Flock of birds, Senegal. Photo by Tim Dodman.

Abundance monitoring of waterbirds at critical sites in the East Atlantic Flyway with a focus on Western Africa

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Content

1. Summary

This document provides background information to “Abundance monitoring of waterbirds at critical sites in the East Atlantic Flyway with a focus on Western Africa”, a component of the CREAF Monitoring Toolbox.

Monitoring waterbird abundance at key sites is important for conservation and management. It helps assess site importance, detect changes in habitat quality and potential effects of human pressures, enables evaluation of management measures and contributes to monitoring the conservation status of international bird populations. When site-level data are combined across the flyway, broader patterns and drivers of change can be better understood.

Effective monitoring programmes should cover both non-breeding and breeding species and populations.

For non-breeding populations, a coordinated January count across the whole site is recommended, aligned with international flyway monitoring efforts. Such a count often requires several days of counting. As peak numbers for some species occur outside this period, additional monthly or bimonthly counts at selected “intensive” sites are advised.

For monitoring breeding populations, the programme should initially focus on colony breeding species. These often represent high biodiversity values and are relatively easy to count and monitor. Because individuals can move between colonies, a simultaneous count period (one or two weeks in a month), is needed across the flyway range of each species.

In western Africa, a count period in May is good for several species of terns and gulls. For other species (cormorants, pelicans) an earlier month is needed, but optimal timing needs further investigation.

In addition to the simultaneous count period, it is recommended that more detailed observations are done at a selection of colonies (one or two per country), including regular counts of the number of breeding pairs present and measurements of breeding success in relation to food choice and predation.

Consistency is critical. Monitoring programmes should be supported by clear protocols, well-defined counting units, reliable data systems, and trained observers. Emerging tools such as drone surveys and AI-supported image analysis can further strengthen monitoring of breeding colonies.

2. Introduction

The Climate Resilience for Critical Sites for Migratory Birds and People along the East Atlantic Flyway (CREAF) project is a large-scale, multinational conservation initiative funded by the International Climate Initiative (IKI) of Germany. Project partners work with local communities, site managers, researchers, and policymakers along the Atlantic coast of Western Africa to improve wetland conservation for the benefit of migratory birds and local people. The project was initiated under the Wadden Sea Flyway Initiative (WSFI) and is coordinated by the Common Wadden Sea Secretariat (CWSS) in collaboration with the partners BirdLife International, Wetlands International, the Regional Partnership for Coastal and Marine Conservation in West Africa, BirdEyes, and eight additional national institutions and NGOs. Effective conservation and management of critical sites along the East Atlantic Flyway should be informed by a robust monitoring system that can serve both as an early warning mechanism and an evaluation tool. However, monitoring can only be effective when based on sound methodology and practical field protocols. To address this need, the project partners are developing the 'CREAF Monitoring Toolkit', which will provide clear, actionable guidance for site managers on organising and implementing effective monitoring schemes for coastal wetlands along the East Atlantic Flyway.

The purpose of the current document is to guide site managers and others who are in the process of establishing or expanding bird abundance monitoring schemes. It provides background information, technical advice on methodologies, and scientific references that underpin the practical advice in the Toolkit. Additionally, it identifies current gaps in knowledge and suggests areas for further development.

3. General Concepts and Definitions

3.1 WHY MONITORING?

Monitoring is the regular and systematic collection of information over time to understand what is happening, measure change, and guide decision-making. It is often referred to as a means to obtain 'early warning signals' or to 'take the pulse' of the health status of biodiversity. Baseline monitoring of biodiversity can signal problems in conservation of species and ecosystems. This kind of monitoring contributes most effectively to conservation if it is embedded in an adaptive management framework ('the management cycle). In this cycle, monitoring signals changes in populations which may trigger conservation concerns. These concerns are further assessed by identifying the underlying causes and potential solutions. This is followed by the implementation of concrete management measures to resolve the problem. To close the cycle, subsequent monitoring is required to evaluate whether the implemented measures have been effective.

3.2 WHY WATERBIRDS?

The term 'waterbirds' as used in this document includes, for Western Africa, all species from the bird families: ducks, geese, grebes, flamingos, rails and coot, cranes, storks, herons, pelicans, cormorants, waders, gulls and terns. Most species are relatively large and occur in open landscapes which makes them easy to quantify. They often congregate in discrete wetland sites which makes total population or site counts possible. Many species are relatively easy to identify in the field, which facilitates the collection of species-specific information. As they represent different ecological groups in terms of food and habitat preference and can react quickly to environmental changes, they are useful indicators of habitat extent and quality. Consequently, they play a pivotal role in international nature policies and agreements, often serving as the basis for selecting sites of international importance, for instance under the Ramsar Convention and the EU Natura 2000 Network.

3.3 WHAT IS A SITE AND SITE MONITORING?

The Ramsar convention defines wetland sites as "areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres" (Grimmett & Jones 1989). The Ramsar convention distinguishes Marine and Coastal Wetlands, Inland Wetlands, and Human-made Wetlands (e.g. fish and shrimp ponds, irrigated agricultural land, salt pans). Wetland sites function more or less as independent areas, providing all the necessary resources for the waterbirds that it supports in a specific period (Grimmett & Jones 1989). While many wetlands are easily distinguished from their surroundings, delineation for monitoring and management becomes more difficult when the wetland habitat is very large. Delineation is sometimes arbitrary, based on traditions, common usage, or legal frameworks. While the delineation of a wetland site is based on ecological principles, the legal boundaries of protected sites (as established under national legislation) can deviate from these. For management purposes, wetland sites can be subdivided into subsites or counting units to delineate different geographical parts or habitats, allowing waterbird distribution and habitat choice within a site, to be described. Counting units may also be defined for consistent counting and monitoring, by dividing larger wetland sites into units that can be feasibly counted by one observer in a single day or tidal period. The sum of the counts at all counting units gives the total count for the site.

When developing monitoring programmes for birds at specific sites, one of the first decisions to be made is when to count. Site managers are often interested in planning counts to cover the period when the maximum numbers of birds are present at the site. This is important as the (average) maximum number is used to assess the international importance of sites (Ramsar criteria). Conversely, sites are used by birds for several different ecological functions during the year (e.g. breeding, stop-overs during migration, non-breeding during northern winters or African dry

seasons.), which may require different conservation and management approaches. Given the diversity of species and populations visiting the site during the year, for different ecological functions, the choice of when and how frequently to count is not an easy one and often requires compromise.

Various methodologies can be used to monitor the abundance of birds. Monitoring of birds using a site can consist of ground counts, aerial surveys by plane or using a drone.

3.4 WHAT IS A FLYWAY AND FLYWAY MONITORING?

Most waterbirds are migratory, spending their breeding and non-breeding seasons in geographically distant locations. Individual birds use separate breeding sites, stop-over, and final non-breeding sites during their annual cycle, often displaying site fidelity, returning to the same locations year after year.

The individual birds form flyway populations: groups that share specific breeding, stop-over, and wintering regions. These populations are often morphologically, genetically, and/or ecologically distinct from other flyway populations of the same species, sometimes leading to their recognition as separate subspecies. In other cases, the distinction is defined primarily as a biogeographical population for management reasons and the relation between breeding area and non-breeding area is less clear.

The same breeding, stop-over and wintering regions are often used by flyway populations of multiple species and are then collectively called a flyway, like the East Atlantic Flyway. A flyway is the collective range of a (group of) migratory bird populations or species with (partially) overlapping migratory pathways, including all areas used during the annual cycle (Boere & Stroud 2006).

Flyway monitoring primarily aims to assess the size of avian flyway populations and track changes over time across all sites in the range of the flyway population. Population size estimates are used for assessing the 1% threshold (1% of the total flyway population size) which is an important criterion used to identify sites of international importance. Information about changes in flyway population sizes (trends) are used to identify populations in need of conservation in an international context and provide comparison information for the interpretation of site or national trends.

Flyway monitoring of waterbirds is carried out by simultaneous counts, taking place at a time when the population is concentrated in relatively few sites, with limited exchange between sites (which would lead to over- or underestimation), and preferably when the population is not mixed with other populations of the same species which cannot be separated in the field. In the East Atlantic Flyway, the simultaneous waterbird counts are taking place in January of each year.

3.5 NON-BREEDING WATERBIRDS, BREEDING WATERBIRDS AND OTHER METHODS OF MONITORING

Sites are used by different groups of waterbirds which have different requirements. An important distinction is between breeding bird populations and non-breeding bird populations.

In addition to abundance monitoring, several other methods of monitoring important for waterbirds and site management exists. It ranges from the inclusion of monitoring of vital rates (reproduction and survival), monitoring of individual tracked birds by studying within sites and between sites distribution and habitat choice (Henriques et al. 2024)) and the monitoring of environmental factors. These different methods of monitoring can be integrated (see figure 1) to better monitor changes in population size and indicate the proximate causes of the population change. Incorporating reproduction and survival into monitoring programmes can improve their early warning function (Furness & Greenwood 2013, Newton 1998, van der Jeugd et al. 2014). The monitoring of environmental factors, including habitat availability, food supply, and human pressures (Piersma 2012, van Roomen et al. 2013) helps to understand the changes in numbers.

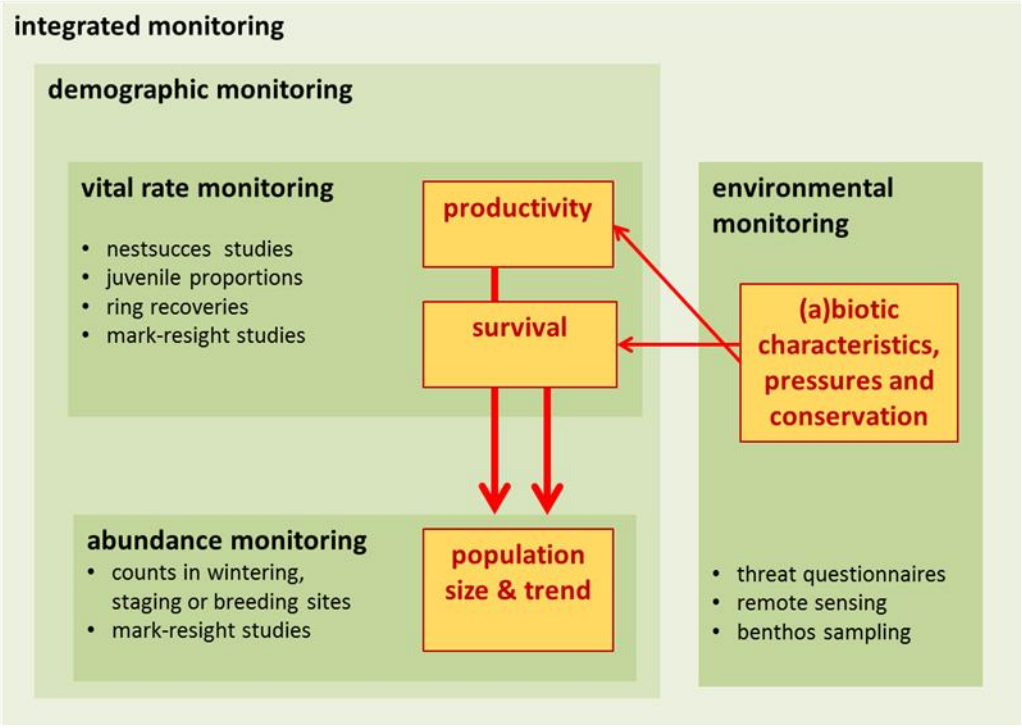


Figure 1. Model of integrated monitoring of waterbirds involving abundance monitoring, vital rate monitoring and environmental monitoring (from van Roomen et al. 2013).

4. Abundance Monitoring of Non-Breeding Waterbirds at Sites

Changes in local bird numbers can be a warning signal of potential environmental changes at the site. Analysing bird numbers in relation to environmental changes is important for advising on conservation, sustainable use and management measures. Furthermore, abundance monitoring results at sites can be evaluated in the context of flyway monitoring results (flyway population size and trends), and this may indicate whether changes are caused locally or a result of drivers operating at a regional or global scale. The January count is the basis of site monitoring as it is also caried internationally, but it is only a starting point. Sites may be visited in other months of the year by even larger numbers of birds, birds from other populations or for different ecological functions (such as breeding (see chapter 4), moulting or pre-migratory fattening), which are all aspects of site use of interest to monitor in view of site conservation and management.

Site monitoring data of non-breeding birds can contribute to answering the following policy and management questions:

- For which species and populations do we have an important responsibility as site managers? Which waterbird species occur in nationally or internationally important numbers? How important is the site at the flyway scale? Is this importance changing over the years?
- At what time of the year is the site important for birds - year-round or at key moments in their annual cycles? Is this seasonal pattern changing over time?
- Are there consistent changes in numbers of birds present at my site? Do these changes indicate a local conservation or management problem, e.g. because similar changes do not occur at other sites in the region or elsewhere in the flyway, and/or they seem linked to certain environmental changes occurring at the site (which may have been identified by an environmental monitoring program)?
- Can we decide if it is related to local site conditions or related to more global changes (site abundance monitoring combining with flyway abundance monitoring)? Can we find correlations/hypotheses with local site conditions (site abundance monitoring with environmental monitoring)? On this basis, can management measures be proposed, to improve the situation?
- Are local management measures helping to improve the situation for the species (e.g. do we see an increase in numbers)? If a negative trend was caused by local conditions and measures taken are improving the local conditions (increase in extent and/or quality of habitat) than positive changes in numbers can be expected. Key resources (guidelines, manuals, protocols)
- General international guidance for how to do a site count to assess abundance of non-breeding birds can be found in Bibby 2000, Gregory et al. 2004, Delany 2005, Wetlands International 2018, Hearn et al. 2018, van Roomen et al. 2014, see Annex 1.
- The course ‘Identifier et dénombrer les oiseaux d'eau d'Afrique du Nord et du Sahel: Comment et dans quels buts?’at MOOC-Conservation, produced by the RESSOURCE project (Binard et al

2025), is an online course which provides guidance on monitoring principles and practical training for species identification and counting of groups of birds (see Annex 1).

- More specific guidance about when to count a site during a year can be found in Crowe et al. 2022, and how frequently to count in Atkinson et al 2006. See also Underhill & Prys Jones 1994 and Farmer & Durbian 2006 about the importance of multiple counts in a year.

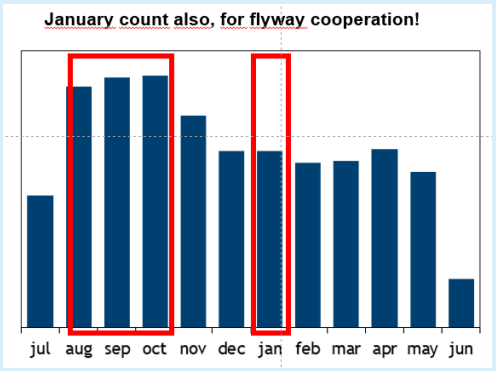
General principles and best practices:

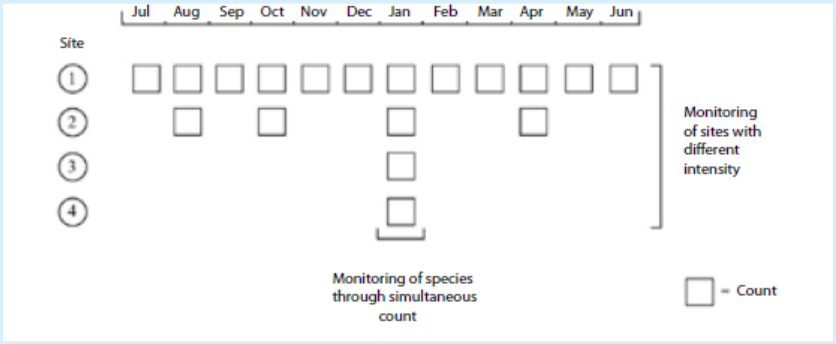
- The January count is an essential part of site monitoring as it contributes to the monitoring of population size and trends at the flyway level. Conversely, the flyway-scale results also benefit the interpretation of site monitoring results. The January count should therefore always be part of the site monitoring regardless of whether it coincides with the time of peak bird abundance at your site.
- More counts per year are useful, and sometimes essential, to cover months when species are present in high numbers, thus increasing the accuracy of the local abundance estimates, or to monitor specific functions of the site to birds (e.g. premigratory staging, site use during dry or wet periods in the region), see Box 1.
- The choice of when to execute extra counts should be based on the seasonal occurrence of waterbirds visiting the site. If the site is primarily a non-breeding site for northern migrants with peak occurrences in November-February, one extra count in this time period in addition to the January count may suffice. If the site is important during migration (March-May and/or August – November) at least one count in each of these periods should be planned. If the site is also important for (wing) moulting waterbirds or for intra-African migrants an extra count in the period of their peak abundance is called for (often in the period June-August, but this can differ between sites).
- As species and populations have different seasonal migration patterns and sites can have different functions for waterbirds throughout the year, it is difficult to pinpoint specific months which will be enough to monitor to fulfil all monitoring aims. To overcome this problem, site managers could decide to count one or more counting units more frequently. An initial scheme with monthly or bi-monthly counts at a selection of the site may also be appropriate when monitoring is started at a site where information on local seasonal abundance patterns is lacking. Once this information has been collated, a long-term monitoring program can be focused on the most important seasons/months.
- When sites are large, i.e. when counts cannot be completed by one observer or team in 3-5 hours or in a single high- or low-tide period) they need to be subdivided in ‘counting units’ that can be covered in such a time period. This facilitates a complete and systematic coverage, through simultaneous counts by several teams or (if simultaneous coverage is not possible) by counting over several consecutive days/tides. Counting units also contributes to the collection of information about the distribution of bird species within the site, see Box 2.

- Depending on the site and species present, the methodology of the counts is most often a total count of all waterbirds present within the counting unit (either roosting or foraging in flocks or occurring more dispersed). Overflying birds are usually not counted, based on the expectation that they will be counted by others when settling in neighbouring counting units.
- Inland sites can best be counted between one hour after sunrise and one hour before the end of the day to prevent double counts of birds moving between neighbouring counting units when traveling between night-time roosting sites and feeding grounds. Counting in the morning is usually more favourable because harsh sunlight and heat shimmer are more often a problem after noon. However, if the focus is on night roosts, which in themselves are an important functional element of sites, the counts should take place in the period from one to two hours before dark until dark in the evening or from dark until one or two hours after dark in the morning.
- At coastal sites counts should be timed in relation to the tide. In sites where the birds roost in open landscapes during high tide, counts should mostly take place in the period from two hours before high tide to two hours after high tide. In coastal tidal areas fringed by mangroves, the counts should take place around low tide as counting birds roosting in mangrove is very difficult and can easily lead to important numbers being missed.
- To guarantee consistency of surveys between months and across the years the development and use of a site-specific count protocol is recommended, especially when different observers are involved. Such a count protocol should give details about the whole site and counting units, detailing routes taken through the counting units, observation points used, the number of counters needed, if counting is done by foot or by car or boat, time needed, and so on.
- Training and capacity building of field observers and programme coordinators (including analyses and reporting) are essential for high-quality monitoring results (Dodman 2025). Separate field training should be organised for inexperienced observers. Counts should be led by experienced counters, with opportunities for less experienced observers to learn alongside them. Bird identification and counting skills cannot be developed through a single annual activity; regular practice at frequently monitored sites is necessary. Motivation also matters—observers should enjoy fieldwork, be interested in identifying all species present, and care about the results. High motivation is a key driver of good monitoring outcomes.

Box 1: Which Month to Count

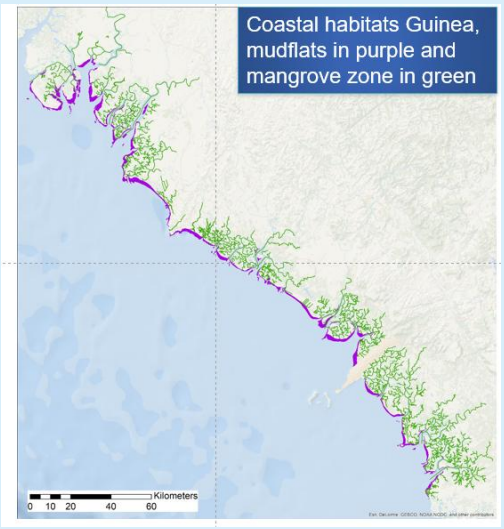
For counts of non-breeding waterbirds, choose at least January as a month to count in, as all sites in the flyway are counted in this month. Secondly, based on knowledge about the seasonal patterns of species at regular counted sites in the same region, one or two additional counting months can be chosen, particularly at moments when a selection of species reaches higher maxima than in January. The result of this strategy is that wetland sites are always counted in January and that based on local needs and possibilities site specific additional counts are carried out in other months.

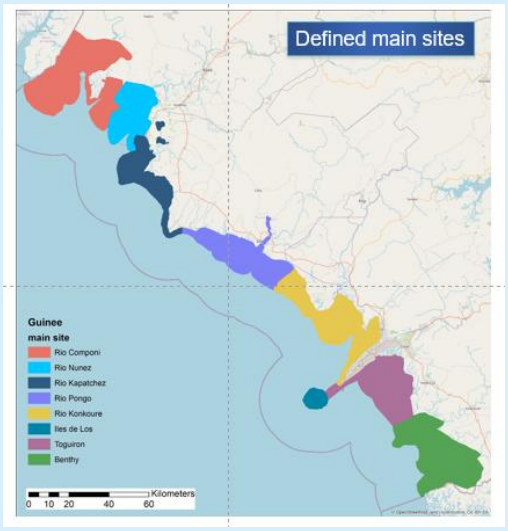


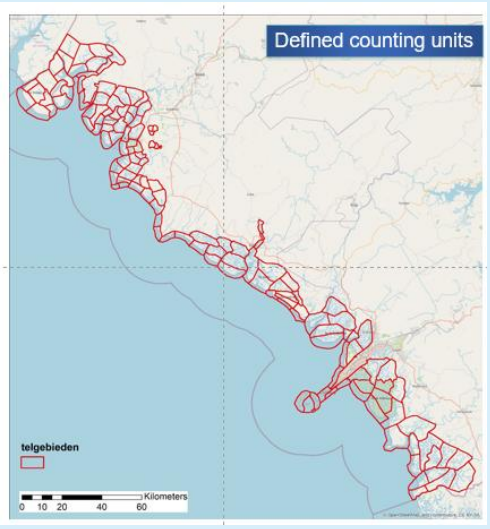


Box 2. Main Sites and Counting Units

The coast of Guinee consists of river estuaries and other coastal wetland types. Mudflats and mangroves are important habitat types for waterbirds. To make coastal counts and estimation of total number of birds feasible, the whole coastline was first divided into main sites based on the different river systems. Second, each main site was subdivided into counting units, that were each given a unique code.







General issues in abundance monitoring of non-breeding waterbirds:

- There is limited scientific evidence on how count frequency affects the accuracy of seasonal maxima and averages, making it difficult to define accurate counting schedules. Developing general rules of thumb is also challenging as these relationships likely vary by species visiting the site, where the site is and site function (e.g., stopover site, breeding site, wintering or moulting). Similarly, it remains unclear to what extent site importance is underestimated when based solely on a January count.

- For site monitoring, there is always the difficulty of interpreting the number present at a site at one moment, which can be assessed during a count, and the accumulated number of individual birds using the site at any point in time, which depends on length of stay and turnover. Case studies are available based on studying colour marked birds, but it is difficult to extent these results to general monitoring programmes (Loonstra et al. 2016).
- Counting errors are common (Rappoldt et al 1985). More field tests are needed to understand whether drone counts or double counting approaches can reduce these errors. In addition, studies are needed to assess the statistical power of monitoring designs as counting errors will always exist (Reneerkens et al. 2024).

5. Abundance Monitoring of Colony-Breeding Waterbirds

Flyway monitoring focuses on estimating population sizes and trends. The most effective approach is to conduct counts when populations are concentrated at a limited number of sites that can be surveyed relatively easily, with counts synchronised across countries to reduce errors from bird movements. For many species, this occurs during the January non-breeding count. For other populations, particularly those that concentrate during the breeding season in large colonies, breeding counts provide a better opportunity for coordinated monitoring. Colony breeding species are also very important for the monitoring of sites itself as they represent important natural values of a site. Therefore, site managers should aim to count and monitor all colonially breeding waterbird species at their sites. Here, we concentrate on the methodology and guidance for counts and monitoring of colony- breeding species.

Policy and Management Questions:

- Monitoring of breeding birds at sites contributes to answering the same types of questions as listed above for monitoring of non-breeding birds".
- Monitoring at breeding sites also enables the collection of data on breeding productivity through repeated visits and recording of the fate of nests and/or estimating numbers of young fledged). This provides insight into the local environment (e.g. food availability, predator and disturbance pressures) and can offer early warning signs of demographic problems, as declines in breeding success of long-lived species may take time to become apparent.

Key Sources (Guidelines, Manuals, Protocols):

- Veen et al. 2025 gives detailed information about simultaneous counts of colony breeding gulls and terns in West Africa and the methodological considerations and pitfalls. See also Veen et al. 2022, Folmer 2023.
- A practical guide and protocol for performing counts at breeding colonies in West Africa is from Veen & Mullié 2015. However, the newest methodologies to survey with drones is not covered in that one.

- Information about the use of drones to monitor colony breeding waterbirds in a flyway context can be found in Holm et al. 2024.
- In Duijns et al. 2025 & Kellenberger et al 2021 an automated system is described for assessing numbers of breeding pairs at colonies at sites and across sites with drones, machine learning software and an online uploading system, see Box 3.

General Principles and Best Practices:

- Decide which species are targeted for the simultaneous count and which sites/colonies need to be counted for a total population estimate. Until now, only terns and gulls have been included in a flyway wide survey in West Africa. Here, also White-breasted Cormorant and White Pelican seem good candidates for inclusion. Some rare species like local populations of Common Tern, Little Tern, Cape Gull, Damara Tern, Grey Heron subspecies monica and Eurasian Spoonbill of the subspecies balsaci can also be considered.
- At site level, all waterbird species having breeding colonies at that site should in principle be targeted for counts and monitoring as they are important site values and contribute new knowledge besides the known non-breeding waterbird numbers.
- Select a time window—typically when the maximum number of nests are in the incubation stage—to avoid double-counting in flyway-wide surveys. This is not always straightforward, as breeding timing varies between species and across sites and countries, while surveys are often most efficient when multiple species are covered simultaneously. Managers may also prefer to count when peak numbers occur locally, complicating agreement on shared survey dates. Synchronised counts are particularly important where birds may relocate and renest after failed breeding attempts, as seen in several tern species.
- Various methods exist for counting breeding pairs or nests in breeding colonies, e.g. counts of (occupied) nests on the ground or from the air (drone imagery), or counts of breeding adults present made from a distance. Counting the number of adults present or counting the number of occupied nests by walking through the colony have long been the most used methods but are gradually being replaced by drone surveys at many sites (Veen & Mullie 2015. Veen et al 2022, Folmer 2023.
- Today, counting by drones is the preferred method where possible, as this yields the greatest accuracy and minimal disturbance in many species. However, a drone and trained pilot are not always available. Drone counts also require a prepared flight plan and system to combine and interpret the footage obtained (See Box 3).
- If adult birds are counted from a distance, it is important to record whether these involved (1) only incubating adults or pairs present on nests or (2) the total number of adults present in the colony. In case of (2), a correction factor will often be needed to convert the number counted to breeding pairs or nests, as non-incubating (resting) partners are often present at/near a proportion of the nests (and in some species some clutches or broods may be left alone by both

parents). Such a correction factor must be obtained (estimated) by comparing distance counts to complete nest counts made at or around the same time. Once obtained the ratio of adults to nests present can then be applied to distance counts at other times (years), but beware that this ratio is likely to vary with local circumstances and over time, so take care to schedule counts in different years at the same stage of the breeding season (Koffijberg et al. 2011).

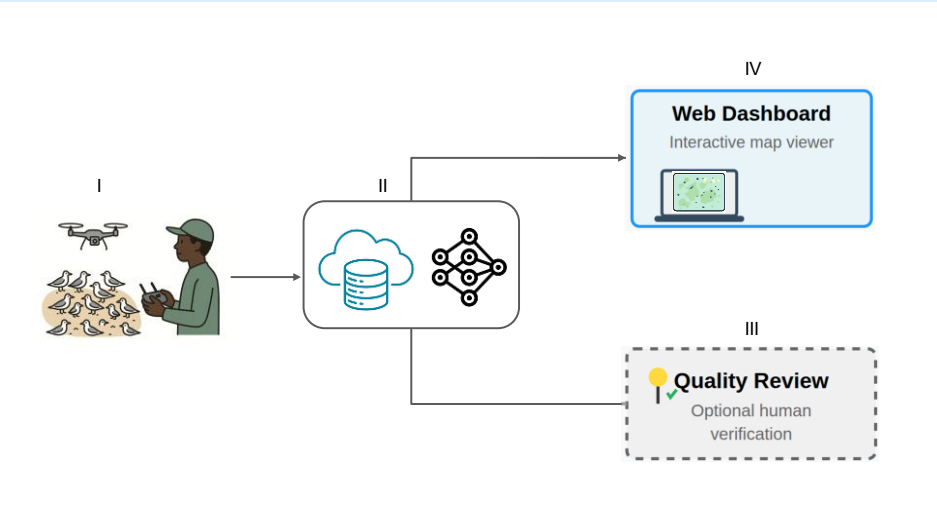
- When counting nests on foot, key challenges are avoiding double-counting and minimising disturbance. Exposed eggs can quickly overheat, and disturbance may increase predation risk. Working in teams improves speed and coverage; progressing in a coordinated front line helps ensure full coverage, with communication between observers to avoid duplication. Marking counted nests (e.g. with a matchstick) can also help. In (sub)tropical regions, avoid surveys during the hottest part of the day.

Box 3: Coastal Breeding Bird Monitoring Workflow Using Drones and AI

Eelke O. Folmer[1] & Sjoerd Duijns[2], [1]Lumax, [2]Sovon Dutch Centre for Field Ornithology

The system transforms drone imagery into reliable data for monitoring breeding bird colonies. It begins in the field (I), where drones capture large sets of overlapping aerial photographs over nesting areas. These images are uploaded to secure cloud storage (II), forming the basis of an automated pipeline. Once the data is secured and uploaded in the cloud, specialised software stitches the individual photos together by photogrammetry, creating a single, detailed map (orthomosaic) of the entire colony site. This map is georeferenced, meaning every pixel has precise geographic coordinates. As these maps are very large, they are automatically divided into smaller files that our machine learning model can process efficiently, but the system also requires large data storage space.

The machine learning model, trained to recognise breeding terns and gulls in aerial imagery, automatically analyses the data and generates bounding boxes around individual birds and nests. These detections, along with their geographic coordinates, are stored in a database. At stage (III), researchers may review and refine the automated detections using annotation software, although the system can work entirely automatically. All results are visualised in an interactive web dashboard (IV) where users can explore the orthomosaic, view detected birds, and analyse colony distribution patterns. The entire pipeline from image upload from the drone to final visualisation runs automatically, allowing researchers to focus on interpreting results and enables efficient monitoring of large breeding colonies.



Further reading:

Duijns, S., P. Manche, J. van Kessel, & E. O. Folmer. 2025. Detectie van vogelgriep met de inzet van drones en machine learning in de Waddenzee, resultaten van een pilot studie. 2025/36, Sovon Vogelonderzoek Nederland, Nijmegen.

Kellenberger, B., T. Veen, E. Folmer, and D. Tuia. 2021. 21 000 birds in 4.5 h: efficient large-scale seabird detection with machine learning. Remote Sensing in Ecology and Conservation 7:445-460.

6. Abundance Monitoring of Non-Breeding Waterbirds at CREAF Key Sites

6.1. BANC D'ARGUIN, MAURITANIA

Counting non-breeding waterbirds in tidal areas is usually done during high tide when waterbirds are driven from their foraging areas and concentrate on so called high-tide roosts. This has two advantages: 1) they concentrate in smaller areas which makes it easier to count and assess total numbers and 2) during roosting they sort more or less species by species. This situation works best in large open tidal areas where the roosts are positioned on bare sandbanks, beaches, sebkahs, saltmarshes and agriculture fields. These types of tidal areas are mostly present in Europe, northern and southern Africa.

The CREAF key site Banc d'Arguin in Mauritania is a good example of such a tidal site in an open landscape.

A relatively well-developed count routine for total counts at the Banc d'Arguin has been established based on experiences over the past 45 years. During this period, 12 total counts have been carried

out. Descriptions of the methodology can be found in Altenburg et al 1982, Zwarts et al 1998, Hagemeijer et al 2004, Oudman et al 2020, Kidé 2020.

Important Components:

- A good site map and consolidated count units (see figure 2). This may be in paper or digital form, using the Locus Map application on mobile phones for better navigation.
- A responsible authority that oversees the organisation and coordination of the count, which is taken care of by PNBA.
- A total count of the whole site takes 9-10 days with 18-20 counters.
- Each day involves counting a combination of counting units close to each other and having often exchange in roosting bird numbers between days. By performing counts of such combinations of counting units on the same day prevent double or under-counting.
- The planning of the counts is carefully scheduled in relation to the time and height of the tide. The count period of 9-10 days is done at 'spring tide" periods, mostly in a period of full moon as tides are mostly higher than at new moon periods. Periods of neap tides are avoided.
- The PNBA involves good counters from the PNBA itself but also from other national parks and NGOs within the country. However, while capacity from within the country is increasing, not enough good counters are present to do a total count. By inviting 6-8 expert counters from abroad the quality of a total count is improved.
- Before the counting period a planning workshop is held with all involved in the fieldwork to discuss the details of the count period, results of last counts and some extra points to take care of in identification and assessing of numbers.
- Besides briefing the counters itself also briefing the drivers of the 4WD cars and boat captains are important for planning and safety. In total 3-4 boats and 4-6 cars are needed for the counts.
- During the counts each evening the results of the day are summarised and consolidated and the plan for the next day are discussed in detail.
- Results of the counts are entered in a database each day by an officer of PNBA. Results entered are checked and after the count a comprehensive site report is produced.

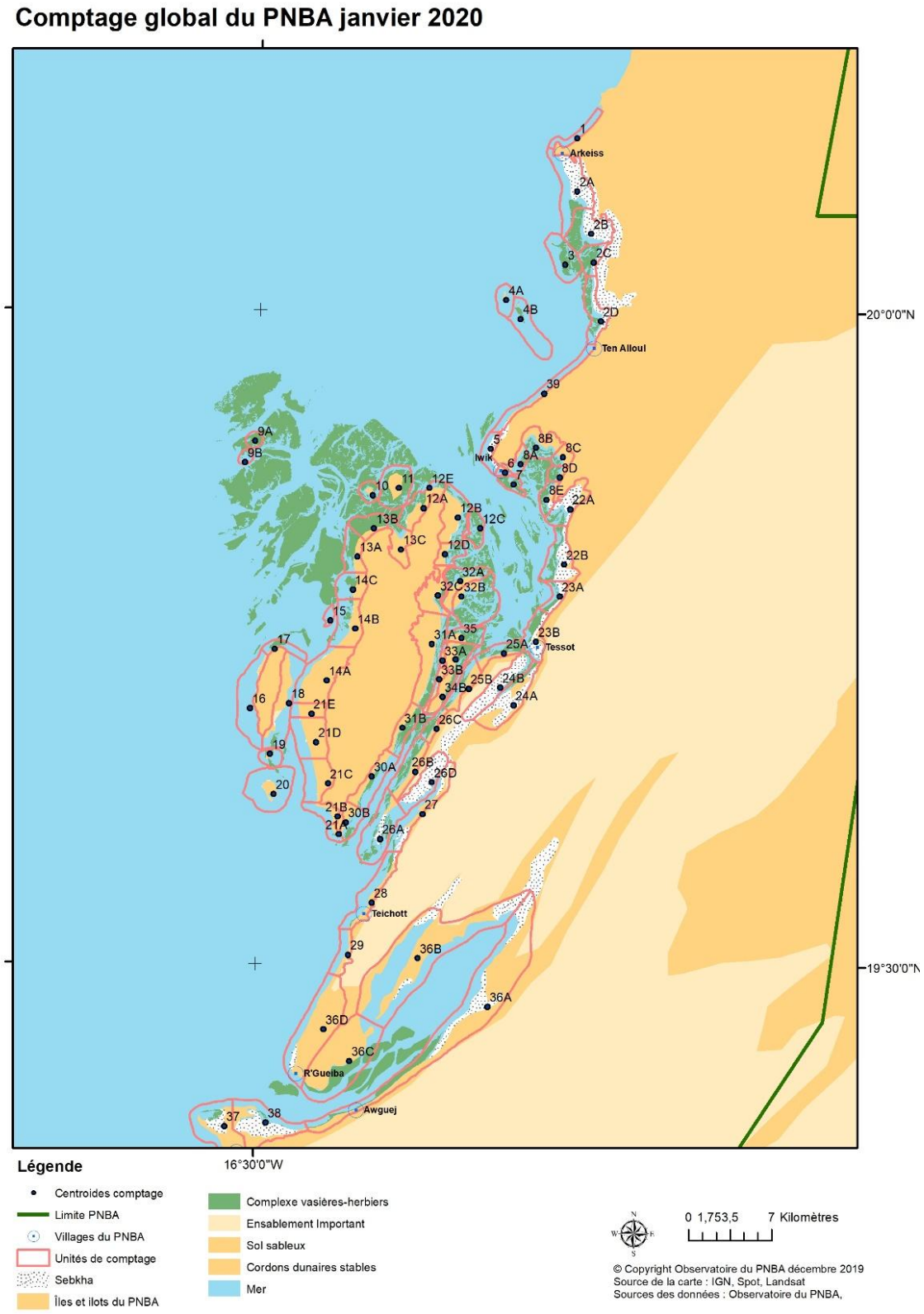


Figure 2 The Banc d'Arguin with its counting units for non-breeding waterbirds.

6.2. DELTA DU SALOUM, SENEGAL

The CREAF key site Delta du Saloum in Senegal is a complex wetland site with marine, estuarine and more inland wetland habitats. It has a long tradition of waterbird counts but overall

coordination for a total count of the whole Delta happens less intensively. This is partly because the delta consists of several independent protected areas authorities, with a stronger focus on the separate protected areas than on the site as a whole. In addition, a complete map with counting units covering the whole Delta is lacking.

Some parts of the Delta are surveyed more intensively than others, while some parts are not covered at all. The best available reference for conducting a total count and defining the necessary coverage of the entire Delta is Schepers et al 1998. In December 2025, a workshop was organised by Wetlands International and DPN to discuss the current status of the waterbird counts of non-breeding waterbirds in the Delta and recommend improvements.

Important Points for Improvement:

- The use of a consolidated map with all counting units. During the workshop, such a map was created on the basis of existing knowledge of older existing count units (see Figure 3). For parts of the Delta without counting units, new provisional units were created by using Schepers et al 1998. Each counting unit has been given a unique code. These are based on the older existing codes for the selection of units already in use in the past and new provisional codes for the new units. When this new units are going to be counted a more official code will be provided.
- Improving the coverage of the Delta by different groups of counters. Besides the counting units also the zones of each protected area and especially the zones where different groups of counters are operating were better defined (Figure 3). This in such a way that all counting units have been distributed over the different zones. Some of these zones are probably be done by the same group of observers. Other zones require an increased local counting effort.
- It will be best if each zone will get a focal point for local organisation and that that person will also be involved in Delta wide preparations and discussions about the counts. Secondly an overall authority and person should be leading the Delta wide counts and analysing the results.
- It will be important to test this system of counting units and coordination during upcoming counts (January 2026 and 2027), and to provide additional training in field identification and counting skills, as many of the most experienced counters have retired and a new generation needs to be trained.
- It is important that past and future count data are analysed and reported, and that outputs such as distribution maps, trend analyses, and interpretations of population changes are produced to support management.

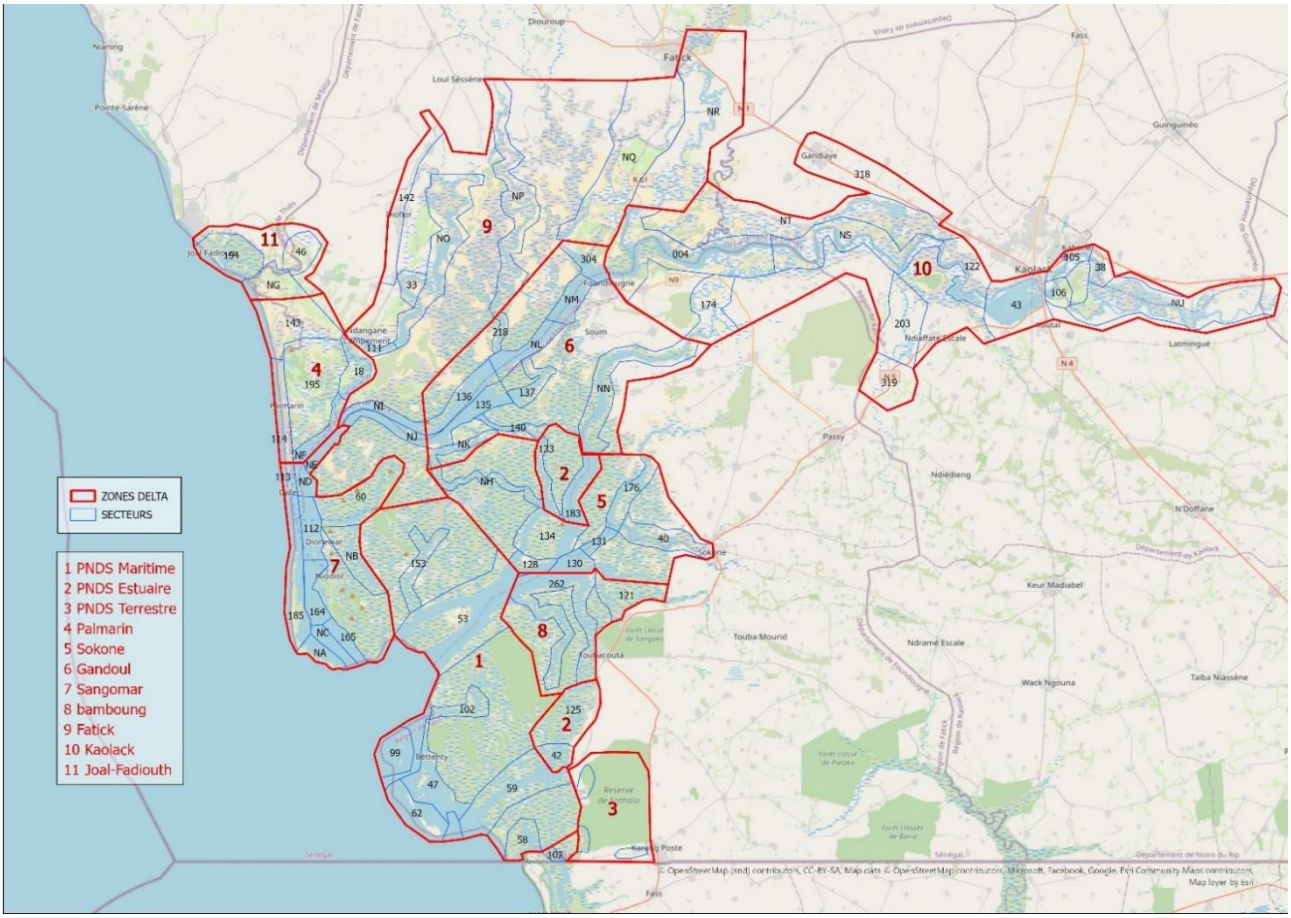


Figure 3. The Delta Saloum with counting units (in blue) and zones of different groups of counters (in red). This is a result of a workshop facilitated by Wetlands International and DPN during December 2025.

6.3. BIJAGÓS ARCHIPELAGO, GUINEA BISSAU

The CREAF key side Bijagós Archipelago in Guinea Bissau is a difficult site for total counts for several reasons. The tidal flats are for a large part bordered by extensive mangrove areas which are used by waterbirds during high tide. They roost in the trees or in open spaces within the forest. Consequently, most waterbirds in these mangrove areas are either not visible or only partly so during high tide. The advised method for this kind of mangrove-fringed estuarine areas is counting during low tide (Zwarts 1988). When the tidal area is not extensive, more or less total counts can be done during low tide. Sites like the Bijagós Archipelago, where the tidal areas cover hundreds of km2, cannot be surveyed completely by low water counts in a short period. The method mostly used for these sites is performing counts in samples of the available foraging habitat during low tide (Figure 4) and extrapolating the obtained densities (number of birds/ha) to an estimate of total numbers, by multiplying with the total surface (ha) of foraging habitat available (Zwarts 1988). However, this way of surveying and applying it is prone to various types of errors (related e.g. to number and representativity of the sampled areas, stratification with respect to habitat types, and estimating the total habitat surface), which must be carefully assessed per site to determine best practice guidelines.

Key sources for abundance monitoring at Bijagós are Zwarts 1988, Henriques et al 2023 and van Roomen et al 2021.

Present Problems and Possible Ways of Improvement:

- Sampling of foraging habitat introduces several sources of error related to position and size of the samples, the number and distribution of the samples, how representative the sample is for the entire area, the accuracy by which the surface area of the sample can be estimated and the number per species counted. A much better understanding is needed of the relationship between the number of samples, their spatial distribution, the total area counted, variation in habitat (Figure 5) and the resulting errors or deviations from the true population estimates, in order to advise on the best monitoring method for Bijagós.
- Estimating the total surface area of habitat across Bijagós is fundamental to these calculations but can be done with different methods with different accuracy. A study is needed to determine which method should be used and which surface of the intertidal mudflats of Bijagós should be used, both for now and for earlier total counts in the past.
- It would be valuable to investigate whether counting complete or sample areas during low tide with drones is feasible (with respect to logistics, disturbance, and species recognition) and whether this can improve the accuracy of site estimates (e.g. by enabling to count more sample-sites or with greater precision of either bird numbers or area surveyed) relative to counts made on the ground.

Figure 4. Position of counted plots within counted units counted in 2020 at Bijagos during low water to estimate densities of waders to be used for extrapolations for estimation of total numbers present.

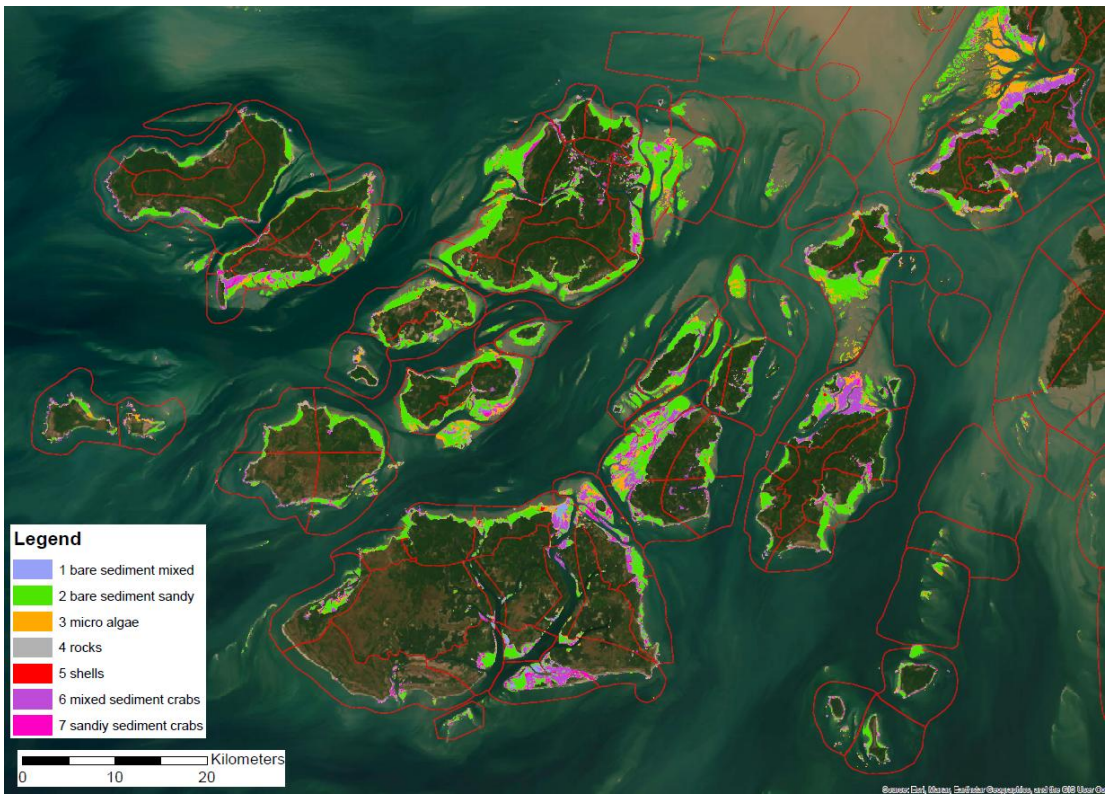


Figure 5. Different intertidal habitat types at Archipelago Bijagós (from Henriques et al. 2022) and the position of counting units.

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