



OWSMRF Continuation

Research Opportunities on Manx shearwater and European storm-petrel

The Offshore Wind Strategic Monitoring and Research Forum ([OWSMRF](#)) is an industry-led collaborative forum that aims to identify and develop research to fill critical knowledge gaps in our understanding of the impact of offshore wind development on the marine environment. This forum is funded by a group of seven developers: EDF Renewables, Equinor, Ørsted, RWE, ScottishPower Renewables (SPR), Shell and SSE Renewables (Scottish and Southern Electricity), and JNCC holds a secretariat role. The Pilot Year (May 2019 – April 2020) focussed on black-legged kittiwake and identified three key Knowledge Gaps (KGs) and produced three reports KG1, 2 & 3 focussed on collision mortality, connectivity and population modelling (see Figure 1).

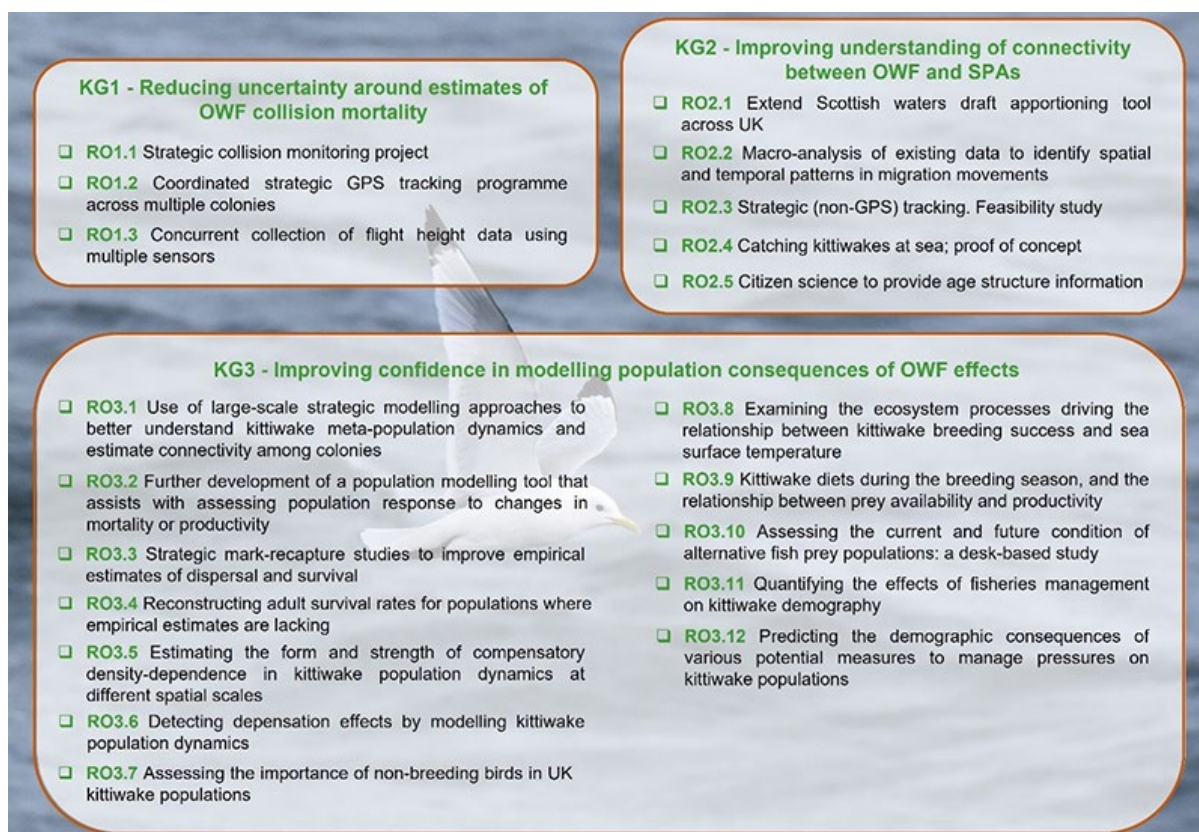


Figure 1. A summary of the Research Opportunities identified for black-legged kittiwake across three key themes during the Pilot Year

The Continuation was initiated in April 2021 and at the first workshop Procellariiformes, specifically Manx shearwaters (*Puffinus puffinus*) and European storm-petrels (*Hydrobates pelagicus*) were identified as posing a key consent risk to offshore wind development in UK waters.

One overarching priority Knowledge Gap to inform impact assessments and improve our overall understanding of these species in UK waters was identified and led to the production of the KG4 report, “Towards better estimates of Manx shearwater and European storm-petrel population abundance and trends, demographic rates and at-sea distribution and behaviour” (Baker *et al.* 2022).

This KG was then broken down into three key areas (see Figure 2):

- Population abundance and trends;
- Demographic rates;
- At-sea distribution and behaviour.

The Joint Nature Conservation Committee (JNCC) has collaborated with nature conservation agencies, researchers and academics to identify a summary of potential research that might help address Knowledge Gap 4. The list of 18 Research Opportunities (RO) are presented below as short concept notes to provide a brief introduction to each RO for potential funders. For each RO, a description is accompanied by a summary of how individual ROs are linked and may act synergistically to improve cost-effectiveness and work to reduce consent risk for the offshore wind sector.

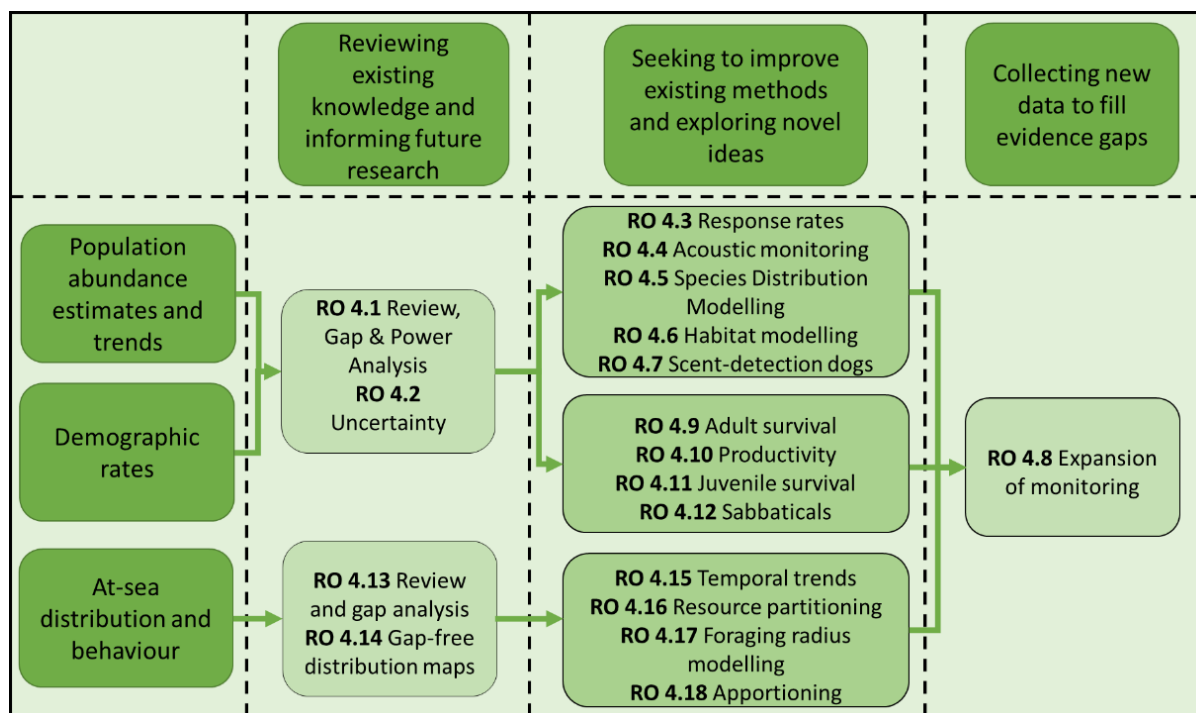


Figure 2. The Knowledge Gap key themes and research areas for KG4 on Manx shearwaters and European storm-petrels are shown in the flowchart above and set out the Research Opportunities identified and how they might work together.

Knowledge Gap 4 –

Towards better estimates of Manx shearwater and European storm-petrel population abundance and trends, demographic rates and at-sea distribution and behaviour

(Baker *et al.* 2022)



RO4.1 Strategic review and gap analysis of existing data and ongoing projects covering population estimates and demographic rates

Short summary of proposed research

This project would seek to conduct a thorough review of all sources of data collected on Manx shearwater and European storm-petrel population and demographic rate monitoring, including historic, ongoing and planned projects, both public and private. This would allow the collation of existing knowledge and identification of evidence gaps, particularly with respect to rates vital for Offshore Wind Farm (OWF) impact assessments. Informed by the review, analyses would be conducted to direct future spatial and temporal data collection.

RO4.1a Strategic reviews of population and demographic rate monitoring

RO4.1b Gap analysis to direct future monitoring effort at a spatial scale

RO4.1c Power analysis to define the frequency of monitoring required to detect change at a population level

Outcomes

There is not currently a single repository of information on existing knowledge, methods and monitoring schemes for these species. Regularly collating this knowledge, signposting to datasets (both public and private) and identifying where current uncertainties lie will allow for better parameterised impact assessments and improve our ability to conduct accurate and precise risk modelling and contribute to consenting processes.

Synergies and efficiencies

This review could be conducted in conjunction with other reviews detailed in the KG4 report:

- RO4.2 Review of methods for estimating population abundance;
- RO4.13 Review of existing tracking and at-sea distribution data.

Furthermore, the outcomes of this project would directly inform data collection of population estimates and demographic rates as detailed in RO4.8.

Reference and contact

Baker, B., Meadows, M., Ruffino, L. & Anderson, O.R. 2022. Towards better estimates of Manx shearwater and European storm-petrel population abundance and trends, demographic rates and at-sea distribution and behaviour. *JNCC Report No. 719*, JNCC, Peterborough, ISSN 0963-8091.

For further information, contact OWSMRF@jncc.gov.uk

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(Baker *et al.* 2022)



RO4.2 Identifying key variables generating uncertainty in abundance estimates from census data

Short summary of proposed research

The aim of this project is to reduce uncertainty in population estimates for Manx shearwater and European storm-petrel by interrogating a variety of monitoring methods, identifying challenges and opportunities, and modelling existing data, which will lead to recommendations for future work.

RO4.2a Review of data and methods for estimating population abundance to identify variables contributing the greatest uncertainty

RO4.2b Analysis of existing data using methods such as sensitivity analyses

RO4.2c Modelling informed by stages a and b to identify drivers of uncertainty

RO4.2d Development of best practice guidance for data collection.

Outcome

Accurate estimates of population size will provide more certainty on the status and trends of UK breeding colonies, including Special Protection Areas (SPAs), and therefore help improve confidence when assessing the potential impacts of OWFs, through, for example, Population Viability Analyses (PVAs).

Synergies between ROs

This review could be conducted in conjunction with other reviews detailed in the KG4 report:

- RO4.1 Review of existing knowledge on population abundance and demographic rates;
- RO4.13 Review of existing tracking and at-sea distribution data detailed in RO4.13.

The outcomes of this project would directly inform data collection of population estimates and demographic rates as detailed in RO4.8 and work alongside methodological improvements suggested under:

- RO4.3 Improving estimates of response rate in playback surveys;
- RO4.6 Apply habitat models to assess extent and distribution of suitable habitat to focus future effort

Reference and contact

Baker, B., Meadows, M., Ruffino, L. & Anderson, O.R. 2022. Towards better estimates of Manx shearwater and European storm-petrel population abundance and trends, demographic rates and at-sea distribution and behaviour. *JNCC Report No. 719*, JNCC, Peterborough, ISSN 0963-8091.

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RO4.3 Improving estimates of response rate in playback surveys

Short summary of proposed research

This project would seek to reduce the uncertainty associated with the most commonly used population monitoring technique for shearwaters and petrels (tape playback) by identifying key sources of error and investigating novel and complementary techniques for improving confidence in population estimates.

RO4.3a Analysis of existing response rate data

RO4.3b Investigation of hierarchical modelling techniques based on recommendations made by Deakin *et al.* 2021 and which may include review of the methods and/or analysis of existing data

Outcome

Accurate estimates of population size will provide more certainty on the status and trends of UK breeding colonies, including SPAs, and therefore help improve confidence when assessing the potential impacts of OWFs, through, for example, PVAs, potentially reducing consent risk through a less precautionary approach.

Synergies and efficiencies

This RO could be carried out as part of RO4.2, which seeks to understand sources of uncertainty in population estimates more broadly but the modelling carried out in RO4.2 would be applicable to the tape-playback technique.

It is likely that population estimates derived from the tape playback technique could be improved by reducing uncertainty in a wide range of parameters, considering that the sources of error are likely to vary between colonies. This would include more accurate estimates of habitat extent (RO4.6) and the potential to improve validation using other methods (RO4.7).

Reference and contact

Baker, B., Meadows, M., Ruffino, L. & Anderson, O.R. 2022. Towards better estimates of Manx shearwater and European storm-petrel population abundance and trends, demographic rates and at-sea distribution and behaviour. *JNCC Report No. 719*, JNCC, Peterborough, ISSN 0963-8091.

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RO4.4 Investigation into the suitability and applications of acoustic techniques to monitor Procellariiformes

Short summary of proposed research

This RO seeks to investigate the use of acoustic monitoring as an alternative method for estimating the breeding population size of shearwaters and petrels in the UK. This project would be conducted in a series of stages, of which the latter field stages would only be carried out if the preceding stages indicate this method is likely to be successful.

RO4.4a Literature review of existing acoustic monitoring studies

RO4.4b Establishing methods for acoustic monitoring for Manx shearwaters and European storm-petrels

RO4.4c Field test of methods established in 4.4b

RO4.4d Roll-out of acoustic monitoring to derive population estimates

Outcome

Given time and investment, this method has the potential to provide a very cost- and labour-effective way of collecting population data. Accurate estimates of population size will provide more certainty on the status and trends of UK breeding colonies, including SPAs, and therefore help improve confidence when assessing the potential impacts of OWFs, through, for example, PVAs.

Synergies and efficiencies

The literature review stage could be carried out as part of the overall review of population monitoring techniques detailed in RO4.1, although more detailed review of specific studies and methodologies would be required for this project.

The outcomes of this project would also directly inform RO4.8 (expansion of monitoring), as a potential alternative method, particularly for very remote colonies or those colonies where presence of breeding birds has not been confirmed.

Reference and contact

Baker, B., Meadows, M., Ruffino, L. & Anderson, O.R. 2022. Towards better estimates of Manx shearwater and European storm-petrel population abundance and trends, demographic rates and at-sea distribution and behaviour. *JNCC Report No. 719*, JNCC, Peterborough, ISSN 0963-8091.

For further information, contact OWSMRF@jncc.gov.uk

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(Baker *et al.* 2022)



RO4.5 Development of Species Distribution Models (SDM) to predict suitable colony locations

Short summary of proposed research

This project would make use of recent advances in modelling to help improve our ability to predict current and future species' breeding ranges by reviewing, testing and validating existing models using existing data. If proven to be successful, these models could eventually be rolled out to identify new colonies or predict changes in species distribution over time.

RO4.5a Review of key drivers of Manx shearwater and European storm-petrel breeding distribution

RO4.5b Test models using existing data

RO4.5c Apply SDMs to predict the locations of potentially unidentified colonies

RO4.5d Validation of model predictions

Outcome

An improved and more thorough understanding of species distributions in the UK will be beneficial to the offshore wind industry in relation to assessing connectivity between colonies and projects, defining which SPAs should be considered in Habitats Regulations Assessments (HRAs) and provide more confidence when apportioning potential OWF impacts to relevant colonies or populations. Models could also be used to make predictions about changes in species distributions over time, particularly in the context of climate change.

Synergies and efficiencies

The outcome of this project could inform the expansion of monitoring (RO4.8) if “new” colonies are identified by models.

Reference and contact

Baker, B., Meadows, M., Ruffino, L. & Anderson, O.R. 2022. Towards better estimates of Manx shearwater and European storm-petrel population abundance and trends, demographic rates and at-sea distribution and behaviour. *JNCC Report No. 719*, JNCC, Peterborough, ISSN 0963-8091.

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RO4.6 Apply habitat models to assess extent and distribution of suitable breeding habitat to focus future effort

Short summary of proposed research

This project would seek to reduce uncertainty in population estimates for Manx shearwater and European storm-petrel by improving the characterisation of suitable breeding habitat on an island, which is vital when extrapolating census results from sample plots to whole island counts. This is particularly important at less well understood colonies, or large islands with complex or difficult-to-survey terrain.

RO4.6a Habitat mapping

RO4.6b Apply models to colonies and locations where access is difficult

RO4.6c Validation of model predictions

Outcome

A better appreciation of the availability of suitable breeding habitat at the scale of an island will improve the accuracy of island-wide population estimates extrapolated from sample plot counts, whilst reducing field worker effort. Undertaking habitat mapping on islands presenting different logistical challenges will go a long way towards improving our overall understanding of the feasibility of the approach and how to apply the technique in different scenarios. Improving accuracy of population estimates and making monitoring more efficient will lead to a more robust evidence base to direct future work and reduce uncertainty in impact assessments.

Synergies and efficiencies

This project would work synergistically with RO4.2 and RO4.3, which both seek to reduce uncertainty and improve accuracy of population estimates, particularly for the tape playback technique to which habitat mapping could be applied.

The outcome of this project would also directly inform RO4.8 (expansion of monitoring), as an improved understanding of the challenges and requirements of individual colonies will make monitoring more efficient and effective.

Reference and contact

Baker, B., Meadows, M., Ruffino, L. & Anderson, O.R. 2022. Towards better estimates of Manx shearwater and European storm-petrel population abundance and trends, demographic rates and at-sea distribution and behaviour. *JNCC Report No. 719*, JNCC, Peterborough, ISSN 0963-8091.

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RO4.7 Use of scent-detection dogs to explore/characterise new colonies

Short summary of proposed research

The aim of this project is to explore the application of a new monitoring method, i.e. scent-detection dogs, for shearwaters and petrels in the UK, which has the potential to reduce resources deployed in the field by improving methodological efficiency, whilst providing robust and valuable results.

RO4.7a Training of scent-detection dogs

RO4.7b Trial of scent-detection dogs

RO4.7c Deployment of scent-detection dogs

Outcome

If dogs can be trained to detect and distinguish between species, and trials demonstrate they can provide accurate estimates of population size, this alternative method could be used in conjunction with or replace other monitoring methods to improve confidence in population estimates and trends as well as the efficiency of colony monitoring. This will ultimately lead to a more robust evidence base that could be used to reduce uncertainty in impact assessments and hence consent risk.

Synergies and efficiencies

Scent-detection dogs could be used to validate other recently developed methods, for example habitat modelling or colony identification as described in RO4.5 and RO4.6, as well as response rate estimates in RO4.3.

The outcome of this project would also directly inform RO4.8 (expansion of monitoring), as an improved understanding of the challenges and requirements of individual colonies will make monitoring more efficient and effective.

Reference and contact

Baker, B., Meadows, M., Ruffino, L. & Anderson, O.R. 2022. Towards better estimates of Manx shearwater and European storm-petrel population abundance and trends, demographic rates and at-sea distribution and behaviour. *JNCC Report No. 719*, JNCC, Peterborough, ISSN 0963-8091.

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(Baker *et al.* 2022)



RO4.8 Expansion of annual monitoring for Manx shearwaters and European storm-petrels

Short summary of proposed research

This project would build on work carried out under previous KG4 ROs to improve our understanding of populations of Manx shearwaters and European storm-petrels by expanding the current population size and demographic rate monitoring, and tracking programmes, at existing and new colonies. This would also involve an increase in frequency of monitoring where possible and appropriate.

RO4.8a Feasibility review to estimate resources required to establish new sites or enhance existing ones

RO4.8b Roll out of geographically and temporally expanded monitoring

Outcome

An increase in frequency and geographic spread of population, demographic rate and tracking monitoring would lead to a significantly improved understanding of population dynamics, trends and at-sea distributions of these species. This has the potential to reduce OWF consent risk by contributing more accurate parameters to population modelling such as PVA as well as enhancing our ability to understand connectivity between colonies and OWFs and apportion any potential impacts.

Synergies and efficiencies

This project will build on reviews of knowledge and understanding (RO4.1, RO4.13 & RO4.14) and methodological improvements and application of potential new methods (RO4.2, RO4.12, RO4.15 & RO4.18).

Reference and contact

Baker, B., Meadows, M., Ruffino, L. & Anderson, O.R. 2022. Towards better estimates of Manx shearwater and European storm-petrel population abundance and trends, demographic rates and at-sea distribution and behaviour. *JNCC Report No. 719*, JNCC, Peterborough, ISSN 0963-8091.

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(Baker *et al.* 2022)



RO4.9 Improving estimates of Manx shearwater and European storm-petrel adult survival

Short summary of proposed research

This project would seek to improve on one of the key input parameters for population modelling (adult survival) for Manx shearwater and European storm-petrel, initially by reanalysing existing data and potentially developing new analytical methods, before considering how monitoring may be expanded.

RO4.9a Review of existing data and understanding

RO4.9b Modelling of existing data to improve current estimates of adult survival

RO4.9c Feasibility review to establish whether adult survival can be incorporated into existing monitoring work

RO4.9d Designing a protocol for future data collection

RO4.9e Roll-out of adult survival monitoring at novel and existing sites informed by gap and power analysis conducted under RO4.1

Outcome

Improving understanding of adult survival would allow the improved parameterisation of population models (Natural England (NE) PVA tool does not currently parameterise for Manx shearwaters or European storm-petrels), which would increase confidence in predictions around potential impacts. In the long-term, this could inform expansion and standardisation of data collection. Reducing uncertainty in this and other demographic rates would go some way to improving upon the current necessarily precautionary approach to impact assessments.

Synergies and efficiencies

Any methodological developments under this project will also inform further data collection as detailed in RO4.8. Recent work has shown that when multiple demographic rates are modelled together (e.g. productivity and adult survival), they can provide a more detailed and nuanced understanding of population dynamics and how rates vary across populations (Wood *et al.* 2021), therefore this RO could be undertaken alongside RO4.10. Adult survival and juvenile survival can both be monitored using ringing studies and could therefore be undertaken together (RO4.11). This work would most logically be initiated with Manx shearwater as there are more data already available, then the same methods could be applied to storm-petrels in the future when more data are available.

Reference and contact

Baker, B., Meadows, M., Ruffino, L. & Anderson, O.R. 2022. Towards better estimates of Manx shearwater and European storm-petrel population abundance and trends, demographic rates and at-sea distribution and behaviour. *JNCC Report No. 719*, JNCC, Peterborough, ISSN 0963-8091.

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(Baker *et al.* 2022)



RO4.10 Improving confidence in Manx shearwater productivity

Short summary of proposed research

This project would seek to improve on one of the key input parameters for population modelling for Manx shearwater and European storm-petrel, productivity, by rolling-out existing methods to test for differences between sites within and between colonies to inform future monitoring work

RO4.10a Use of habitat mapping to identify new sites for productivity monitoring

RO4.10b Roll-out of new study plots

RO4.10c Analysis and comparison of productivity between plots

RO4.10d Roll-out of productivity monitoring at novel and existing sites informed by gap and power analysis conducted under RO4.1

Outcome

Improving understanding of productivity would allow the improved parameterisation of population models (NE PVA tool does not currently parameterise for Manx shearwaters or European storm-petrels), which would increase confidence in predictions around potential impacts. By extending productivity monitoring to new sites, as well as multiple colonies within sites, it will be possible to improve understanding of spatial and temporal variability in productivity as well as identify drivers of variability. Reducing uncertainty in this and other demographic rates would go some way to improving upon the current necessarily precautionary approach to impact assessments.

Synergies and efficiencies

Any methodological developments undertaken in this project will also inform further data collection as detailed in RO4.8. Recent work has shown that when multiple demographic rates are modelled together (e.g. adult survival and productivity), they can provide a more detailed and nuanced understanding of population dynamics and how rates vary across populations (Wood *et al.* 2021), therefore this RO could be undertaken alongside RO4.9. If a project on Manx shearwater is successful, then similar work could be carried out for storm-petrels.

Reference and contact

Baker, B., Meadows, M., Ruffino, L. & Anderson, O.R. 2022. Towards better estimates of Manx shearwater and European storm-petrel population abundance and trends, demographic rates and at-sea distribution and behaviour. *JNCC Report No. 719*, JNCC, Peterborough, ISSN 0963-8091.

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(Baker *et al.* 2022)



RO4.11 Juvenile survival of Manx shearwaters

Short summary of proposed research

This project would seek to improve our understanding of juvenile survival for Manx shearwater, one of the key input parameters for population modelling, by reviewing methods and data and then conduct further analysis using updated datasets.

RO4.11a Review of existing data and current methods

RO4.11b Analysis of existing juvenile survival data to improve estimates

Outcome

Better estimates of juvenile survival would improve the parameterisation of population models, which would increase confidence in predictions around potential OWF impacts. Reducing uncertainty in any key demographic rates would go some way to improving upon the current necessarily precautionary approach to impact assessments.

Synergies between ROs

Any methodological developments undertaken in this project will also inform further data collection as detailed in RO4.8. Recent work has shown that when multiple demographic rates are modelled together (e.g. adult survival and productivity), they can provide a more detailed and nuanced understanding of population dynamics and how rates vary across populations (Wood *et al.* 2021), therefore this RO could be undertaken alongside RO4.9. Adult survival and juvenile survival can both be monitored using ringing studies and could therefore be undertaken together (RO4.9 & RO4.10). If this project is successful for Manx shearwater, then this could be applied to storm-petrels in the future.

Reference and contact

Baker, B., Meadows, M., Ruffino, L. & Anderson, O.R. 2022. Towards better estimates of Manx shearwater and European storm-petrel population abundance and trends, demographic rates and at-sea distribution and behaviour. *JNCC Report No. 719*, JNCC, Peterborough, ISSN 0963-8091.

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(Baker *et al.* 2022)



RO4.12 Assessment of rate of sabbaticals

Short summary of proposed research

This project would seek to improve our understanding of sabbatical rates for Manx shearwater and European storm-petrel through largely exploratory work based on existing data and modelling approaches. Initially a feasibility analysis would seek to establish data requirements, such as sample size and dataset length for analysis. If sufficient, good quality data are available, methods for analysis could be explored and potentially applied to existing data.

Outcome

A better quantitative assessment of birds likely to skip breeding in any given year will go some way to reducing precaution in impact assessments. Improved sabbatical rates would contribute to population (PVA) and apportioning (in Scottish waters) models as well as generally enhancing our understanding of the breeding ecology of these species.

Synergies and efficiencies

This work would benefit from being carried out alongside other demographic rate monitoring, particularly adult and juvenile survival rates (RO4.9 & RO4.11) to improve our overall understanding of the ecology and life-history of these species. Any methodological developments under this RO will also inform further data collection as detailed in RO4.8.

Reference and contact

Baker, B., Meadows, M., Ruffino, L. & Anderson, O.R. 2022. Towards better estimates of Manx shearwater and European storm-petrel population abundance and trends, demographic rates and at-sea distribution and behaviour. *JNCC Report No. 719*, JNCC, Peterborough, ISSN 0963-8091.

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(Baker *et al.* 2022)



RO4.13 Review of existing at-sea distribution data and gap analysis to identify research needs

Short summary of proposed research

This project would seek to conduct a thorough review of all sources of tracking and at-sea distribution data for Manx shearwater and European storm-petrel, both public and privately held, so that a stock-take can be carried out and priority areas for future data collection can be identified to improve our understanding of where these species occur and how they use the marine environment.

RO4.13a Review of existing tracking data, particularly from SPA colonies

RO4.13b Gap analysis to direct future monitoring effort at a spatial scale

Outcomes

There is not currently a single location or repository for tracking and at-sea distribution data for these species. Collating this knowledge, signposting to datasets (both public and private) and identifying where current knowledge gaps lie will allow for better parameterised impact assessments, improve our ability to assess connectivity and apportion potential OWF impacts, direct future research effort to data-poor regions and improve our ability to conduct accurate and precise risk modelling and contribute to consenting processes.

Synergies and efficiencies

This review could be conducted in conjunction with the review of population abundance and demographic rates as detailed in RO4.1. The results of this review would provide information that will feed into RO4.14 (production of gap-free distribution maps).

The outcomes of this project would directly inform new data collection (RO4.8) by highlighting the evidence gaps in at-sea distribution.

Reference and contact

Baker, B., Meadows, M., Ruffino, L. & Anderson, O.R. 2022. Towards better estimates of Manx shearwater and European storm-petrel population abundance and trends, demographic rates and at-sea distribution and behaviour. *JNCC Report No. 719*, JNCC, Peterborough, ISSN 0963-8091.

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(Baker *et al.* 2022)



RO4.14 Produce gap-free at-sea distribution maps for Manx shearwater and European storm-petrel

Short summary of proposed research

This project would seek to produce maps of Manx shearwater and European storm-petrel distribution by combining tracking data with at-sea survey data, as well as specific behavioural maps to identify key sites for foraging or resting, etc. It is hoped this would be an iterative process so that the maps can be updated when new data becomes available.

RO4.14a Feasibility review

RO4.14b Production of behavioural distribution maps

RO4.14c Long-term maintenance of maps and incorporation of new data when available

Outcomes

There is not currently a map/s where tracking and at-sea distribution data for these species are combined. Collating this knowledge will allow for better parameterised impact assessments, improve our ability to assess connectivity and apportion potential OWF impacts, consider seabird behaviour across different regions and improve our ability to conduct accurate and precise risk modelling, all contributing to consenting processes.

Synergies and efficiencies

This project will use data identified and collated under RO4.13. The outcomes of this project would directly inform new data collection (RO4.8) by highlighting the evidence gaps in at-sea distribution.

Reference and contact

Baker, B., Meadows, M., Ruffino, L. & Anderson, O.R. 2022. Towards better estimates of Manx shearwater and European storm-petrel population abundance and trends, demographic rates and at-sea distribution and behaviour. *JNCC Report No. 719*, JNCC, Peterborough, ISSN 0963-8091.

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(Baker *et al.* 2022)



RO4.15 Assess temporal changes in distribution at regional scales¹

Short summary of proposed research

This project would seek to make use of existing long-term tracking datasets for Manx shearwater to identify changes in breeding distribution over time, specifically with relation to climate change. The scope of this work will rely on the availability and quality of data and may require a feasibility and/or power analysis to define and direct the temporal analysis.

Outcomes

This work will improve our understanding of how at-sea breeding distribution may change over time. This knowledge could then be incorporated into future impact assessments and inform on risk which will aid in spatial planning and/or inform strategic compensation measures should they be required.

Synergies and efficiencies

This project could potentially use data identified and collated under RO4.13, but should insufficient data be available this could inform future data collection under RO4.8.

Reference and contact

Baker, B., Meadows, M., Ruffino, L. & Anderson, O.R. 2022. Towards better estimates of Manx shearwater and European storm-petrel population abundance and trends, demographic rates and at-sea distribution and behaviour. *JNCC Report No. 719*, JNCC, Peterborough, ISSN 0963-8091.

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¹ This method can currently only be applied to Manx shearwaters as there are currently not enough data available for European storm-petrel, once more data are available this method could be applied to storm-petrels.

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(Baker *et al.* 2022)



RO4.16 Better understanding of resource partitioning between breeding adults/non-breeding adults/immatures

Short summary of proposed research

Existing evidence (Fayet *et al.* 2015) shows that different age-classes of Manx shearwater forage in different areas and display opposing foraging strategies. This project would seek to make use of existing tracking datasets to highlight different foraging areas throughout the breeding season and between age-classes.

Outcomes

This work will improve our understanding of how distribution at-sea varies between individuals. In long-lived species such as Manx shearwaters and European storm-petrels, populations are particularly sensitive to impacts on adult survival, therefore enhancing our understanding on the potential impacts on specific age classes will go a long way to improving the accuracy of impact assessments. This knowledge would directly inform apportioning of potential OWF impacts to different age classes and inform on future risk, which will aid in spatial planning and/or inform strategic compensation measures should they be required.

Synergies and efficiencies

This project could potentially use data identified and collated under RO4.13, but should insufficient data be available, this could inform future data collection under RO4.8. This RO could also work alongside RO4.18 (apportioning of seabirds at sea to colonies).

Reference and contact

Baker, B., Meadows, M., Ruffino, L. & Anderson, O.R. 2022. Towards better estimates of Manx shearwater and European storm-petrel population abundance and trends, demographic rates and at-sea distribution and behaviour. *JNCC Report No. 719*, JNCC, Peterborough, ISSN 0963-8091.

For further information, contact OWSMRF@jncc.gov.uk

Knowledge Gap 4 –

Towards better estimates of Manx shearwater and European storm-petrel population abundance and trends, demographic rates and at-sea distribution and behaviour

(Baker *et al.* 2022)



RO4.17 Explore the use of foraging radius models as an alternative to tracking data to predict at-sea distribution

Short summary of proposed research

This project would investigate modeling approaches to predict at-sea distribution of Manx shearwater and European storm-petrel as an alternative to tracking data by making use of existing tracking data from well-studied colonies to test and validate models. If proven to be a sound approach, this could be applied to colonies where no tracking data currently exist.

RO4.17a Identify colonies for analysis of dual-foraging strategy tracks

RO4.17b Carry out assessment of foraging radius models

RO4.17c Expand modelling approach to data-poor colonies/regions

Outcomes

Tracking seabirds at-sea can be logistically challenging, requires significant resources and has potential ethical implications, however it is currently one of the best methods for collecting at-sea distribution data. This project would investigate alternative methods, such as recently developed modelling approaches, to assess whether they could provide a reliable and cost-effective means of predicting at-sea distribution. Understanding at-sea distribution is vital for assessing connectivity between OWF footprints and SPA colonies, apportioning potential OWF impacts and to input into future planning and risk/impact assessments.

Synergies and efficiencies

This project could potentially use data identified and collated under RO4.13 and the distribution maps developed as part of RO4.14 to validate model outputs.

Reference and contact

Baker, B., Meadows, M., Ruffino, L. & Anderson, O.R. 2022. Towards better estimates of Manx shearwater and European storm-petrel population abundance and trends, demographic rates and at-sea distribution and behaviour. *JNCC Report No. 719*, JNCC, Peterborough, ISSN 0963-8091.

For further information, contact OWSMRF@jncc.gov.uk

Knowledge Gap 4 –

Towards better estimates of Manx shearwater and European storm-petrel population abundance and trends, demographic rates and at-sea distribution and behaviour

(Baker *et al.* 2022)



RO4.18 Apportioning of seabirds-at sea to colonies using tracking data

Short summary of proposed research

This project would seek to improve apportioning methods for Manx shearwaters and European storm-petrels, which are currently not included in existing tools and are difficult to apportion due to their foraging strategies and extensive foraging ranges.

RO4.18a Review of existing apportioning tools and models

RO4.18b Where possible, apply existing models to Manx shearwaters and European storm-petrels or develop new approach appropriate for these species.

Outcomes

Current apportioning methods cannot account for non-breeding or immature birds. Use of tracking data collected from adults, non-breeders, and immatures would allow more precise apportioning of the potential impacts of OWF. Understanding at-sea distribution is vital for assessing connectivity between OWF footprints and SPA colonies, apportioning potential OWF impacts and to input into future planning and risk/impact assessments.

Synergies and efficiencies

This project could potentially use data identified and collated under RO4.13 and the distribution maps developed under RO4.14 as a start point of our current understanding on at-sea distributions. Understanding the distribution of different age-classes (RO4.16), as well as the age structure of populations (RO4.9, RO4.11 & RO4.12), is vital for accurately apportioning OWF impacts to relevant colonies so the outputs of other projects would benefit this RO.

Reference and contact

Baker, B., Meadows, M., Ruffino, L. & Anderson, O.R. 2022. Towards better estimates of Manx shearwater and European storm-petrel population abundance and trends, demographic rates and at-sea distribution and behaviour. *JNCC Report No. 719*, JNCC, Peterborough, ISSN 0963-8091.

For further information, contact OWSMRF@jncc.gov.uk

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Deakin, Z., Hansen, E.S., Luxmoore, R., Thomas, R.J., Wood, M.J., Padget, O., Medeiros, R., Aitchison, R., Ausden, M., Barnard, R. & Booth, V. 2021. Decline of Leach's Storm-petrels *Hydrobates leucorhous* at the largest colonies in the northeast Atlantic. *Seabird*, **33**, 74–106.

Fayet, A.L., Freeman, R., Shoji, A., Padget, O., Perrins, C.M. & Guilford, T. 2015. Lower foraging efficiency in immatures drives spatial segregation with breeding adults in a long-lived pelagic seabird. *Animal Behaviour*, **110**, 79-89.

Wood, MJ., Canonne, C., Besnard, A., Lachish, S., Fairhurst, SM., Liedvogel, M., Boyle, D., Patrick, S.C., Josey, S., Kirk, H. & Dean, B. 2021. Demographic profiles and environmental drivers of variation relate to individual breeding state in a long-lived trans-oceanic migratory seabird, the Manx shearwater. *PLoS ONE*, **16**(12), e0260812.