Innovating waterbird monitoring along the East Atlantic Flyway

Following a request from the Dutch Ministry of Agriculture, Fisheries, Food Security and Nature (LVVN) and its counterparts in Germany and Denmark

D1.4.2 Roadmap and Implementation Plan

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This project is funded by the European Union via the Technical Support Instrument (TSI) and implemented by the EUCC in collaboration with its experts, in cooperation with the European Commission's Directorate General for Reform Support (DG REFORM).

1. INTRODUCTION

The European Commission's Directorate General for Structural Reform Support (DG REFORM), following the request from the Ministry of Agriculture, Fisheries, Food Security and Nature of the Netherlands, also on behalf of counterparts in Denmark and Germany, awarded the Coastal and Marine Union (EUCC) with funding to support the development of the project entitled "Innovations for migratory bird monitoring along the East Atlantic Flyway" (original name Digitalizing Monitoring of the East Atlantic Flyway"). The project aims to improve migratory bird monitoring along the East Atlantic Flyway (EAF). A State of Play Assessment (SoPA) has been conducted to analyse and summarise the state of current monitoring efforts, data gaps, and possible technologies for improving migratory bird monitoring along the EAF. A consultation phase has taken place, including a questionnaire and an international workshop for experts on monitoring technologies. Both highlighted data gaps and needs but also possibilities for improvement. The SoPA resulted in a Table of Recommendations (Annex 1) that served as the foundation for selecting methods to improve migratory bird monitoring along the EAF, which are now included in this Roadmap.

The Roadmap is intended to fascilitate the project Steering Group and especially the Wadden Sea countries of Denmark, Germany and the Netherlands to align their activities for further improvements of the EAF monitoring. The Roadmap is delibarately flexible to accommodate iterations, allowing the Steering Group to incorporate new information and refine their strategies continuously. It should be treated as a joint working document. A joint statement for futher implementation after the TSI project about innovations from the Netherlands, Germany and Denmark can be found as Annex 4.

An overview of the Roadmap development process is laid down in the schematic diagram shown in Figure 1.

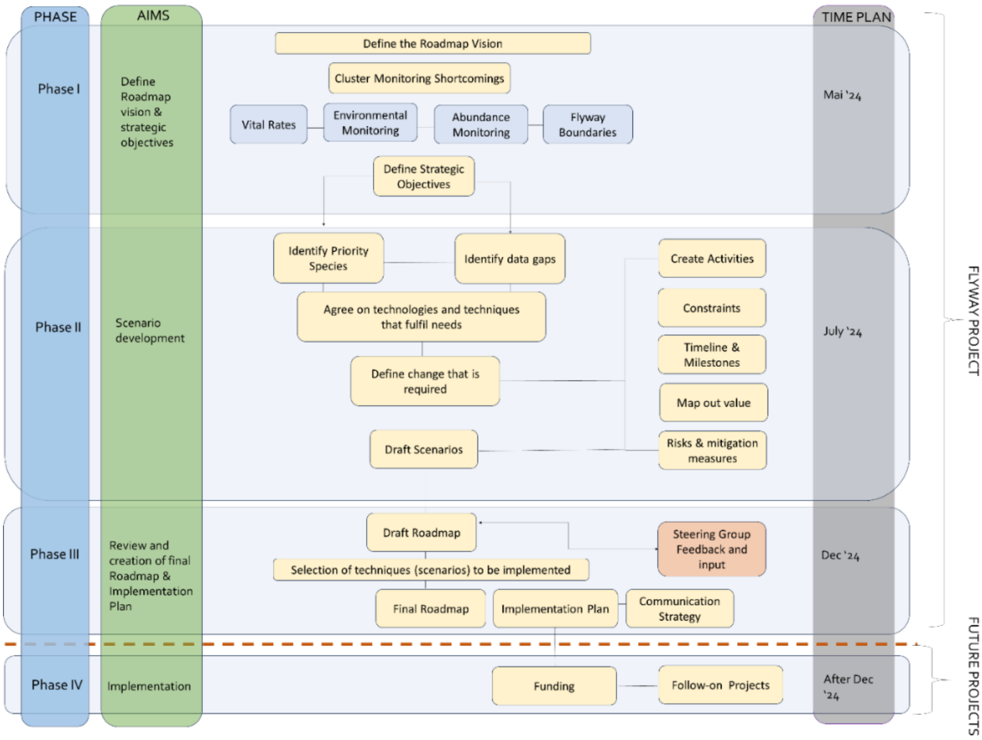

Figure 1: Planning process steps

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2. ROADMAP VISION AND OBJECTIVES

The Steering Group has jointly agreed upon the desired direction of further implementation of the innovations project. This vision provides a shared goal for improving migratory waterbird monitoring along the East Atlantic Flyway. Commitment to this vision by the three project beneficiaries, the Dutch Ministry of Agriculture, Fisheries, Food Security and Nature, The German Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection, and the Danish Environmental Protection Agency at the Ministry of the Environment and Food, is assured through the approval of this collaborative document and is understood by the governments of the Trilateral Wadden Sea cooperation (see full statement in Annex 4).

The Roadmap vision:

“Improving the effectiveness of migratory waterbird monitoring along the East Atlantic Flyway with innovative and integrative techniques, to enhance Wadden Sea policy-making and management”

The objectives of the Roadmap are based on the four themes which were identified in the SoPA, as being important building blocks to improve the monitoring scheme.

The Roadmap’s objectives:

1 - Improving abundance monitoring to provide accurate data about numbers, distribution and changes in these of important waterbird species on flyway level;

2 - Improving the monitoring of vital rates to understand demographic processes behind changes in numbers, and based on these provide advise about effective management measures;

3 - Improving environmental monitoring to understand natural and antropogenic pressures at sites and evaluate conservation measures taken to also provide advise about effective management measures;

4 - Reducing uncertainty about population-specific flyway boundaries as the basis for the flyway oppproach to conservation and management for Wadden Sea relevant waterbird species along the East Atlantic Flyway.

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3. SELECTED TECHNIQUES AND SCENARIO'S FOR IMPLEMENTATION

3.1. Techniques Selected for Implementation

The techniques that have been selected by the project beneficiaries as prioritites for further implementation are listed below. The techniques have been grouped according to the objective for which they are expected to bring the biggest improvement. Several of them will have benefits for other objectives as well. Selection of techniques has been based mainly on Impact and Urgency (Annex 1). Some innovations are taken together in one technique for inclusion in this Roadmap.

3.1.1. Techniques Selected for Improving Abundance Monitoring

Power Analyses, Simulations, Imputation and Trend Detection Methods (Pilot on Statistics): The current monitoring can benefit from power analyses, re-sampling techniques and simulations to improve reliability by adjusting frequency and site selection. Implementing new methods to correct for missing data (imputation) and trend detection can enhance the efficiency, power, and reliability of waterbird abundance monitoring.

Observer Training and Site Monitoring Protocols (Protocol and App): Improved instructions and training for observers through Apps and other training methods, along with clear monitoring protocols for sites, can enhance long-term commitment, motivation, improved skills and reliability, especially in areas with no history of bird counting.

Innovative Counting Techniques (Drones): Aerial counts from drones can increase the accuracy of counts. Pilots are needed to test suitability of these techniques at high tide roosts or at low water foraging areas. In colonally breeding species, drone counts are already implemented, but can be further improved and extended including AI analyses of images.

Colour Marking (see vital rates) and Tracking (see flyway boundaries) will also enable better abundance monitoring.

3.1.2. Techniques for Improving Vital Rates Monitoring

Integrated Population Models (IPM): Combining estimates of survival and reproduction with abundance monitoring in integrated population models can pinpoint where and when population growth is limited, aiding in the formulation of effective conservation measures. Within such a model weaker or missing data on vital rates can be estimated and these models allow future population size projections under different pressure and conservation scenario's.

Color-Marking Schemes (Color-Ringing): Implementing and maintaining color-marking schemes for key species provide valuable data on vital rates, site use, and population estimates. This approach requires catching and colourmarking sufficient individuals of several key study species at stratetic chosen places along the flyway with sufficient observers, often citizen scientists, for ring-reading.

Nest and Chick Survival (Nest and Chick Survival): Monitoring reproductive success is important to estimate annual reproductive success and incorporate these estimates into integrated population models. It should be conducted for several populations in different breeding environments. Given the rapid ecological changes in the Arctic, investing in long-term monitoring of reproductive success of Arctic-breeding populations in relation to environmental circumstances is crucial.

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Tracking (see flyway boundaries) also contributes to vital rates monitoring.

3.1.3. Techniques for Improving Environmental Monitoring

Remote Sensing and Satellite Imagery (Remote Sensing): There is significant potential for using satellite imagery to remotely assess environmental conditions. This method can provide systematic, quantitative measurements of habitat availability and human pressures, which can be linked to changes in waterbird abundance.

3.1.4. Techniques for Improving Flyway Boundaries Monitoring

Tracking (Tracking): The importance of identifying the boundaries of a flyway population through tracking is pivotal; it is the basis for further analyses of flyway trends and population sizes. Tracking will also give insight in connectivity between sites and within site use which can help in linking population changes to environmental changes and other reasons behind population change. Satellite tracking is currently available for most species and further expansion of existing datasets should help to identify the flyway boundaries of these species.

3.2. Scenario's for implementation

For the purpose of implementation, the elements listed above have been assigned to different implementation scenario's. Figure 2 is a graphical representation of the four scenario's for implementation and the techniques they contain. The objectives (themes) for which knowledge gaps were identified are highlighted within oval-shaped text boxes at the top of Figure 2.

The general reasoning behind the scenario's is that under scenario 1 relatively easy improvements of current ongoing monitoring will be carried out with major improvements on data quality (abundance monitoring and environmental monitoring) and the Integrated Population Models (IPM's) will help in understanding the population changes. In scenario 2 new techniques will be included with regard to tracking, nest- and chick survival, drone-counts and color-marking. These techniques are currently already being implemented as part of several research projects and further innovations will build on ongoing efforts. Important for the realization of scenario 2 will be the incorporation of these activities in ongoing monitoring efforts with important decisions to be made on cooperation agreements, financing, data use, analyses and reporting. Under scenario's 3 and 4 the implementation of the activities started under scenario 2 will be extended to cover more species and additional sites, reflected in increasing financial investments needed.

More details about the different scenario's for implementation can be found in chapter 4-6. An analyses of priority species for implementation of innovative techniques can be found in Annex 2 and cost indications of implementation of the different scenario's in Annex 3.

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Roadmap and Implementation Plan

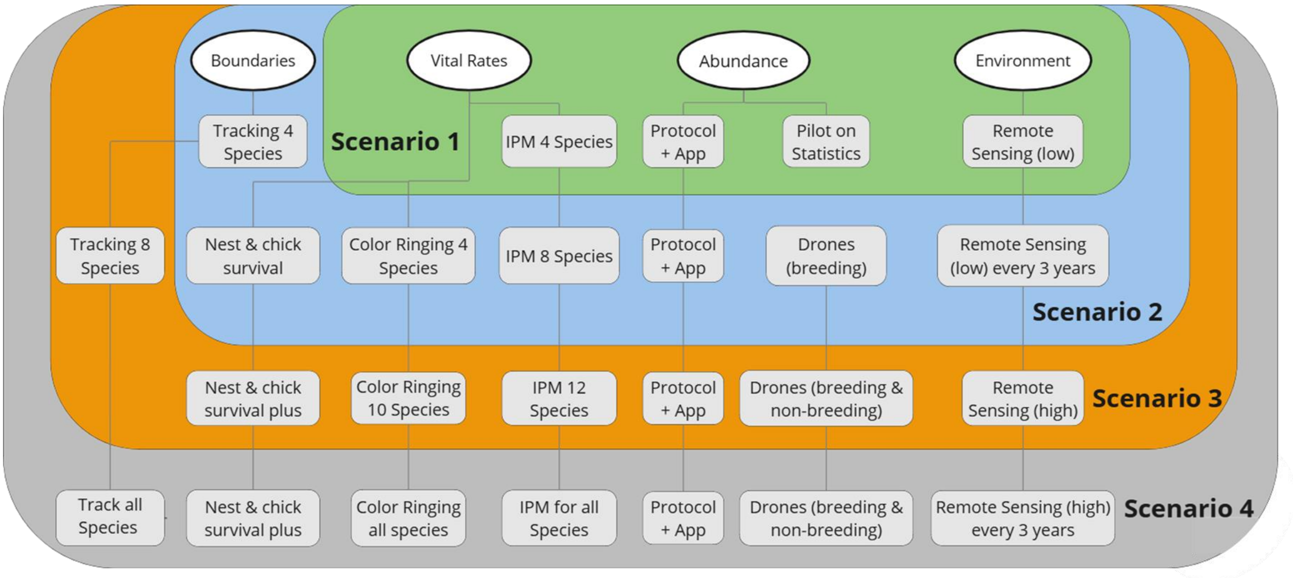

Figure 2: Scenario's for implementation of techniques.

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4. IMPLEMENTATION UNDER SCENARIO 1

Especially current monitoring activities under scenario 1 will be supplemented with new effords to improve quality and accuracy.

The Statistical Pilot is part of scenario 1. The pilot will focus on sampling design (frequency and spatial coverage) and statistical aspects (e.g. zero-inflation, detection bias and imputation method). It will also explore power analyses, simulations of different sampling designs and/or the re-sampling of current data, which can indicate the relative importance of inclusion of certain sites into the monitoring scheme and/or identify which frequency of counts provides more accurate data. The pilot study is essential for making a detailed plan of the spatial and temporal coverage of the counts. It will also improve correction for missing data (imputation), enhance the efficiency, power, and reliability of waterbird abundance monitoring.

Introducing Protocols and Apps are also part of scenario 1. Improved instructions and training for observers, along with clear monitoring protocols, can enhance long-term commitment and reliability, especially in areas with no history of bird counting. Screening and analysis of existing apps will be conducted to assess their suitability and introduce an online application to facilitate data collection.

Scenario 1 introduces Satellite Remote Sensing to improve environmental monitoring. The investment will provide systematic, quantitative measurements of habitat availability and human pressures, which can be linked to changes in waterbird abundance.

The development of Integrated Population Models (IPM) for four species is also part of scenario 1. Estimates of survival and reproduction will be combined with abundance monitoring in integrated population models that can pinpoint where and when population growth is limited, aiding in the formulation of effective conservation measures. For some species, sufficient data is already available to develop an IPM, so evaluating the potential bottlenecks for these species will soon be possible.

Implementation of scenario 1 is estimated at ~ 800.000 EUR for a 3 year period (see Annex 3 for cost calculation per technical activity).

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5. IMPLEMENTATION UNDER SCENARIO 2

Under scenario 2 new techniques will be implemented which will increase the possibilities to explain patterns found in the monitoring. It is focussed on measuring vital rates, identifying flyway boundaries and site connectivity and habitat use within the flyway.

Measuring Nest and Chick Survival: Actions will be implemented to monitor the annual population-level reproductive success of many coastal waterbird species by field observations and/or within catches of birds. Estimates of survival and reproduction, in combination with abundance monitoring, will then be incorporated into integrated population analyses to pinpoint where and when population growth is limited. This is an investment in long-term ecological monitoring of especially the reproduction of Arctic-breeding birds in relation to their (changing) food and predators.

Color Marking schemes: Under this scenario, colour marking schemes will be expanded. An investment to continue existing programmes is required to reach sufficiently large sample sizes, using existing knowledge on ecology and demographic modelling. It will ensure the long-term maintenance of already existing colour-ringing schemes of pivotal species (e.g. Avocet, Brent Goose, Barnacle goose, Bar-tailed Godwit, Common Tern, Lesser Black-backed Gull, Oystercatcher, Sanderling, Sandwich Tern, Eurasian Spoonbill, Red Knot, Whimbrel), and include the analyses of annual survival of these species into the reporting of the monitoring of waterbirds along the East Atlantic Flyway. This approach requires long term fieldwork and data analysis.

Satellite Tracking is currently possible for many species. Investment is needed to further identify the flyway boundaries of different populations. This is especially urgent as circumstantial evidence is accumulating that the traditional boundaries are out of date as many populations are changing their migratory habits and wintering quarters as a result of global warming. Satelite Tracking of individual birds will also contribute to knowledge about site connectivity and habitat use. In this scenario tracking of 4 species will be performed.

Innovative counting techniques: Scenario 2 focuses also on the wider introduction of drones and aerial counts from large unmanned aerial vehicles (uav) to improve and supplement the acurarcy of ground counts. Important choices need to be made regarding the species to monitor, considering feasibility and knowledge levels. Under scenario 2, the structureal use of drones for colony-breeding coastal waterbird species is foreseen. It also extends drone monitoring of colonially breeding birds in Africa by providing training for local people in drone usage and data analysis. The implementation of drones for monitoring will be further tested for non-breeding waterbirds in scenario 3. This investment also considers the use of Artificial Inteligence (AI). Machine learning models will be developed bringing a gradual increase in species identification performance. Integrated Population Model's will be made for a total of 8 species, including those developped in scenario 1, remote sensing of environmental conditions will be done every three years and usage of apps and count protocols are continued.

Implementation of scenario 2 is estimated at ~ 3.350.000 EUR for a 3 year period (see Annex 3 for cost calculation per technical activity).

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6. IMPLEMENTATION UNDER SCENARIO 3 AND 4

Under scenario 3 and 4 the implementation of techniques at scenario 2 will be extended to more species (Tracking, Color-ringing, IPM's) and other activities will be done in a more complete and accurate way (Nest and Chick Survival plus, high resolution remote sensing and drone counts also for non-breeding birds. Similar to scenario 2, the usage of apps and count protocols will be continued.

Implementation of scenario 3 is estimated at ~ 6.500.000 EUR for a 3 year period and scenario 4 is estimated at ~ 13.000.000 EUR (see Annex 3 for cost calculation per technical activity).

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ANNEX 1 – RECOMMENDATIONS FROM STATE OF PLAY REPORT

Recommended innovation	Topic	Overarching theme	Spatial scale	Implementation speed	Monetary cost	Impact	Urgency
Individual bird tracking (7.1)	Tracking different subspecies, boundaries	Flyway boundaries	Flyway	++ **	Logistical $$ Financial $$	+++	++
Population genetics (7.2)	Distinguishing and assigning subspecies	Flyway boundaries	Flyway	++ / +++ *	Logistical $ Financial $$	++	++
Individual colour-ring scheme (7.4)	Observations along flyway	Flyway boundaries	National - Flyway	+ / +++ *	Logistical $$ Financial $	++	+
Stable isotopes (7.3)	Flyway boundaries	Flyway boundaries	Flyway	++ / +++ *	Logistical $$ Financial $$	0	0
Power analyses, simulations, re-sampling methods (8.2)	Reliability flyway counts	Abundance	Flyway	+++	Logistical $ Financial $	+++	+++
Phone app, count protocol (8.3.1)	Reliability counts	Abundance	Flyway	++	Logistical $ Financial $$	+++	+++
Mark-recapture models (colour-marked birds) (8.2.1-3)	Estimating bird numbers	Abundance	Local - Flyway	+ / +++ *,**	Logistical $ - $$ Financial $ - $$	++	++
Drones for counting (8.1.2)	Reliability counts	Abundance	Local	++	Logistical $$ Financial $$	++	++
Counts using satellite imagery (8.1.4)	Reliability counts	Abundance	Local – Flyway	+	Logistical $$$ Financial $$$	+++	+
Mark-recapture models (unmarked individuals) (8.2.4)	Estimating bird numbers	Abundance	Local - Flyway	+++	Logistical $ Financial $$	++	+
Counts from planes (8.1.3)	Reliability counts	Abundance	Regional	++	Logistical $ Financial $$$	+	+
Species distribution models (8.2.5)	Geographical distribution in changing world	Abundance	Flyway	++	Logistical $ Financial $	+	0
Integrated population models (9.3)	Understanding causes of population trends	Vital rates	Local – Flyway	+ / +++ *	Logistical $ Financial $	+++	+++
Mark-recapture analyses (colour-ringing projects) (9.2)	Estimating (variation in) survival	Vital rates	Local - Flyway	+ / +++ *	Logistical $ - $$ * Financial $ - $$	+++	+++
Estimating population-level reproductive output (9.1)	Understanding causes of population trends	Vital rates	Local - Flyway	+ / +++ **	Logistical $$$ Financial $	+++	+++

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Roadmap and Implementation Plan

Recommended innovation	Topic	Overarching theme	Spatial scale	Implementation speed	Monetary cost	Impact	Urgency
DNA methylation markers (9.1)	Ageing individual birds	Vital rates	Local - Flyway	++ *	Logistical $ Financial $$$	++	++
Estimating nest and chick survival (9.1)	Understanding causes of population trends	Vital rates	Local	++ / +++ **	Logistical $ Financial $	+	++
Phone app (8.3.1)	Reporting colour-ringed bird and/or juvenile percentages	Vital rates	Flyway	++	Logistical $ Financial $$	+	+
Individual bird tracking (10.1)	Nest success	Vital rates	Flyway	++	Logistical $ Financial $$	+	0
Satellite remote sensing of habitat quality (10.2)	Describing (changes in) habitat	Environment	Local - Flyway	+++	Logistical $ Financial $$	+++	+++
Individual bird tracking (10.1)	Habitat use, connectivity	Environment	Local - Flyway	++	Logistical $ Financial $$	++	+++
Phone app (8.3.1)	Standardised local reporting of environmental variables	Environment	Flyway	++	Logistical $ Financial $$	+	+
Drones for quantifying habitat quality	Improving knowledge of local habitat	Environment	Local	+++	Logistical $ Financial $$	+	+

Implementation speed, monetary costs, impact, and urgency of the possible innovations discussed in this report. Each innovation addresses different topics and can be applied at different spatial scales. The number between brackets after each name of the innovation refers to the section in the State of Play Assessment where the innovation is described. Characteristics are scored using four different categories: 0 = negligible, + small, ++ moderate or +++ large ($ signs are used when indicating monetary costs). Note that more +'s for implementation speed indicates that the innovation can rather quickly be applied. Innovations that need pilot studies first will have a low implementation speed. The innovations are ordered, within the overarching themes (Flyway boundaries -grey, Abundance - green, Vital rates -red, and Environment – blue), based on urgency, impact and subsequently according to costs and implementation speed. Innovations that are useful at a local scale can be implemented at many sites, upgrading it to a regional or flyway-scale, but with consequences for the implementation speed, costs and impact.

* Depends on the availability of existing data or samples. Where these are available a fast implementation can be achieved as indicated by the second assessment. ** Depending on species and method

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ANNEX 2 – PRIORITY SPECIES LIST

Species population priority list indicating how useful investments in that population are for improved abundance monitoring and understanding population dynamics, only species occurring in the Wadden Sea in significant numbers are considered. Then, we determined whether the flyway boundaries are sufficiently known and whether tracking, colour-ringing and/or population-level variation in annual reproduction can be reliably measured. We also determined whether an integrated population model (IPM) is possible with the currently available data and whether an IPM could be made possible within five years with extra investments in measurements of vital rates (survival using colour-ringing schemes and/or measurements of population-level variation in annual reproduction).

English name	Scientific name	Occurs in Wadden Sea	Use of Wadden Sea	tracking ongoing	Colour-ringing ongoing	repr data availab	IPM	<5yr IPM	TOTAL POINTS
Lesser Black-backed Gull	*Larus fuscus graellsii*	Yes	Stop-over migrant	1	1	1	1	1	5
Lesser Black-backed Gull	*Larus fuscus intermedius*	Yes	Stop-over migrant, Breeding	1	1	1	1	1	5
European Herring Gull	*Larus argentatus argenteus*	Yes	Wintering, Breeding, Resident	1	1	1	1	1	5
European Herring Gull	*Larus argentatus argentatus*	Yes	Wintering	1	1	1	1	1	5
Sanderling	*Calidris alba*	Yes	Stop-over migrant, Wintering	0	1	1	1	1	5
Eurasian Spoonbill	*Platalea leucorodia*	Yes	Breeding	1	1	1	1	1	4
Brent Goose	*Branta bernicla*	Yes	Wintering, stop-over migrant	1	1	1	1	1	3
Barnacle Goose	*Branta leucopsis*	Yes	Wintering, Breeding	1	1	1	1	1	3
Eurasian Oystercatcher	*Haematopus ostralegus*	Yes	Wintering, Breeding, Resident	1	1	1	1	1	3
Greylag Goose	*Anser anser*	Yes	Wintering, Breeding	0	1	1	1	1	3
Black-headed Gull	*Chroicocephalis ridibundus*	Yes	Wintering, Breeding	0	1	0	1	1	3
Sandwich Tern	*Thalasseus sandvicensis*	Yes	Breeding	0	1	1	1	1	3
Bar-tailed Godwit	*Limosa lapponica taymyrensis*	Yes	Stop-over migrant	1	1		1	1	2
Red Knot	*Calidris canutus islandica*	Yes	Wintering, stop-over migrant	1	1	1	1	1	2
Red Knot	*Calidris canutus canutus*	Yes	Stop-over migrant	1	1	0	1	1	2
Common Tern	*Sterna hirundo*	Yes	Breeding	1	1	1	0	1	6
Dunlin	*Calidris alpina alpina*	Yes	Wintering	0	1	0	0	1	6
Whimbrel	*Numenius phaeopous islandica*	Yes	Stop-over migrant	1	0	0	0	1	5
Kentish Plover	*Charadrius alexandrines*	Yes	Breeding	1	1	1	0	1	4
Pied Avocet	*Recurvirostra avosetta*	Yes	Breeding	1	1	0	0	1	4
Grey Plover	*Pluvialis squatarola*	Yes	Wintering, stop-over migrant	1	1	0	0	1	4
Grey Heron	*Ardea cinerea*	Yes	Wintering, Breeding, Resident	0	0	0	0	1	4
Little Egret	*Egretta garzetta*	Yes	Wintering, Breeding	0	0	1	0	1	4
Great Cormorant	*Phalacrocorax carbo sinensis*	Yes	Wintering, Breeding, Resident	0	1	0	0	1	4
Common Eider	*Somateria mollissima*	Yes	Wintering, Breeding	0	0	1	0	1	3
Common Ringed Plover	*Charadrius hiaticula hiaticula*	Yes	Breeding	0	1	1	0	0	5
Ruddy Turnstone	*Arenaria interpres*	Yes	Wintering, stop-over migrant	0	1	0	0	-1	4
Purple Sandpiper	*Calidris maritima*	Yes	Wintering	0	1	0	0	-1	4
Bar-tailed Godwit	*Limosa lapponica lapponica*	Yes	Stop-over migrant, Wintering	0	1	0	0	-1	3
Whimbrel	*Numenius phaeopus phaeopus*	Yes	Stop-over migrant	0	0	0	0	-1	3
Common Redshank	*Tringa totanus robusta*	Yes	Wintering	0	0	0	0	-1	3
Common Redshank	*Tringa totanus totanus*	Yes	Stop-over migrant	0	1	0	0	-1	3
Common Redshank	*Tringa totanus totanus*	Yes	Breeding, Resident	0	0	0	0	-1	3
Little Tern	*Sternula albifrons*	Yes	Breeding	0	0	0	0	-1	3
Mew Gull	*Larus canus*	Yes	Wintering, Breeding	0	0	0	0	-1	3
Eurasian Curlew	*Numenius arquata*	Yes	Wintering, Breeding	1	1	0	0	-1	2
Gull-billed Tern	*Gelochelidon niloteca*	Yes	Breeding	0	1	1	0	-1	2
Common Shelduck	*Tadorna tadorna*	Yes	Wintering, Breeding	0	0	0	0	-1	2
Horned Grebe	*Podiceps auritus*	Yes	Wintering	0	0	0	0	-1	1
Mallard	*Anas platyrhynchos*	Yes	Wintering, Breeding	0	0	1	0	-1	1
Curlew Sandpiper	*Calidris ferruginea*	Yes	Stop-over migrant	0	0	1	0	-1	1
Little Stint	*Calidris minuta*	Yes	Stop-over migrant	0	0	0	0	-1	1
Common Ringed Plover	*Charadrius h. psammodromus*	Yes	Stop-over migrant	0	0	0	0	-1	0
Common Goldeneye	*Bucephala clangula*	Yes	Wintering	0	0	0	0	-1	0
Red-breasted Merganser	*Mergus serrator*	Yes	Wintering, Breeding	0	0	0	0	-1	0
Greater Scaup	*Aythya marila*	Yes	Wintering	0	0	0	0	-1	0
Northern Shoveler	*Spatula clypeata*	Yes	Wintering, Breeding	0	0	0	0	-1	0
Gadwall	*Mareca strepera*	Yes	Wintering, Breeding	0	0	0	0	-1	0
Eurasian Wigeon	*Anas Penelope*	Yes	Wintering	0	0	0	0	-1	0
Northern Pintail	*Anas acuta*	Yes	Wintering, Breeding	0	0	0	0	-1	0
Common Teal	*Anas crecca*	Yes	Stop-over migrant, Breeding	0	0	0	0	-1	0
Great Crested Grebe	*Podiceps cristatus*	Yes	Wintering, Breeding, Resident	0	0	0	0	-1	0
Common Sandpiper	*Acitis hypoleucos*	Yes	Stop-over migrant	0	0	0	0	-1	0
Spotted Redshank	*Tringa erythropus*	Yes	Stop-over migrant	0	0	0	0	-1	0
Common Greenshank	*Tringa nebularia*	Yes	Stop-over migrant	0	1	0	0	-1	0
Black-necked Grebe	*Podiceps nigricollis*	Yes	Stop-over migrant, Breeding	0	0	0	0	-1	0

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ANNEX 3. INDICATION OF COSTS

The table below lists costs for the implementation of the different techniques. Some techniques are one off and investments are only needed once. However as part of a monitoring project mosts techniques reguire annual investment. Costs are rough indications based on information within the State of Play Analysis and pilot studies. Some activities will only be done once in three year (Remote sensing low and high resolution 3 years) and costs of these once in three year activities have also be split in yearly costs to remain consistency with the annual costs of other activities.

Technique	once	annual
Pilot on statistics	€ 250,000	
Protocols and Apps	€ 200,000	€ 20,000
Drones (breeding)	€ 150,000	€ 150,000
Drones (breeding + non-breedi	€ 300,000	€ 300,000
Colour ringing (4 species)		€ 100,000
Colour ringing (10 species)		€ 200,000
Colour ringing (all species)		€ 400,000
IPM 4 species	€ 200,000	
IPM 8 species	€ 400,000	
IPM 12 species	€ 600,000	
IPM all species	€ 800,000	
Nest & Chick Survival (Arctic)		€ 300,000
Nest & Chick Survival (Arctic)		€ 600,000
Remote sensing (low res)	€ 100,000	
Remote sensing (low res 3 yrs)		€ 33,000
Remote sensing (high res)	€ 225,000	
Remote sensing (high res 3yrs)		€ 75,000
Tracking 4 species		€ 1,000,000
Tracking 8 species		€ 2,000,000
Tracking all species		€ 6,000,000

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ANNEX 4. JOINT STATEMENT ABOUT FLYWAY MONITORING INNOVATIONS FROM THE WADDEN SEA COUNTRIES

Recognition by the three Wadden Sea countries of the need for innovations to improve the waterbird monitoring along the East Atlantic Flyway for better conservation and management of the Wadden Sea

The importance of monitoring waterbirds along the East Atlantic Flyway for the conservation and management of the Wadden Sea

The Wadden Sea World Heritage Site is the largest unbroken stretch of intertidal mudflats on earth and used by millions of waterbirds. Most of these waterbirds are migratory and use the area for feeding, roosting, moulting and breeding during specific times of the year. This makes the Wadden Sea a key site in the network of sites that forms the East Atlantic Flyway (EAF) which stretches from Canada to Central Siberia in the Artic to the western coasts of Europa all the way to southern Africa.

The conservation status of migratory waterbirds depends on a healthy Wadden Sea and on the size and quality of sites and habitats in other countries along the flyway. All these sites are used by the same individual birds during their seasonal movements between breeding, stopover and wintering sites. As such, the conservation and management of the Wadden Sea and its waterbirds requires close cooperation with other countries along this flyway as well. Recognising the need for a global flyway approach, the three Wadden Sea countries Denmark, Germany and the Netherlands have established the Wadden Sea Flyway Initiative (WSFI) to strengthen international cooperation on conservation, management and research along the East Atlantic Flyway

Conservation and management start with frequently updated information about the status of species (e.g. changes in abundance) and their sites (e.g. strong decreases of fish-eating species at certain sites together with strong increases in fishing intensity for human consumption at these sites). Monitoring is crucial to signal changes and generate hypotheses about causes for possible mitigation measures, ultimately leading to advice on the best policy and management options.

Initiated by the Wadden Sea Flyway Initiative (coordinated by the Common Wadden Sea Secretariat) and in cooperation with Wetlands International and BirdLife International an integrated Monitoring Programme for waterbirds and their sites along the East Atlantic Flyway was started in 2013. Activities in the first ten years concentrated on the abundance monitoring and a qualitative assessment of environmental conditions organised by national partners and their network of observers (36 countries and more than 13.000 observers). This programme collected important information, but further improvements are needed to identify causes of population declines.

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The TSI FLYWAY project

The EU Biodiversity Strategy for 2030 emphasises the need for more decisive action to restore degraded marine ecosystems, including carbon-rich ecosystems and important fish spawning and nursery areas like the Wadden Sea. Improved monitoring activities along the East Atlantic Flyway can support the ambitions of restoring 20% of European land and sea areas by 2030 by providing essential information for the development and evaluation of restoration plans under the new Nature Restoration Law.

The EU -financed project under DG REFORM's Technical Support Instrument on 'Improving Monitoring of the East Atlantic Flyway' was carried out in 2023 and 2024 and resulted in a comprehensive assessment of available innovations for waterbird monitoring to better inform management (Reneerkens et al. 2024). Recommendations for implementation of innovations were formulated around three types of monitoring: abundance, vital rates and environmental, which form a logical framework of the integrated monitoring programme. In addition, updated information is needed on flyway boundaries of each population and changes therein possibly caused by global warming. The innovations enable signalling changes in numbers and distribution, but also provides insight in probable causes for observed changes. The East Atlantic Flyway monitoring will contribute to knowledge resulting in effective restoring of global connectivity of marine ecosystems.

Sustaining and Innovating Monitoring Efforts Along the East Atlantic Flyway

A continued investment in waterbird monitoring along the East Atlantic Flyway remains essential to inform conservation and management in the Wadden Sea for the benefit of migratory waterbirds. Monitoring results are not only important for actions in Wadden Sea but also to advance conservation efforts across the interconnected wetlands of the flyway. Every step taken to enhance monitoring along the flyway contributes directly to the protection and understanding of the Wadden Sea itself.

The existing integrative monitoring programme provides a good basis, but advancements in technology, methodology and analytical accuracy are needed to inform effective policies and management strategies. Innovations must be aligned and build on existing datasets to ensure the integrity of long-term datasets. Alongside technological advancements, fostering good communication and capacity-building within the extensive network of countries, site managers, observers, and scientists is crucial to achieving lasting success.

Innovation, however, requires substantial additional funding. Exploring ways to implement the roadmap with increased investments from the Wadden Sea countries is a priority, while also inviting other nations along the flyway to join the effort. Collaborative research and capacity-building initiatives are key to generating the information needed for effective conservation and management across the flyway. Given the deeply interconnectedness of the wetland sites, this programme holds value not only for the Wadden Sea but for the entire network of sites along the East Atlantic Flyway. By joining the international efforts, countries can further amplify the impact of our efforts and collectively strengthen the conservation of this vital migratory network.

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