

Using Public Participation GIS (PPGIS) to relate local concerns over growth in tourism and aquaculture to integrated coastal zone management in the Tromsø region, Norway

Emma Annika Salminen^{a,*}, Francisco Javier Ancin Murguzur^a,
Victoria Marja Sofia Ollus^a, Sigrid Engen^b, Vera Helene Hausner^a

^a Department of Arctic and Marine Biology, UiT – The Arctic University of Norway, Tromsø, Norway

^b Norwegian Institute for Nature Research, Tromsø, Norway

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ABSTRACT

Blue growth has been promoted as a strategy for generating jobs and welfare in Europe. Aquaculture and coastal tourism, which both fall under EU's blue growth strategy, have expanded in the last two decades raising environmental concerns and conflicts with traditional uses in coastal communities. In Norway, inter-municipal coastal zone planning aims to balance the different interests and concerns deriving from growth in aquaculture and tourism, but their potential to mitigate local concerns has rarely been examined. In this study, we invited 1312 participants from the Tromsø region to identify locations of concern relating to a growing aquaculture and tourism industry using an online Public Participation GIS (PPGIS) platform. We compared the PPGIS data over present and future concerns with areas designated for aquaculture and tourism in the recent coastal zone plan (for the years 2023–2033). We also inquired about people's opinions about growth in marine industries, and background information. Participants mapped 115 markers for concerns over aquaculture and 63 locations for concerns over tourism. The participation rate was 9.4 %. A majority of spatial concerns were mapped in close proximity to aquaculture and tourism zones. Most participants preferred a decrease in salmon aquaculture and were neutral about other kinds of aquaculture. They were neutral or preferred to decrease tourist fishing and cruise tourism, whereas attitudes to other coastal tourism were more positive. Finally, we discuss the use of PPGIS to collect spatial information from a large range of participants to inform coastal planning about present and future concerns over development.

1. Introduction

The rapid increase in ocean industrialization, also referred to as blue growth (Jouffray et al., 2020), describes an exponential growth in human activities relating to marine transportation, aquaculture, tourism, oil and gas drilling, seabed mining and biotechnology (Lowerre-Barbieri et al., 2019). The combined pressures on coastal and marine environments from all these activities (Bennett et al., 2021) have resulted in declining fish stocks, an increase in pollution, habitat destruction and biodiversity loss threatening the health of the ocean and the resilience to environmental changes (Bennett et al., 2021; Halpern, 2008; Singh et al., 2021). Coastal zone planning aims to balance the growth in marine industries with the concerns of coastal communities, but spatial information about what people perceive as present and future

threats has generally not been available for planners (Noble et al., 2019). There is a need to include this missing social layer to ensure a more integrated planning where coastal communities can express their concerns over present and future activities in specific locations (Pennino et al., 2021).

Blue growth encompasses the long-term sustainable development in the marine and maritime sectors and was promoted by the European Commission as part of their strategy to foster growth and create new jobs relating to biotechnology, renewable energy, coastal and maritime tourism, aquaculture and mineral resources without compromising the health of marine ecosystems (European Commission, 2012), but has been met by criticism due to its vagueness for use in political decision making (Brent et al., 2020; Lee et al., 2020; Martínez-Vázquez et al., 2021) and for the focus on economic development at the expense of

* Corresponding author.

E-mail address: emma.salminen@uit.no (E.A. Salminen).

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environmental and social considerations (Bennett et al., 2021; Brent et al., 2020; Farmery et al., 2021). At first sight, the blue growth strategy appears to be similar to the notion of the blue economy, promoted by the United Nations at the Rio+20 Earth Summit (UN, 2012), but the strategy has a stronger emphasis on the economic expansion of ocean-related industries, whereas the UN's concept of the blue economy is founded on the three pillars of sustainable development to balance the need for development with conservation, social inclusiveness and resilience (Eikeset et al., 2018).

Coastal communities have expressed concerns about the environmental impacts of blue growth, potential conflicts with traditional uses of the coast (Bax et al., 2022; Bennett et al., 2021) and have questioned the equity aspects of such developments (e.g., access to marine resources, displacement of local users, Indigenous rights abuse) (Bennett et al., 2021). The exclusion from governance could result in a lack of trust and lack of cooperation between decision-makers and local communities over time (Bennett et al., 2021). Examples include e.g., the conflict between the EU, Norway, Iceland and the Faroe Islands about fishing quotas (Saviolidis et al., 2020), between fishermen and offshore wind farms in Norway (Knol-Kauffman et al., 2023), between aquaculture and Indigenous rights in Canada (Wiber et al., 2021), and displacement of local fishing communities from fishing grounds due to ocean industrialization (Okafor-Yarwood et al., 2020).

Integrated coastal zone management (ICZM) could help mitigate some of the negative impacts of blue growth activities and weigh the use of ocean resources and spaces among different interests (Hauge et al., 2021; Hovik and Stokke, 2007). ICZM aims to avoid fragmentation and sectoral decision-making (Khakzad et al., 2015), advocates a multidisciplinary approach by including local communities, scientists, industries and governments for collaborative decision-making (Eikeset et al., 2018; Tsiouvalas et al., 2022), and seeks to integrate economic, ecological and social sustainability and to mitigate conflicts between different sectors and actors (Hovik and Bjørn Stokke, 2007). To ensure that ICZM includes the concerns of coastal communities, a first necessary step is to map and analyze the different values, priorities, and concerns of diverse stakeholders. Spatially explicit social data could provide detailed information on locals' knowledge, values and concerns regarding areas that they care about (Brown et al., 2015), what activities people would like to allocate to different areas (Brown, 2004a), and areas that they think are sensitive to environmental change (Kamel Boulos and Wilson, 2023).

Online Public Participation GIS (PPGIS) platforms refer to GIS-based tools that allow a diversity of participants in a planning process to map their own values, priorities and concerns relevant to planning (Pocewicz et al., 2012). Mapping environmental changes that people have observed or threats associated with future development could also help planners consider present and future concerns of industrial expansion and climate risks in the coastal zone. PPGIS has previously been used as part of coastal zone planning processes in e.g., Sweden (Hansen et al., 2021), Australia (Munro et al., 2019) and Scotland (Green, 2010). The advantage of the online version of PPGIS is that a large number of participants could be reached, most of which usually do not participate in face-to-face planning processes (Brown, 2012). The tool can benefit those who prefer to participate anonymously, people with physical disabilities, or where access to planners and decision-makers is hampered by long travel distances or other barriers (Kyttä et al., 2023). PPGIS platforms could provide feedback from the communities on coastal developments affecting local traditional uses and culture or environmental changes that people experience as concerning (Kivinen et al., 2018; Morse et al., 2020). A common drawback of PPGIS is the biased representation of the overall population with more men with a higher education and income participating in surveys (Brown, 2017).

This study examines environmental concerns of coastal communities relating to two sectors, tourism and salmon aquaculture, and their role in the municipal planning processes in the Tromsø region of northern Norway. These two sectors have generated economic benefits and

income, but have also raised concerns and resulted in conflicts within coastal communities in northern Norway (Brattland et al., 2020; Young et al., 2019). In Norway, ICZM is led by municipalities, often in collaboration among multiple neighboring municipalities, referred to as inter-municipal plans (Hauge et al., 2021). The highly decentralized planning processes in Norway are believed to emphasize broad and inclusive participation, but many of these processes have been criticized for being too narrow in their scope (Buanes et al., 2004) and for ignoring local concerns by letting business-led actors dominate the decision-making (Hovik and Bjørn Stokke, 2007). The Tromsø region is among the regions where the coastal zone plans have caused conflicts, due to concerns for ecological and social sustainability (Engen et al., 2021; Olsen et al., 2024; Runge et al., 2020; Viken, 2022; Knol-Kauffman et al., 2023; Olaussen, 2018; Sandersen and Kvalvik, 2015; Saviolidis et al., 2020; Tsiouvalas et al., 2022). Coastal fishermen, Indigenous people and environmental organizations have raised environmental concerns and conflicting area use between aquaculture and tourism with other interests, such as fisheries and environmental protection (Kvalvik and Robertsen, 2017; Aanesen et al., 2023b; Engen et al., 2021; Krøvel et al., 2019). A considerable proportion of the population has opposed the expansion of the aquaculture sector in northern Norway, where there was opposition to new aquaculture facilities in 2015 (Aanesen et al., 2023; Bailey and Eggereide, 2020). The present and future concerns of local communities have, to a limited degree, been integrated into the planning process (Bjorkan and Eilertsen, 2020).

In this study we ask: what is the spatial relation between markers placed by participants and areas designated to these activities in the Intermunicipal Coastal Zone Plan for Tromsø, Balsfjord and Karlsøy that was recently established for the 2023–2033 period? What are the concerns over present and future growth in aquaculture and tourism within these coastal communities and is there a difference between concerns over the present versus the future situation? We also wanted to evaluate how spatial information collected by online PPGIS on present and future concerns about coastal development and environmental change could enhance ICZM, as well as the limits of such platforms for capturing the concerns of coastal communities. We analyzed data from an online PPGIS designed to map locations of present and future concerns of coastal communities and examined the spatial relationship between mapped concerns and existing/planned areas designated for aquaculture and tourism. Spatial information about local experiences of environmental changes and future concerns over coastal development has rarely been collected and is usually lacking as a GIS layer in planning processes. There is a need to incorporate data on local knowledge and the social dimensions with other spatial ecological and economic data to enhance socio-ecological resilience towards change (Noble et al., 2019) and social data layer that capture the needs, priorities and concerns of coastal communities is required for GIS related planning in marine and coastal areas (Armenio and Mossa, 2020).

2. Methods

PPGIS data over concerns for aquaculture and coastal tourism were collected with the online Maptionnaire Community Engagement Platform (www.maptionnaire.com) (Kyttä et al., 2023). Here we focused on a subset of this larger PPGIS study (Appendix 1), which was carried out in 2021 in all coastal municipalities in northern Norway (see (Salminen et al., 2024)). We collected data in the year 2021 after which responses were no longer considered. Our focus here is on the municipalities of Tromsø, Balsfjord and Karlsøy, where data collection took place from October to December 2021 (Fig. 1). The municipalities have 76 000, 5600 and 2200 inhabitants, respectively. Important economies include seafood industries, i.e., fisheries and aquaculture, and tourism which has been booming in Tromsø in the last two decades (Maher, 2017). The first coastal zone plan included more municipalities but was not approved due to the conflicts with coastal communities over the large expansion of

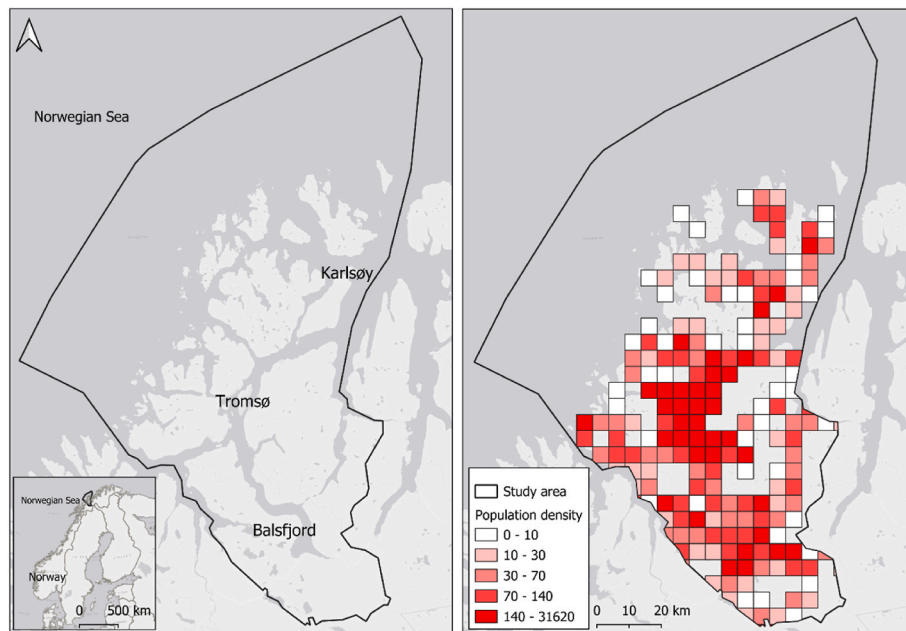


Fig. 1. Study area of the Tromsø-region including the municipalities Tromsø, Balsfjord and Karlsøy in northern Norway (left) and population density (right) (Population density data from [Kartkatalogen, 2024](#)).

salmon aquaculture licenses. A new and downscaled plan was therefore initiated including only three municipalities. The development of this plan started in 2018 ([Tromsø municipality, 2024](#)). Tromsø has 16 existing aquaculture facilities (14 farms for all species of fish, one farm for other species than salmon, and one kelp farm) and eight planned (six farms for all species of fish and two kelp farms), whilst Balsfjord and Karlsøy, which share a coastal zone plan, have 15 existing aquaculture facilities (14 farms for all species of fish and one farm for other fish species than salmon) and three planned (one farm for all species of fish and two kelp farms). Regarding tourism, Tromsø has 55 existing and seven planned areas for recreational and tourism use, whilst Balsfjord and Karlsøy have 17 existing and seven planned areas for recreational and tourism use ([Tromsø municipality, 2024](#)).

We invited participants from the Tromsø region to identify locations of concern relating to a growing aquaculture and tourism industry using an online Public Participation GIS platform. Participants were recruited both by directly inviting randomly selected inhabitants, and indirectly through social or other media without direct invitation. For direct invitations, the tax register was used to randomly select 5% of the population, aged 18–79 years, living in Tromsø, Balsfjord and Karlsøy municipalities. We sent a letter and a reminder containing information and the link to the online PPGIS survey in the mail (to 1000 persons in Tromsø, 212 in Balsfjord and 100 in Karlsøy). For indirect invitation, volunteers were invited to participate through newspapers, social media posts, and a social media campaign after we finished random sampling ([Salminen et al., 2024](#)).

Upon entering the Maptionnaire survey (<https://mpt.link/kyst> (where 'kyst' stands for the Norwegian word 'coast')), participants were given information about their rights in accordance with the General Data Protection Regulation (GDPR) (Wolford, 2020) before providing their consent to continue to fill in the survey. In the mapping component, the MapBox Street was used as the basemap and the default for the zoom level was set to 6.9 (6.9 is approximately 1: 2 500 000 in scale) to show the whole Tromsø region with the possibility for participants to zoom in and out. We encouraged participants to zoom in before placing the marker on the map. We used points as using polygons in mapping has been shown to result in lower response rates and lower data quality since mapping polygons takes more time ([Brown and Pullar, 2012](#)). Participants were first asked to identify and map places that they value (in the

survey: "Mark places that are important to you") after which they were asked to identify and map places where they had observed changes (in the survey: "What changes do you think have negative impacts on the fjord/coast in your area?"). We focused on aquaculture and tourism due to the known concerns for these in the Tromsø region ([Runge et al., 2020](#); [Wilke, 2023](#)). After placing the marker on the map in the survey: "Place/area that I am concerned about due to current or future aquaculture/tourism development", a pop-up window asked to state if the concern was about the present situation ("I have observed negative effects as a result of aquaculture/tourism in this area") or the future situation ("I am concerned that we may experience changes as a result of aquaculture/tourism in this area"), of which participants could choose one or both present and future. Participants also had the option to write further in the pop-up window about what they were concerned about due to aquaculture/tourism ("Please describe what you are concerned about regarding increased aquaculture/tourism"). The participants could choose one or several concerns, including tourism, aquaculture, habitat destruction, pollution from industry, overfishing, motorized vehicle use and area restrictions. Participants also had the option to map why they value an area, including 'Local income' and thereafter choosing between several income-generating options, including aquaculture and tourism. We have chosen not to include these values since the focus of this paper is on where there are concerns related to blue growth. Only a total of 13 markers were mapped for the value of generating income from aquaculture and 19 for tourism, which makes these data of too low quality for spatial analysis.

To analyze the representativeness of our participants in relation to the overall population in the three municipalities, we examined the demographics including age, gender, education and income, and the background information of participants. We asked people to self-identify as Kven, Sámi or Norwegians. Kven is an old-Finnic ethnic minority group in Norway ([Lane, 2016](#)), whereas Sámi are recognized as Indigenous People. Participants could belong to different ethnicities and therefore self-identify as having e.g., both Sámi and Norwegian heritage. We performed a chi-square test of independence in R (version 4.3.2.) to test differences in present and future concerns over aquaculture and tourism and between women and men. Education, income and age were presented in percentages.

We created maps in QGIS Desktop (version 3.34.0) to visualize places

of concern regarding present and future aquaculture and tourism activities in Tromsø, Balsfjord and Karlsøy, and how the mapped places were spatially related to areas designated to aquaculture and tourism activities in the coastal zone plan (for the years 2023–2033). For tourism, we combined areas designated for recreation and outdoor activities (“*friluftsområde*” in Norwegian) and leisure and tourism (“*touristformål*” in Norwegian), hereafter recreation and tourism, in the coastal zone plan. Layers for these facilities were provided by the Tromsø municipality, [Geodataenheten \(Plandata/Kystsoneplan_2023_2033 \(FeatureServer\)\)](https://geodataenheten.no/plandata/kystsoneplan_2023_2033).

To further explore how the plotted concerns over aquaculture and tourism relate to areas designated to these activities, we calculated straight line distances between mapped concerns and these areas and created histograms showing the effect of distance on the number of mapped concerns. These are presented as visual assessments, where each column shows the number of placed markers within a specific range of distance from areas designated to aquaculture or tourism, i.e., the number of markers that fall within a kilometer’s radius from a designated area. For areas designated to aquaculture, we excluded areas for kelp cultivation and only included areas for fish farming due to their very different environmental impacts (Folke et al., 1998). Using R (version 4.3.2.), we created histograms showing (i) the number of mapped concerns over present fish farms in relation to distance from present aquaculture areas, (ii) the number of mapped concerns over future fish farms in relation to distance from present and future aquaculture areas, (iii) the number of mapped concerns over present tourism in relation to distance from present areas designated to recreation and tourism, and (iv) the number of mapped concerns over future tourism in relation to distance from present and future areas designated to recreation and tourism. Points that represented both present and future concerns for aquaculture/tourism were considered both in the analysis of present concerns and the analysis of future concerns for aquaculture/tourism.

A questionnaire followed the mapping component of the survey. We asked the participants about their opinions (in the survey: “When thinking about the area where you are living, what considerations would you make in these situations?”) on the following five categories: i) tourist fishing, ii) cruise tourism, iii) other coastal tourism, iv) salmon aquaculture, v) other aquaculture. The participants could choose

between: ‘increase’, ‘neutral’, ‘decrease’ or ‘I don’t know’. Here, we used the perceptions of all the participants who had mapped at least one marker on the map within the Tromsø region. The results were plotted in a stacked bar chart to show the distribution for each perception.

3. Results

3.1. Participants

Most of the participants that mapped concerns over aquaculture and tourism were invited inhabitants who had been randomly selected from the tax register (N = 1312). Volunteers that were recruited by e.g., use of social media, accounted for 24 participants. The number of letters that we expect participants to have received, due to undelivered letters, was 1062 of which 100 participants mapped concerns over aquaculture or tourism resulting in a participation rate of 9.4 %. The average zoom level that participants used was 9.86, which is on a scale of approximately 1: 150 000 (the default zoom level was set for 6.9 which is a scale of approximately 1: 2 500 000). The mean time participants spent surveying was 115 min, whereas the majority (82% of the participants) used under 30 min to finish the survey (Salminen et al., 2024). Participants were skewed towards middle-aged persons with higher education, and slightly more men mapped concerns over aquaculture and slightly more women mapped concerns over tourism (Table 1). The participants who mapped concerns over aquaculture were primarily of Norwegian origin (67%), had a good knowledge of the municipality (54%), owned property (48 %), and had had their families living in the region for several generations (35 %) (Table 2). Participants that mapped concerns over coastal tourism, were 79% of Norwegian origin, 69% reported good knowledge of the municipality, 56% owned property, and 39 % had had their families living for generations in the area (Table 2). Sámi origin accounted for 12.5% and 23.1% mapping for aquaculture and tourism. People of Kven origin accounted for 4.2% and 13.5% of the concerns mapped for aquaculture and tourism, respectively. None of the participants worked in aquaculture and those who worked in tourism, only 6.3% were concerned over aquaculture and 3.8% were concerned over tourism. The number of participants reporting working in management or planning, oil and gas industry was also low.

Table 1

Number of participants that mapped locations for all concerns (tourism, aquaculture, habitat destruction, pollution from industry, overfishing, motorized vehicle use, area restrictions) and for aquaculture and tourism alone. Statistics over the population in the municipalities are presented for comparison (from SSB, Statistics Norway).

	Number of participants						Statistics Norway (year 2023)		
	All concerns	Percentage (%)	Aquaculture	Percentage (%)	Tourism	Percentage (%)	Tromsø	Balsfjord	Karlsøy
Randomly sampled	131	82	35	73	41	79			
Volunteers	29	18	13	27	11	21			
Gender									
Women	68	43	19	40	26	50			
Men	77	48	22	46	24	46	30 370	2176	902
No answer	15	9	7	15	2	4			
Mean age	50		54		48		39.4	45.7	48.5
Education									
Lower secondary school	11	7	9	19	1	2			
Upper secondary school	37	23	11	23	11	21	20 011	1983	650
Education, undergraduate	55	34	14	29	19	37	17 662	738	292
Education, graduate (M.Sc., Ph.D.)	39	24	7	15	18	35	11 496	184	73
Unknown	18	11	7	15	3	6			
Income									
Lower (NOK ^a <270 000–790 000)	48	30	16	33	16	31			
Higher (NOK ^a 791 000–1 500 000>)	73	46	22	46	24	46			
Unknown	39	24	10	21	12	23			

^a NOK = Norwegian Krone.

Table 2
Background information for all participants that mapped at least one marker for concerns relating to aquaculture and tourism.

Background	All concerns (%)	Aquaculture (%)	Tourism (%)
Norwegian origin	70.6	66.7	78.8
Good knowledge of the municipality	59.3	54.2	69.2
I own property	55	47.9	55.8
My family has lived here for several generations	37.5	35.4	38.5
Member of an outdoors organization	13.8	14.6	17.3
Member of a hunting or fishing organization	8.8	10.4	9.6
I work as a researcher or consultant	3.8	2.1	5.8
Member of an environmental organization	6.9	8.3	9.6
Sámi origin	15	12.5	23.1
Kven origin	9.4	4.2	13.5
I am from an EU country	6.3	6.3	7.7
I work with management or planning	5	4.2	3.8
I am from a non-EU country outside of Norway	4.4	4.2	1.9
I work in the oil and gas industry	6.9	6.3	5.8
I work in tourism	5.6	6.3	3.8
I work in the fisheries	1.3	0	0
I am a fisherman	1.9	4.2	0
I work in aquaculture	1.2	0	0

3.2. Aquaculture

A total of 115 markers were mapped for concerns over aquaculture. Interestingly none of the participants mapped concerns both for aquaculture and tourism. The mapping effort per participant for concerns over aquaculture was 2.39 markers per person (Fig. 2). Six points were excluded from the analyses as no information was given about the concern being in the present or future. Of the remaining 109 points, 15 % represented present concerns (16 points), 64 % represented future concerns (70 points), and 21% represented both present and future concerns (23 points).

Participants wrote that they were concerned about present aquaculture due to perceptions of parasitic lice affecting wild salmon populations, fish welfare, conflict over area use with fishing activities, dead fish, infectious salmon anaemia, negative effects on fish biodiversity (fewer species than before the aquaculture facility in the area), inedible wild fish due to pollution from a facility of close proximity, pollution from spillover of chemicals, fodder and feces in the coastal ecosystems, negative impact on the sea floor as well as light pollution. Future concerns included pollution, changes in the marine ecosystem and negative effects on wild fish. One participant wrote about accepting new aquaculture facilities as long as the facilities are not established in close proximity to the participant’s home.

Concerns over present and future aquaculture were frequently mapped in the vicinity of areas designated to fish farming (Fig. 3). Both for present and future concerns, most locations were mapped within 3 km from the areas designated to fish farms. However, concerns over future aquaculture installations were mapped at locations further away from areas designated to fish farms (up to 52 km away) than were

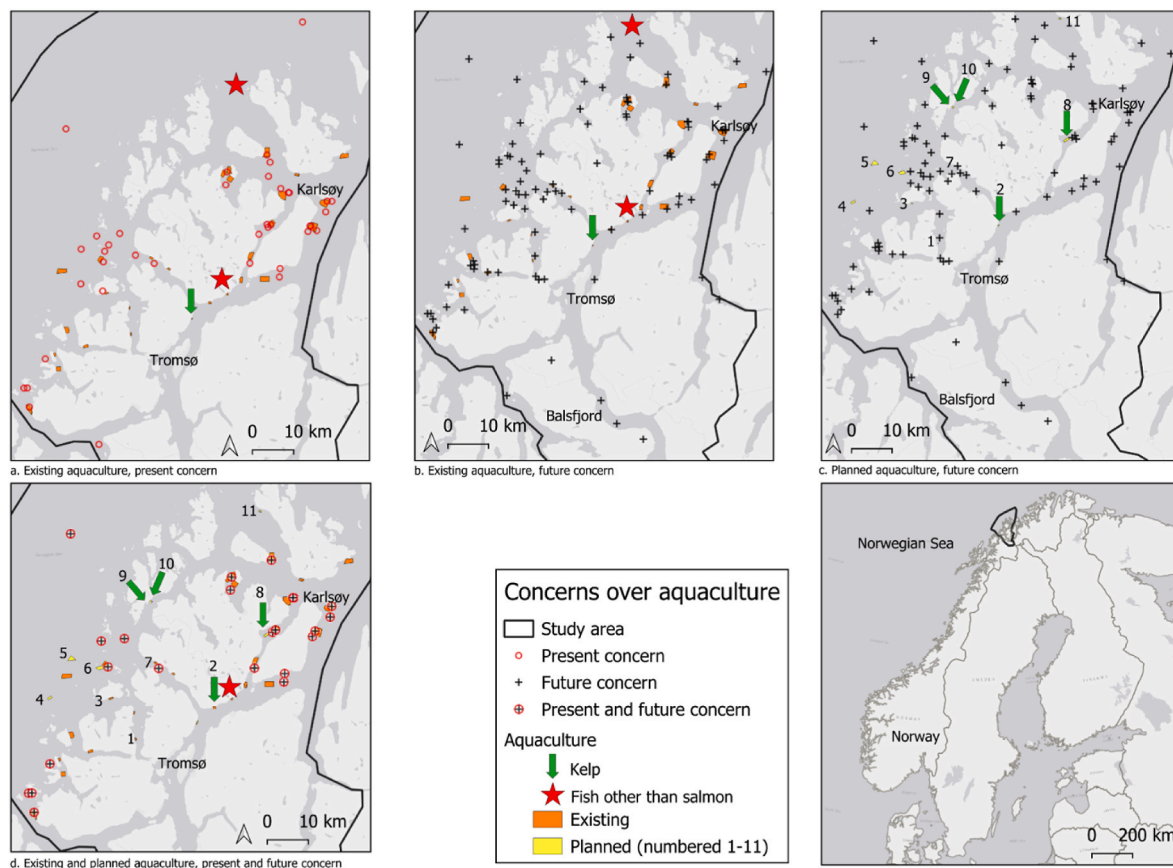


Fig. 2. Concerns over aquaculture presenting a. present concerns and areas designated to aquaculture, b. future concerns and areas designated to aquaculture, c. future concerns and planned aquaculture and d. markers where participants chose both the concern to be in the present and in the future with present and planned aquaculture. Layers for the designated areas where aquaculture were provided by the Tromsø municipality, [Geodataenheten \(Plandata/Kystsonenplan_2023_2033 \(FeatureServer\)\)](#).

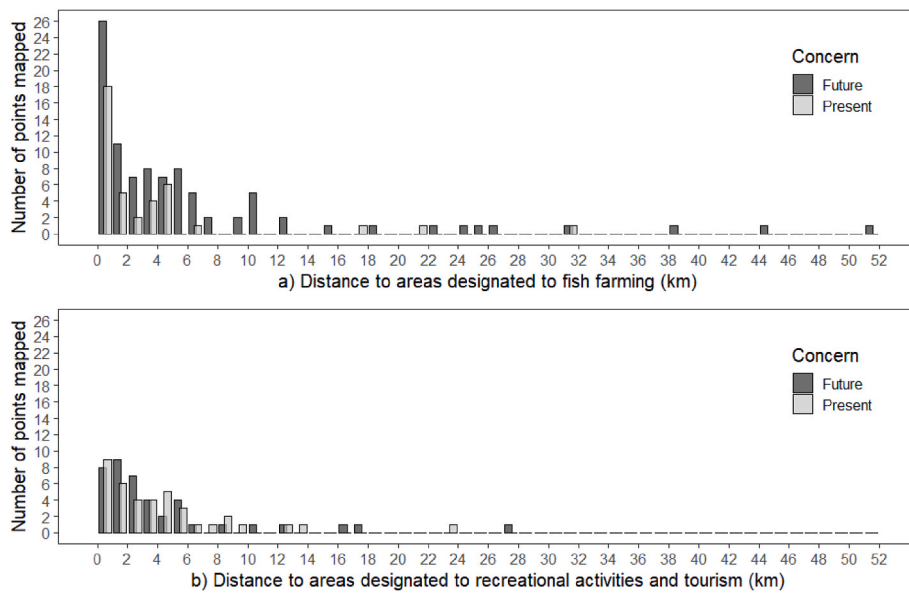


Fig. 3. Number of mapped concerns over present and future aquaculture (a) and tourism (b) in relation to distance from existing and planned areas designated to fish farming and recreational areas and tourism, respectively.

concerns over present aquaculture (up to 32 km away).

Some 40 % of women compared to 46 % of men were mapping concerns over aquaculture (14 % were checking neither or did not answer). Our chi-square analyses showed that men and women were equally concerned about present and future effects of aquaculture ($\chi^2 =$

1.3472, $df = 4$, $p\text{-value} = 0.8533$).

3.3. Tourism

A total of 63 markers were mapped for concerns over tourism by 52

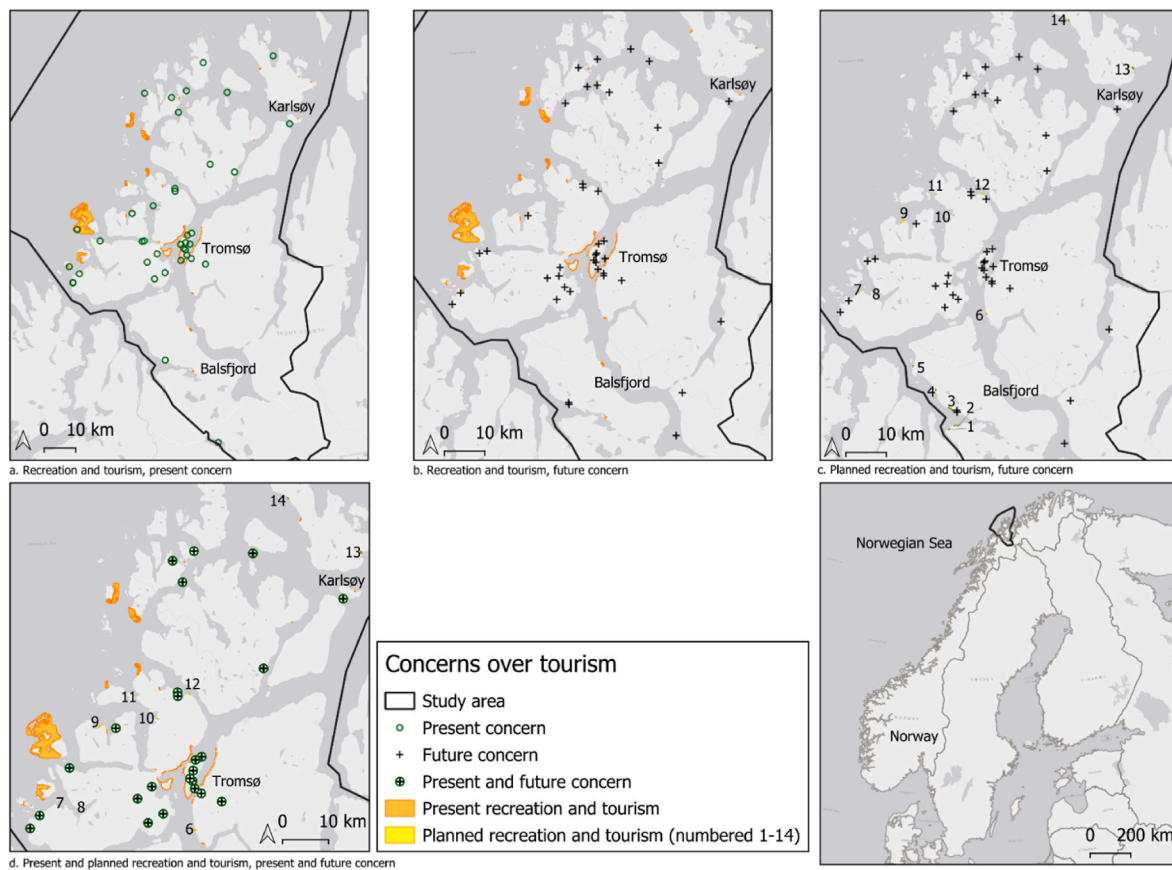


Fig. 4. Concerns over tourism presenting a. present concerns and areas designated to recreation and tourism, b. future concerns and areas designated to recreation and tourism, c. future concerns and planned recreation and tourism and d. markers where participants chose both the concern to be in the present and in the future with present and planned recreation and tourism. Layers for the designated areas over tourism were provided by the Tromsø municipality, [Geodataenheten \(Plandata/Kystsonoplan_2023_2033 \(FeatureServer\)\)](#).

participants (Fig. 4). The mapping effort for tourism concerns per participant was 1.21. Seven points were excluded from the analyses as no information about the present or future concerns was given. 27 % of tourism concerns represented present concerns (15 points), 30 % represented future concerns (17 points), and 43 % represented both present and future concerns (24 points).

Participants listed same concerns in the present and future. Commercial fishing, tourist fishing, cruise tourism, unsustainable use of nature, nature degradation, wildlife disturbance (whale safaris), litter, traffic and fecal waste were concerns about tourism both in the present and in the future.

Similar to concerns over aquaculture, concerns over present and future tourism were mapped more frequently in the vicinity of areas designated to recreation and tourism than in other areas (Fig. 3).

Some 50 % of women compared to 46 % of men were concerned over tourism (4 % of participants were of other gender or did not answer). Our chi-square analyses showed that men and women were equally concerned about present and future effects of tourism (X-squared = 1.3472, df = 4, p-value = 0.8533).

3.4. Participants responses to attitudinal questions about aquaculture and tourism

A total of 222 participants, placing at least one marker (*i.e.*, value or concern), responded to the attitudinal questions about aquaculture (*i.e.*, salmon aquaculture, other aquaculture) and tourism (*i.e.*, tourist fishing, cruise tourism and other coastal tourism). For aquaculture, overall, participants preferred to decrease salmon aquaculture (52.9 %) and they were neutral to (39.1 %) or wanted to decrease (35.4 %) other types of aquaculture (Table 3). In the case of tourism, participants were neutral to (46.8 %) or preferred to decrease (41.9 %) tourist fishing (Table 3). Similarly, they were neutral to (44.3 %) or preferred to decrease (42.9 %) cruise tourism (Table 3). For other types of coastal tourism, they were mostly neutral (65.9 %), and a larger proportion of participants preferring an increase (19.8 %) than a decrease (8.8 %) (Table 3, Fig. 5).

4. Discussion

Amid the growth of aquaculture and coastal tourism, known local concerns over aquaculture and tourism (Runge et al., 2020; Wilke, 2023), and increasing conflicts with other interests (*e.g.*, environmental protection, recreational use, fisheries) in the Tromsø region (Tiller et al., 2015), we aimed to study the concerns over aquaculture and tourism among local communities and the spatial dimensions of these concerns. This social layer is missing in coastal zone planning (Noble et al., 2019) and PPGIS maps could add relevant information of areas where people have either observed or experienced environmental changes or where they fear that changes could take place that could affect the values they care about. Our results showed that locals are concerned over aquaculture due to *e.g.*, parasitic lice, worsened fish quality, pollution and over tourism due to *e.g.*, unsustainable use of nature, litter and nature degradation. Both present and future concerns over aquaculture and

Table 3
Perceptions of participants for the five different categories in percentage (%).

Perception	Increase (%)	Neutral (%)	Decrease (%)	I don't know (%)	Number of answers
Tourist fishing	8.5	46.8	41.9	2.7	222
Cruise tourism	7.3	44.3	42.9	5.4	219
Other coastal tourism	19.8	65.9	8.8	5.5	217
Salmon aquaculture	7.2	33.9	52.9	5.8	221
Other aquaculture	11.8	39.1	35.4	13.6	220

tourism were mapped in the close proximity to areas (<3 km) designated for these activities in the coastal zone plan.

4.1. Aquaculture

Fish welfare was listed as concerning by the participants in the survey. Over half of the participants in our study preferred to decrease salmon aquaculture but were neutral about aquaculture of other fish species followed by a preference for decrease rather than an increase of aquaculture of other species. The present and future concerns relating to fish farming rapidly declined, with few concerns registered beyond 3 km. Concerns over the future impacts of aquaculture were mapped more than present concerns, which could be due to the long-term negative impact of aquaculture facilities on the environment (Martinez-Porchas and Martinez-Cordova, 2012) or the concern of expanding the existing aquaculture facilities. Krøvel et al. (2019) studied the attitudes of 1001 persons in Norway and found that 21 % of the general public was concerned about the environmental impact of aquaculture facilities (Krøvel et al., 2019). Public hearings were held prior to new aquaculture facilities, but people were not sufficiently informed about environmental impacts (Krøvel et al., 2019). The main negative environmental impacts due to aquaculture include sea lice, pollution and fish escapes (Olaussen, 2018), which were also listed as a concern by participants in our survey. Escaped fish can result in competition with wild fish and predation on wild fish, spread of diseases and parasites and in gene pool exchange (Olaussen, 2018). Fish welfare in aquaculture is regulated by law, but raises concerns due to sea lice problems and the treatments to fight the sea lice in the facilities (Olaussen, 2018). The public is divided when it comes to expanding aquaculture, which is influenced by personal values and beliefs, and knowledge of the environment (Aanesen et al., 2023). Present concerns were mapped in the close proximity of existing aquaculture facilities, even overlapping these. The more dispersed markers of future concerns around existing facilities (Fig. 2b) could be due to the wider impact aquaculture facilities have over time, *i.e.*, the environmental impact extends over a larger area from where the facility is located (Olaussen, 2018) and maybe also due to the concern of expanding aquaculture in the close proximity of existing facilities.

4.2. Tourism

Most participants were neutral or preferred a decrease when asked about tourist fishing as well as when asked about cruise tourism. Participants were also neutral about other coastal tourism, followed by a willingness for increasing other coastal tourism. We can see that the present and future concerns relating to tourism decreased also after a distance of 3 km designated to areas of tourism in the coastal zone plan and rapidly decreased beyond 5 km. Many markers were located in Tromsø which is known to be a tourist destination. Coastal tourism has become important for northern Norway and there has been an exponential growth after the Covid-19 pandemic (SSB, 2022). Negative environmental impacts due to coastal tourism include coastal habitat destruction, pollution (incl. litter, sewage), resource overconsumption and disturbance of wildlife (Davenport and Davenport, 2006), all of which were also perceived as concerning by participants in the survey (*e.g.*, unsustainable use of nature, nature degradation, wildlife disturbance, litter, traffic and fecal waste).

4.3. Concerns related to living places

The development of the coastal zone plan started in 2018, and PPGIS data was collected in 2021. About half of the participants mapping concerns over aquaculture referred to their own property. We do not know whether participants knew about the new coastal zone plan and planned areas when mapping, but they appear to have mapped concerns over future fish farms close to areas that are important to them, such as close to their own property. Even though we could not see any

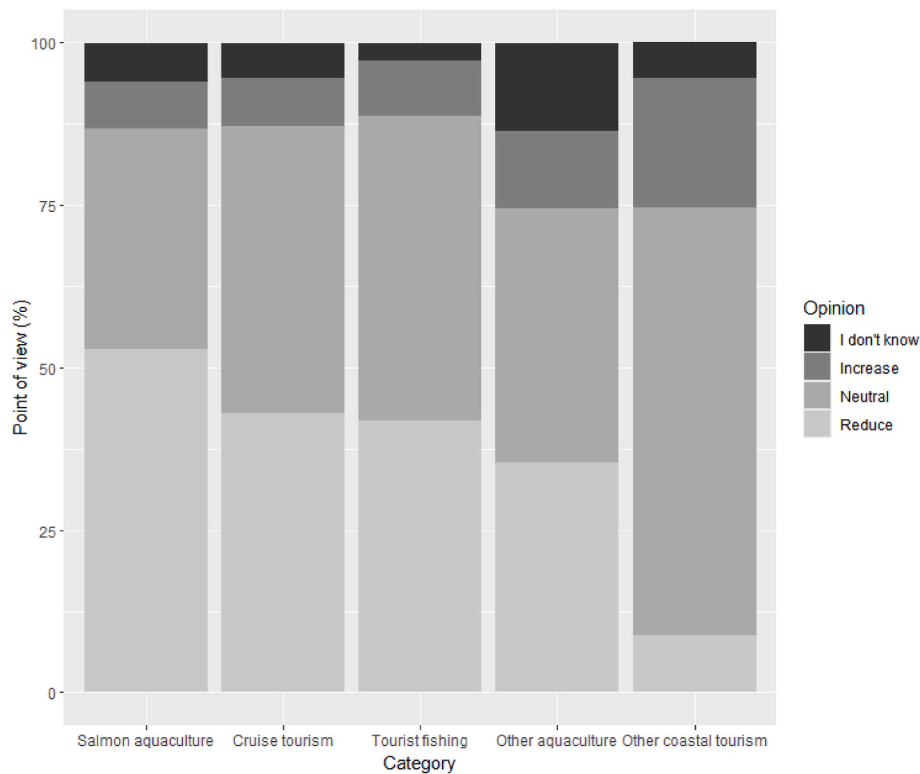


Fig. 5. Perceptions for salmon aquaculture, cruise tourism, tourist fishing, other aquaculture and other coastal tourism among all participants in the Tromsø region.

indications in the survey for participants referring to the coastal zone plan explicitly, there is evidence that local communities have been opposing new aquaculture facilities in Norway (Bjørkan and Eilertsen, 2020). In a choice experiment conducted in the Tromsø region for the previous plan, Aanesen et al. (2023b) also found that information about the environmental impacts resulted in a public preference of fewer locations compared to when they were not informed (Aanesen et al., 2023a,b).

Most participants that were concerned about tourism were property owners in the municipality. Previous studies have found more negative attitudes toward tourism increasing close to the location in which participants live or spend leisure time (Brown and Glanz, 2018; Litvin et al., 2020). The Tromsø area is known for its scenic landscape and many tourists come to the area to spend time outdoors, and the public right of access allows people to access property and nature close to where people live (Kaltenborn et al., 2001).

4.4. Mapping spatial concerns

PPGIS data could contribute to future coastal zone planning by examining spatially explicit local attitudes towards expansion and growth of different industries. Adding the missing layer of social data over how people perceive present and future threats could enhance coastal zone planning (Noble et al., 2019). People living close to the coast often have cultural and social ties to the coast and sea (White et al., 2020). Attending to local environmental concerns is important for protecting the cultural heritage, and enhancing people's 'sense of place' (Armstrong and Stedman, 2019). Spatial data of the concerns relating to concrete locations could benefit strategic environmental assessments in the coastal zone planning and avoiding unnecessary conflicts between locals and decision-makers (Mikkelsen et al., 2022). When locals are actively involved and explicitly informed in the process of creating a new plan, it can lead to a feeling of greater ownership of the plan among people and they are more likely to support new decisions and regulations (Edwards et al., 1997).

Benefits of online PPGIS include the potential for diverse interests to influence planning and decision making (Kahila-Tani, 2015; Panagou et al., 2017). There are also challenges of recruiting participants representing the public (Brown, 2017). Participants in our study were skewed towards middle-aged persons and those with high income and education, which has been reported elsewhere with similar biased representations (Brown et al., 2015). Here, men and women were equally concerned over aquaculture and tourism in the present and future. Considerable percentages of participants with Sámi (23.1%) and Kven (13.5%) background were concerned over tourism. This is not surprising given that increased tourism can result in conflict between Sea Sámi, *i.e.*, Sámi people who live close to the coast, and tourist fishing (Engen et al., 2021), and in competition over area use between coastal tourism activities and traditional uses, *e.g.*, reindeer herding (Brattland et al., 2020).

Mistrust in the quality of spatial information that is delivered by a crowd of participants has been one of the main obstacles for uptake in planning and decision-making (Brown, 2012). Placing a marker on the map can result in spatial errors that affect data quality. To mitigate such errors, we set the average zoom level higher than the set default in our survey. Participants zoomed in even further, resulting in an increased precision of the placed markers. The close proximity between mapped locations and designated areas and additional comments of observed change/concerned change in the future and the questionnaire about industry growth indicate that there is accuracy in participants' mapping effort, *i.e.*, participants did not randomly place markers on the map. Spatial errors are considered to be minor compared to the low response rate of PPGIS surveys (Brown, 2012; Salminen et al., 2024). The main bottleneck is to get sufficient participants who are willing to spend time on mapping, preferably at computers as tablets and mobiles have too small screens. Our participation rate of 9.4 % aligns with previous PPGIS studies, where the average is 12% for online platforms (Brown, 2017; Salminen et al., 2024). Another measure of data quality is the number of points mapped and the time spent mapping. Average mapped markers have ranged from 15 to 78 per person in previous studies (Beverly et al.,

2008; Brown and Brabyn, 2012; Brown and Reed, 2000; Brown and Weber, 2012). For the concerns addressed here, mapping effort in our PPGIS was 2.39 and 1.21 for aquaculture and tourism. It is important to recall that these two activities were only a subset of the different features mapped by the participants. The concerns are also location specific with few residents living in many of the areas where farms have been established or where tourists travel. Interestingly, none of the participants mapped concerns over both aquaculture and tourism in the Tromsø region. An area use conflict between aquaculture and tourism does exist (Krøvel et al., 2019; Mather and Fanning, 2019), but the fact that none of the participants mapped both could be simply due to the lower mapping effort per participant for both activities.

People's preferences tend to stay stable over time (Brown and Weber, 2012), whereas concerns could arise in response to observed or anticipated changes. Land use changes can change people's spatial values (Brown and Weber, 2012), and in the increase of human activities relating to blue growth in northern Norway, people's spatial concerns over these activities could change over time, which is why repetitive surveys are important, and one of the goals of our PPGIS study.

4.5. Social data in coastal zone planning

Intermunicipal coastal zone planning has been criticized for letting the government and businesses dominate the process and excluding smaller local businesses (Tiller et al., 2015; Wilke, 2023). In addition, the shifting responsibility from the governmental to municipality-level decision-making in Norway has complicated the dynamics of participation (Wilke, 2023). Effective coastal zone planning requires a holistic understanding of the whole local socio-ecological system, and our study adds another dimension to traditional surveys by including the spatial information and distance of the perceived negative impact due to aquaculture and tourism. Maps and spatial data visualizations engage some members of local communities (Buckley et al., 2017) and make complex issues easier to understand (Metze, 2020), possibly increasing motivation among residents to participate in decision-making processes. Better visualization of spatial data of perceived impacts could foster inclusivity and could lead to more inclusive decision-making when both people's concerns and those of experts are combined (Buckley et al., 2017). In marine and coastal environments, where ecosystems are interconnected and dynamic, spatially mapped concerns are fundamental for sustainable management (Sink et al., 2023).

4.6. Implications for management

The types of maps visualized in this study provide spatial information of the "unseen" values and concerns among locals and could preferably be used to inform the planning of new aquaculture sites or tourist activities. Many markers in our study suggest that the conflict potential might be high so care should be taken when considering expanding aquaculture or tourism sites into places where activities related to these sectors are not yet present. Municipalities where aquaculture and tourism are already present should take further steps to assess what people's concerns are and deal with them, in e.g., carrying out environmental assessments and communicating with companies about current practices. Areas without concerns for aquaculture or tourism could also be a result for low mapping effort and should not be interpreted as having no conflicts. The data could in addition to other qualitative data (individual interviews, or mapping workshops) add spatial information about different sites, and become of such good quality that maps containing these social concerns could and should be incorporated into coastal zone planning from an early stage of planning with other data from other interest groups, such as from the aquaculture industry (Tiller et al., 2015) and fishers (Hersoug et al., 2012). Although PPGIS has been used in addressing potential conflict in area use (Brown et al., 2017; Brown and Raymond, 2014), the recognition of people's values, has not been incorporated in environmental decision-making (Kantola et al.,

2023). There is a challenge regarding the power and the status of these types of maps, and an ambition could be to evaluate how these types of maps of "invisible values and concerns" could receive similar attention as areas where aquaculture and tourism sectors would like to expand their activities or where e.g., fishers have their fishing grounds. With a good quality of spatial data, the social values and concerns maps could be incorporated into coastal zone planning in a similar manner as for instance fishing areas. Criticism has been raised among fishers that once aquaculture zones have been placed on a draft of a planning document, it is very difficult to remove these afterwards (Tiller et al., 2015), highlighting the importance of including all stakeholders, including the local community, in an early phase into the planning process. With the growth of the sectors of aquaculture and tourism in northern Norway and directly affecting local communities (Runge et al., 2020; Wilke, 2023), combining PPGIS maps with other qualitative work could enhance the reliability of such social data so that the "silent majority" (Brown, 2004b) of the local communities would be acknowledged, recognized and their opinions taken into consideration in new coastal zone plans.

4.7. Limitations

This study focused on a subset of a larger PPGIS survey. Only two out of seven concerns were selected due to the focus on blue growth. We did not include the survey's mapped locations of values. The sample size was rather small with only 100 persons mapping concerns over aquaculture and tourism. However, PPGIS tend to have low participation (Brown, 2017), so our participation rate of 9.4 % aligns with previous environmental PPGIS studies. Due to privacy issues, we could not use participants' living locations to calculate distances between these and mapped locations over concerns. Data was collected in the year 2021 and the new coastal plan for the three municipalities was established in the year 2023, therefore, we suspect that participants were not aware of the new plan or participants could have placed markers even closer to the planned facilities.

5. Conclusion

Aquaculture and coastal tourism are important industries in northern Norway as they contribute to economic growth, but they also face challenges with environmental sustainability and social impacts. Many of the well-known negative impacts caused by these industries, e.g., pollution, habitat destruction and competition over space, were identified by participants in a PPGIS study in northern Norway, and participants mapped concerns over aquaculture and tourism close to designated facilities of aquaculture and tourism, indicating a potential high areal conflict. Adding the missing layer of present and future concerns of local communities could enhance resilience, inclusivity and balance power relationships between different interest groups in future coastal zone planning. With increasing coastal activities, it is of importance to repetitively survey people's concerns over the growth.

CRediT authorship contribution statement

Emma Annika Salminen: Writing – original draft, Methodology, Formal analysis, Conceptualization. **Francisco Javier Ancin Murguzur:** Writing – review & editing, Methodology, Formal analysis, Data curation. **Victoria Marja Sofia Ollus:** Writing – original draft, Methodology, Formal analysis, Conceptualization. **Sigrid Engen:** Writing – review & editing. **Vera Helene Hausner:** Writing – review & editing, Supervision, Project administration, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence

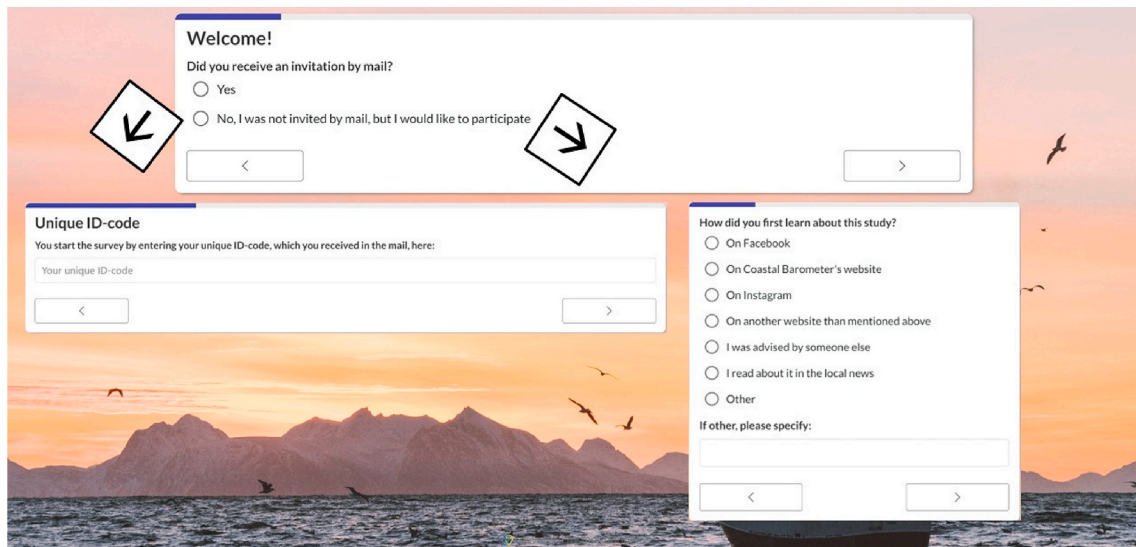
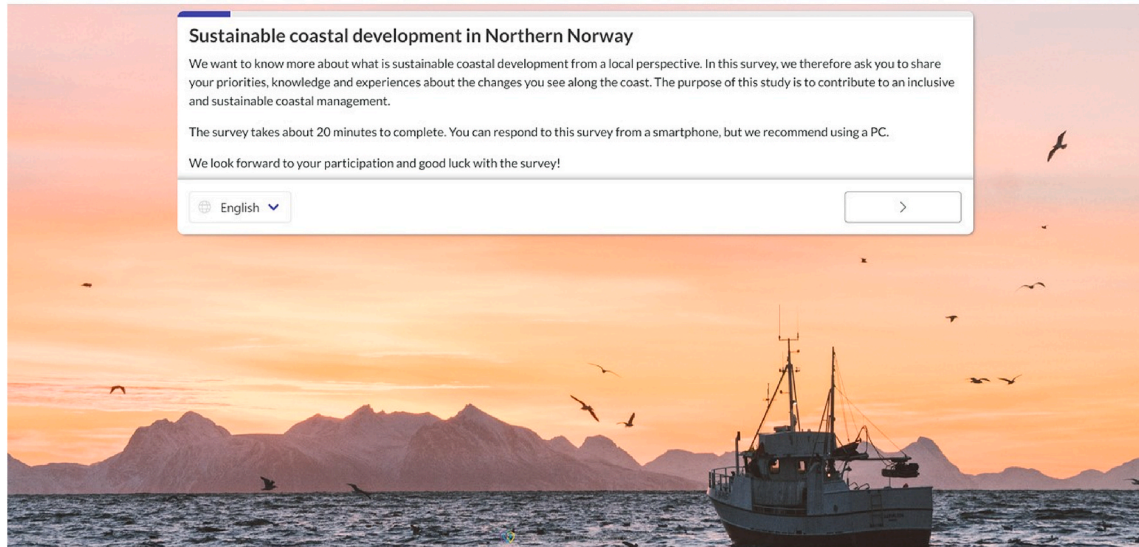
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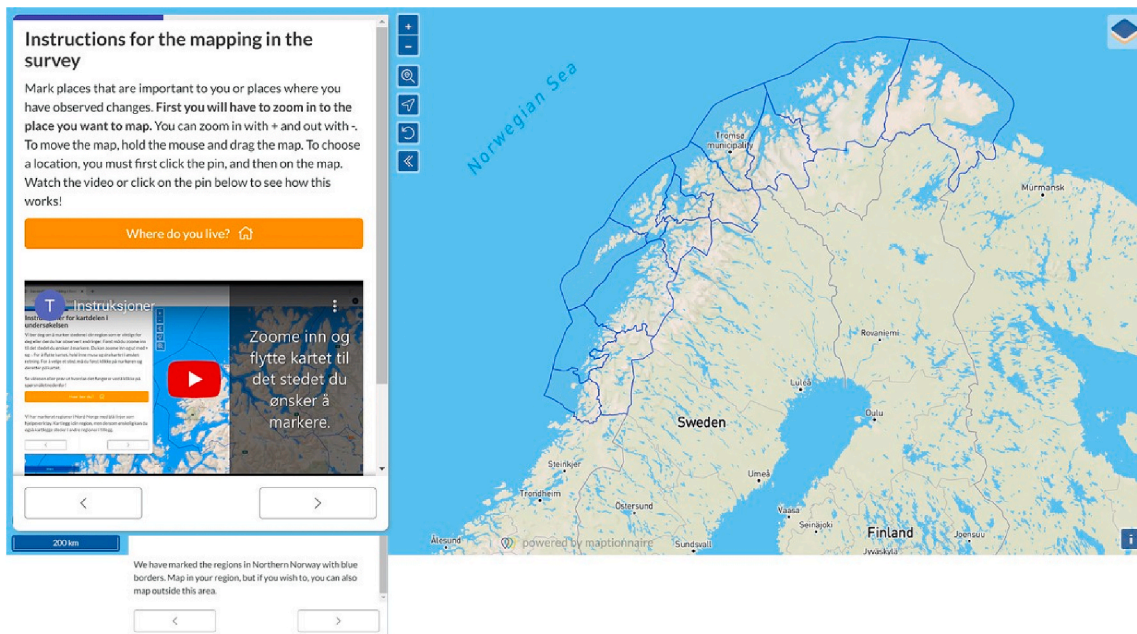
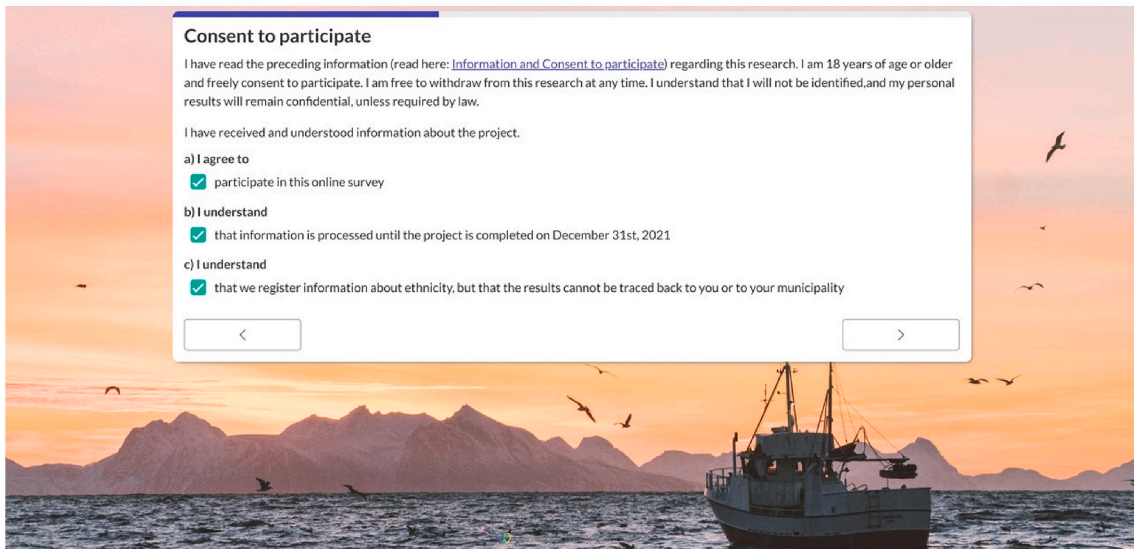
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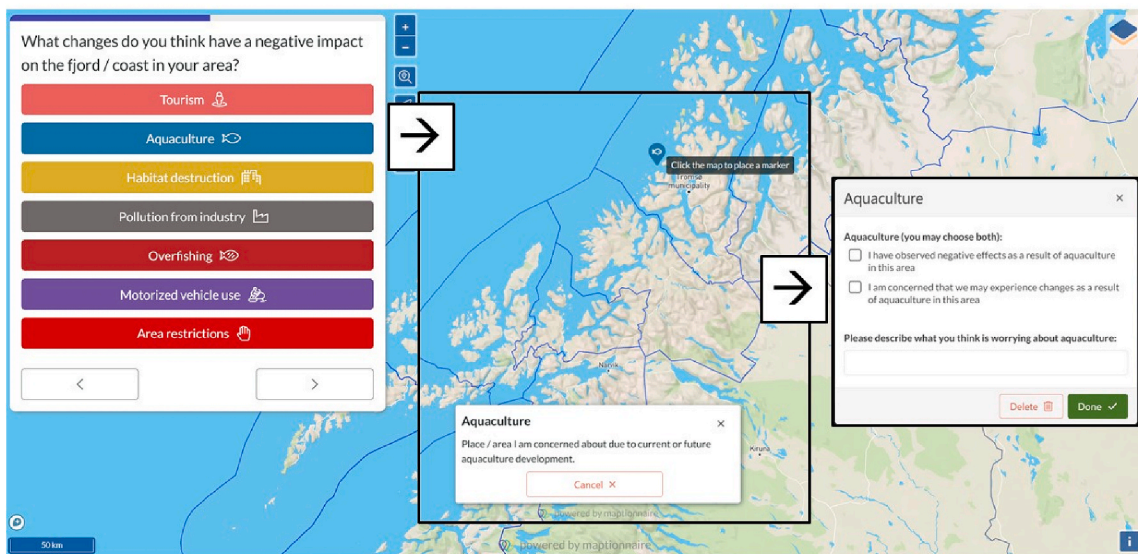
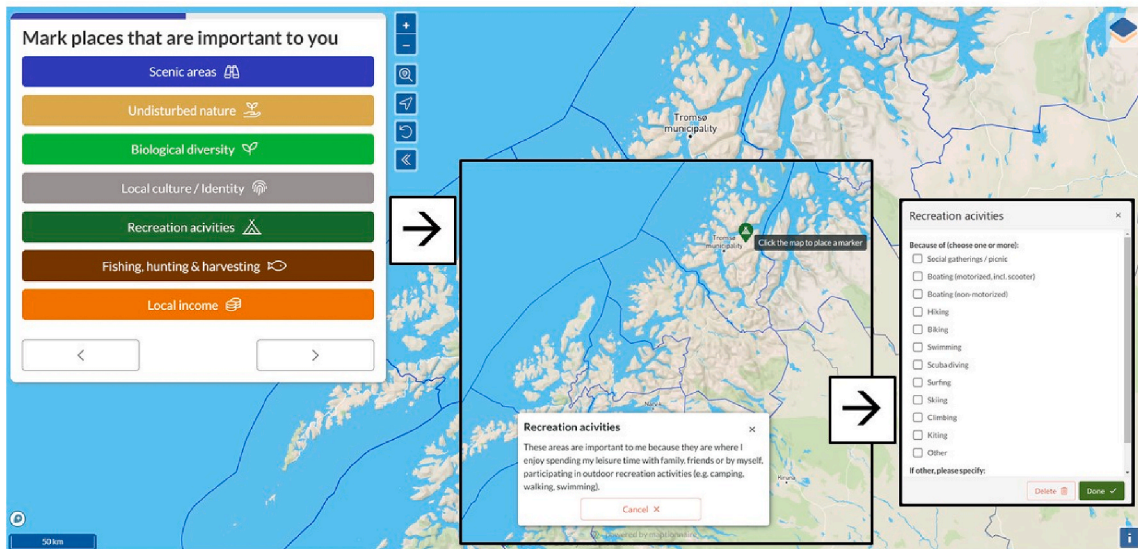
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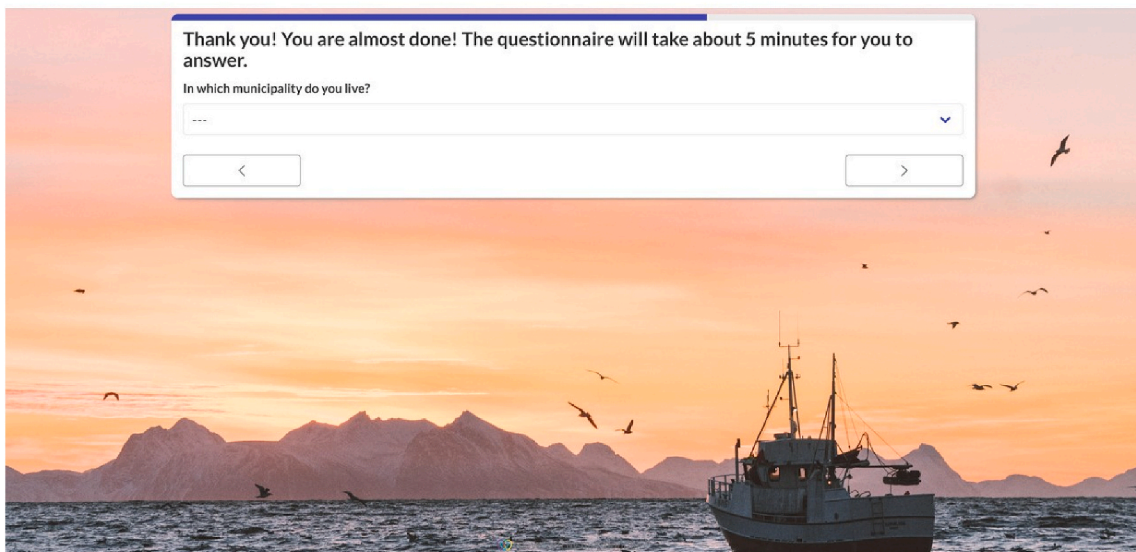
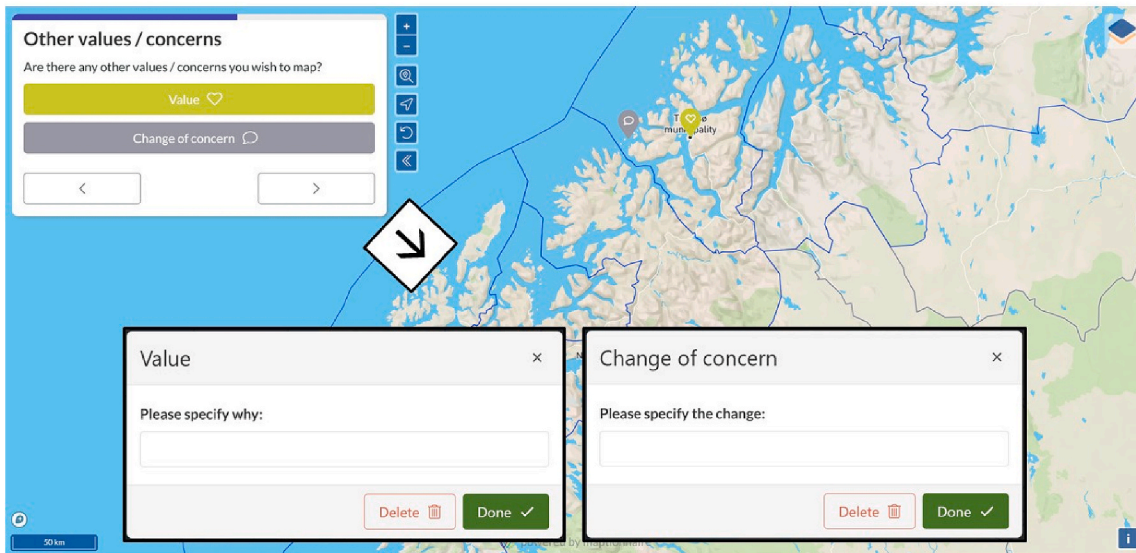
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Appendix I. PPGIS survey design









How much do you agree or disagree with the following statements?

	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
Local workplaces and income should be secured even if it conflicts with environmental interests.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Beautiful coastal landscapes need to be protected.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
We must take steps to ensure that coastal ecosystems are in good ecological condition.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The best way to preserve natural diversity is to create marine conservation areas.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I could not live somewhere else than where I live now.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I feel a strong bonding to other people who live where I live.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Local knowledge is sufficiently passed on to the next generation where I live.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I am pleased with my possibilities to influence decisions regarding coastal development in my municipality.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I identify myself strongly with the place I live in.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Fishing quotas should be redistributed from the large seagoing fishing vessels to the coastal fleet.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
My life revolves around the place where I live.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Point of views

When thinking about your living area, what considerations would you make in these situations?

	Not acceptable	I don't know	Acceptable
Wind farms	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Oil and gas	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Other comments:

Point of views

When thinking about your living area, what considerations would you make in these situations?

	Decrease	Neutral	Increase	I don't know
Tourist fishing	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Cruise tourism	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Other coastal tourism	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Salmon aquaculture	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Other aquaculture	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Kelp harvesting	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Commercial exploitation of new products (Calanus)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Other comments:

<
>

Background information

Gender

Female

Male

Other / I don't want to answer

Age

Highest level of education

For taxes and other deductions, how much is your household's approximate gross annual income, including your own income?

How long have you lived in your municipality?

+2 years

2-5 years

+5 years

I have lived here my whole life

I live in the municipality but spend a lot of time elsewhere

Which of these apply to you? (Choose all that apply)

My family has lived here for several generations

I own property (e.g. a house, cottage, land area)

I have a good knowledge of the municipality

I am of Sami origin

I am of Kven origin

I am of Norwegian origin

I am from an EU country

I am from a non-EU country outside of Norway

I work in the fisheries

I am a fisherman

I work in aquaculture

I work in tourism

I am a local politician

I work with / in the oil and gas industry

I am a member of an environmental organization

I am a member of an outdoors organization

I am a member of a hunting and fishing organization

I work with management and / or planning

I work as a researcher or consultant

Other

If other, please specify:

<
>

Background information

Has the Covid-19 pandemic affected how you use or relate to nature? Please describe:

Do you want a summary of the results via e-mail?

Yes

No

Would you like to be contacted again by email to participate in future rounds (every 2nd or 3rd year) of the survey?

Yes, I want my email address to be stored for participation in future Coastal Barometer's surveys.

No, I want my email address deleted from the database and I do not want to be contacted regarding future surveys.

E-mail address (if you chose at least one of the above that requires your e-mail address):

This ends the survey! Thank you so much for your time and participation. If you have more comments, you can write them down here:

< Done!

Data availability

The data that has been used is confidential.

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- Emma Annika Salminen** is a fourth-year doctoral student. Her PhD focuses on participatory mapping of values and concerns of coastal communities related to the blue economy in northern Norway.
- Francisco Javier Ancin Murguzur** is a data analyst working with cumulative impacts, biodiversity and coastal ecosystems.
- Victoria Marja Sofia Ollus** is a second-year doctoral candidate. Her PhD focuses on ecosystem-based management and marine birds and mammals.
- Sigrid Engen** is an environmental social scientist working inter- and transdisciplinary with natural resource management and conservation in coastal, marine, and terrestrial ecosystems.
- Vera Helene Hausner** is a professor in Sustainability Science. She works with participatory mapping using new technologies and approaches for interdisciplinary and collaborative science in coastal and marine environments.