 m vessels in the south coast designated maritime area plan for offshore wind.
- We conducted face-to-face interviews with 78 vessel owners on board their vessels to collect and validate data on 244 yearly fishing activities related to 22,700 fishing days.
- Lobster, crab and shrimp potting were the three main fisheries accounting for 78% of the total days fished with a range of other fisheries also operating in the area.
- Of the four refined maritime areas where future offshore wind farms may be located, most fishing occurred in Maritime area A, followed by B and C with no fishing reported in area D.
- Combined fisheries maps and associated data are immediately available for marine spatial planning purposes.

Có-mhaoinithe ag an Aontas Eorpach
Co-funded by the European Union

Rialtas na hÉireann
Government of Ireland

Introduction

The under 12 m vessel sector forms an important component of Ireland's commercial fishing fleet. Some 1,144 < 12 m vessels accounted for 20% of revenue, 56% of employment and 82% of the total number of vessels in the Irish fleet in 2022. The sector generally operates in remote coastal locations and brings much needed money to local communities and their hinterlands (Perry et al., 2024).

There are major gaps in spatial knowledge of fishing activities for < 12 m vessels as they are generally not required to carry vessel monitoring systems (VMS). VMS is generally mandated for control and enforcement and also used for fisheries management. The new fisheries control regulation (EU regulation 2023/2842) will require VMS on < 12 m vessels, but this will take time to implement. In the interim, < 12 m vessels need a way to provide valid, high-resolution spatial data on their activities for marine spatial planning (MSP) purposes.

Marine spatial developments such as offshore windfarms (OW) and marine protected areas (MPAs) raise major challenges for the fishing industry due to competition for space. Under its Climate Action Plan, Ireland has a long-term target of 37 gigawatts (GW) of power produced from offshore wind which will require substantial areas at sea to develop associated infrastructure. In the shorter term, Ireland has a target of 80% renewable energy with 5 GW coming from offshore wind by 2030. 3.1 GW of this will come from phase one, developer-led projects in the Irish Sea and Sceirde Rocks off the Midwest Irish coast. The remainder will be produced under a plan-led regime under designated maritime area plans (DMAPs), the first of which, is based off the south coast.

The south coast DMAP (SC-DMAP) will ensure that the scale, location and timing of future OW developments will continue to be informed by the best available data and acknowledges the need for ongoing engagement with the seafood sector and other bodies on addressing data gaps for < 12 m vessels. The plan also outlines how individuals and communities will be able to fully participate in the planning process and make submissions on any offshore renewable energy development in the SC-DMAP area as part of that process (DECC, 2024).

The 2023 Irish MPA Act aims to contribute to the protection of a minimum of 30% of Ireland's marine area by 2030 in line with requirements under the EU Biodiversity Strategy. The Irish government appointed expert advisory groups to identify candidate MPAs in the Irish and Celtic Seas. These groups noted major data gaps in relation to < 12 m vessels and encourage the provision of new data in this regard (MPA Advisory Group, 2023 and 2024).

Participatory mapping has been defined as a practice, through which citizens can communicate their spatial thoughts, feelings, or knowledge in support of a specific research aim or decision-making goal, utilizing a cartographic visualization. It was developed as a way of empowering citizens by incorporating nuanced knowledge into the decision-making process and enhancing opportunities for democracy within communities (Carver 2003; Denwood et al., 2022; Sieber 2006).

Recent technical developments in the participatory mapping field include the development of the Map-Me participatory geographic information system (PGIS) platform which collects digitised spatial information using an airbrush-style or 'spray-can' interface (Huck, Whyatt and Coulton, 2014). This approach has been successfully used to investigate segregation and sharing of spaces by religious communities in Northern Ireland (Huck et al., 2019) and perceived ease of access to desired destinations by walking in Sydney, Australia (Roper et al., 2024).

Participatory mapping approaches have previously been used to address data gaps for small vessels for marine spatial planning purposes. For example, Kafas et al (2017) conducted extensive face-to-face interviews and used a mapping application where fishers could identify polygons of their fishing activities. No analytical validation of the spatial accuracy of these polygons was conducted. Instead, the study relied on qualitative verification through follow up meetings with survey participants. The authors suggested that further software developments to include key marine features could assist participants in locating their activities and improving mapping accuracy.

Grati et al (2022) used participatory mapping to enhance knowledge of small-scale fisheries towards development of management policies and mitigation of competition for marine resources across eight countries in the Mediterranean. They conducted face-to-face interviews and used paper maps which were subsequently digitised to capture spatial information on fishing activities. Scientists from each national team cross checked the data for inconsistencies and conducted some on board observations at sea as a further means of validation.

The quality of participatory mapping data depends on many factors including the data collection strategy, mapping efforts, accuracy, precision, type of spatial data collected, and data usability in terms of how it fits the purpose (Fagerholm et al., 2021). Shepperson et al (2014) assessed the accuracy of participatory mapping for fisheries management purposes by comparing community derived data with VMS data. They concluded that sample size is an important factor in determining the methodological accuracy of participatory mapping.

Fisheries participatory mapping outcomes generally consist of trade-offs between data accuracy; availability and willingness of survey participants; technical, resource and logistical constraints around survey design and implementation. The capacity to comprehensively survey participants in a fast and effective manner is likely to improve participant willingness and sampling rates while minimising resource requirements. The ability to cross validate survey data while conducting interviews could also assist in improving data accuracy while addressing resource constraints through avoidance of repeat interviews or follow-up field observations.

In this study, we describe the development of a new fisheries participatory mapping approach which combines face-to-face interviews, a new spray-can application with detailed marine features, and vessels chart plotters to facilitate real-time spatial validation of fisheries activities. The study aimed to enable < 12 m vessel owners operating in the SC-DMAP to provide valid information on their activities for MSP purposes. The potential application of this method to other marine spatial planning challenges is also discussed.

Methods

Marine spray-can application

To collect data on fishing activities, we developed a new marine spray-can application in JavaScript using the open-source Leaflet Mapping Framework (https://leafletjs.com). To provide geographic context, the application included admiralty nautical charts www.admiralty.co.uk/charts as base maps in the software (Figure 1). Depicting the depth and nature of the seabed, along with navigational information, these charts enabled survey participants to accurately identify the location of their fishing activities.

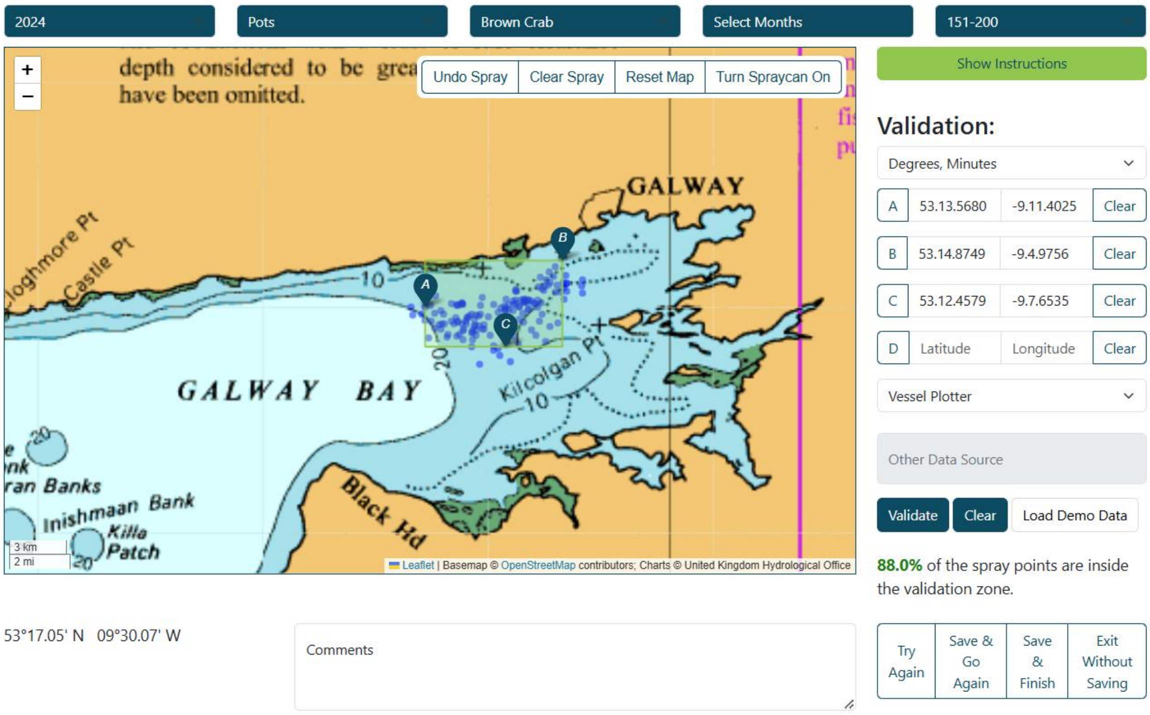


Figure 1. Screenshot from the marine spray-can application with dummy data for demonstration purposes.

We designed a Structured Query Language (SQL) relational database (Maria DB) hosted on an Ubuntu Virtual Machine to house project data. Given that survey participants were generally remotely located, we designed the application so that data could be uploaded to the database post-hoc. This permitted collection of data on an interviewer's local machine and then once connected to the internet, the data could be uploaded by running a bespoke script. This version of the application was developed using a local XAMPP server, with software updates delivered using Git applications. We also developed an online version on a password-protected local domain mainly for demonstration purposes.

The PGIS procedure largely followed Huck et al. (2018). Using the spray-can interface, yearly fishing activities were added to the map. Spray data were collected in the form of a series of individual points, each of which represented a single 'dot of paint'. These contained a series of attributes that could be used to link it to other dots in the same spray pattern, to the participant and information on their fishing activities.

During the spraying process, points were added to the map randomly within a certain radius of the mouse location. This radius might be considered as describing the width of the 'spray nozzle' and is a direct function of the zoom level of the map at the time of spraying (i.e., a more 'zoomed in' map gives a smaller radius). The density of the points within the radius is a function of the amount of time the user holds down the mouse over a given location. While possible to use zoom level as a proxy for data quality (e.g., Huck et al., 2018), we simply used this feature to facilitate effective collection of data from diverse fisheries. For example, lobster potting can be highly localised as fishers target specific areas of rocky ground whereas demersal trawling can span over relatively large areas.

Survey design

The study area was based on the south coast DMAP proposal issued by the Irish government in July 2023 (Figure 3). The area extended from the high-water mark on Irelands south coast to the 80 m depth contour and/or the edge of the Irish exclusive economic zone. The western boundary was based on restricted military and aviation areas while the eastern boundary was the demarcation between the Irish Celtic Sea and Irish Sea. Following public consultation on the south coast DMAP proposal, the DMAP area was subsequently refined to four maritime areas where future fixed offshore wind projects may be located (Figure 3). These refined areas were published in May 2024 and were again subject to public consultation which concluded in August 2024. Neither the original DMAP area nor the four maritime areas were included in the spray-can application to help minimise any potential spatial bias.

At the outset, BIM met with the southeast regional inshore fisheries forum (SERIFF) which provides local representation for the < 12 m fishing vessel sector to outline and request support for the project. The forum welcomed the project and provided its support.

The 2024 Irish Fleet Register was downloaded from the Department of Agriculture, Food and the Marine's website (link) to identify survey participants. BIM employs regional development officers who regularly engage with small vessel owners on the south coast to provide technical support and services. Two of these officers used their expert knowledge to identify active vessels operating near the four maritime areas which were based in ports between Ardmore and Kilmore Quay) on the Waterford and Wexford coasts. We aimed to sample all active < 12 m vessel owners in those ports. Some vessels were also sampled in the western part of the DMAP area in the ports of Ballycotton and Youghal off the Cork coast.

Survey participants were mainly interviewed over the course of two weeks in June and July 2024 and asked to provide information on their fishing activities over the course of one full year. We facilitated provision of information as far back as 2022 to make allowances for participants who were not fully active in 2023 or 2024 due to health, mechanical or other issues.

Interview process

The BIM scientist who managed the participatory mapping project and the local BIM regional officers initially conducted the interviews together but subsequently conducted interviews individually as each party gained experience in the process. Participants were interviewed on board their fishing vessels while docked in port to facilitate access to their chart plotters.

Interviews formally commenced with a statement of project purpose and data protection, and a consent request. These were located on an introductory landing page on the application which also contained fields for general information such as participant contact and vessel details.

Interviewers collected the following fishery data using the spray-can application: months and year in which the fishing activity took place, gear type, main target species, and approximate effort in days fished in 50-day bins. Once these data were collected for a specific fishery, the participant was asked to spray the location of their operations on the map.

Next, participants were asked to show the geographic location of the fishery on their plotter. The interviewer either manually entered latitude or longitude positions in the application or selected the positions directly on the map using a mouse. The interviewer subsequently validated the positions in real time by clicking the 'validate' button producing a validation score. This was derived from the proportion of their spray map data that fell within the area covered by the plotter points. Then, the map was either saved or the participant was given one opportunity to recommence the process to allow for potential errors before starting a new fishery or finishing the survey.

At the end of the interviews, overall comments regarding the interview process and feedback on the spray-can application were recorded. Field interviews typically lasted 30 minutes to one hour. Follow-up meetings were held with six participants to discuss commercially sensitive information which also provided an opportunity to gather additional feedback on the process and project outputs.

Data analysis and validation

We cumulated the midpoints of the 50-day bins on days fished to provide estimates of total fishing effort for maps and plots. Not all participants had vessel plotters, and it was important to try and include as many vessels as possible in the validation process. We used Bayesian analysis to estimate certainty around validation scores in each cell, which is formulated as per Equation 1:

$$C = \frac{C_i \cdot C_p}{(C_i \cdot C_p) + ((1 - C_i) \cdot (1 - C_p))} \tag{1}$$

where: C refers to the confidence value for a given cell (the 'posterior'), C_i refers to the validation score associated with participant i, and C_p refers to the confidence score before C_i is included (the 'prior'). The above approach was applied iteratively to all participants that sprayed in each cell, with the initial prior set to 0.5, and then being replaced by the previous C value at each subsequent step, until the final (posterior) confidence level was determined.

Map outputs

We used Python for data processing and made the fishing activity maps in QGIS (an open-source geographic information systems application). Rather than presenting the 'raw spray' on the maps (i.e., as many points), we generalised the data to a continuous surface of 1km squares, which facilitated clear visualisation. This was also essential for aggregation into participant counts, fishing effort calculations, and uncertainty analysis.

We produced combined maps of cumulative days fished by all participants and the total number of participants operating in each cell across the study area. We also mapped the certainty score in each cell derived from the Bayesian analysis.

We produced maps of specific fisheries e.g. lobster potting by all participants. Even though they were aggregated by all participants, these maps revealed the location of individual fishing activities by some participants. This information was commercially sensitive, so it was not possible to publicly share these maps. Instead, we described the spatiotemporal distribution of these fisheries using additional plots and text.

Results

Combined fisheries

The BIM regional officers identified 96 active < 12 m vessels operating from Wexford and Waterford ports. Some 70 of these were surveyed providing a sampling rate of 73% of targeted vessels. The remainder were not sampled primarily due their unavailability or declining to participate. The 70 vessels were owned by 68 participants, two of whom owned two vessels. A further 10 participants and 11 vessels were surveyed in Ballycotton and Youghal in Cork.

We recorded a total of 244 yearly fishing activities: 208 in 2024, 32 in 2023 and 4 in 2022. These comprised 8 gear types and 19 target species which were combined to define 11 key fisheries for the purposes of this study (Table 1). The map of all fisheries by days fished showed that most fishing by < 12 m vessels was concentrated relatively close to the coast but that there were also important fishing grounds further offshore across the study area (Figure 2). In relation to the proposed offshore wind locations, Maritime area A had the greatest number of fishing days of all the maritime areas, followed by B, then C with no fishing recorded in area D (Table 2). Some 24 vessels fished in area A, 7 in B and 3 in C. The maps of all participants generally followed the map of days fished with particularly high concentrations of vessels operating off Tramore, Dunmore East and Slade to the east, and Helvick and Ardmore to the west of the DMAP proposal area (Figure 3).

Vessels with plotters were generally larger than vessels without plotters. The majority of fishing activities were validated. Validation scores range from 30 to 100 with a mean of 81 (Table 3). The Bayesian analysis of fishing activity validation scores showed a high level of certainty in areas A and C, and some uncertainty in the southern part of B (Figure 4).

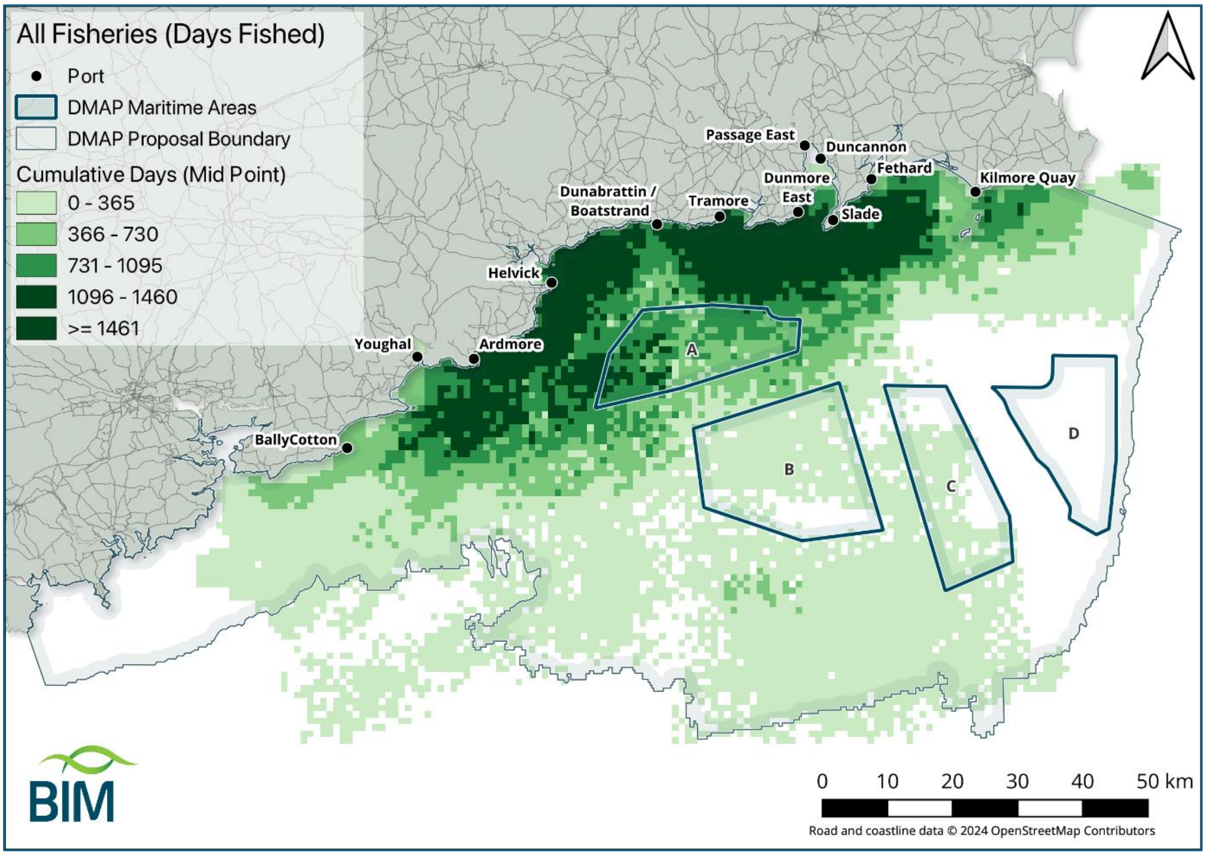


Figure 2. Map of combined fisheries by days fished in the DMAP proposal and maritime areas

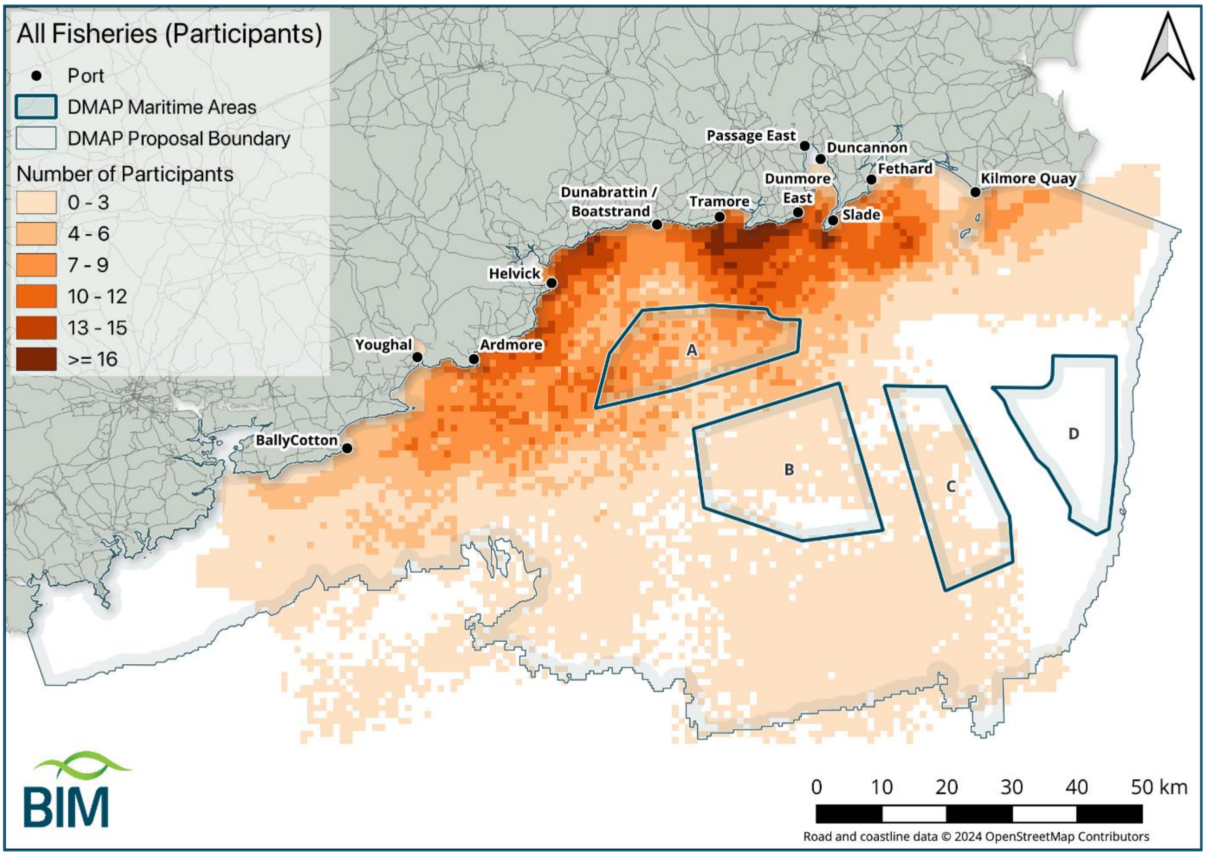


Figure 3. Map of combined fisheries by participants (vessels) in the DMAP proposal and maritime areas

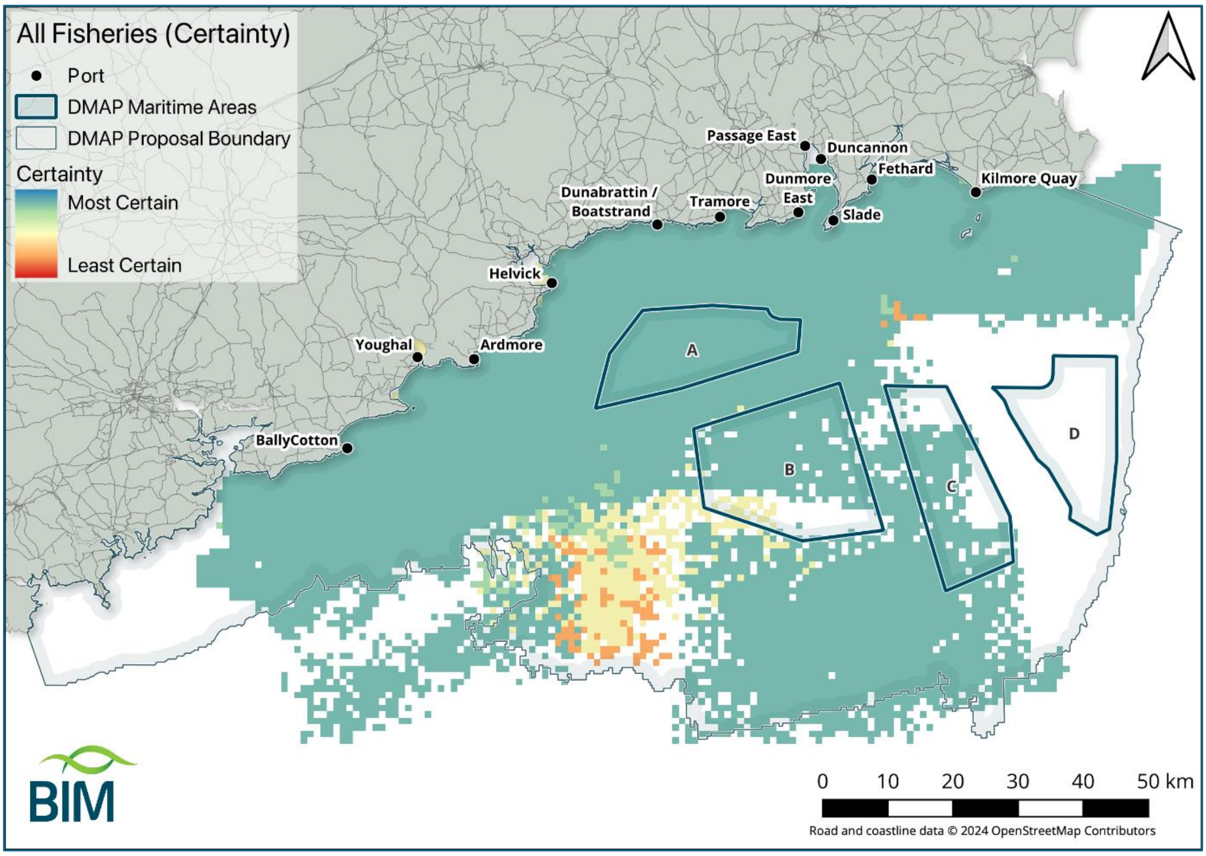


Figure 4. Map of certainty using observed validation scores and Bayes theorem

Table 1. Defined fisheries based on gear types and species

Fishery	Gear type	Species
Brown crab	pots	brown crab
Demersal trawl	single	haddock
		monkfish
		nephrops
		plaice
	twin-rig	nephrops
		plaice
Dredge	dredges	surf clam
Gillnets	gill nets	black pollack
		hake
		plaice
		pollack
		turbot
Hook & line	hook & line	mackerel
		pollack
Lobster	pots	lobster
Mid-water trawl	single	sprat
Other crab	pots	green crab
		spider crab
		velvet crab
Shrimp	pots	shrimp
Tangle nets	tangle nets	crayfish
		monkfish
		plaice
		spider crab
		turbot
Whelk	pots	whelk

Table 2. Days fished in DMAP proposal and Maritime areas.

Fishery	Total	A	B	C	D
Lobster	9000	550	275	0	0
Brown Crab	5275	1700	500	350	0
Shrimp	3450	0	0	0	0
Demersal Trawl	1250	1125	125	125	0
Other Crab	900	0	0	0	0
Gill Nets	775	175	225	100	0
Tangle Nets	775	50	25	0	0
Hook & Line	700	0	0	0	0
Whelk	300	50	0	0	0
Mid Water Trawl	150	0	0	0	0
Dredge	125	0	0	0	0
Totals	22700	3650	1150	575	0

Specific fisheries

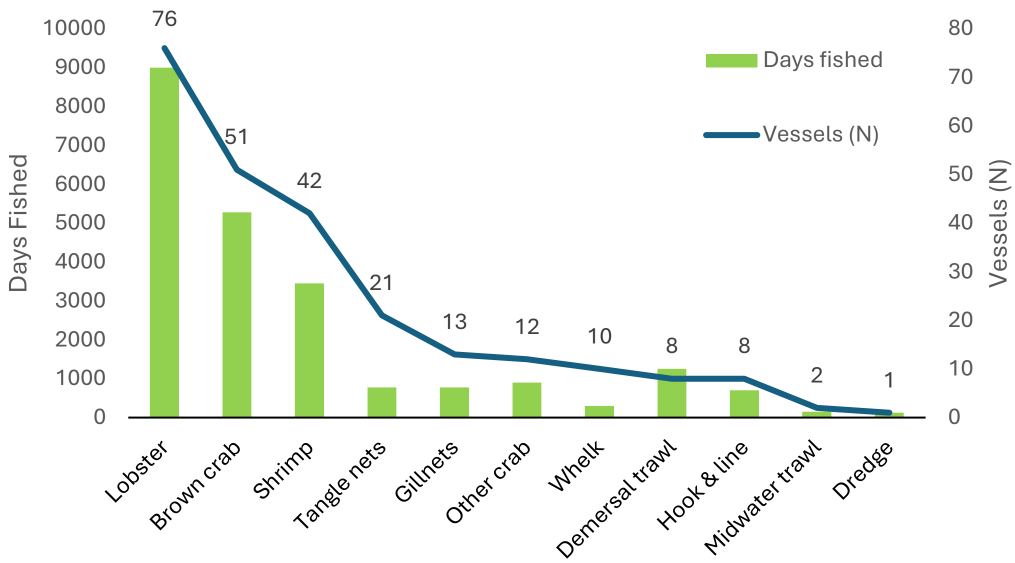


Figure 5. Cumulative days fished and number of vessels in each defined fishery

Lobster, crab and shrimp potting were the three main specific fisheries, accounting for 78% of the total days fished and the greatest numbers of vessels (Table 2 & Figure 5). The number of fisheries conducted by individual vessels ranged from 1 to 6 with an average of 2.9 across all vessels.

Maritime area A had the greatest number of fishing days of all the maritime areas. Brown crab, demersal trawling, lobster and gillnets were the most important fisheries in area A. Brown crab and lobster potting were more concentrated in the northeast while demersal trawling and gillnetting were more concentrated to the west of area A. The same fisheries generally occurred in areas B and C to a lesser extent although no lobster fishing occurred in area C. No fishing was recorded in area D (Table 2).

It should be noted that vessels could engage in more than one fishery or travel over relatively large areas during their activities, particularly in the case of demersal trawling. This explains why the combined days fished across the maritime areas exceeds the total days fished for demersal trawling (Table 2).

Table 3. Vessel plotter and validation figures

Characteristic	N	STDEV
Mean vessel size	8.3	2.0
Mean vessel size with plotter	9.2	1.6
Mean vessel size without plotter	6.6	1.4
Fishing activities	244	
Validated fishing activities (N)	147	
Validated fishing activities (%)	60	
Mean validation score (%)	81	18.0

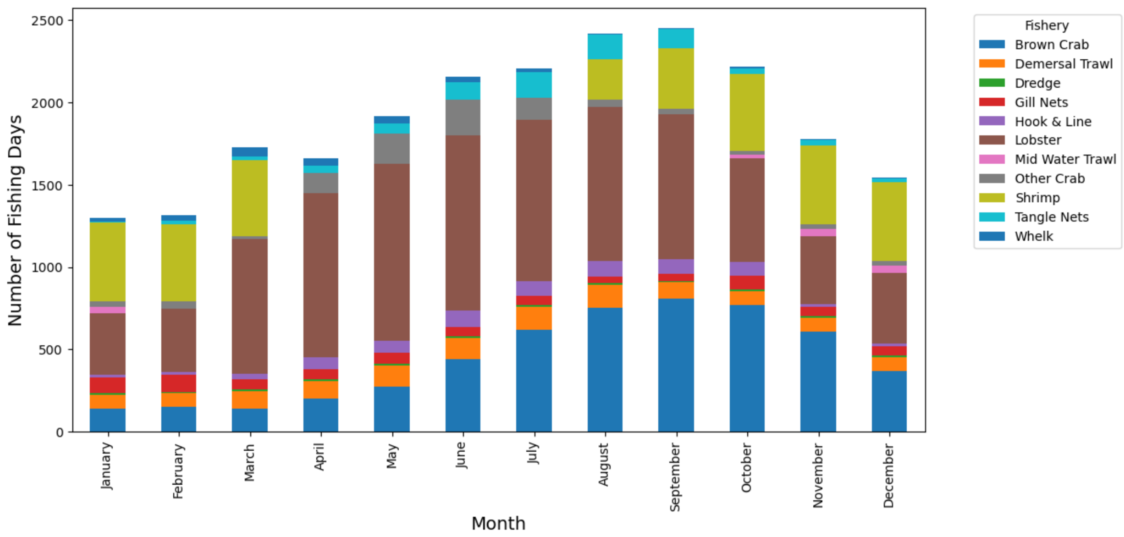


Figure 6. Stacked bar chart showing number of fishing days per each fishery in each month

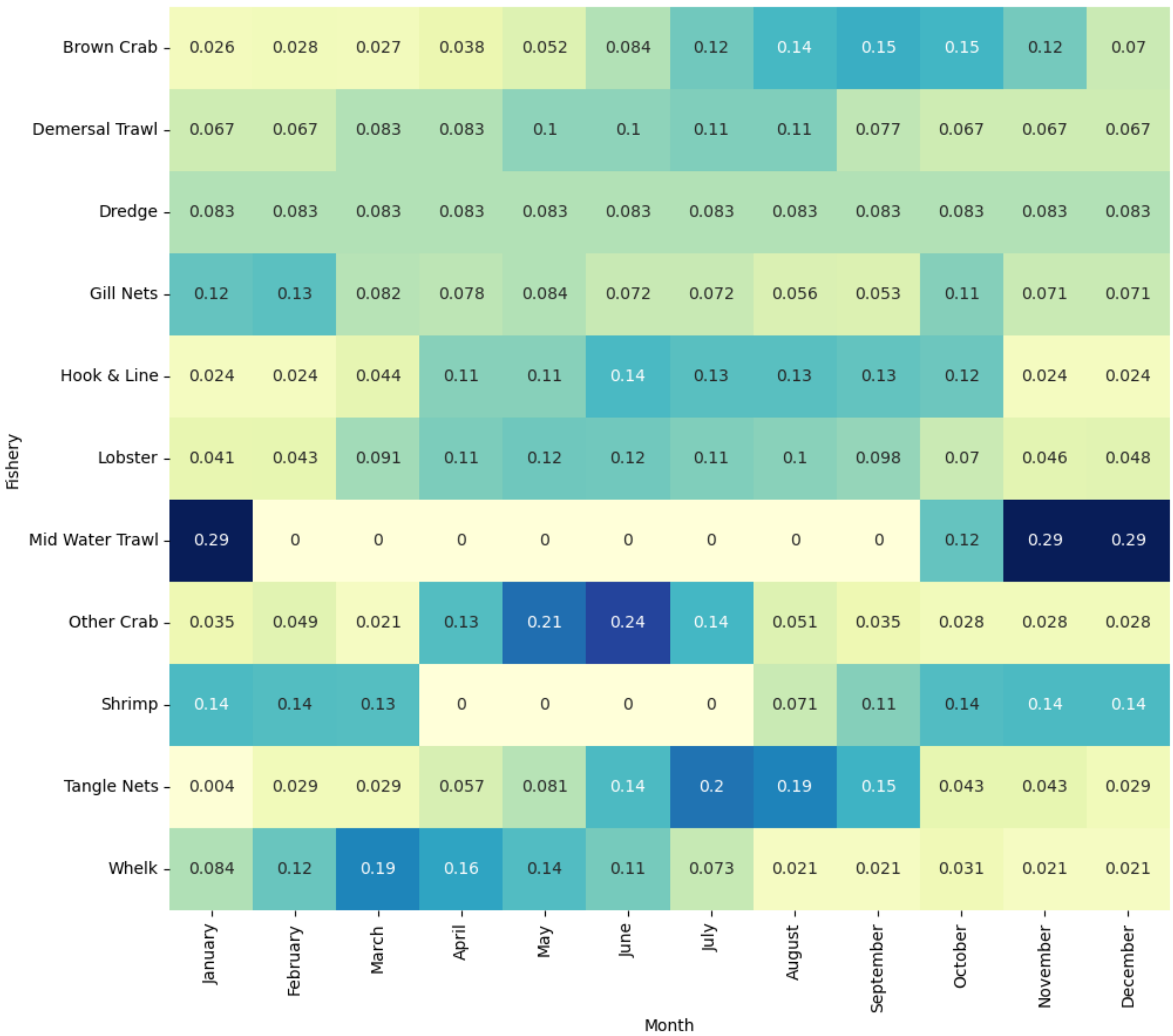


Figure 7. Heat map of fisheries by month standardised by fishery

Seasonally, the number of fishing days across all fisheries gradually increased in the summer months before peaking in September and reducing to a lower level in winter months (Figure 6). The lobster fishery mainly occurred during summer months while the crab fishery occurred slightly later, during the autumn. The shrimp fishery, midwater-trawl fishery targeting sprat, and gillnet fishery targeting demersal fish species occurred mainly during winter months. Whelk potting primarily occurred in spring while remaining fisheries were mostly concentrated in summer months (Figure 7).

Specific fishery maps which are not published in this report due to commercially sensitive information showed:

- Lobster fishing mainly occurred near the coast across the entire survey area.
- The brown crab fishery also occurred coastally but was more concentrated beyond the nearshore area and extended further offshore over broader areas including out to the southern end of the DMAP proposal area. The greatest concentration of crab fishing effort occurred just beyond the near shore area between Dunabrattin and Kilmore Quay.
- Shrimp potting occurred coastally between Ballycotton and Kilmore Quay with a particular concentration of fishing between Ardmore and Tramore.
- Demersal trawling mostly occurred in the northwestern quarter of the DMAP proposal area with a particular concentration off Helvick and Ardmore.
- Gillnetting was spread relatively evenly to the west and south of the DMAP proposal area.
- Potting for crab species other than brown crab occurred coastally around Helvick, Slade and Kilmore Quay.
- Tangle netting was dispersed throughout the study area.
- The hook and line fishery for mackerel and pollack occurred around Ballycotton and along the coasts from Tramore to Kilmore Quay.
- Whelk potting occurred from near shore to slightly more offshore areas between Helvick and Kilmore Quay.
- The mid-water trawl fishery for sprat occurred coastally off Helvick and between Tramore and Fethard.
- The dredge fishery for surf clams was restricted to the Waterford Estuary between Dunmore East and Slade

Discussion

Overall, the BIM participatory mapping project worked well resulting in detailed maps of fishing activities by < 12 m vessels in the south coast DMAP area. The 73% sampling rate indicates a broadly positive response from survey participants enabling them to provide detailed information on their activities for MSP purposes. We hope to improve on this sampling rate in future iterations of this work through demonstration of project outcomes and benefits. It is important to acknowledge the owners of 27% of targeted vessels who did not participate in the project. These vessel owners will still need to be considered in the planning process through direct engagement by offshore wind developers and/or by other means.

The combined fisheries maps and associated data are immediately available for MSP purposes. Potential applications include input to the consultation on land-fall routes from the maritime areas and submissions on proposed offshore wind infrastructure under the planning process.

In addition, maps and data on fishing activities provided by individuals can also be made available to them for MSP purposes. We plan to include automated provision of individual reports to survey participants in further developments of the approach. Should the industry desire and where resources allow, it may also be possible to explore confidentiality agreements whereby specific fishery maps and data e.g. lobster fishing by all participants, are shared privately with offshore wind developers and other relevant parties where needed.

Provision of relatively high-resolution data under the participatory mapping approach is an advantage over satellite-based VMS used on larger vessels which transmit positional data relatively infrequently resulting in lower spatial resolution (Thoya et al., 2021). However, inshore VMS (iVMS) uses mobile phone signals to provide positional information at <10 min intervals resulting in relatively high-resolution temporal and spatial data. VMS data also has the benefit of continually providing real-time data whereas participatory mapping provides a snapshot of fishing activities in time.

The Irish Marine Institute (MI) has successfully deployed iVMS on board < 12 m vessels targeting razor clams in the Irish Sea in line with legislative requirements for that fishery. The MI and BIM also deployed iVMS on board a number of < 12 m sentinel vessels operating in various locations around the Irish coast. The aim of that programme is to provide fisheries data which are mainly representative of the broader under 12 m sector for fisheries management and economic purposes (Perry et al., 2024). Subject to underlying data agreements, sentinel vessel data could be useful in further cross validating participatory mapping data, and this could potentially be explored in future projects.

Our participatory mapping approach has major potential to address data gaps where comprehensive iVMS data are not available. The majority (44) of the vessels in the current study and over 70% of all < 12 m vessels on the Irish fleet register are < 9 m. These vessels will not be legally required to carry VMS until 2029 (EU regulation 2023/2842). Extensive planning using best-available data for < 12 m vessels will be needed prior to 2029 to meet Irish targets of 5 GW power from offshore wind and 30% protection of Irish waters by 2030.

The participatory mapping approach provides a way of empowering or enabling members of the fishing industry to provide spatial information on their activities where needed. Our early engagement and support from the local regional inshore fisheries forum worked well as a first step in this process which should be retained in future studies.

The developed approach also has major potential to address < 12 m vessel data gaps in relation to candidate MPAs in the Celtic Sea. This would require further interviews with fishers operating along the Cork coast. The Irish fleet register has over 300 < 12 m vessels in Cork. Active vessels would need to be identified but the number of interviews needed to comprehensively sample fishers in that area is likely to substantially increase compared with the current study. The resource requirements and survey design would need to be carefully considered to ensure successful outcomes.

Conducting face-to-face interviews is a labour-intensive process but this was an essential component of the current study given the need to validate the fishing activities using vessel plotters. Interviewing fishers on board their vessels made for a relaxed environment likely contributing to their willingness to participate and good response rate. The strong working relationships and trust between BIM regional officers and fishers also greatly assisted. The resulting direct mapping approach is not always achievable in participatory mapping projects due to a lack of cooperation with local fishing communities (Thiault et al., 2017).

There are a number of potential reasons why fewer smaller vessels had chart plotters including lack of cabins or shelter from the elements, or resource constraints. Using the Bayesian approach provided an effective means of including these vessels in the validation process. It also provided a practical way of determining confidence in the presence of multiple fishing activities in a specific location. This approach was superior to simply taking an average of validation scores in a cell which would overstate associated uncertainty:

Supposing we have a cell that contains data from two participants, one of which has a good level of confidence (90%), while the other has a lower (but still reasonable) level of confidence (60%). The average of these two numbers would be 75%, meaning that the second dataset has effectively reduced our confidence in the first, even though it has increased the overall amount of evidence supporting the position. The Bayesian approach is more robust in this regard, as additional evidence with confidence > 50% will always increase the overall confidence level. The resulting maps provide a simple means of assessing certainty of the validation scores and associated spatial data.

In conclusion, the BIM Participatory Mapping project has been a successful exercise in enabling < 12 m vessel owners in providing valid data on their activities in the SC-DMAP. Ongoing engagement with the fishing industry, government departments, offshore wind developers and other relevant parties will be key to ensuring participatory mapping data are effectively used in marine spatial planning decisions.

Acknowledgements

BIM would like to sincerely thank the vessel owners who participated in the study. Thanks to the SERIFF for meeting with us, discussing and supporting the project. Thanks to Steven Lynam, Terri Carthy and Janet Humphries from BIM for IT support. Thanks also to Oliver Tully and Nicola O'Brien from the MI for feedback on the project and assistance with admiralty charts. Thanks to Rory Campbell for advice. Thanks to Martin, Patrick, and Morgan Oliver for helping to test the application.

Software development for the PGIS application was undertaken by Lune Geographic Ltd. (https://lunegeographic.co.uk). Acknowledgement for the admiralty charts used in the tool: © Crown Copyright and/or database rights. Reproduced by permission of the Keeper of Public Records and the UK Hydrographic Office (www.ukho.gov.uk/copyright).

This work was funded by the Irish Government and part-financed by the European Union through the EMFAF Operational Programme 2021 – 2027.

References

Carver, S. 2003. The future of participatory approaches using geographic information: Developing a research agenda for the 21st century. Urisa Journal 15 (1):61–71.

DECC. 2024. The South Coast DMAP. Department of the Environment, Climate and Communications (DECC). 87pp.

Denwood, T., Huck, J.J. and Lindley, S. 2022. Participatory mapping: A systematic review and open science framework for future research. Annals of the American Association of Geographers, 112(8), pp.2324-2343.

Fagerholm, N., Raymond, C.M., Olafsson, A.S., Brown, G., Rinne, T., Hasanzadeh, K., Broberg, A. and Kyttä, M. 2021. A methodological framework for analysis of participatory mapping data in research, planning, and management. International Journal of Geographical Information Science, 35(9), pp.1848-1875.

Grati, F., Azzurro, E., Scanu, M., Tassetti, A.N., Bolognini, L., Guicciardi, S., Vitale, S., Scannella, D., Carbonara, P., Dragičević, B. and Ikica, Z. 2022. Mapping small-scale fisheries through a coordinated participatory strategy. Fish and fisheries, 23(4), pp.773-785.

Huck, J.J., Whyatt, J.D. and Coulton, P. 2014. Spray-can: A PPGIS for capturing imprecise notions of place. Applied Geography, 55, pp.229-237.

Huck, J.J., Whyatt, J.D., Dixon, J., Sturgeon, B., Hocking, B., Davies, G., Jarman, N. and Bryan, D. 2019. Exploring segregation and sharing in Belfast: A PGIS approach. Annals of the American Association of Geographers, 109(1), pp.223-241.

Kafas, A., McLay, A., Chimienti, M., Scott, B.E., Davies, I. and Gubbins, M. 2017. ScotMap: Participatory mapping of inshore fishing activity to inform marine spatial planning in Scotland. Marine Policy, 79, pp.8-18.

Marine Protected Area Advisory Group 2023. Ecological sensitivity analysis of the western Irish Sea to inform future designation of Marine Protected Areas (MPAs). Report for the Department of Housing, Local Government and Heritage, Ireland. 130 pp.

Marine Protected Area Advisory Group. 2024. Ecological sensitivity analysis of the Celtic Sea to inform future designation of Marine Protected Areas (MPAs). Report for the Department of Housing, Local Government and Heritage, Ireland. 125 pp.

Perry, S., Jackson, E., Curtin, R. 2024. Annual Fisheries Report: Findings of the National Seafood Survey 2024. Bord Iascaigh Mhara (BIM). 52 pp.

Roper, J., Ng, M., Huck, J. and Pettit, C. 2024. A participatory mapping approach to capturing perceived walkability. Transportation Research Part A: Policy and Practice, 186, p.104133.

Shepperson, J., Murray, L.G., Cook, S., Whiteley, H. and Kaiser, M.J. 2014. Methodological considerations when using local knowledge to infer spatial patterns of resource exploitation in an Irish Sea fishery. Biological Conservation, 180, pp.214-223.

Sieber, R. 2006. Public participation geographic information systems: A literature review and framework. Annals of the Association of American Geographers 96(3):491–507.

Thiault, L., Collin, A., Chlous, F., Gelcich, S. and Claudet, J. 2017. Combining participatory and socioeconomic approaches to map fishing effort in small-scale fisheries. PLoS One, 12(5), p.e0176862.

Thoya, P., Maina, J., Möllmann, C. and Schiele, K.S. 2021. AIS and VMS ensemble can address data gaps on fisheries for marine spatial planning. Sustainability, *13*(7), p.3769.