MASTS ASM 2024 Workshop Proceeding: Tracking Top Predators in Marine Renewable Energy Development Areas

Thursday 7th November 2024, 09:00-12:00

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Abstract

Technological developments over the last few decades have resulted in an ability to track animals in high resolution at sites of ongoing and planned industrial development and use. The resulting animal-borne tracking data (e.g. GPS, biologging, telemetry) provides multi-scalar and often high- resolution information on individual habitat use and behaviour. This can be used to predict species vulnerability as well as assess negative effects such as displacement, disturbance, and collision risk. This potential is acknowledged by both developers and governments with calls for increased use of archival datasets as well as in the generation of new data. However, in the experience of the conveners, the use and understanding of such data varies widely between interested parties and there is ample opportunity for misuse and misinterpretation of any results yielded. We therefore organized a workshop at the Marine Alliance for Science and Technology Scotland (MASTS) Annual Science Meeting (ASM) 2024 to bring the Scottish marine wildlife tracking community together to identify gaps and opportunities in its use for marine and offshore renewable energy impact studies. Over the course of 3 hours of discussion and brainstorming around thought-provoking questions, attendees identified a number of challenges in the current use of tracking data as well as concrete steps to improve efficiency.

Tracking data needs to be used in a way that maximizes its strengths while acknowledging its limitations. To prevent misuse, there needs to be standardisation and guidelines for its incorporation into decision-making processes (e.g. Environmental Impact Assessment (EIAs), marine spatial planning), including specifying the questions it is most suited to answer. For example, tracking gives insights into the drivers of behaviour and predictive models of “risky” behaviours could be developed for development areas based on such data. Tracking can also be well-suited to cumulative and interacting effects studies as movements of an individual year-round and beyond one development site can often be followed. Attendees also identified that while there are existing datasets from priority species in key areas (i.e. Moray Firth, Orkney, Inner Hebrides), there is a need for this information to be more readily accessible to practitioners. To address these needs and progress understanding, it was agreed that the creation of a Special Interest Group within a MASTS Forum (i.e. mobile species) would be investigated following the workshop conclusion and dissemination of its contents to the wider MASTS community.

Proceedings

Agenda

1) 9:00-9:30 Presentation, divide into 4 groups of ca. 4-5 people each

2) 09:30- 10:15 First batch of flipchart questions, discussion

3) 10:15- 10:30 Short comfort break

4) 10:30-11:15 Second batch of flipchart questions, discussion

5) 11:15- 12:00 Third batch of questions, discussion, wrap-up

Attendees

The workshop was capped at 24 participants, of which 24 signed up and 18 attended on the day. These were mostly researchers based at Scottish and UK universities and research institutes (Figure 1). For those unable to attend on the day, an online questionnaire was circulated: https://padlet.com/isakssonnatalie/tracking_renewables

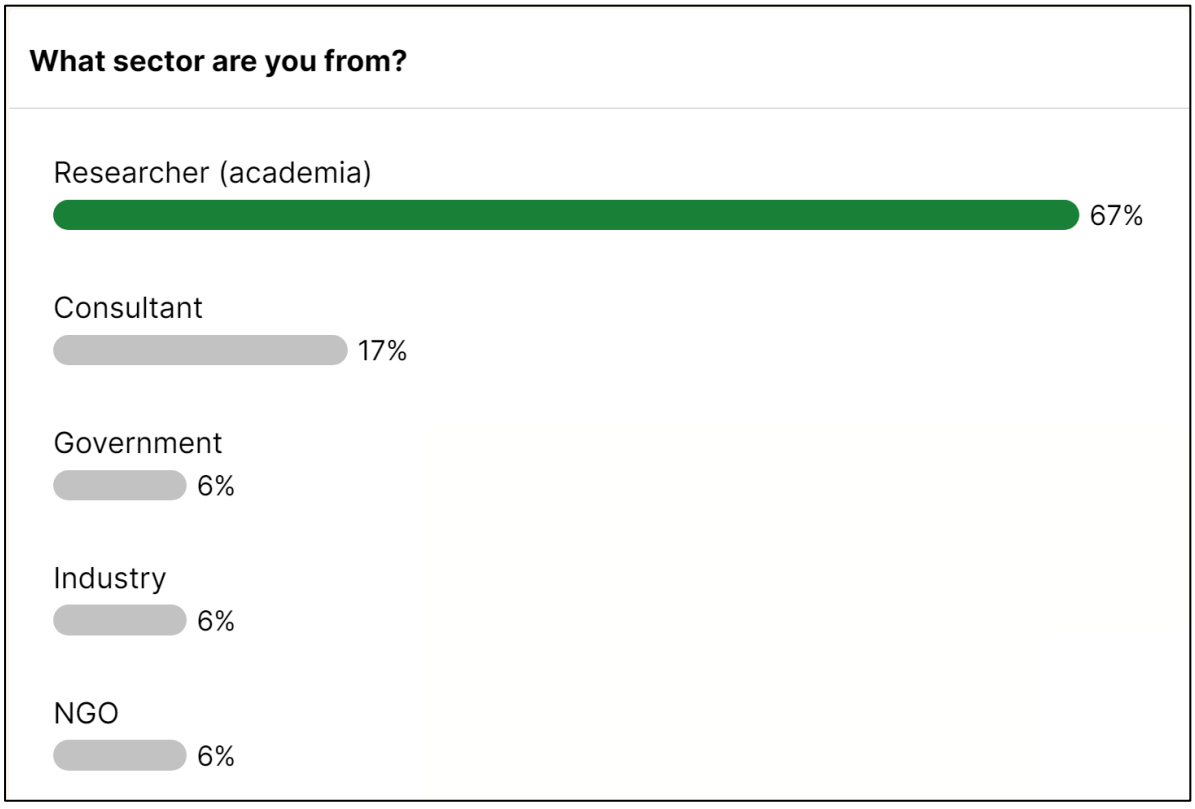


Figure 1. Results from Slido questionnaire to attendees asking them to vote on which sector they belonged to.

The workshop was divided into a main presentation section and an interactive rotation between questions on flipcharts. In the main presentation attendees were asked to interact with Slido questionnaires to identify the sectors represented (Figure 1) and what they hoped to achieve by attending the workshop (Figure 2). Most attendees identified as academics and presumably attended

to achieve greater understanding of the topic and seek collaborations. Other notable reasons for attending were to "make sure sharks and fish are included!" in the discourse and to "steer science effort in useful directions" (Figure 2).

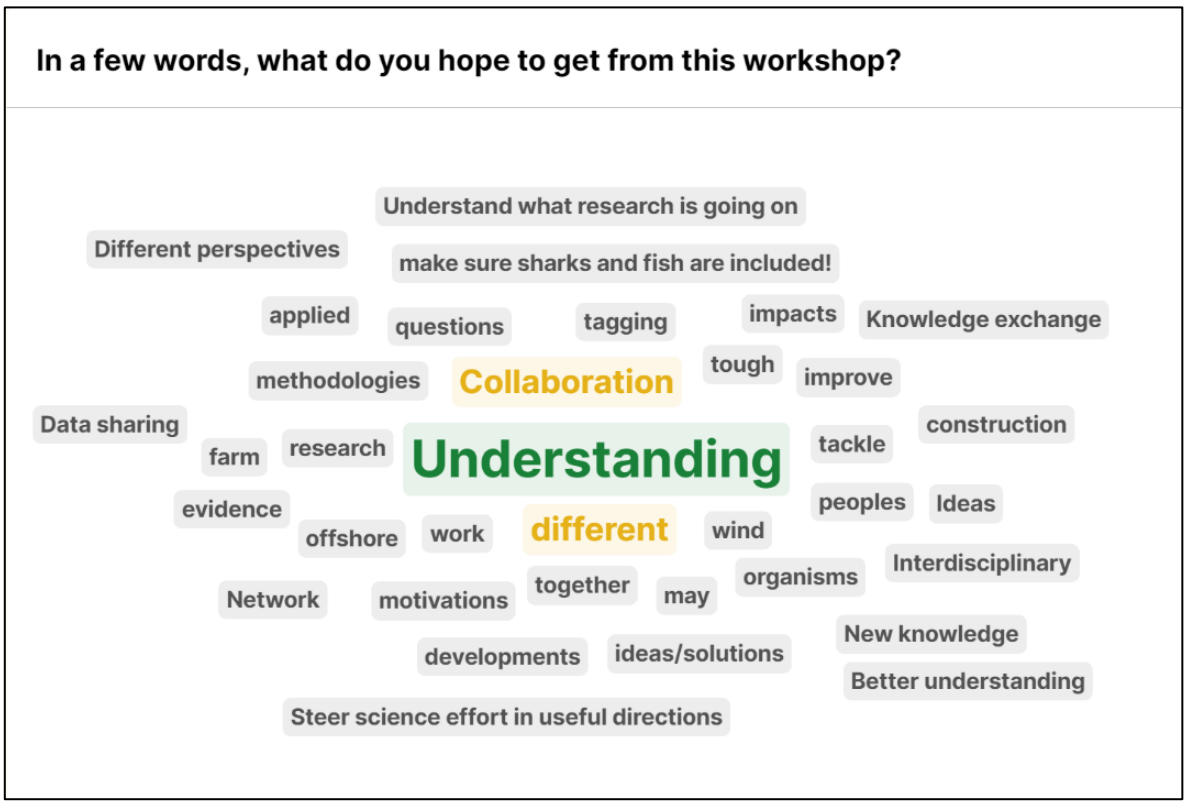


Figure 2. Results from Slido questionnaire asking attendees to describe in key words why they attended the workshop.

The flipchart questions were placed throughout the room and the attendees were split into 4 groups and given ca. 6 minutes to answer them; the groups were asked to move to another flipchart after the time interval so that each group would get to answer and/or comment on each question (Figure 3). There were three batches of questions covering two topics: identifying knowledge gaps/challenges and seeking solutions (Figure 4). The specific questions asked, and the transcript of the answers provided can be found in Appendix 1. During development of the workshop, it became clear that while several tools and techniques fall under the heading of "tracking" as they provide tracks of animals (i.e. active acoustics, imaging sonar), in the interest of having more actionable points we decided to limit the scope where possible to animal-borne tags (i.e. telemetry, biologging).

Figure 3. Workshop attendees discussing and answering flipchart questions.

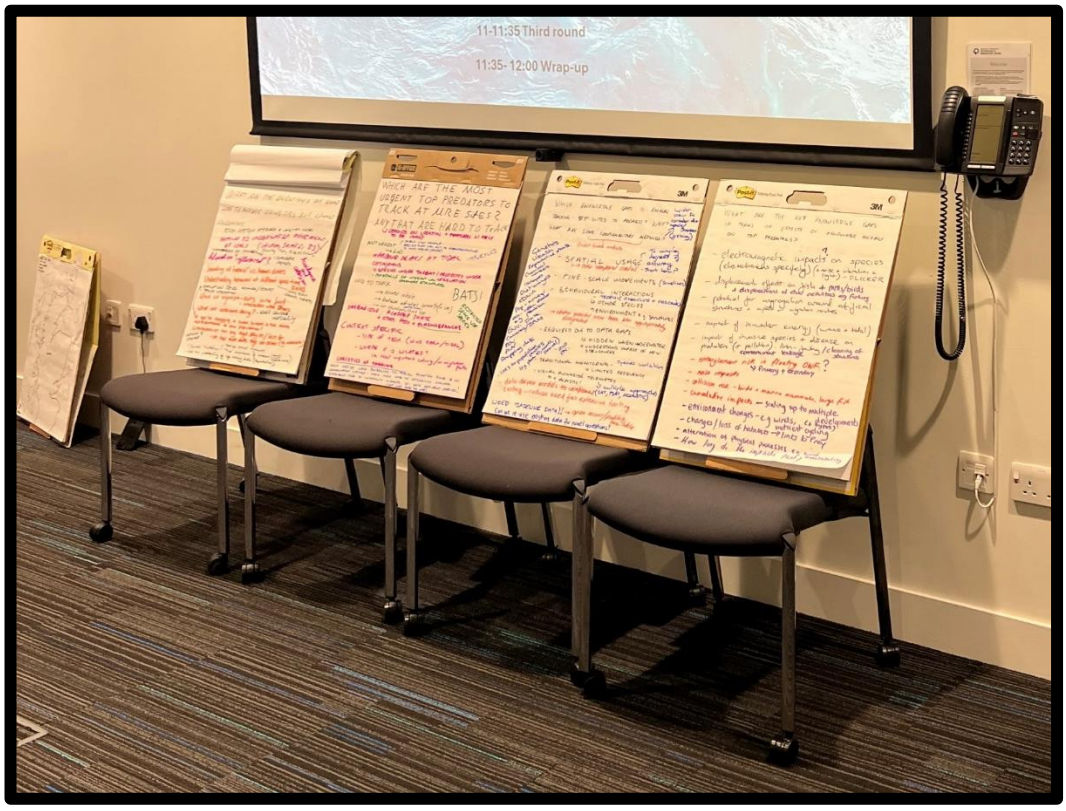


Figure 4. Fully populated flip charts demonstrating the breadth and detail of discussion captured through the exercise.

Knowledge gaps and challenges

Effects of renewable energy on top predators

Attendees identified a number of effects of marine and offshore renewable energy on top predators that are still poorly or incompletely understood:

- The causes and mechanisms of displacements on fish, marine mammals and birds and their consequences on a holistic ecosystem-scale including net gain or net loss of biomass and how to measure these.
- The extent to which animals avoid structures and the implications of this on energetics, and therefore survival and fecundity.
- The potential for aggregation around structures and the impact this might have on migration routes.
- Effects of developments and structures on multi-species interactions and ecosystem functioning, for example changes in fish prey abundance affecting predator behaviour
- Pollution impacts, especially as regards to structures facilitating the spread of invasive species and disease on predators and the extent to which anti-fouling plays a role.
- Primary and secondary entanglement due to interaction between cables, infrastructure, and derelict gear (e.g. ghost fishing gear).

Participants highlighted that electromagnetic and noise impacts on species, especially elasmobranchs, are still insufficiently understood. Specifically, the combination of noise, vibration and light leading to flicker effects. More generally, participants identified the need to address cumulative impacts and environmental changes including how to account for multiple development types in areas visited within predators' lifetimes and to be able to differentiate these from other drivers (i.e. wind, surface currents, stratification, nutrient cycling, etc.). The need to link any changes in habitat use to predator-prey interactions and to assess how long impacts may last for was also discussed. During discussions it also became clear that uncertainty exists within the research community, especially when it comes to the scale in both space and time necessary for meaningful conclusions from monitoring campaigns. It was identified that this was a point where increased dialogue with industry partners and regulatory bodies would be needed.

The untapped potential of tracking data

Participants identified a wide range of questions that can be investigated using tags but that are either currently limited by lack of data and logistical difficulties or by scope of projects. Substantial discussion time was devoted to the question of how there can be differences between regulatory and research priorities, which leads to "parachute tagging". This type of tagging, where animals near a development are tracked, can result in a lack of baseline data because it is typically collected while structures are being built or after, with limited information on movements beforehand. The focus is often also on the tracking itself, with valuable metadata that comes from continuously monitoring the population/aggregation/colony where the individual was tagged being neglected. While understandable why this happens, it nevertheless makes it more difficult to understand why individuals are behaving the way they are and how developments or structures are influencing this.

At the broad scale, we would like to gain a more complete understanding of the life histories of mobile top predators, including the connectivity between development sites across time and the causes and consequences of variability in behaviour. For many migratory or long-distance movement top predators, this would include knowledge of rates, timing and scale, beyond that of one development that would have relevance for protection and management measures. While this is possible for larger

species, gaining such information is limited by our ability to attach tags of sufficiently high resolution to species year-round; it also often falls outside the remit of what a developer needs to provide for an EIA, making it difficult to justify collecting.

Also at a large scale is the question of interactions between species and social dynamics, how these are shaped by the environment and how these can influence interactions with energy infrastructure. In particular, the question of how predators interact with their prey is of interest and whether changes in prey behaviour around energy infrastructure does in fact predictably lead to changes in predator behaviour (as has been suggested by seals presumably foraging around wind turbine monopiles). Within this larger question lies also the need to differentiate between and quantify natural and anthropogenic drivers of behaviour; notably also potential for interaction with vectors of disease such as avian flu and sensitivity to climatic and oceanographic conditions. Notably, tags equipped with the requisite sensors could be used to measure environmental conditions of the animals in-situ, instead of relying solely on proxy data from satellite measurements and oceanographic models. While tagging can certainly provide much of the information required, these are questions where combinations of sensors and data collection methodologies would be required, at similar sites both with and without development; this would require a large planning and logistical effort.

Finally at the fine-scale, 3D movements of seals, cetaceans, and seabirds is still lacking. Having higher-resolution and multi-sensor information (achievable by combining depth and accelerometery sensors in tags) could allow for important insights into avoidance versus evasion behaviour around moving infrastructure (i.e. turbines), which would increase confidence in collision risk assessments.

Limitations of tracking

Every technology has its limitations and tracking is no different. Limitations of tracking data can be broadly categorized as falling into three categories: context-specific issues, logistics, and data handling. Within 'context-specific issues', attendees noted that the type of installation being assessed can often impact animal presence as well as site location and crossover with habitat use. This renders tagging most useful at locations where species are known to aggregate predictably (e.g. seabirds at breeding colonies), and given the often large-scale movements marine top predators are capable of, this could be at locations not immediately adjacent to development sites. However, this will also increase the chances of low overlap with the development of interest, while still yielding potentially valuable data for habitat use modelling that is more widely applicable (although often more challenging to analyse and interpret). Under 'logistics', the issue of lack of baselines was identified that make it challenging to assign priorities, as well as the inherently stressful nature of tagging that raise the ethical quandary about its appropriate use. Discussions among participants revealed concerns about the levels of stress being applied to tagged individuals, with some arguing that we "owe" it to those subjected to the experience to make the most out of this and capture as much data as possible. Others argued that as priorities are almost always assigned based on conservation listings, implying a high burden on the population already, that new tagging campaigns on these species must be considered very carefully. The issue of politics was also raised, where some countries permit tagging of potentially vulnerable species (e.g. porpoise in Norway) while others do not. Specifically, the tagging of cetaceans (porpoise, dolphins, and whales) is not conducted in UK waters, with attendees citing politics as a barrier to discussion. It was also noted that there is little consensus within the research community on what is an acceptable tag effect, which is often dictated by percent weight of tag to species and any drag effects (rather than explicitly measuring effect on survival and/or breeding success, which can be challenging and expensive). However, some species are sensitive to handling regardless of tag size. Furthermore, not all tags are created equally, therefore introducing complicating factors around the amount and quality of data that is possible to be collected.

Finally, tags often produce high quantities of data that can require extensive processing and analysis that requires specialised skills. While biologging data can often be handled using open-source software (which is an advantage), it is not always straightforward how to process the data, especially in the common cases where there are gaps. The kind of processing and analysis will also depend on the end-product required (e.g. utilisation distribution maps or collision risk model inputs), and there appears to be little consensus on best-practice that would allow for readily interpretable and comparable results between species and development areas. There is then ultimately also the need to either translate the information gathered from a few individuals into population-wide recommendations or acknowledge this limitation (i.e. that tags yield individual movement behaviour data that is not necessarily representative of the wider population) more explicitly.

Solutions

Strengths of tracking and complementary methods

The strengths of tracking data include that it provides empirical evidence and quantifiable data for many species, especially those that are otherwise non-abundant or highly spread out and difficult to monitor. Top predator tracking data is best suited to address spatial usage of areas over several spatial and temporal scales, and in combination with additional sources of data (i.e. environmental), to develop process-based and predictive models and characterize fine scale movement and habitat use and the drivers of these. Tracking also allows for apportioning of risk to specific populations, for example in the case of breeding seabirds from Special Protected Areas. It also allows for very high resolution information on an animals whereabouts and movement behaviour, and has the potential to yield information on 3D underwater movement that is otherwise very difficult to obtain. While acoustics are a possibility, these data are often very challenging to process and are only possible at specific sites. Participants also highlighted that this kind of data often brings a community of researchers together as it provides opportunities to collect other samples (e.g. diet, morphometrics) and has the flexibility to allow for combining with datasets collected using other instrumentation (e.g. acoustics, visual observations). A summary of the most informative uses of tracking data in the context of assessing effects from marine and offshore renewables is provided in Table 1.

Table 1. List of most informative uses of tracking data for MRE site consenting/planning/monitoring

Tracking use	**Comments/Issues**
Assess long-term changes to populations	-Depends on dataset availability -Define long-term -Baseline vs post installation -Depends on regulatory priorities
Collision risk	-Behaviour around infrastructure -Ability to link movement to critical habitats and life history events -Model/predict risk based on environmental factors
Provide baselines of animal behaviour, pre-, during- and post- installation	-What are the consenting requirements? -Juxtapose with monitoring happening outside of consent process -Identify differences in habitat use -Allows for generalisation of datasets and wide-scale applicability -Predictive/explanatory modelling
Identify locations suitable for MRE development	-Specifically identify locations where high overlap between future development and top predators, therefore preferably avoided -Mapping

Chief complementary methods especially at the within-development scale include visual and acoustic monitoring, while diet, genetic and eDNA analyses were also discussed as metadata that could provide crucial insights into the reasons behind individual movements and habitat use. Combining tracking data with multi-sensor platforms and fisheries and shipping data were also discussed, however here it was acknowledged that sound methodologies for doing so are needed as well as greater access to the required data. This spurred further conversations about the need for open and accessible baseline and tracking data collected by all interested parties (including industry) and the question of reusing existing data for novel questions. As pertains to top predator tracking data, this question was further explored in the mapping exercise later (see Priorities section).

Necessary developments

While individual movement and habitat use from tags is useful, one limitation is translating this into population-wide recommendations. This process is highly species-dependent and will also depend on population size, and the degree of variability between life stages, sexes, and individuals. However, if underlying behavioural drivers can be understood then this can be converted into predictions for other development sites and areas where animals aggregate (e.g. breeding colonies for seabirds, haul-out sites for seals). This can be facilitated by combining tracking with other methods (e.g. visual counts) as well as by use and where necessary development of appropriate analytical methodologies. As these are often advanced, this would require greater inter-disciplinary and international collaborations, especially where migratory species are concerned. Where such efforts are not possible then tracking data can be used to sign-post or inform research into population behaviours that are conducted using other methodologies more appropriate for this.

One of the key outstanding questions identified was collision risk for top predators, both above and especially below water, where developments in technology and methodologies are needed. Specifically, the issue of proving avoidance by individuals of moving parts (e.g. turbine blades). Habitat use at large scales and the connectivity between development sites could also be helped by facilitating comparison and integration of different datasets as well as developments in the battery life and cost-effectiveness of instruments, sensors, and tags. It would also be beneficial for attachment methodologies for tags to be developed such that tags can be deployed for longer on individuals without negative effects. Developments in measuring energy expenditure of individuals as well as eDNA validation was also identified. Ultimately, however, attendees agreed that one of the biggest barriers to increased understanding lies in data processing and sharing, where greater interdisciplinary research efforts and more direct involvement with stakeholders (including government, manufacturers of tags, the renewables industry) would boost efficiency in how tag data is used. There was also discussion of the need to prioritize making the evidence base readily available and incorporated into existing management frameworks. This includes collecting and collating baseline data (i.e. pre-development or non-development) that can be used to validate, contextualise, and better understand behavioural drivers that will increase confidence in predictive models of future behaviours.

While tracking promises high-resolution understanding of animal use of development areas, the inconsistency in its current use in consent and monitoring hinders the efficacy of its application. Participants recommended that existing (and archival) tracking data be collated and incorporated in marine spatial planning exercises and in designating Marine Protected Areas. It was also recommended that EIA's and Habitat Regulation Assessments (HRA's) include and define the questions that can be answered by tags explicitly, which might result in other monitoring methods being assessed as more appropriate to answer some questions. Specifically, a few attendees lobbied for fish acoustic telemetry to be incorporated in EIA's. The question was also raised whether there is

a formal way to build upon information gathered as part of EIA's and whether such information is readily available. It was acknowledged that there is a conflict here between open dissemination and commercial sensitivity of data, that is between the requirements of the academic community and industry, that needs to be more openly discussed and resolved.

Finally, tracking allows for connectivity between sites and other anthropogenic activities to be identified which is a strength that becomes overlooked when the focus is on one technology or development site. Therefore, tracking should more often be used to identify potential cumulative and interacting effects at the scales relevant to the species of interest. To be able to do this, attendees identified the need for strategic monitoring campaigns and the development of repeatable methodologies that allow for existing and future tracking data to be used in a FAIR way.

Priorities

Seabirds, seals, cetaceans, porbeagle sharks and flapper skates were identified as the most urgent top predators to track at MRE sites. It was acknowledged that this would vary depending on the specific device (e.g. harbour seals at tidal energy sites) but that ultimately it should be dictated by those species under threat as well as their scale of movement. This due to the potential risk posed to large-scale migrants from multiple (different) developments over the course of their lifetimes and range. Some species/clades were identified as difficult to track (mainly due to logistics of applying tags and/or regulatory constraints in UK waters), which included delphinids, baleen whales, bats, and non-abundant sharks, skates and large fish. Here it was acknowledged by participants that for some species tracking will not be the most appropriate method to collect behavioural data.

To help provide clarity on where efforts for projects assessing effects of marine and offshore renewables on top predators can be prioritised, workshop attendees were asked to annotate a map of Scotland, identifying areas, and for what species, they were aware tracking data existed (Figure 5). The map soon became well populated, with tracking data for seals, seabirds, elasmobranchs, seabirds, and fish identified around the coast of mainland Scotland. Tracking efforts for Risso's (west coast) and bottlenose dolphin (east coast) were added, however these are photo-identification effort not data from animal-borne tags. Effort 'hotspots' were identified, such as the Inner Hebrides, Orkney, Moray Firth and the Firth of Forth. The exercise showed that when experts specialising on different animal groups, and from different professional backgrounds, were brought together, a sense of prime and data-deficient areas of animal tracking data was quickly forthcoming. A more comprehensive exercise to map existing and ongoing tracking data collection could be useful for future project developments, as well as facilitating synergies between expert groups.

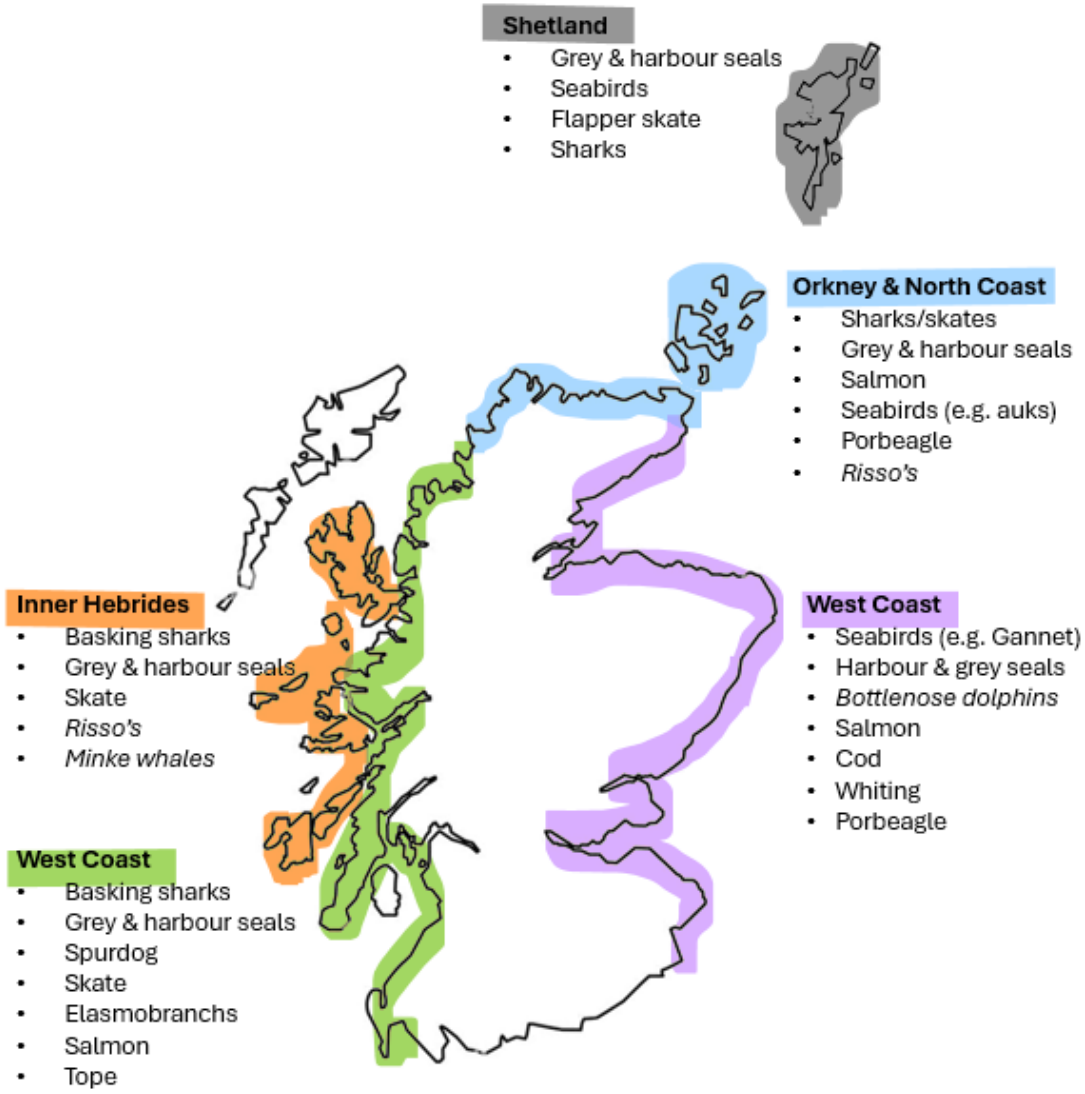


Figure 5. Summary of Scotland map populated by workshop attendees of where tagging of species has been known to occur. Italics indicate species where 'tagging' of known individuals is conducted from photo-identification efforts, and not from animal-borne biologging tags.

Workshop Conclusions & Next Steps

Workshop attendees were appreciative of the opportunity to interact and discuss with other experts, especially those specializing in other study species than themselves. The discussions, including those during breaks, ratified the idea that there is a significant pool of data and expertise in the intersection between tracking, mobile species, and renewable energy, yet this is not used to its full capacity. Forming a special interest group within MASTS with representation not only from research but also industry, government, NGO's and consultancies, seemed to be the most popular first step in remedying this. The contents of the workshop are summarized below.

Key knowledge gaps about effects of marine renewables on top predators still remain: especially surrounding fine-scale behaviour around turbine blades (i.e. the extent to which avoidance can be quantified), the causes and mechanisms of displacement, the extent of cumulative effects and how any effects contribute to net gain or net loss of biomass. Top predator tracking data is best suited to address spatial usage of areas over fine and large spatial and temporal scales, as well as to develop process-based and predictive models about animal movement and habitat use and the drivers of these. Tracking also allows for apportioning of risk to specific populations. Notably there is potential for more holistic, cumulative effects studies using tracking as in many cases the movements of an individual year-round and beyond one development site can be followed. As with any technology, tracking has its limitations, which are often either misunderstood or insufficiently accounted for. One major limitation is that tracking readily provides information on an *individual's* movements and habitat use, which is not necessarily representative of that of the population. To address limitations of tracking, there is therefore a need to use the data in appropriate ways. These include the use of explanatory and predictive models, where appropriate combining it with other monitoring techniques, and using tracking data to inform development of studies using methodologies suitable for population-wide inferences. Specific recommendations for efficient use of tracking data in Scotland included:

- Improve the way that tracking data are collated and incorporated in marine spatial planning exercises and in designating Marine Protected Areas; for example by making tracking datasets publicly available.
- EIA's and HRA's should include and define the questions that can be answered by tags explicitly.
- Development of best practice guidelines and frameworks for incorporation of tracking data into EIA's, marine spatial planning, and other decision-making processes.
- Fish acoustic telemetry should be incorporated in EIA's.
- Developments in tag specifications and attachment methods need to continue.
- Tracking should be used in cumulative and interacting effects studies, requiring therefore strategic monitoring campaigns as well as development of FAIR methodologies for any resulting data handing and analysis.

Seabirds, seals, cetaceans, porbeagle sharks and flapper skates were identified as the most urgent top predators to track at MRE and offshore wind sites. While magnitude of urgency will depend on the type of device, ultimately prioritization should depend on data availability, population status and scales of movement (i.e. how likely the animals are to come into contact with multiple developments over a lifetime). Increased efficiency in how tracking data is collected and used can be achieved by greater interdisciplinary research efforts and more direct involvement with stakeholders, including government, manufacturers of tags, and the renewables industry.

Attendees identified the following action points for next steps of this group or any derivative thereof:

1) Circulate a workshop report to the MASTS (and wider) community
2) Form a special interest group, possibly under the auspices of the existing MASTS mobile species working group
3) Acquire funding
4) Development of or contribution towards an interactive tool or map to signpost users to archival and ongoing tracking projects around Scotland
5) Write a policy brief and/or peer-reviewed paper on the state of play and steps forward
6) Consider approaching other working groups on the subject (i.e. IMAREST or ICES).

Appendix

Appendix 1: Flipchart questions

Raw transcription from flipcharts, including the questions

What technological/methodological/analytical/ development are needed to answer outstanding questions?

- interdisciplinary research efforts
- involving stakeholders (government/manufacturers/academic)
- current technology is sufficient but could be used more effectively
- better presentation of data/materials is required
- data processing hampers speed of output
- comparison of data sources/integration of data
- subsea collision risk
    - technology
    - methodology
    - How to prove avoidance?
- eDNA validation
- cheaper methods and reusable materials
- battery life of instruments and platforms
- attachment methods
- How to measure energy expenditure

How would you like tracking to be used in MRE site consenting/monitoring? Examples?

- Incorporate tracking in EIA (Fish acoustic telemetry)
- Allow existing data (tracking) to be incorporated in marine spatial planning (better data accessibility)
    - Incorporating old data?
- Ensure baseline in ongoing surveys using tracking
    - BACI protocol
- Obligate developers to fund work
- Connectivity with other sites/activities
- Monitoring of spp. around URE technology
    - Site use
    - Behaviours
    - Any info to de-risk consenting/allow for appropriate EIA
- Designating areas for MPA (Mobile MPAs)
    - Understanding animal use of MPA
- Define questions in EIA/HRA that can be answered by tags
- Strategic monitoring that can be used by all
- Develop repeatable methodologies

Which knowledge gaps is animal tracking best suited to address? Why? What are some complementary methods?

- Process based models
- Incorporating a wider view to consider impacts and stressors (fishing)
- Spatial usage
    - Temporal scales
    - Varying degrees of accuracy for different stakeholders
    - Short term vs long term
- Fine scale movements and habitat uses
- Behavioural interactions
    - Trophic interactions and cascades
    - Other species and connectivity impacts
    - Environment e.g structures
- Have protected areas been appropriately designated?
- Which gaps are caused by data gaps?
    - Interactions are hidden when underwater
    - Understand the impact of new structures
- Traditional monitoring
    - Limited frequency
    - Species variation
- Visual alongside telemetry and acoustics
    - Multiple approaches that can be combined
- Data driven models to compliment testing -> reduces need for extensive and expensive testing
- Need for baseline data
    - Make it open and accessible
    - Can we reuse existing data for novel questions?
- Genetics and eDNA
- Diet analysis
- ROV/AUV and multi-sensor platforms for long term monitoring
- Shipping data

What are the key knowledge gaps in terms of effects of renewable energy on top predators?

- Electromagnetic impacts on species (elasmobranchs)
    - Noise + vibration + light -> flicker effects
- Displacement effects on fish, marine mammals and birds
    - Causes of displacements
    - Net gain or loss of biomass?
- Potential for aggregation around artificial structures + impact on migration routes
- Impact of invasive species + disease on predators (pollution impacts)
    - How does anti-fouling fit into this?
    - Cleanup of structures and contaminant leakage
- Entanglement risk in floating OWF
    - Primary and secondary
- Impact of noise
- Collision risk of birds and marine mammals
    - Similar risk for large fish?

- Cumulative impacts
    - Scaling up to multiple development types
- Environmental changes
    - Wind, surface currents, stratification, nutrient cycling
- Changes/loss of habitats -> links to changes in habitat use and predator prey interaction
- How long do impacts last and are they here to stay?

Can insights from tracking individuals be more readily translated into population wide recommendations? How?

- Species dependent, population size, life stage + sex
- Ensure outputs are curated
- Use tracking data as a sign post/inform ongoing research
- If combined with other methods, it needs to be validated with other data
- Dependent on the temporal scale over which data is collected
- Collaborations across countries, especially for migrating species
- Depending on what tags were deployed and in what numbers translation to entire population might leave big gaps
- If you can understand underlying behavioural drivers -> this can be translated to predictions for other sites/colonies

Please list and rank the most informative uses of tracking data for MRE site consenting/planning/monitoring

- Long term changes to populations
    - Depending on dataset availability
    - What is long term?
    - Baseline vs post installation
        - Depends on regulatory priorities
- Collision risk bs post installations
    - Behaviour around infrastructure
    - Avoidance
    - Displacement
    - Link movement to critical habitats + life history events
- Consenting process includes baselines, pre, during and post
    - All of equal importance
    - Vs-monitoring outside of consent process
        - Difference in habitat use
        - Generalisation of datasets and wide scale applicability
- Identifying locations suitability for MRE development

What are the most urgent top predators to track at MRE sites? Any that are hard to track?

- Most urgent
    - Seabirds
    - Harbour seals at tidal sites
    - Cetaceans

        - Species under threat and large scale migrants
    - Porbeagle
    - Flapper skates
- Hard to track
    - Minke whale
    - Balean whales (in UK waters)
    - Non-abundant sharks, skates and large fish
    - Bats
- Context specific issues
    - Type of installations impact animal appearances
    - Type of tag (not all tags are created equally)
    - Site location and crossover with animal habitat use
- Logistics of tagging
    - Many species lack a baseline to assign priorities
    - Focus is on conservation listings
    - More data is always needed
    - unknown impacts on species make predicting 'need' incredibly difficult

What are the strengths/limitations of tracking data?

- Bring a community of researcher together
- Provide opportunity to collect other samples
- Sometimes it is the only information we have for non-abundant species
- Empirical evidence
- Quantifiable
- Track nonvisible animals
- Ability to work in conjunction by other datasets collected by other instruments like biologgers, acoustics or vision
- Potential high resolution of underwater 3D movement
- Volume of data and tag loss can create large costs
- Data processing can be extensive and may require specialised skills/software
- Having the location of an animal doesn't mean knowing what it is doing
- Can only work/be applied to certain animals
    - Depending on regulations and ease of access
- Data interpretation can be subject
- Stress to animals/changes in behaviour which don't reflect the natural state

What are the questions we would like to answer using tags but cannot currently?

- Eco-system approach to habitat usage
- Detailed 3D movement of seals
- Importance of connectivity between sites a
- Is behaviour natural or influenced?
    - Separating all natural and human drivers
- Understanding behaviour at different spatial and temporal scales
- Avoidance vs collision

- Population level and subsequent species interaction
- What an organism eats
    - Interaction with other species and how they are shaped by the environment
- What are cetaceans doing?
    - What causes variability in behaviour
- Disease vectors
- Sensor limitations
    - Species social dynamics
    - 'true' experience of stressors
- Gain full understanding of life history

What other questions/applications can animal tracking data from MRE sites address?

- Developing of new management frameworks
    - Evidence based
- Understanding natural variability/drivers/seasonality
- Interactions with anthropogenic activities
- Tagged animals to record the environment
    - CTD
- Understanding prey + prey variability
    - Potential food web interactions
- Protected area applicability, new and old
- Climate sensitivity
- Oceanographic conditions
    - Weather
    - Physio-ecological drivers
- Migration
    - Rates, timing and scale
- Transboundary interactions
- Acoustic tag detection at MRE sites for animals tagged elsewhere
- More date = better population level of understanding
- Understanding and addressing management measures

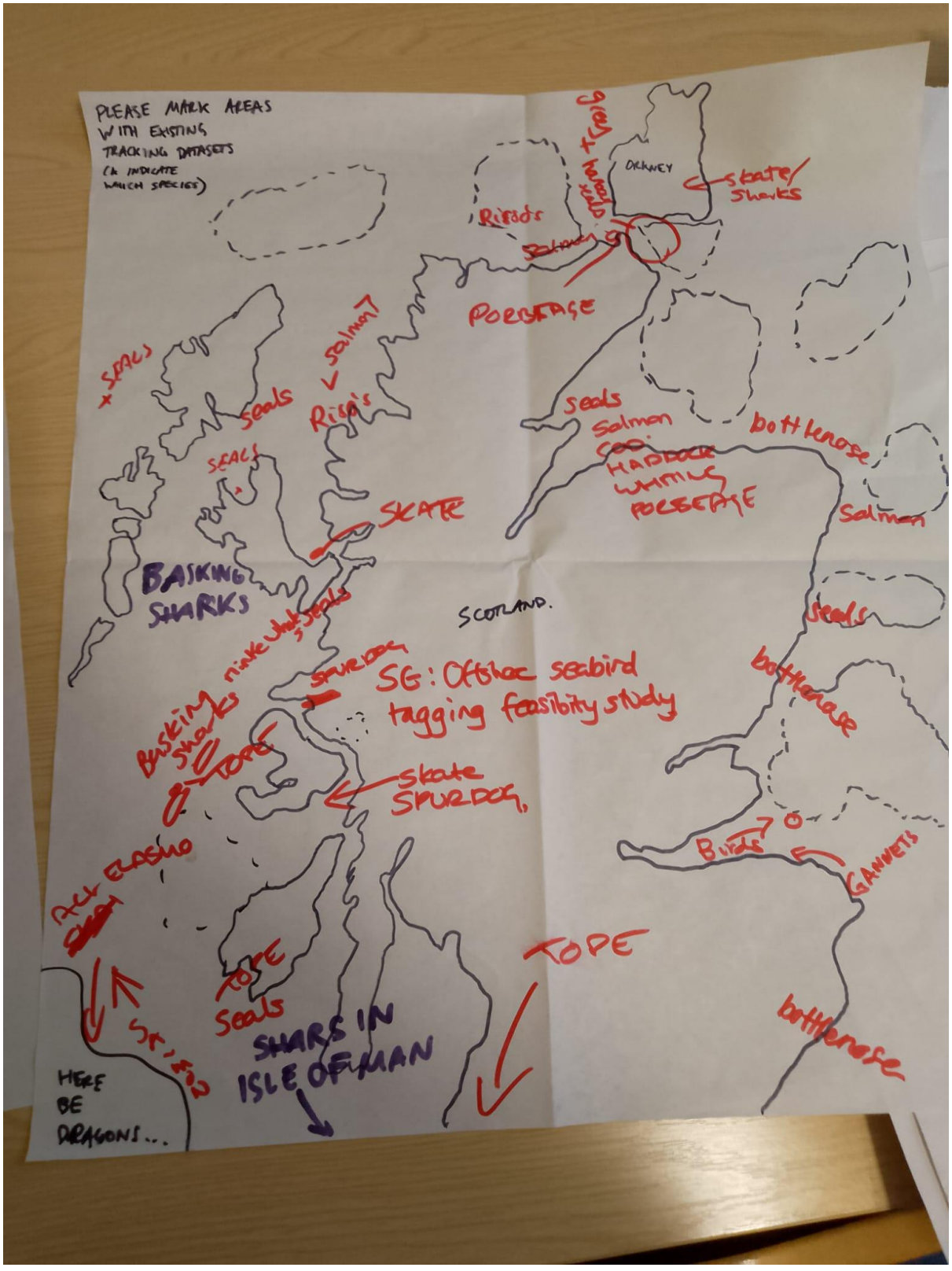


Figure 6. Map of Scotland, MRE and offshore developments indicated roughly by dotted lines, where participants were asked to indicate areas with tracking datasets, to species level where possible.

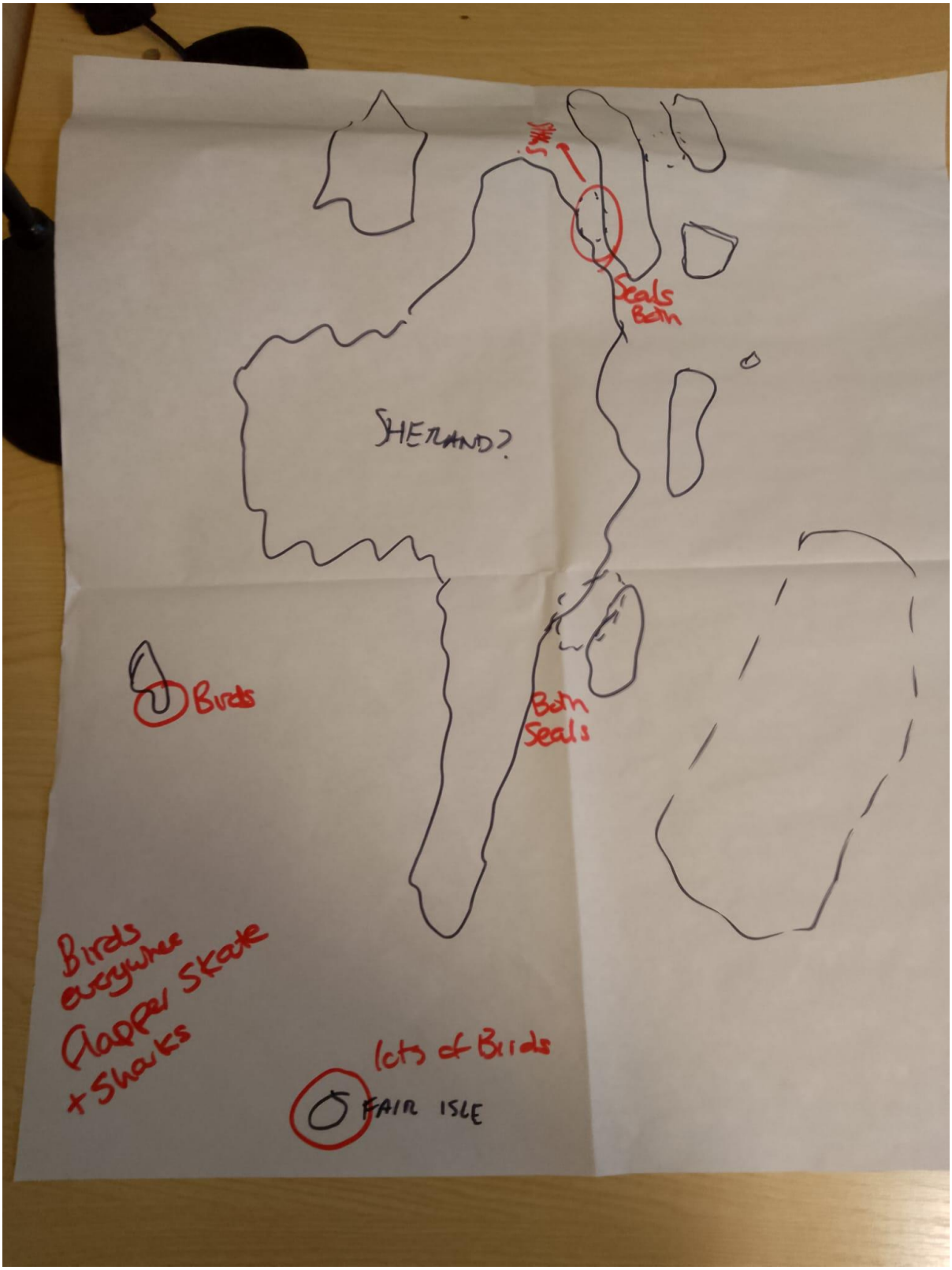
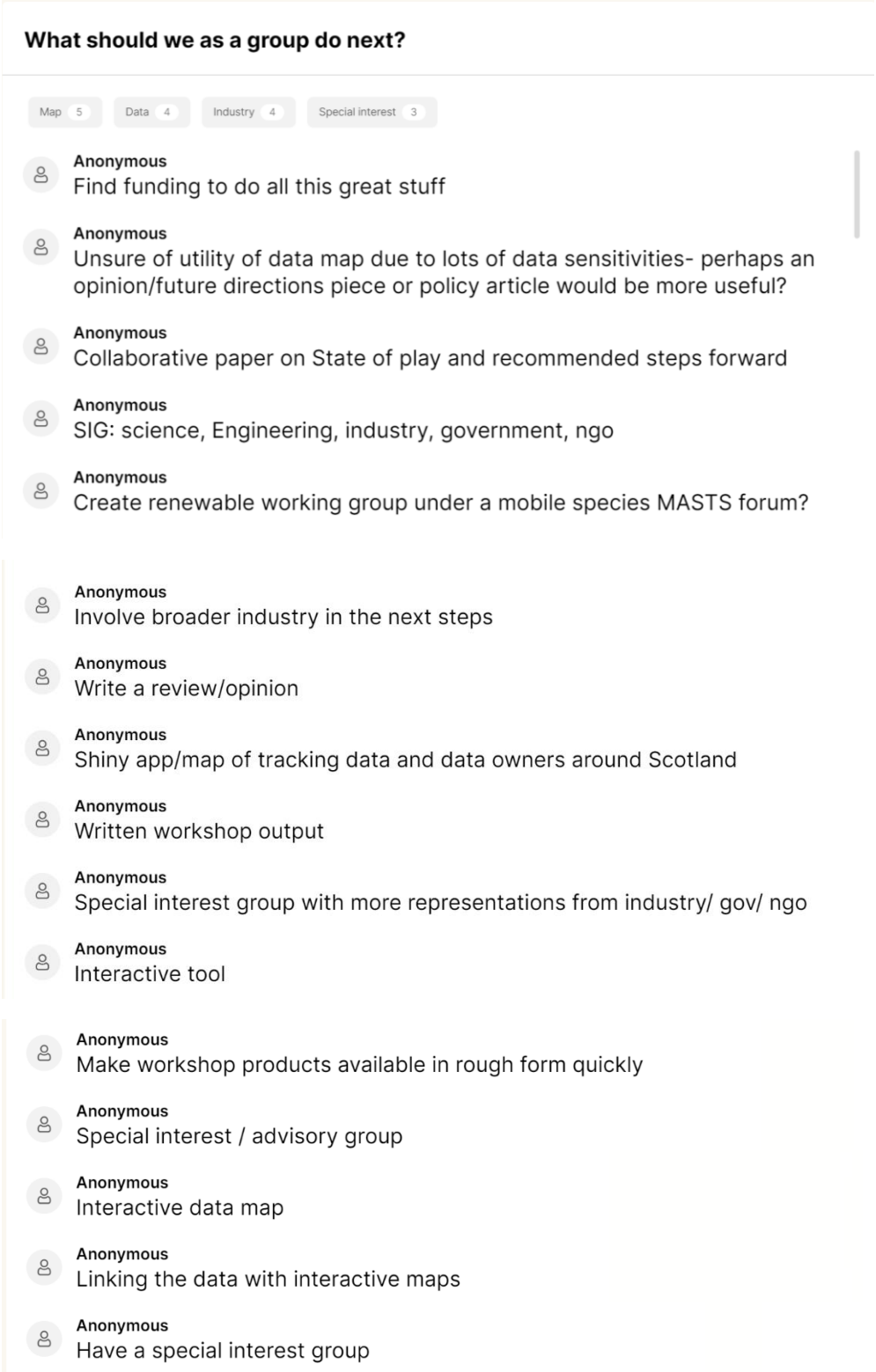


Figure 7. Map of Shetland, MRE and offshore developments indicated roughly by dotted lines, where participants were asked to indicate areas with tracking datasets, to species level where possible.

Appendix 2: Slido next steps

Raw results from the Slido questionnaire about what the workshop group (organizers as well as those attendees interested), would like to do with the outcomes from the workshop.



Share the outcomes of the meeting with other relevant groups

Anonymous
Interactive maps of what type of data is where (type of tracking/tag), which species, and who to contact.

Anonymous
Formalise the MASTS community of researchers tracking animals.

Anonymous
MASTS forum on Top Predaters/Highly Mobile Species? To be discussed over pints.

Anonymous
Map of existing tracking datasets

Anonymous
Workshop summary → policy brief/map of datasets and key interests

Anonymous
Policy brief

Anonymous
Form a forum?

Anonymous
Working group