Best Management Practices for Data Transferability and Collection Consistency for MRE

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Background

The term 'Best Management Practices', or BMPs, was coined in the US nearly 35 years ago as a way to describe acceptable practices that could be implemented to protect water quality, as well as associated resources and habitats. The first published description of BMPs was released as guidance by the US Environmental Protection Agency (EPA) guidance for developing BMPs for National Pollutant Discharge Elimination System (NPDES) facilities to prevent the release of toxic and hazardous chemicals (EPA 1993). This guidance defined BMPs as practices or procedures, that are qualitative and flexible. The guidance described BMPs as general (or baseline) practices and specific practices, with general/baseline practices widely applicable and practiced, and easily implemented, while specific practices are applicable to a specific location or process and have practices that are often tailored to meet certain requirements.

The EPA guidance suggests that BMPs be separated into three phases: planning; development and implementation; and evaluation/reevaluation. The planning phase includes demonstrating management support for the BMP plan and identifying and evaluating what areas,topics, or issues will be addressed by BMPs. The development phase consists of determining, developing, and implementing general and specific BMPs. The evaluation/reevaluation phase consists of an assessment of the components of a BMP plan and reevaluation of plan components periodically.

For purposes of creating BMPs for the transferability of data[1] from early or existing MRE projects to future projects, this document addresses the planning and development phases of BMPs.

[1] *Could be* raw or quality controlled data but *more likely* analyzed data, synthesized data to reach some conclusion, reports, etc.

Planning Phase for BMPs

In developing BMPs for data transferability and collection consistency, the planning phase has consisted of: 1) defining those areas of potential environmental effects of MRE development, as documented in the accompanying paper "Data Transferability and Collection Consistency Framework"; and 2) assessing the acceptability of transferring learning from early to later stage MRE projects among US regulators, through a series of workshops. It will be necessary to continue to iterate on these planning steps to ensure that draft BMPs meet the needs of regulators, and to extend the interactions to regulators in other Annex IV nations.

Development Phase for BMPs

The development phase begins with the drafting of BMPs in this document, and continues through examination and improvement of the BMPs at the workshop convened around ICOE. At the workshop, a plan for implementing the BMPs will be discussed. Further development of the BMPs and an implementation plan will be carried out in cooperation with the Annex IV analysts following the workshop.

Development of BMPs for Data Transferability and Collection Consistency

For the purposes of these BMPs, we define data transferability as data and/or information collected through research studies and/or monitoring from other projects that can be used to inform future projects. We define collection consistency as the collection of monitoring data that informs environmental effects in a prescribed manner that allows comparison among datasets.

It is assumed that all datasets and information transferred from one project or jurisdiction to another must be applicable all national/regional/local laws and regulations.

The purpose of examining the potential for data transferability is to shorten timelines and provide clarity in data requirements to permit/consent MRE projects across multiple jurisdictions. Following the publication of the *2016 State of the Science Report* as well as extensive discussions with MRE developers, regulators, and other stakeholders, five interactions between MRE devices and the marine environment were chosen as those most commonly associated with challenging consenting/permitting processes:

- Collision risk, largely for tidal and river turbines;
- Underwater noise from wave and tidal devices;
- Effects of electromagnetic fields (EMF) from power cables;
- Changes in benthic and pelagic habitats from placement of wave and tidal devices; and
- Changes in flow and wave heights from placement and operation of MRE devices (changes in physical systems).

The development of the *Data Transferability Framework* provides a method to determine the pathway for transferring data (learning). Coupled with the *Data Collection Consistency Table* (see below), the framework provides the background for what can be achieved to define and facilitate the transfer of learning from existing projects to inform future project permitting/consenting processes.

Collection of Data in a Consistent Manner

Inherent in the effort to enable the transfer of monitoring data about MRE devices and their applications from one jurisdiction to another is the need to understand how similar the data might be. Ensuring that the data used from an existing project are compatible with the needs of future projects, and that multiple data sets from one or more projects can be pooled or aggregated, requires an evaluation of the degree to which the data are consistent. To date, few efforts have prescribed or compared collection methods, instrumentation, or analyses. A key example of this is shown in data collected to evaluate acoustic output from wave devices to evaluate the potential deleterious effects that noise might have on marine animals (Table 1; Copping et al. 2016).

Table 1. Field measurements of acoustic data from Copping et al. (2016) to illustrate the variety of measurements used when collecting environmental effects data.

Project Location	Device Type	Developer, Project/ Device Name	Project Phase	Project Scope	Sound Levels and Pressure Spectral Densities	Organism Type	Results
Strangford Lough, Northern Ireland	Tidal; two 16 m open-bladed rotors, attached to a pile in the seabed in 26.2 m of water	MCT (Marine Current Turbines) SeaGen™	Ambient	Used hydrophones to measure ambient noise	Range of 115 to 125 dB re 1 µPa	NA	High frequencies (200 Hz – 70 kHz) attributed to sound of tidal flow.
			Construction	Measure noise levels of construction activities and marine mammal response to construction noise	• Driving pin-piles: 136 dB 1 µPa at 28 m; 110 dB 1 µPa at 2130 m • Drilling: 20-100 Hz. Equiv. to background noise at 464 m	Harbor porpoise	Temporary displacement of harbor porpoises during construction. Baseline abundances resumed following completion of construction.
			Construction	Calculate the perceived noise levels by marine animals during drilling	• Harbor seal: 59 dB_{ht} at 28 m and 30 dB_{ht} at 2130 m • Herring: 62 dB_{ht} at 28 m and 25 dB_{ht} at 2130 m	Harbor seals, harbor porpoise, herring, dab, trout	Perceived levels of sound from pin-pile driller were generally lower than ambient levels of sound in the narrows. Calculations of perceived noise suggest marine animals in Strangford Lough were unlikely to be disturbed at distances more than 115 m from drilling.
			Operation	Determine harbor seal behavior in area of operating device	Ambient plus device signature	Harbor seals	No significant displacement of seals or porpoises. Marine mammals swam freely in the Lough during operation. Noted evasion at channel center during turbine operation.
Cobscook Bay, Maine, USA	Tidal; a single, barge-mounted, cross-axis turbine generator unit in 26m of water	Ocean Renewable Power Company, Cobscook Bay Tidal Energy Project	Operation	Measure noise levels of the barge-mounted turbine	Less than 100 dB re μPa^2/Hz at 10m	NA	At 200 to 500 m from the turbine, sound was not detectable above ambient noise within the bay.
East River, New York, USA	Tidal; six three-bladed unducted turbines bottom-mounted in 10 m of water	Verdant Power, Roosevelt Island Tidal Energy Project	Operation	Measure noise levels around the array of tidal turbines	Up to 145 dB re 1µPa @ 1m from the array	14 fish species in the area	During the study, blades on one turbine were broken and another turbine was failing, resulting in more noise generation than would be expected. Conclude sound at damaged turbine array did not reach levels known to cause injury for 13 species of fish examined.
Puget Sound, Washington, USA	Wave; 1/7th-scale wave buoy	Columbia Power Technologies, SeaRay™	Ambient and Operation	Measure sound signature of the wave device and surrounding area	• Ambient: 116-132 dB re 1µPa in frequency of 20 Hz to 20 kHz when ships were nearby. • Device: 126 dB re 1µPa	NA	Ambient noise levels masked the wave device sound. Sound from the SeaRay was closely correlated to the wave period.

Assuring Data Consistency

MRE is an international industry, with permitting/consenting processes and research norms differing from country to country. It would be extremely difficult to enforce the use of specific protocols or instruments to collect data for pre- or post-intallation monitoring. However, encouraging the use of consistent processes and units for the collection of monitoring data would increase confidence in the transfer of data or learning from one location to another. For the four stressor interactions chosen for intial BMP development, a set of processes, reporting units, and general analysis or reporting methods are proposed (Table 2).

Limits of Data Consistency

Without strict adherence to common methods and instruments for collecting data, there will continue to be inherent differences among data sets that will require judgement calls on the part of the regulators, in order for them to accept data for transfer to their jurisdictions.

Combined with the format in which data are likely to be presented, these judgements can be informed by following guidance for evaluating qualitative data (next section).

Guidelines for Evaluating Qualitative Data

Data that are most likely to be presented to regulators as part of the permitting/consening process may be analyzed, synthesized, or presented as conclusions in reports. Collectively these data should be considered as qualitative rather than as quantitative data (Echambadi et al. 2006; White et al. 2012). There are approaches to the management and interpretation of qualitative datasets that can assist with determining how similar (and therefore how comparable data might be). Quality criteria used in *quantitative* research (e.g., internal validity, generalizability, reliability, and objectivity) are not suitable to judge the quality of *qualitative* research (Korstjens and Moser 2018). In qualitative research, key evaluation questions involve the trustworthiness of the data. Trustworthiness of data and criteria for judging that trustworthiness have been defined (Table 3), while strategies to ensure trustworthiness in qualitative research data are laid out (Table 4).

Table 2. Data Collection Consistency. For each key interaction, the preferred measurement methods or processes are reported, along with preferred reporting units and the most common methods of analysis or interpretation and use of the data.

Stressor/Interaction	Process or Measurement Tool	Reporting Unit	Analysis or Interpretation
Collision Risk	Sensors include: - acoustic only, - acoustic + video, - other	Number of visible targets in field of view, number of collisions.	Number of collisions and/or close interactions of animals with turbines used to validate collision risk models.
Underwater Noise	Fixed or floating hydrophones	Amplitude dB re 1µPa at 1 m Frequency: broadband or specific frequencies	Sound outputs from MRE devices compared against regulatory action levels. Generally broadband noise unless guidance exists for specific frequency ranges.
EMF	Source: - cable; - other; - shielded or unshielded	AC or DC; voltage; amplitude	Measured EMF levels used to validate existing EMF models around cables and other energized sources.
Habitat Change	Underwater mapping with sonar; video; other Habitat characterization from mapping; existing maps	Area of habitat altered, specific for each habitat type.	Compare potential changes in habitat to maps of rare and important habitats, to determine if these are likely to be harmed.
Changes in Physical Systems	Modeling, with or without validation	No units. Indication of datasets used for validation, if any.	Data collected around arrays should be used to validate models.

Table 3. Trustworthiness: definitions of quality criteria in qualitative research. Based on Lincoln and Guba (1985) (adapted from Korstjens and Moser 2018)

Quality Criteria	Definition
Credibility	The confidence that can be placed in the truth of the research findings. Credibility establishes whether the research findings represent plausible information drawn from the participants' original data and is a correct interpretation of the participants' original views.
Transferability	The degree to which the results of qualitative research can be transferred to other contexts or settings with other respondents. The researcher facilitates the transferability judgment by a potential user through thick description.
Dependability	The stability of findings over time. Dependability involves participants' evaluation of the findings, interpretation and recommendations of the study such that all are supported by the data as received from participants of the study.
Confirmability	The degree to which the findings of the research study could be confirmed by other researchers. Confirmability is concerned with establishing that data and interpretations of the findings are not figments of the inquirer's imagination, but clearly derived from the data.
Reflexivity	The process of critical self-reflection about oneself as researcher (own biases, preferences, preconceptions), and the research relationship (relationship to the respondent, and how the relationship affects participant's answers to questions).

Table 4. Definition of strategies to ensure trustoworthiness in qualitative research. Based on Lincoln and Guba (1985) and Sim and Sharp (1998) (adapted from Korstjens and Moser 2018)

Criterion	Strategy	Definition
Credibility	Prolonged engagement	Lasting presence during observation of long interviews or long-lasting engagement in the field with participants. Investing sufficient time to become familiar with the setting and context, to test for misinformation, to build trust, and to get to know the data to get rich data.
	Persistent observation	Identifying those characteristics and elements that are most relevant to the problem or issue under study, on which you will focus in detail.
	Triangulation	Using different data sources, investigators and methods of data collection. • Data triangulation refers to using multiple data sources in time (gathering data in different times of the day or at different times in a year), space (collecting data on the same phenomenon in multiples sites or test for cross-site consistency) and person (gathering data from different types or level of people e.g. individuals, their family members and clinicians). • Investigator triangulation is concerned with using two or more researchers to make coding, analysis and interpretation decisions. • Method triangulation means using multiple methods of data collection
	Member check	Feeding back data, analytical categories, interpretations and conclusions to members of those groups from whom the data were originally obtained. It strengthens the data, especially because researcher and respondents look at the data with different eyes.
Transferability	Thick description	Describing not just the behaviour and experiences, but their context as well, so that the behaviour and experiences become meaningful to an outsider.
Dependability and confirmability	Audit trail	Transparently describing the research steps taken from the start of a research project to the development and reporting of the findings. The records of the research path are kept throughout the study.
Reflexivity	Diary	Examining one’s own conceptual lens, explicit and implicit assumptions, preconceptions and values, and how these affect research decisions in all phases of qualitative studies.

Best Management Practices for Data Transferability for MRE Projects

BMPs designed to assist with data transferability and collection consistency must meet minimum requirements, and conform to a set of practices. The assumption is that the Data *Transferability Framework* will guide the process.

Minimum Requirements for Transferring Data

The minimum requirements for data transferability from an existing project to a future project using the *Data Transferability Framework* include the need for:

1. The projects to share the same archetype (same stressor, same site conditions, same technology, same receptor). Regarding the *Guidelines for Transferability*, it is preferable that they share several of the next steps in the framework as well (same species, similar technology, similar wave/tidal resources, close geographic proximity), with the need to share decreasing as you progress down the hierarchy.
2. The data to be collected in a consistent manner (from Table 2).

Proposed Best Management Practices

BMPs proposed to meet the data transfer for the five key interactions (collision risk, underwater noise, EMF, changes in habitats, changes in physical systems) are stated first as general processes and then tailored to each interaction. Each BMP is accompanied by a set of process steps to clarify their use. Each data set or body of learning must be considered for transfer, as follows:

BMP 1: Meet the minimum requirements (rules of transferability + MREPAs) to be considered for data transfer from one location or project to another.

Process: Determine MREPA(s)for your project site. Search for similar MREPAs in Monitoring Dataset matrix and choose datasets that match.

BMP 2: Determine likely datasets that meet data consistency needs.

Process: Using the *Data Collection Consistency Table*, determine whether collection methods for listed datasets are sufficiently similar.

BMP 3: Use models in conjunction with and/or in place of datasets.

Process: Once sufficient data exist for an interaction, models should be created to describe the interaction; these models will begin to take the place of larger field data collection efforts. In some cases (for example to determine changes in physical systems) models may be used prior to collection of field data. For each model used, note the type of model, whether the model has been validated with field data, and the major stated assumptions and limitations.

BMP 4: Provide context and perspective for datasets to be transferred.

Process: Where available, ancillary datasets should be collected to provide context for the MRE interaction data. These datasets might include: behavioral studies of animals, hydrodynamics and wave climate of the site and surrounding area locations, habitat maps, etc.

Implementation of BMPs

The process for implementing BMPs for data transferability and collection consistency will require the involvement of all parties to permitting/consenting MRE devices. It is desireable that all parties support and apply the BMP processes:

- Regulators are willing to accept the premise of data transferability, so that they apply the principles of data transferability and collection consistency (as outlined in this document) to evaluate permitting/consenting applications.
- Device and project developers recognize the value of data transferability and commit to collecting and providing data that are consistent with the collection guidelines and that will best fit the *Data Transferability Framework* and guidelines for collection consistency.
- Researchers and consultancies inform themselves of the data consistency requirements and potential use of the data to be collected around MRE devices to ensure data are usable for transfer.

During the early trial period of applying data transferability and collection consistency processes, it would be helpful to convene a virtual group with representatives from across the MRE community (regulators, developers, researchers, consultants) to provide technical assistance in using the framework and BMPs under development, and to guage the success of the venture. Such a group could be convened by Annex IV or other international consortium.

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