MSS CEF - Integration, cumulative impacts & uncertainty

Technical working group
November 18th 2020

Cumulative effects for Seabirds

Three stages, following the framework developed in the MS SEANSE project:

Stage 1: specifying the baseline spatial distribution and density of birds
Stage 2: estimating annual effects of ORDs on demographic rates
Stage 3: population viability analysis, summarising and presenting impacts

UK Centre for Ecology & Hydrology

BioSS

MacArthur Green

JNCC

Tools used within the CEF

Role	Tool(s)
Bird densities	**Generic**: MERP (at-sea) & FAME (GPS) maps **Specific**: bird densities can be taken from Data Store, or specified directly by the user
Collision Risk	sCRM
Displacement Risk	Displacement Matrix // Original SeabORD (no collision) // Extended SeabORD (includes collision)
Breeding season apportioning	SNH Apportioning Tool // MSS Apportioning Tool
Non-breeding season apportioning	BDMPS
PVA	NE/JNCC PVA tool

Objectives of this TWG

Reach consensus on how CEF should deal, **for seabirds**, with:

1. **Integration of tools**
2. **Cumulative impacts**
3. **Uncertainty quantification**

The CEF will consider three contexts:

1. **Using the Displacement Matrix**
2. **Using Original SeabORD (displacement/barrier only)**
3. **Using Extended SeabORD (displacement/barrier + collision)**

Objectives of this TWG

The CEF will use **existing tools and methods**

Whilst it would be useful to flag situations where new tools are needed, or existing tools need to be developed further, actual development of these will not occur within the CEF

Main focus here is on how to use existing tools & methods within the CEF…

Displacement Matrix or SeabORD?

Need to consider the **situation in which the Matrix Approach is used**, because:

- Assessments to date have largely not used SeabORD
- SeabORD is only currently available for 4 species (kittiwake, guillemot, razorbill, puffin)
- SeabORD ideally relies on having good GPS data

Need to consider the **situation in which SeabORD is used**, because:

- The alternative approach to quantify displacement (the Displacement Matrix) is based on expert elicitation only, and relies on assumed displacement mortality rates (for which there is minimal empirical evidence)

Displacement Matrix or SeabORD?

Today we will split discussions based on whether the Matrix Approach or SeabORD is used

- because the issues of how to integrate tools, calculate cumulative effects, and quantify uncertainty, differ between these two situations

When the Matrix Approach is used, we will focus primarily on ensuring that the CEF reflects the way that tools are currently used in assessments

When SeabORD is used, we will focus primarily on ensuring that the CEF reflects the way SeabORD could defensibly be used in future assessments, or to re-evaluate effects of existing projects

Structure of the day

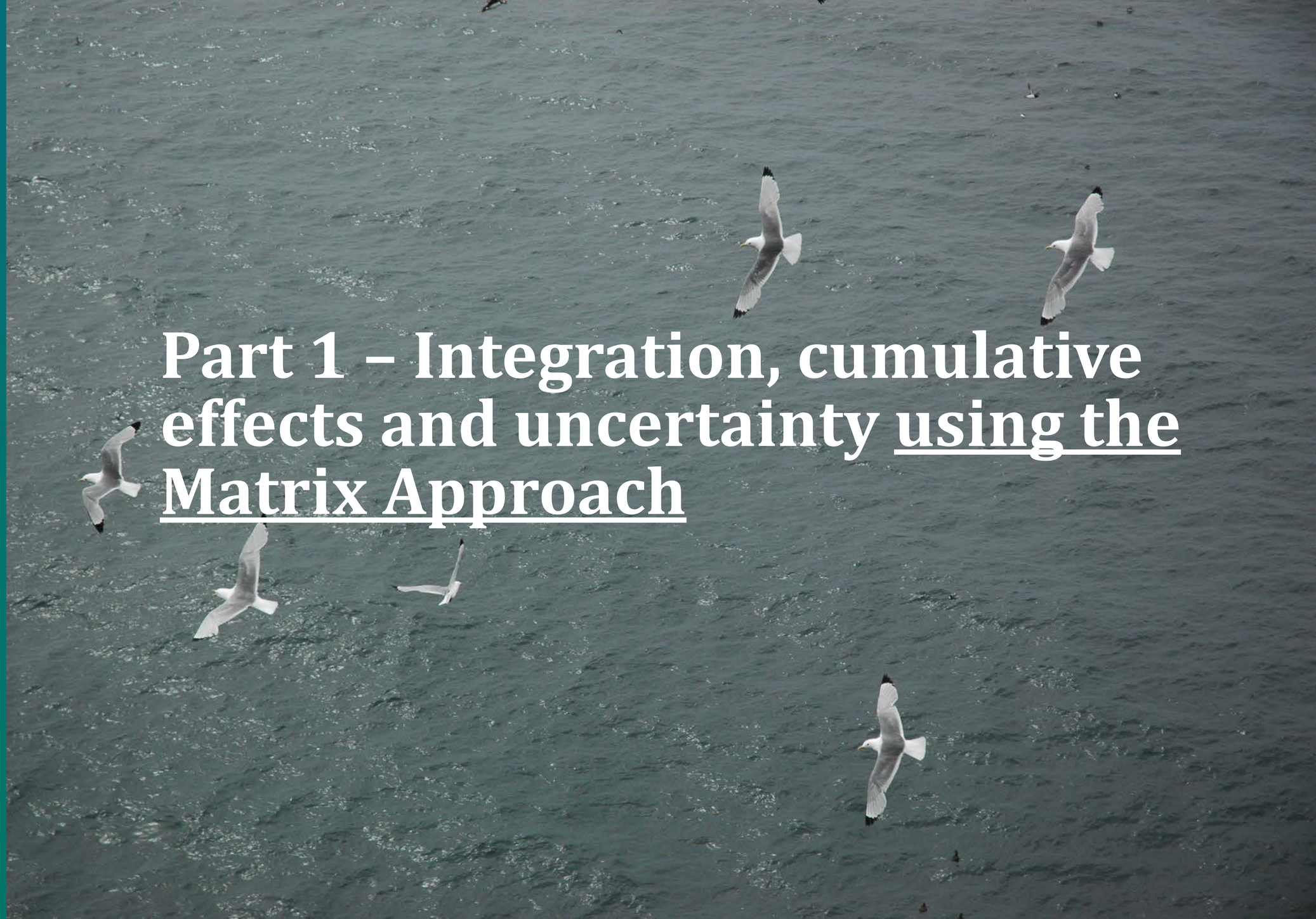
We will separate the day into three parts:

MORNING

1. Integration, cumulative impacts & uncertainty using the Matrix Approach

AFTERNOON

2. Integration, cumulative impacts & uncertainty when using Original SeabORD
3. Integration, cumulative impacts & uncertainty when using Extended SeabORD



Part 1 – Integration, cumulative effects and uncertainty using the Matrix Approach

Part 1 – Integration, cumulative effects and uncertainty using the Matrix Approach

Role	Tool(s)
Bird densities	**Generic**: MERP (at-sea) & FAME (GPS) maps **Specific**: bird densities can be taken from Data Store, or specified directly by the user
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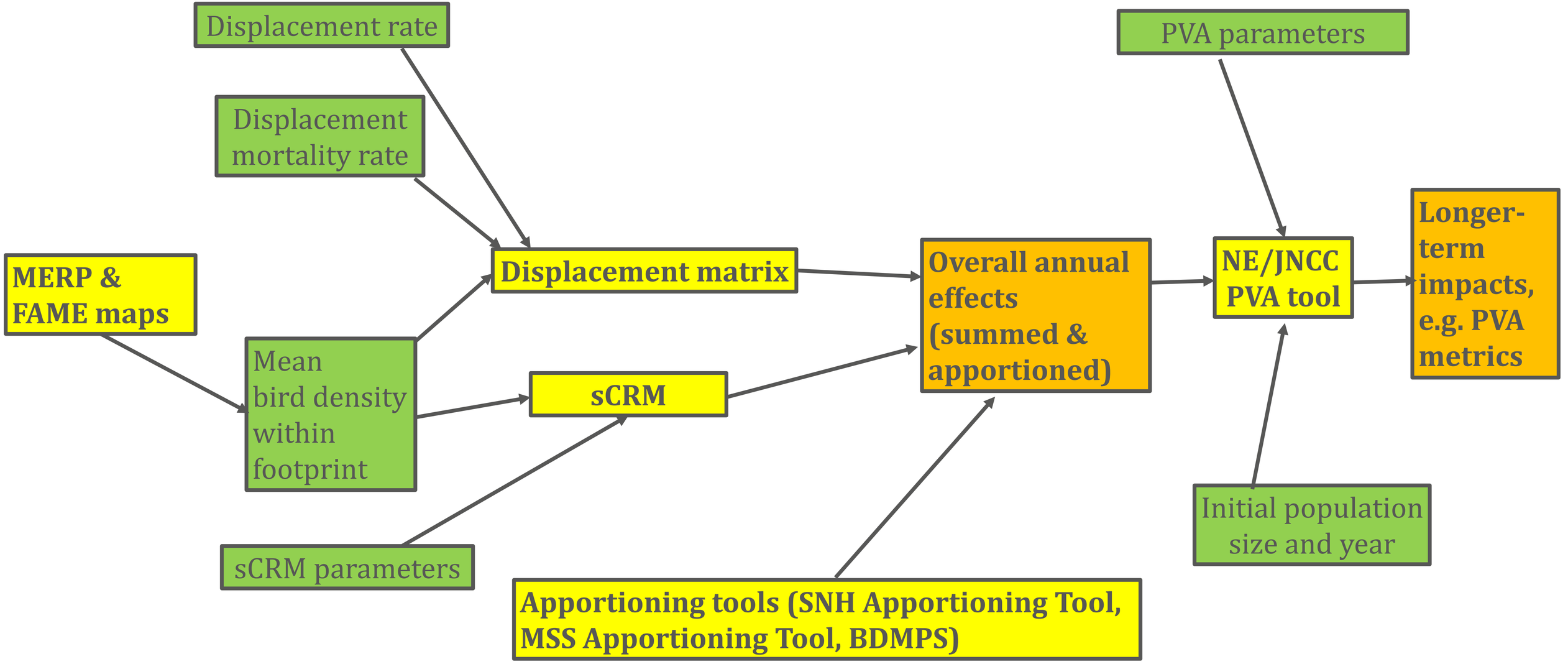
Integration of tools – pathway with Matrix Approach



Integration of tools – pathway with Matrix Approach

Issues with summing estimates from sCRM and Displacement Matrix:

Potential for double counting

- Assigning an individual to die twice (from collision **and** displacement) leading to over-estimation of effects
- But, rate of double counting is likely to be very low, relative to the estimated sizes of collision and displacement effects
- E.g., if collision and displacement occur independently, a collision mortality of 3% and displacement mortality of 1% result in a (0.01*0.03=0.0003) 0.03% probability of double counting, changing the actual mortality to 3.97% from 4.0%
- In practice, displacement and collision are very unlikely to be independent – because birds that are susceptible to displacement cannot, by definition, be simultaneously susceptible to collision
- We logically expect *negative* dependence between the probability of collision and the probability of displacement, and this is likely to further reduce the rate of double counting

Integration of tools – pathway with Matrix Approach

Issues with summing estimates from sCRM and Displacement Matrix:

Inconsistencies in 'displacement' and 'avoidance' rates

- The displacement matrix and sCRM both require an input parameter that captures 'macro-avoidance' in some form:
  - the percentage of birds seen in the footprint pre-construction that would be displaced entirely from the area and not enter the footprint post-construction
- However, there are important inconsistencies in how these parameters are specified and used within the two modelling approaches:

1. The displacement rate in the matrix approach applies to ***all birds*** observed within an OWF footprint (in flight and on the water); whilst the avoidance rate in sCRM approaches is applied ***only to birds in flight***
2. The avoidance rate used in sCRM calculations encompasses ***three different scales of avoidance: micro, meso and macro***. However, the displacement rate used within the matrix approach is intrinsically assumed to capture ***only macro avoidan***ce (birds not entering the OWF footprint at all)
3. The avoidance rate used within sCRM models ***incorporates a correction*** to account for model error (e.g., in relation to how flux rate is estimated)

Selection of tools – proposed options

We propose that the **“Matrix” variant of the CEF** has

54 basic options available for kittiwake, guillemot, razorbill and puffin (FAME species)

24 for remaining species

These are based on all possible combinations of the options given in the next slide…

Selection of tools – proposed options

Data source for mean density in footprints
1. Mean values in data store (or user-specified)
2. MERP maps (derived from at-sea survey data)
3. FAME maps (should we remove this option? For EIA this is probably not useful. For HRA this would fulfil one part of the in-combination assessment)

Apportioning
a. No apportioning – EIA does not require apportioning
b. SNH Apportioning Tool in breeding season and BDMPS in non-breeding season
c. MSS Apportioning Tool (derived from GPS tracking data) in breeding season, and BDMPS in non-breeding season

Types of impact
1. Collision only
2. Displacement only
3. Both collision and displacement

Format of output
a. Annual effects
b. Longer-term impacts (via NE/JNCC PVA tool)

(Note – green text: only available for kittiwake, guillemot, razorbill, puffin)

Key practical issues in linking tools

Q1.1. Are all of these options needed/useful?

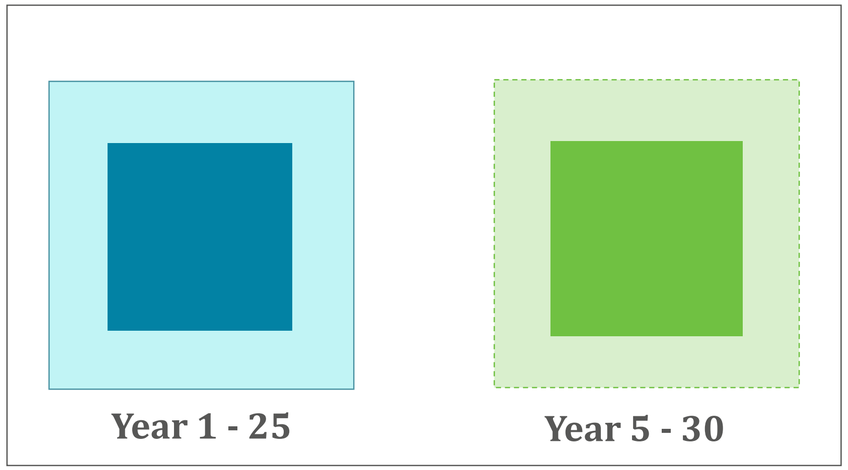
Q1.2. Are there are any other options needed that we have not considered?

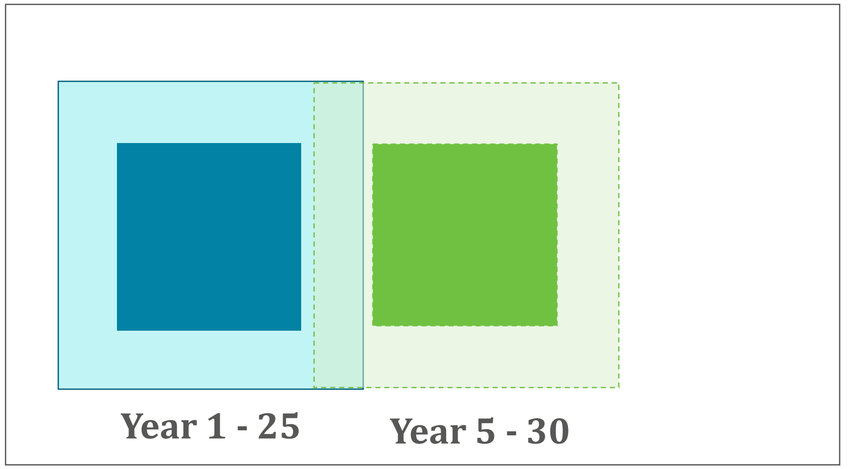
Q1.3. Do these options represent all of the main calculations and tools currently used in HRAs and, in particular, EIAs?

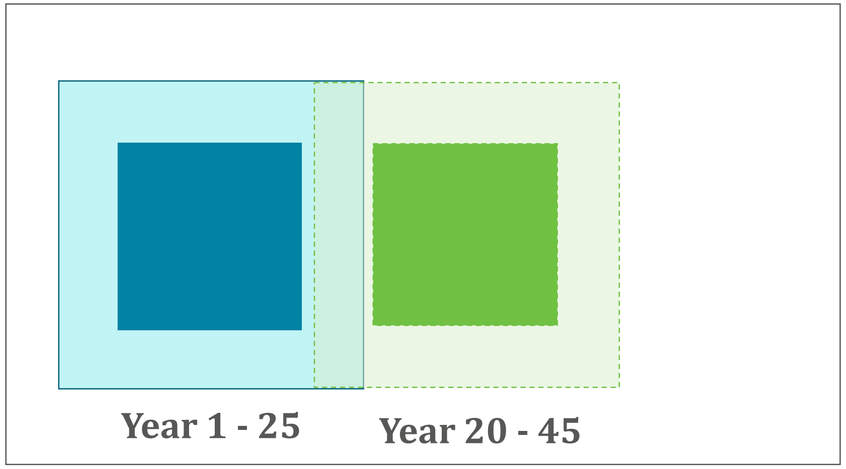
Q1.4. The FAME maps and MSS Apportioning Tool are also based on specific foraging ranges (Wakefield et al., 2017), which do not align with those commonly used in SNCB guidance – how should the CEF reflect this when they are used as inputs/methods?

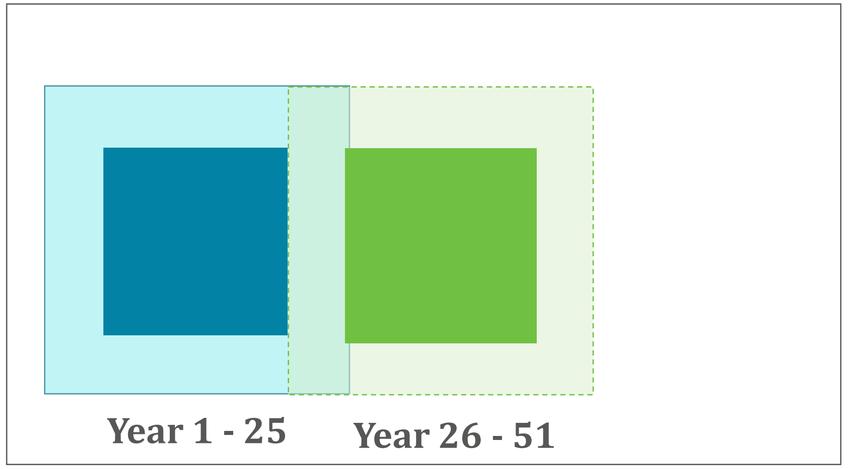
Q1.5. How to identify the BDMPS region that each wind farm footprint lies within?

Overlapping buffers & timing issues









Cumulative & in-combination effects

When using the Matrix Approach, we propose cumulative or in-combination effects of multiple wind farms will be combined additively: i.e.,

1. **Displacement matrix, sCRM and apportioning tools run separately for each project**

2. **Annual effects of these summed together across projects, and the combined effects input into the NE/JNCC PVA tool**
    - **Should the PVA then not allow these values to be altered?**

Q1.6. Are there are any existing alternative approaches we should include/consider? – i.e., any adjustments to the calculations to account for overlap in footprint+buffer areas or temporal overlap of different OWFs?

Uncertainty

Uncertainty and variability can be **propagated** between tools, using a simulation-based approach

We envisage our technical approach to propagation of uncertainty being based on that used in the MS SEANSE project (MS SEANSE Final Report)

This project involved producing a framework for integrating tools within ORE assessments

The approach was demonstrated using two scenarios of (hypothetical) future ORE construction in the Forth-Tay area

Projects involved a comparison of both SeabORD and Matrix Method approaches

Uncertainty

For the **Matrix Approach** we:

a. Estimated mean densities per footprint derived from either MERP maps or FAME maps (potentially drop FAME maps from here if decide to rule out as an input in earlier discussion)

b. used the sCRM and Displacement Matrix

c. Apportioned birds to breeding colonies using either the SNH or MSS Apportioning Tool in the breeding season and using BDMPS in the non-breeding season

d. Applied these effects within the NE PVA tool to derive final population level impacts

Uncertainty

Uncertainty quantification within the MSS SEANSE project (non-SeabORD part)

Tool	Uncertainty considered?	Sources of uncertainty considered	How uncertainty was represented
MERP maps	Yes	Estimation uncertainty	In outputs, via bootstrap samples (Waggitt et al., 2019)
sCRM	Yes	Variation in parameters using SDs (mixture of variation and uncertainty)	Outputs: probability density plots of annual collision and box and whisker plots for monthly collision and tables of mean (annual and monthly) mean collision with other summary statistics (e.g. SD, median, CV)
Displacement Matrix	No*	---	---
SNH Apportioning	Yes	Uncertainty in foraging range	In inputs, by simulating colony-specific foraging ranges using standard deviations from Thaxter et al.
MSS Apportioning	No*	---	---
BDMPS	No*	---	---
NE PVA	Yes	Uncertainty in collision & displacement impacts; environmental & demographic stochasticity	Inputs: Uncertainty in ORE impacts; Variability in baseline demography Outputs: probabilistic PVA metrics

* these tools did not not account for internal uncertainty, but did feed uncertainty in inputs through to the next stage

Uncertainty

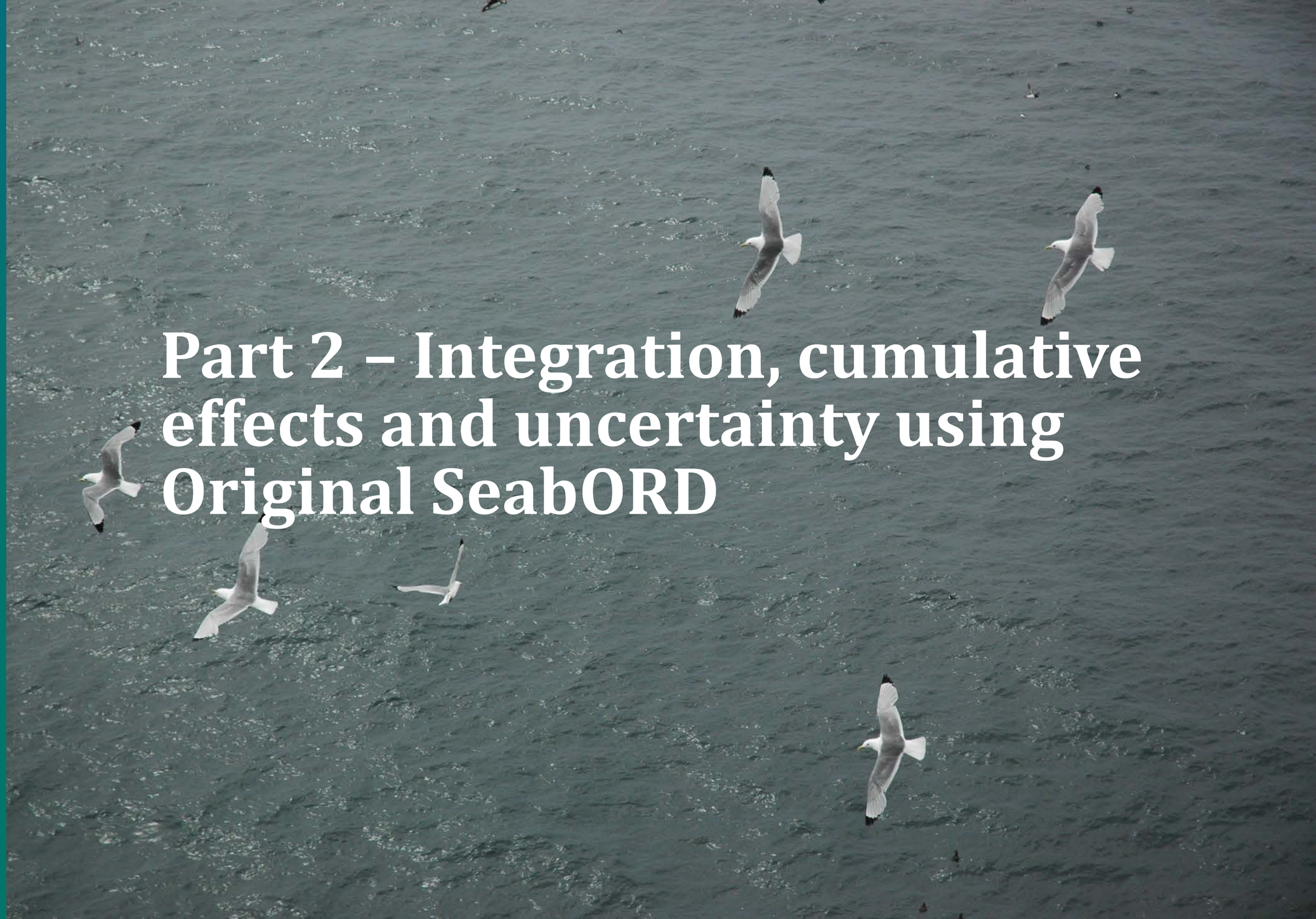
- **Q1.7. Within the CEF is there agreement that we should be allowing for propagation of uncertainty between tools?**

- **Q1.8. How do we deal with the fact that some tools and data sources (e.g. FAME maps, colony sizes, BDMPS) currently have no quantification of uncertainty, and in other tools uncertainty can only be partially quantified?**

- **Q1.9. Is the general (simulation-based, probabilistic) approach using in MS SEANSE reasonable?**

- **Q1.10. Is the distinction between where the tools are accounting for uncertainty or variability clear?**

- **Q1.11. How do we account for the way the Displacement Matrix quantifies uncertainty, which is more qualitative than that used in the other tools**



Part 2 – Integration, cumulative effects and uncertainty using Original SeabORD

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Role	Tool(s)
Bird densities	**Generic**: MERP (at-sea) & FAME (GPS) maps **Specific**: bird densities can be specified directly by the user
Collision Risk	sCRM
Displacement Risk	Displacement Matrix // Original SeabORD (no collision) // Extended SeabORD (includes collision)
Breeding season apportioning	SNH Apportioning Tool // MSS Apportioning Tool
Non-breeding season apportioning	BDMPS
PVA	NE/JNCC PVA tool

Original SeabORD

SeabORD can be used to estimate the population consequences of displacement and barrier effects on survival and productivity (i.e., it can replace the Displacement Matrix)

SeabORD is an individual-based simulation model that follows individual birds over the chick-rearing period, using changes to time-activity budgets and energy-mass-survival relationships to estimate impacts of ORDs in breeding birds

The original version only considers ORD impacts via displacement and barrier effects, not collision

Integration of tools with original SeabORD

Potential options for distance-decay within SeabORD

Option 1. Simple **parametric model** for how colony-specific bird density declines with distance from colony

i.e. bird density proportional to **exp(-rate * distance)** or **distance^(-rate)**

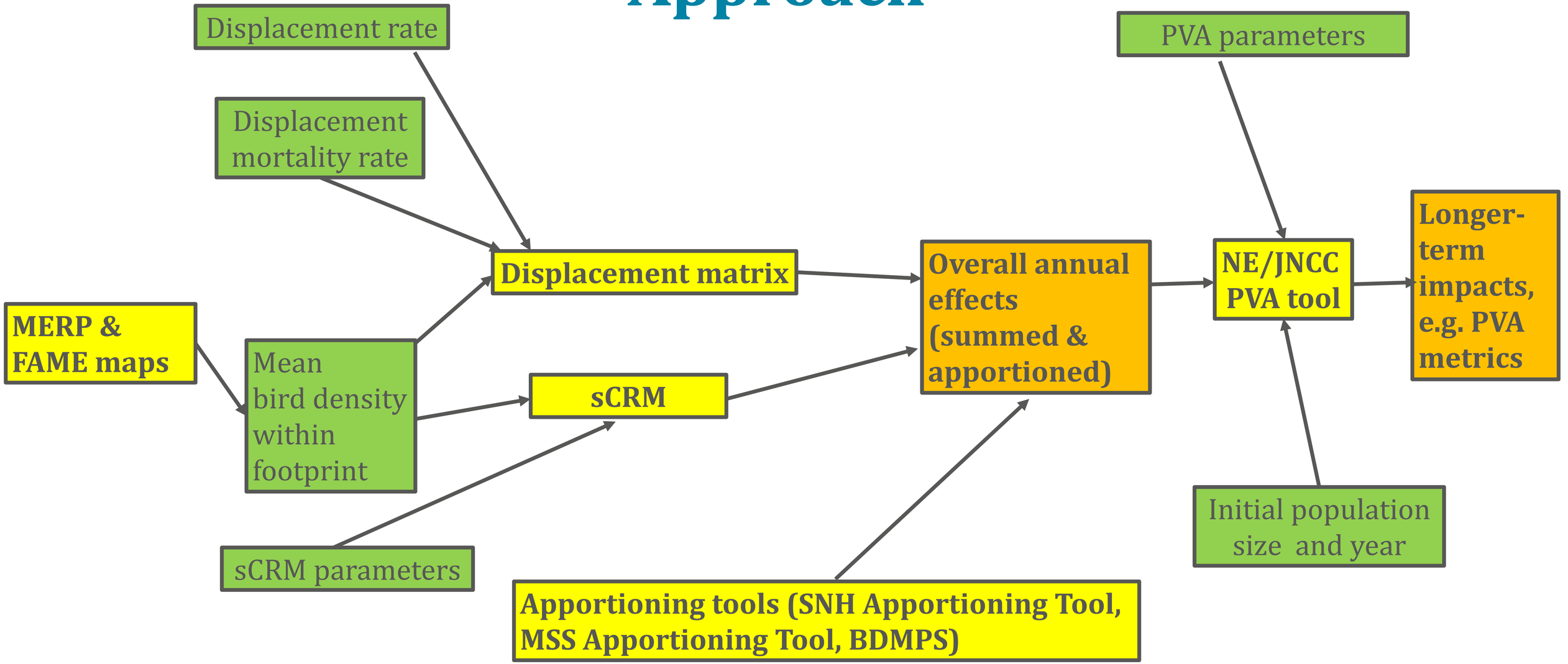
where "**rate**" is a parameter to be specified

Option 2.
(a) Use **MERP maps** to provide overall maps of abundance
(b) apportion MERP map to colony of interest by applying **SNH apportioning tool** through the spatial grid
(c) **rescale** to give colony-specific bird density map

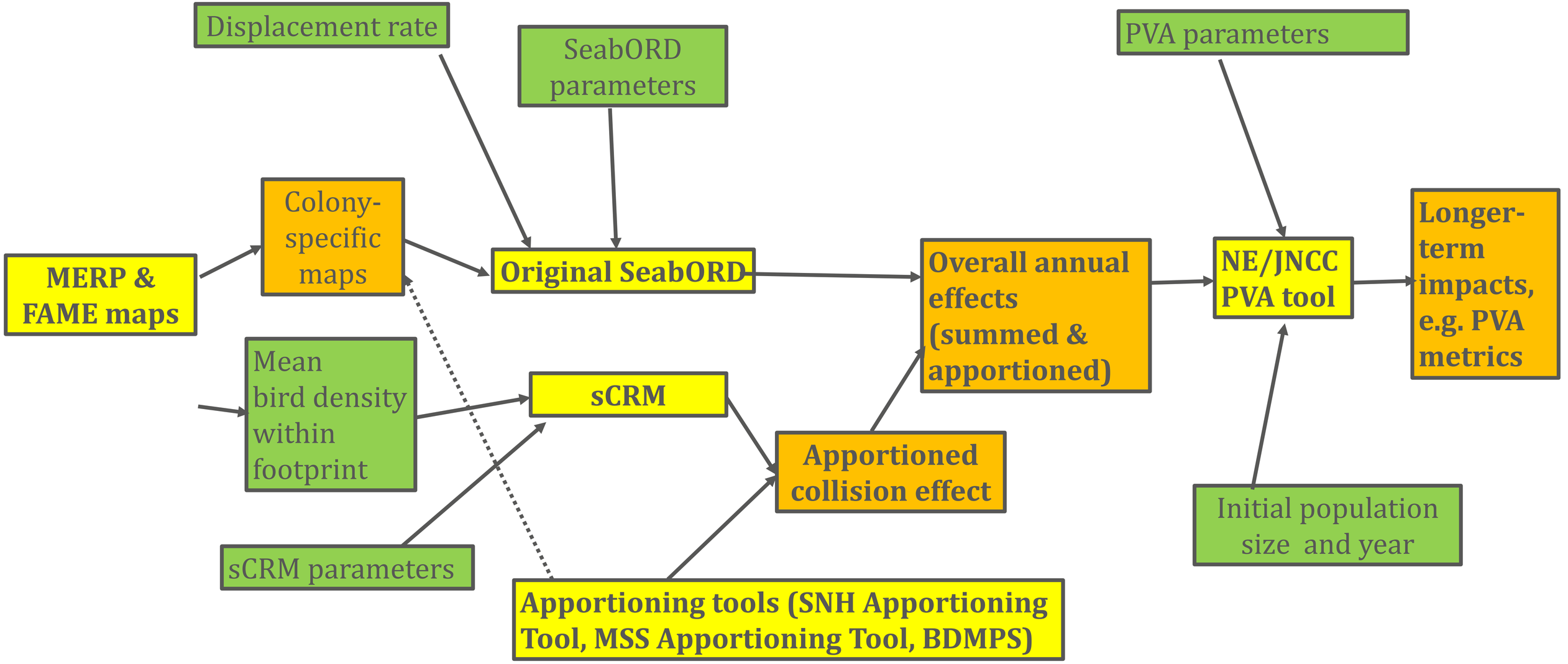
Key ways in which SeabORD differs from the Displacement Matrix

1. Estimates the displacement mortality rate directly, rather than using this as an input, so more biologically plausible
2. Inherently linked to specific breeding colonies (so can be used for HRA, but not EIA)
3. Requires a map of the relative distribution of birds around the source colony, most usually derived from GPS tracking data
4. Chick-rearing period only
5. Different approach to quantification/representation of uncertainty
6. Much more computationally intensive to run

Integration of tools – pathway with Matrix Approach



Integration of tools: pathway with original SeabORD



Integration of tools with original SeabORD

Overall approach to integration of tools is similar to that with Displacement Matrix, and follows the approach used in the MS SEANSE project

Key differences are:

a) SeabORD requires apportioning to have been done beforehand

b) SeabORD requires an entire map, so cannot run with only mean density values

c) SeabORD is usually run with a map derived from GPS tracking data

Selection of tools – proposed options

Data source for Utilisation distribution
1. User-supplied maps for bird UDs
2. Distance decay
3. FAME maps (derived from modelling of GPS tracking data, and then aggregating across colonies using Seabird 2000 colony sizes)

Format of output
a. Annual effects
b. Longer-term impacts (via NE/JNCC PVA tool)

Types of impact
1. Displacement/barrier only
2. Both collision and displacement/barrier

Data source for mean density (for sCRM)
1. Mean values in data store (or user-specified)
2. MERP maps (derived from at-sea survey data)
3. FAME maps (should we remove this option? For EIA this is probably not useful. For HRA this would fulfil one part of the in-combination assessment)

Apportioning (for sCRM)
a. SNH Apportioning Tool in breeding season and BDMPS in non-breeding season
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(Note – green text: only available for kittiwake, guillemot, razorbill, puffin – FAME species)

Integration of tools with original SeabORD

- **<u>Q2.1.</u> Should MERP at-sea maps be available within the CEF for use in SeabORD? Should this only be an option available for puffins?**
  - **derive colony-specific UDs by applying SNH apportioning to MERP maps**

- **<u>Q2.2.</u> How should the “distance-decay” option in SeabORD work?**
  - **assume a simple decay with distance**

- **<u>Q2.3.</u> Should we always combine breeding season estimates for displacement mortality with non-breeding season displacement mortality derived from the Displacement Matrix?**

Uncertainty Quantification in SeabORD

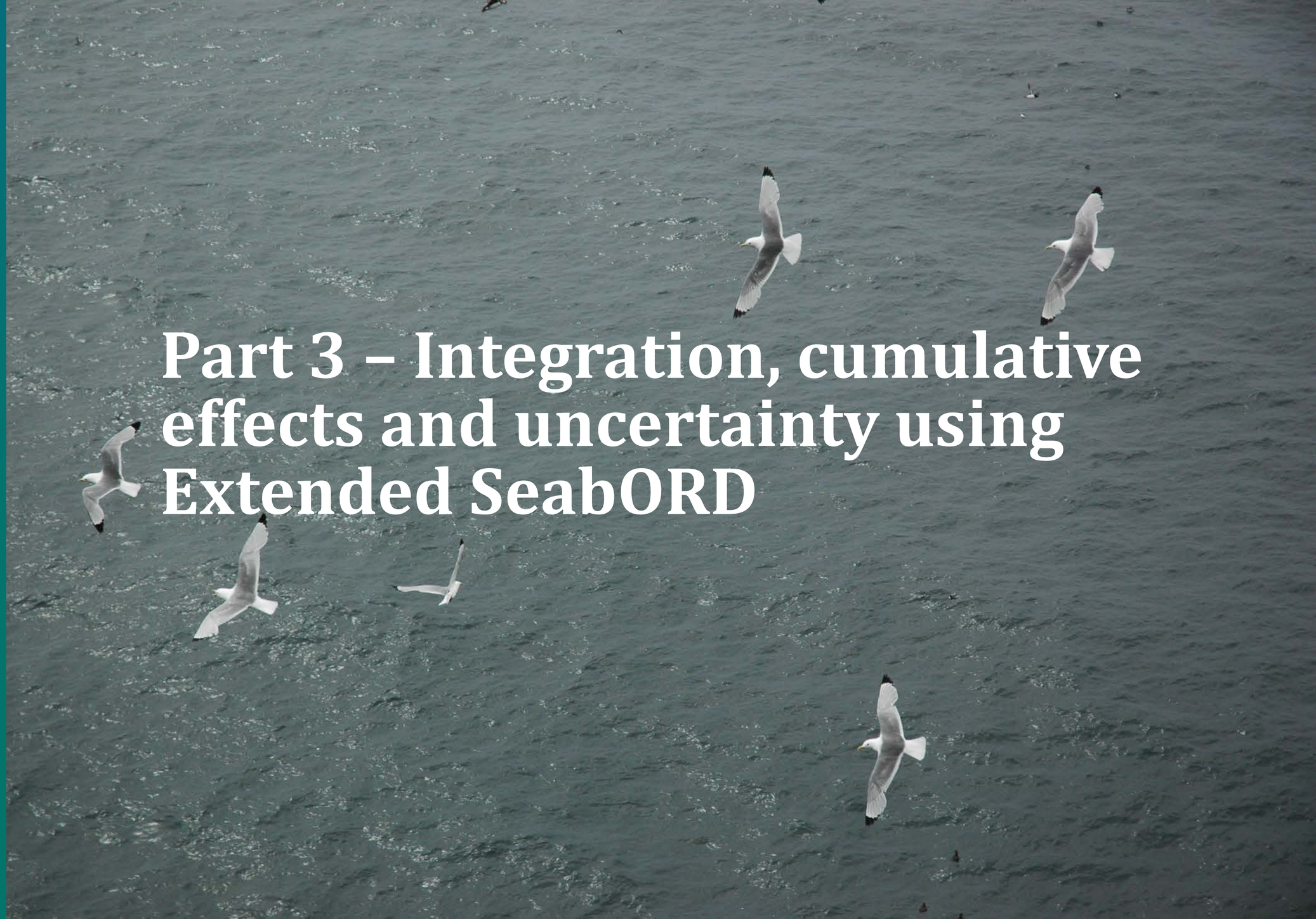
SeabORD currently accounts for uncertainty in prey availability by averaging across simulations with different prey availabilities to provide a mean impact at the population level with a 95% confidence interval.

Other sources of uncertainty such as those associated with the mass-survival relationship, bird distributions, and time-energy-growth relationships are not currently included.

- **Q2.4. If GPS-derived UDs are used in SeabORD (as recommended), uncertainty in bird distributions is currently not available. Therefore, based on current inputs, SeabORD cannot propagate uncertainty in bird distributions through to a PVA.**

- **How should the CEF communicate to users that, based on currently available inputs, quantification of uncertainty is limited when SeabORD is used to estimate impacts?**

- **How do we communicate this for all tools in the CEF, where quantification of uncertainty is only partially possible?**



Part 3 – Integration, cumulative effects and uncertainty using Extended SeabORD

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Bird densities	**Generic**: MERP (at-sea) & FAME (GPS) maps **Specific**: bird densities can be specified directly by the user
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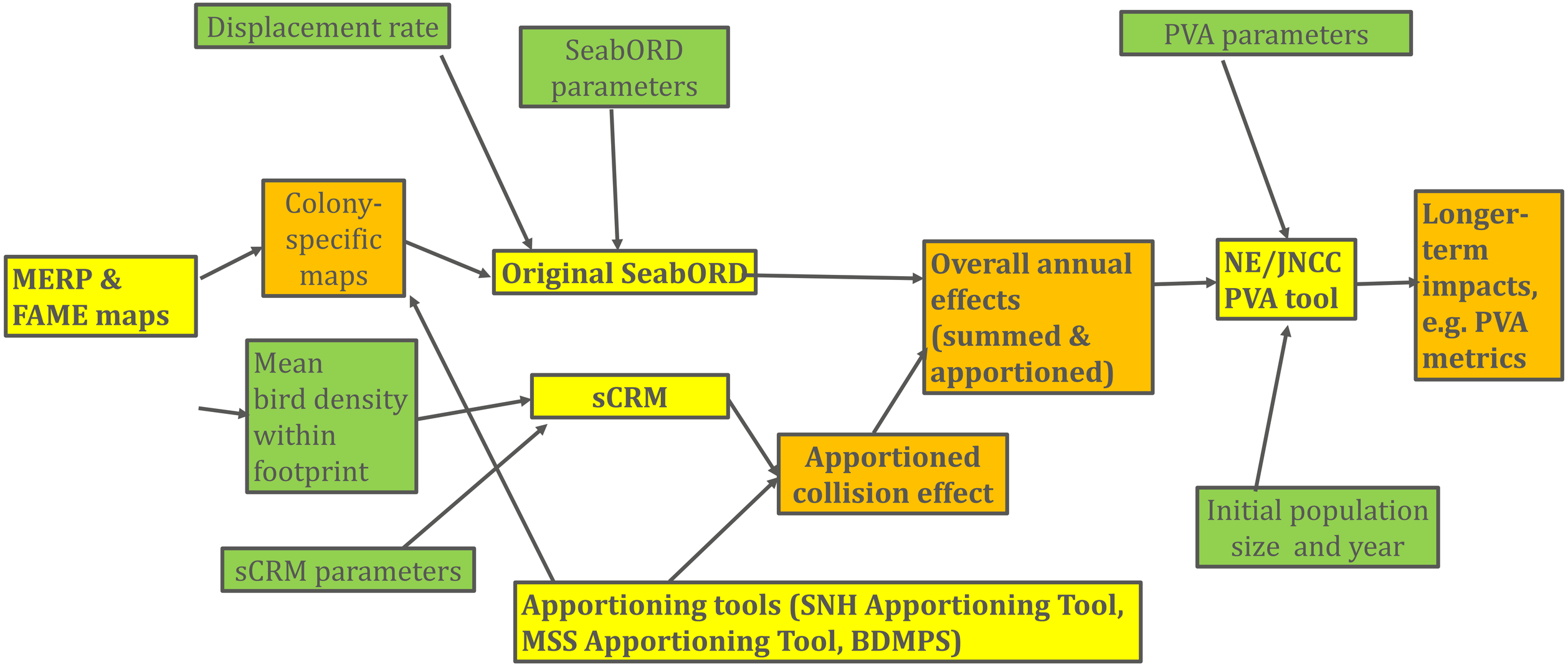
Breeding season apportioning	SNH Apportioning Tool // MSS Apportioning Tool
Non-breeding season apportioning	BDMPS
PVA	NE/JNCC PVA tool

Extended SeabORD

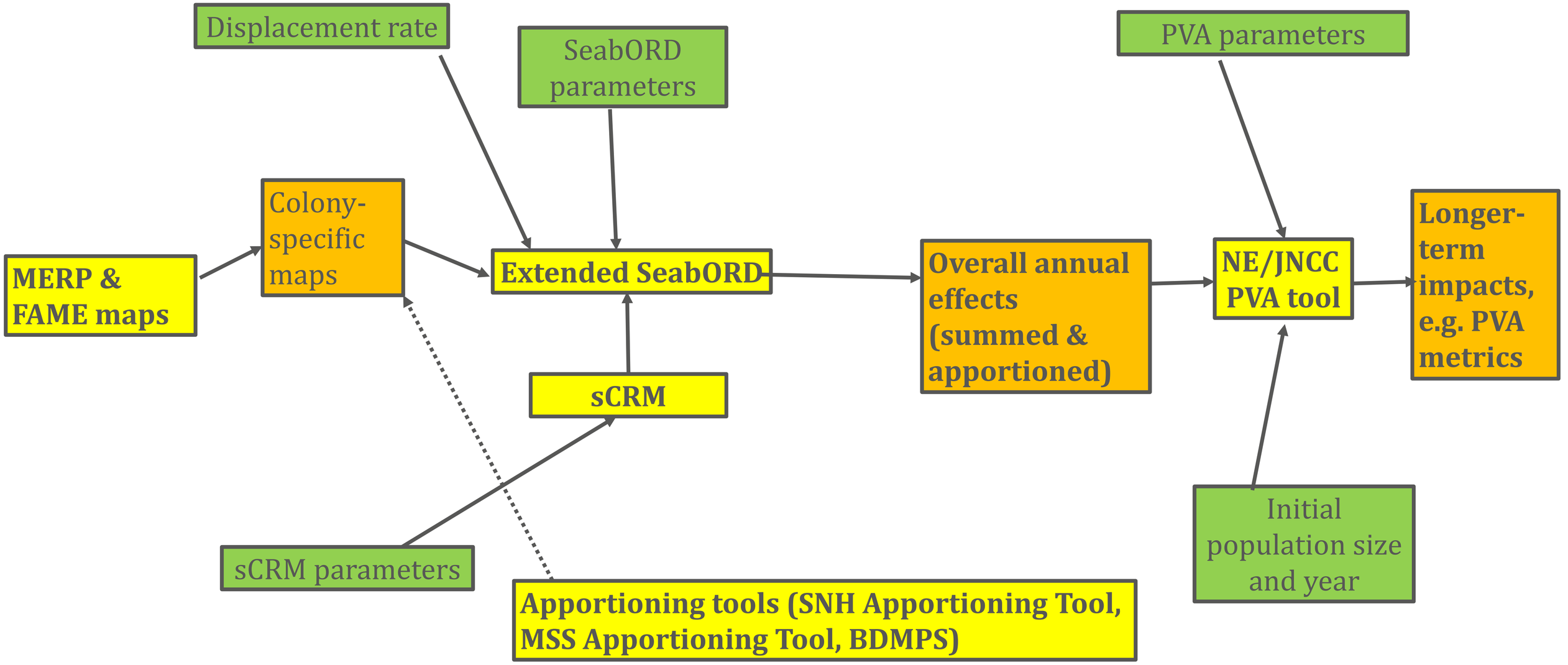
The new version of SeabORD can be used to estimate the population consequences of displacement, barrier **and** collision effects on survival and productivity (i.e., it replaces the Displacement Matrix, and takes outputs from the sCRM)

The extended version considers ORD impacts via displacement and barrier effects as in the original SeabORD, but also integrates impacts from collision using output generated from the sCRM

Integration of tools: pathway with original SeabORD



Integration of tools: pathway with extended SeabORD



Selection of tools – proposed options

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Format of output
a. Annual effects
b. Longer-term impacts (via NE/JNCC PVA tool)

Types of impact
1. Displacement/barrier only
2. Both collision and displacement/barrier

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1. Mean values in data store (or user-specified)
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Apportioning (for sCRM)
a. SNH Apportioning Tool in breeding season and BDMPS in non-breeding season
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(Note – green text: only available for kittiwake, guillemot, razorbill, puffin – FAME species)

Integration of tools: extended SeabORD

- **<u>Q3.1.</u> How to account for the possibility that the collision risk densities may have been derived from a different data source than the maps used for running SeabORD? (e.g., have come from project-level at sea survey data?)**

  - **Extended SeabORD run using sCRM outputs**