

MIGRALION | 2021 - 2025

A large-scale research programme on the flying fauna of the Gulf of Lion (Mediterranean sea, France)

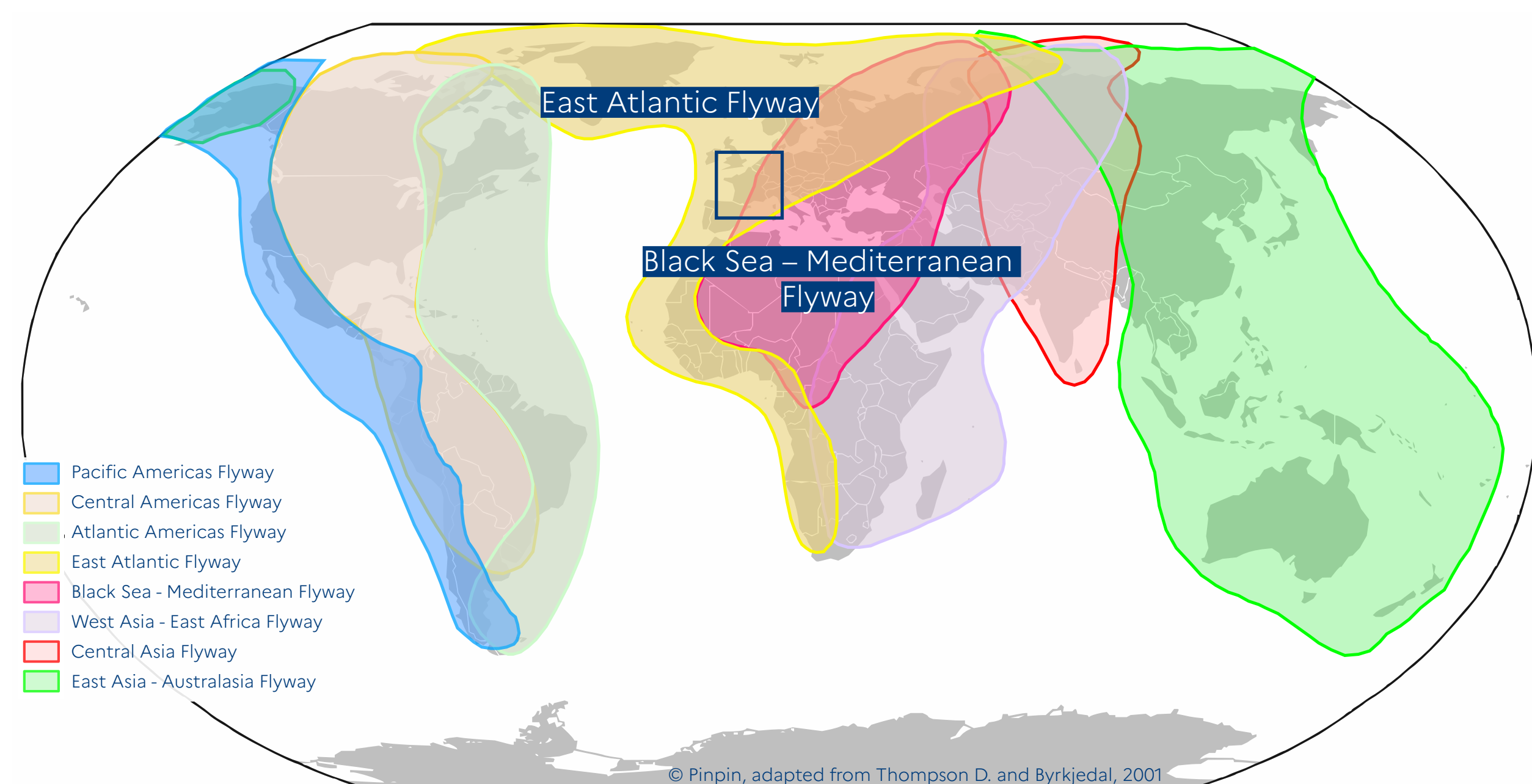
Contributors to the programme: PLANQUE Yann^{1*}, AUDIFFREN Constance^{2*}, ASSALI Camille³, BESNARD Aurélien⁵, BON Cécile¹, CANONNE Coline^{1,5}, CAT Victor⁵, CHAMPAGNON Jocelyn⁴, CHATEAUGIRON Théo⁴, COURBIN Nicolas⁵, DAÏDE Cyprien², DEFANCESCHI Christophe⁵, DELELIS Nicolas², DE GRISSAC Sophie⁶, DELCOURT Vincent², DENOVAL Léo⁵, DRAGONNET Thomas⁴, DUFOUR Paul^{4,5}, DURIEZ Olivier⁵, FRETIN Marie⁴, GAILLY Virginie⁴, GREMILLET David⁵, HERMELOUP Coralie⁴, HERROUIN Guy⁷, JEANNIN Bastien⁴, JIGUET Frédéric⁶, LAURET Valentin^{1,5}, LECORPS Florian³, LIEBAULT Vincent³, PREVOT Jehanne³, QUEROUE Maud⁵, REY Fanny⁴, ROQUES Sébastien⁵, ROUSSEAU Ronan¹, SAEZ Jade⁷, SCHMID Baptiste⁸, SCHROLL Louis⁵, TILLO Stéphan⁴

¹ France Energies Marines, Brest, France | ² Office Français de la Biodiversité (OFB), Brest, France | ³ Biotope, Mèze, France | ⁴ Tour du Valat, research institute for the conservation of Mediterranean wetlands, Arles, France | ⁵ Centre d'Ecologie Fonctionnelle et Evolutive (CEFE - CNRS), Montpellier, France | ⁶ Muséum national d'Histoire Naturelle (MNHN-CESCO), Paris, France | ⁷ Pôle Mer Méditerranée, Toulouse, France | ⁸ Vogelwarte, Station ornithologique Suisse, Sempach, Suisse

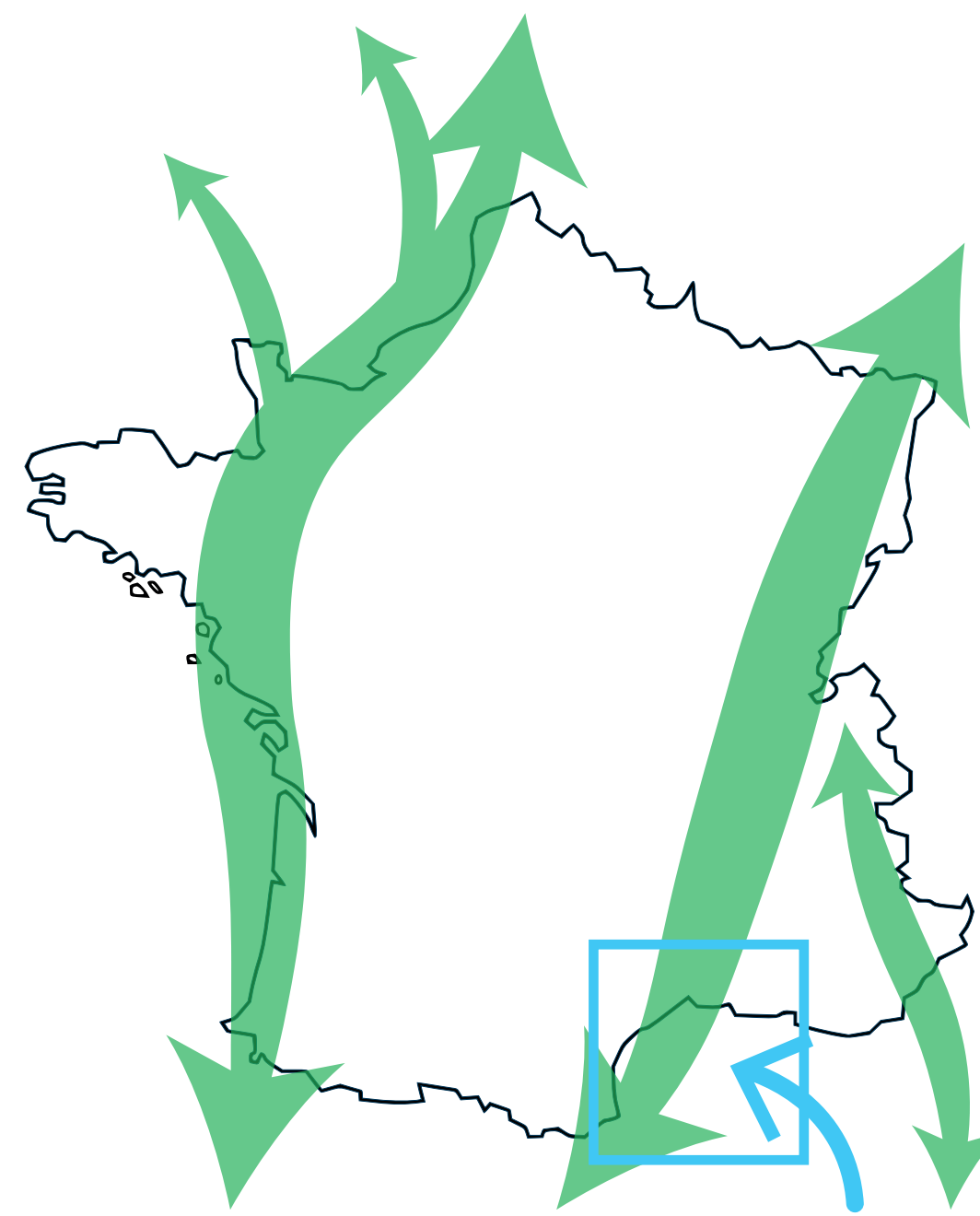
*Contacts : yann.planque@france-energies-marines.org (project coordination), constance.audiffren@ofb.gouv.fr (project management)

Avifauna at sea in the Gulf of Lion, Mediterranean Sea, France

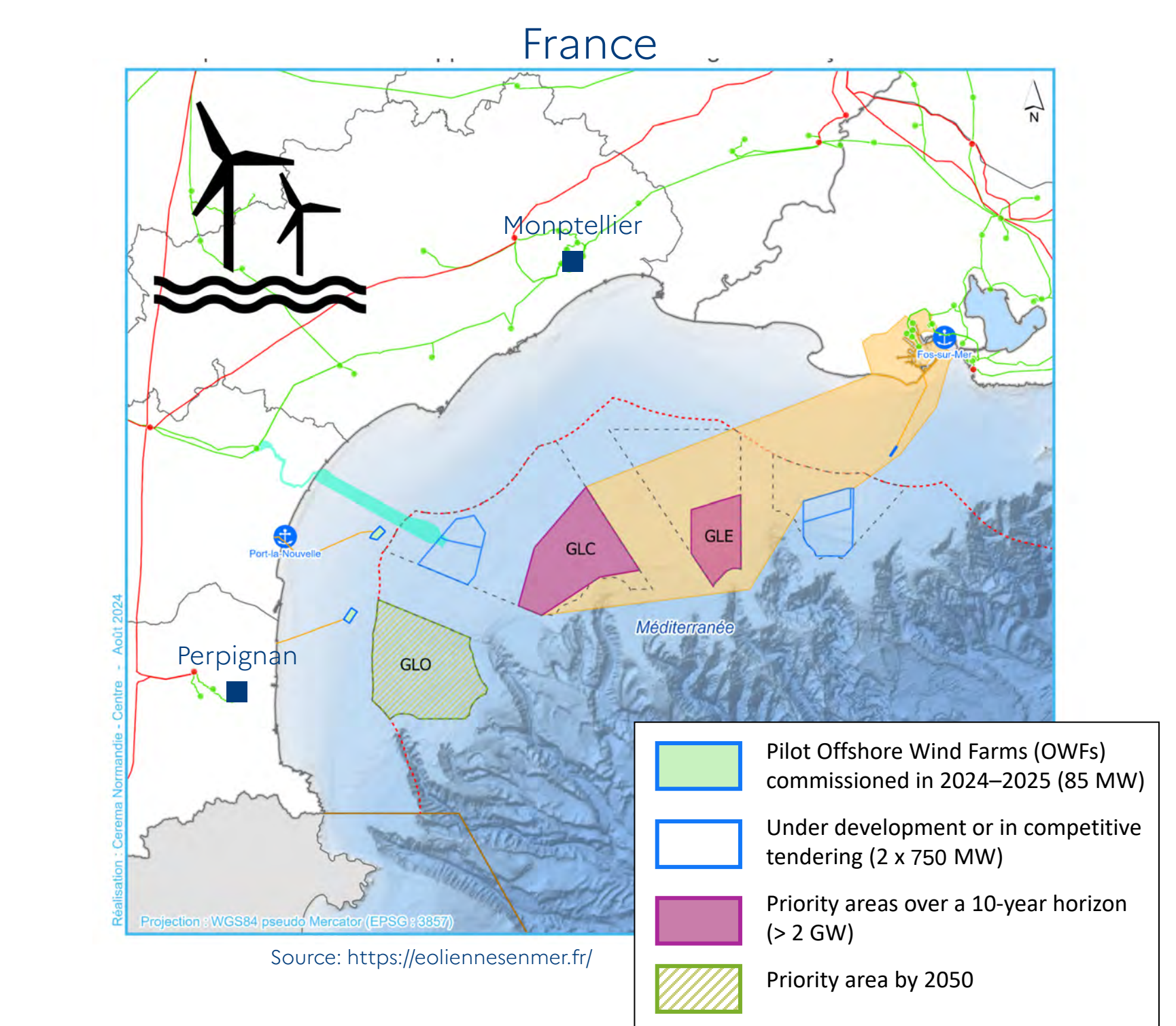
France is a **crossing point** of two major migration routes for avifauna



The **Gulf of Lion** (Mediterranean Sea) holds **major importance** for avian migration



Floating **offshore wind farms** are set to be developed over the coming years



Avifauna can be impacted by offshore wind energy (collision, habitat modification, barrier effect...) But **high knowledge gaps** on the use of the Gulf of Lion by avifauna...

An unprecedented data collection effort to fulfill knowledge gaps

MIGRALION'S OBJECTIVE | Budget: €4.2M

To **provide new knowledge to help in assessing the impact of human activities**—particularly offshore wind energy—on the flying fauna that use this maritime area

- Which parts of the Gulf are used by seabirds?
- Which migratory species cross it?
- What are the patterns of migratory flows over the sea, and when do they occur?
- At which altitudes do these species fly?

SEABIRDS
Year-round presence at sea.

TERRESTRIAL MIGRATORY BIRDS
Occasional passages at sea during migration

3 consecutive years of data from complementary surveys

Poster 2

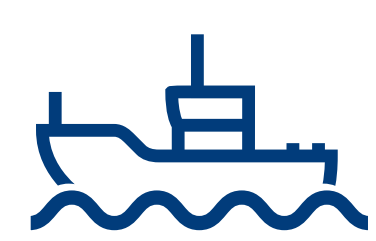
Telemetry tracking



GPS tags (large birds)
+ 500 individuals
21 species



GLS tags (small birds)
+ 300 individuals
19 species



Poster 3

At-sea surveys by boat



Visual observations
Number of bird individuals per species, distribution



Onboard radars
Bird density, altitudes, flight directions



Acoustic monitoring
Detection of birds & bats



Poster 4

Coastal bird radar

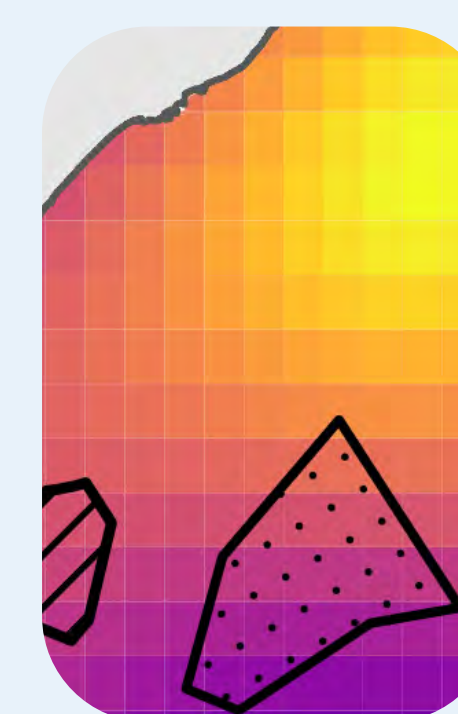


- Fixed radar (one site)
- Mobile radar (multiple sites)
- BirdScan type

Innovative modelling

Poster 5

Combined analysis of data



- Seabird **relative spatial usage**, weighted by vulnerability to offshore wind farms
- **Preferred flyways** of large terrestrial migratory birds at sea
- **Flight altitude** distributions of large terrestrial migratory birds

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Telemetry tracking

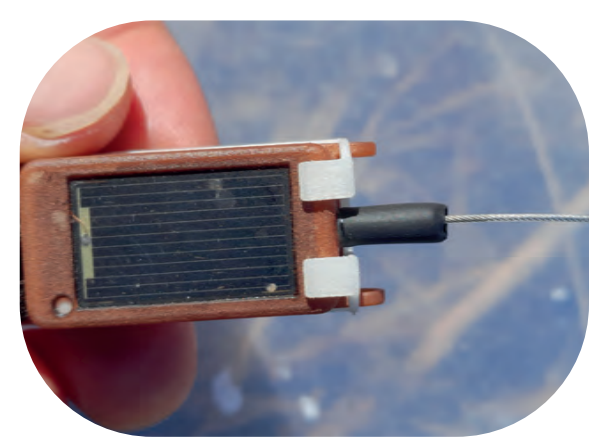


Contributors to the WP3 Telemetry tracking: CHAMPAGNON Jocelyn, COURBIN Nicolas, DUFOUR Paul, TILLO Stéphan, DENOVAL Léo, GRÉMILLET David, JIGUET Frédéric, DURIEZ Olivier
Contacts: champagnon@tourduvalat.org (WP3 coordinator), yann.planque@france-energies-marines.org (project coordination), constance.audiffren@ofb.gouv.fr (project management)

Objectives

- Acquire tracking data on seabird and terrestrial migratory bird species identified as being of conservation concern
- SEABIRDS:** Identify the maritime areas used for foraging and resting both during the breeding and wintering seasons, as well as their flight altitudes.
- TERRESTRIAL MIGRATORY BIRDS:** Determine the migratory routes and migration timing, as well as flight altitudes, during movements to and from the Gulf of Lion coastline.

Methodologies



GPS tags

Tags from 3 g to 25 g (for birds from at least 75 g)
 Data transmitted via the mobile phone network
 → no recapture required to get the data



Data:

- Precise locations (GPS)
- Flight altitudes (GPS)

Deployment effort:

- 458 individuals from 18 large terrestrial migratory bird species
- 51 individuals from 3 sea-bird species fitted with GPS tags from 2021 to 2024 + Additional data from previous projects



Analyses:

- Seabirds: Use distribution maps taking into account autocorrelation
- Large terrestrial migratory birds: Migrating strategies used, presence in offshore wind areas, flight altitudes



GLS devices

Tags from 0.5 g to 1.2 g (for birds from 15 g to 70 g)
 No data transmission
 → Individuals must be recaptured to obtain data



Data:

- Light measures
- Atmospheric pressure
- Temperature
- Activity

Deployment effort:

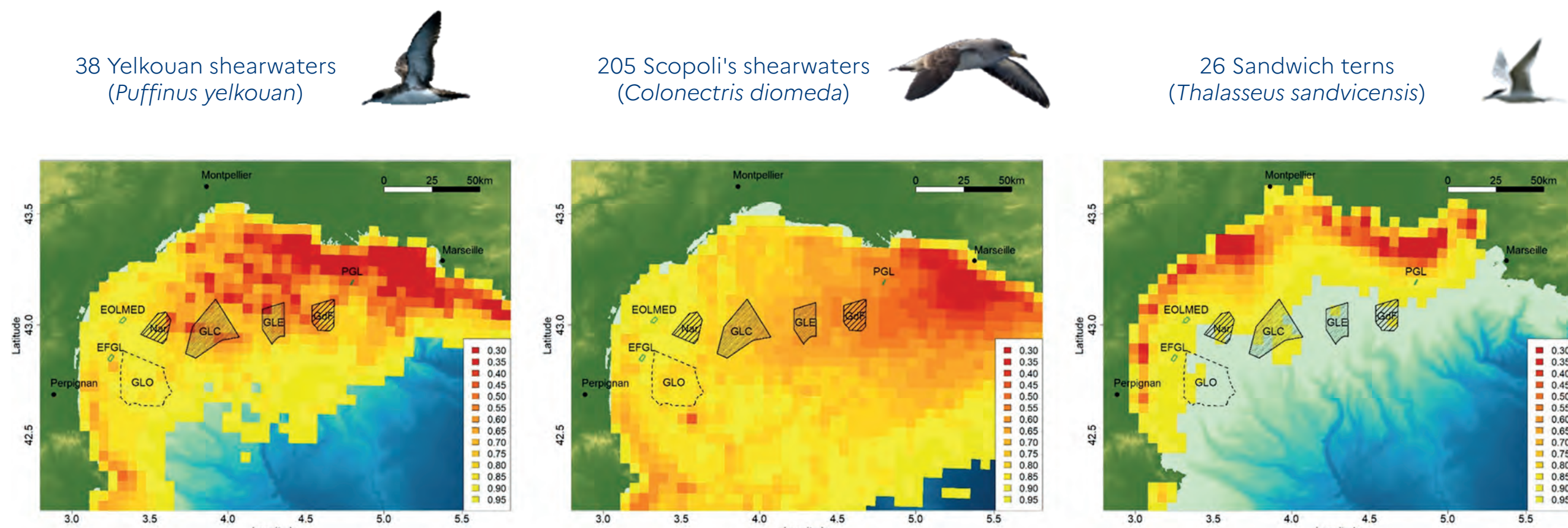
- 321 individuals from 19 species of small terrestrial migratory birds
- 21% of tags recovered

Analyses:

- Estimate stopover sites using pressure data (Nussbaumer et al. 2023) in order to infer migration over the Mediterranean sea
- Flight altitude profiles

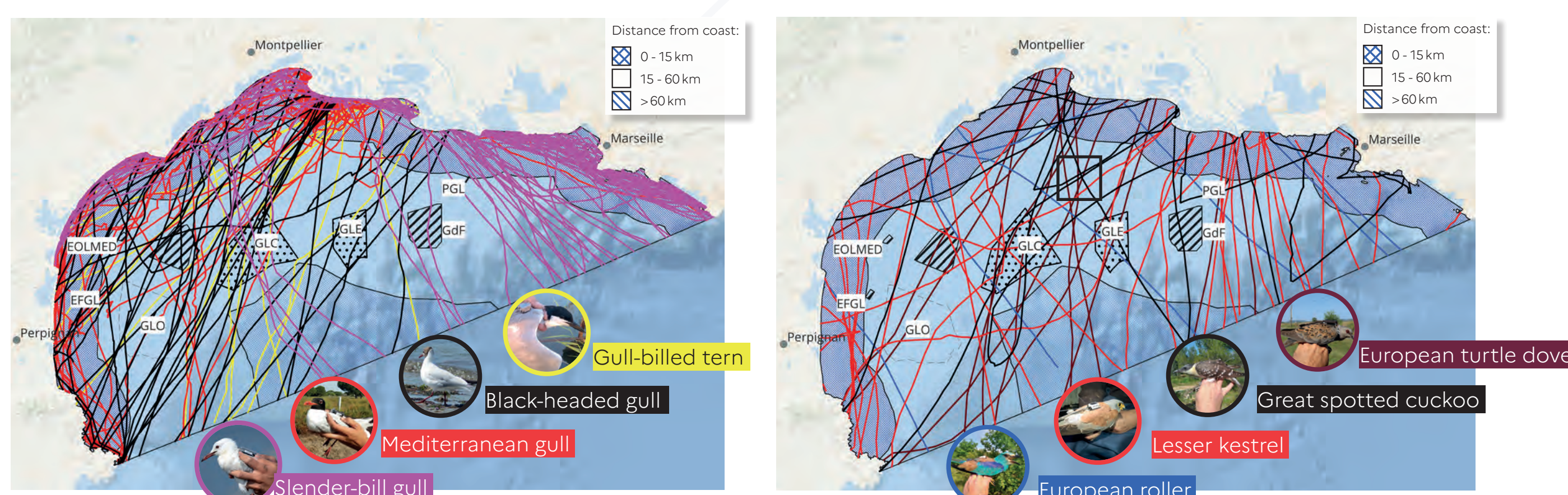
Examples of results

Where are seabirds at-sea?



What are bird trajectories over the Gulf of Lion?

Example of bird flight paths during autumn migration



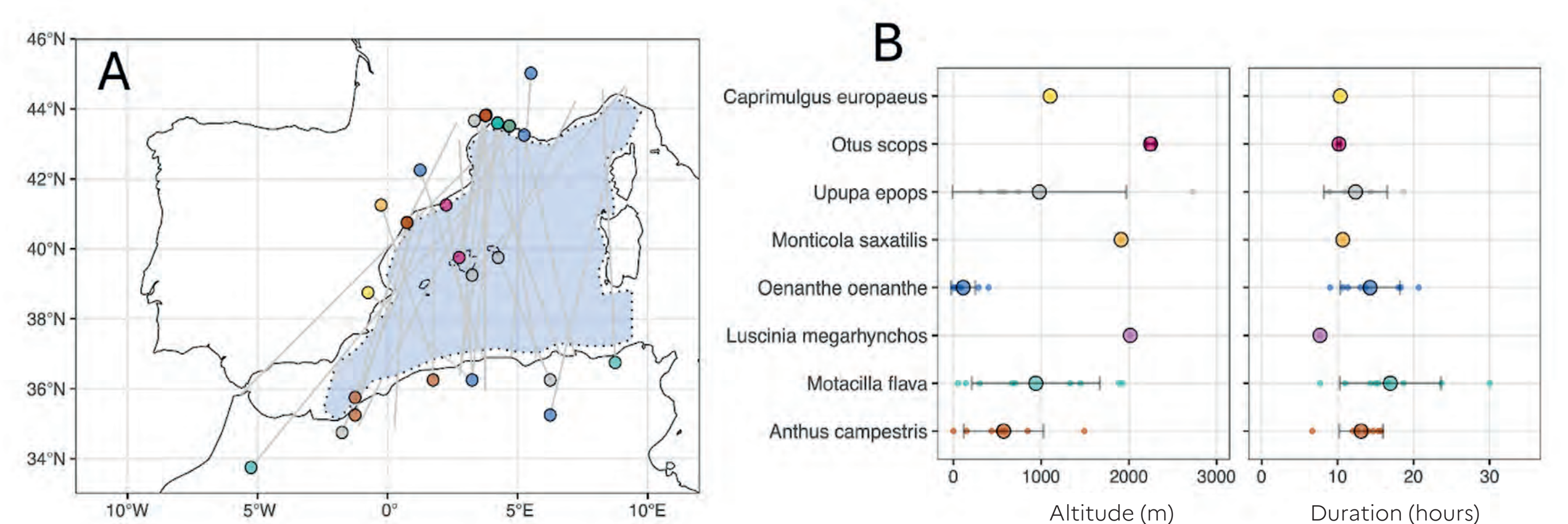
Autumn migration: Birds spent 49% of their time in coastal areas (0-15 km from shore, covering 30% of the total surface area of the Gulf of Lion), 44% in more offshore areas (15-60 km; i.e. 58% total area) and 11% in offshore areas at least 60 km from shore i.e. 14% total area).

Spring migration: Birds spent 59% of time in coastal areas (0-15 km), 39% in more offshore areas (15-60 km) and 20% in the most offshore areas of the Gulf of Lion.

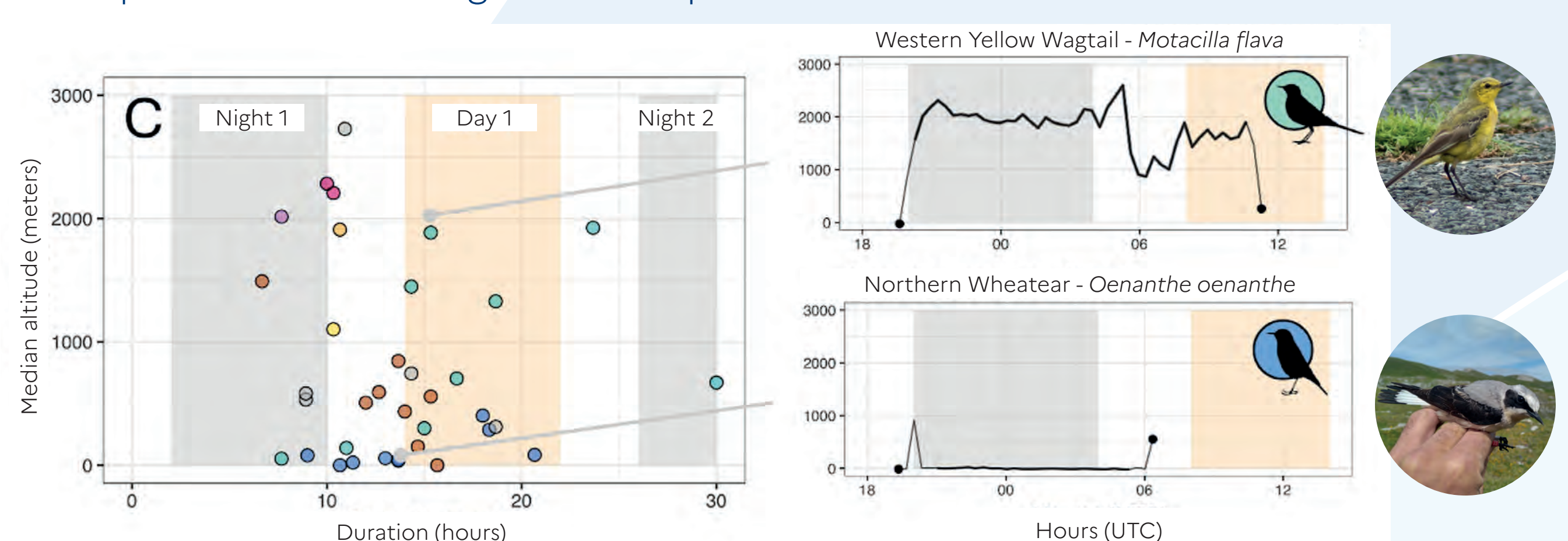
What are the flight paths and altitudes of smaller migratory birds?

28 flight travels identified over the Mediterranean sea
 (mean duration = 12h15)

8 species concerned out of 17 species (individuals concerned/total individuals): Northern wheatear (*Oenanthe oenanthe*) 3/3, Tawny pipit (*Anthus campestris*) 4/5, Eurasian hoopoe (*Upupa epops*) 4/4, Western yellow wagtail (*Motacilla flava*)



Example of associated flight altitude profiles



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At-sea surveys by boat



Contributors to the WP4 At-sea surveys by boat: ASSALI Camille, DELCOURT Vincent, LIEBAULT Vincent, DELELIS Nicolas

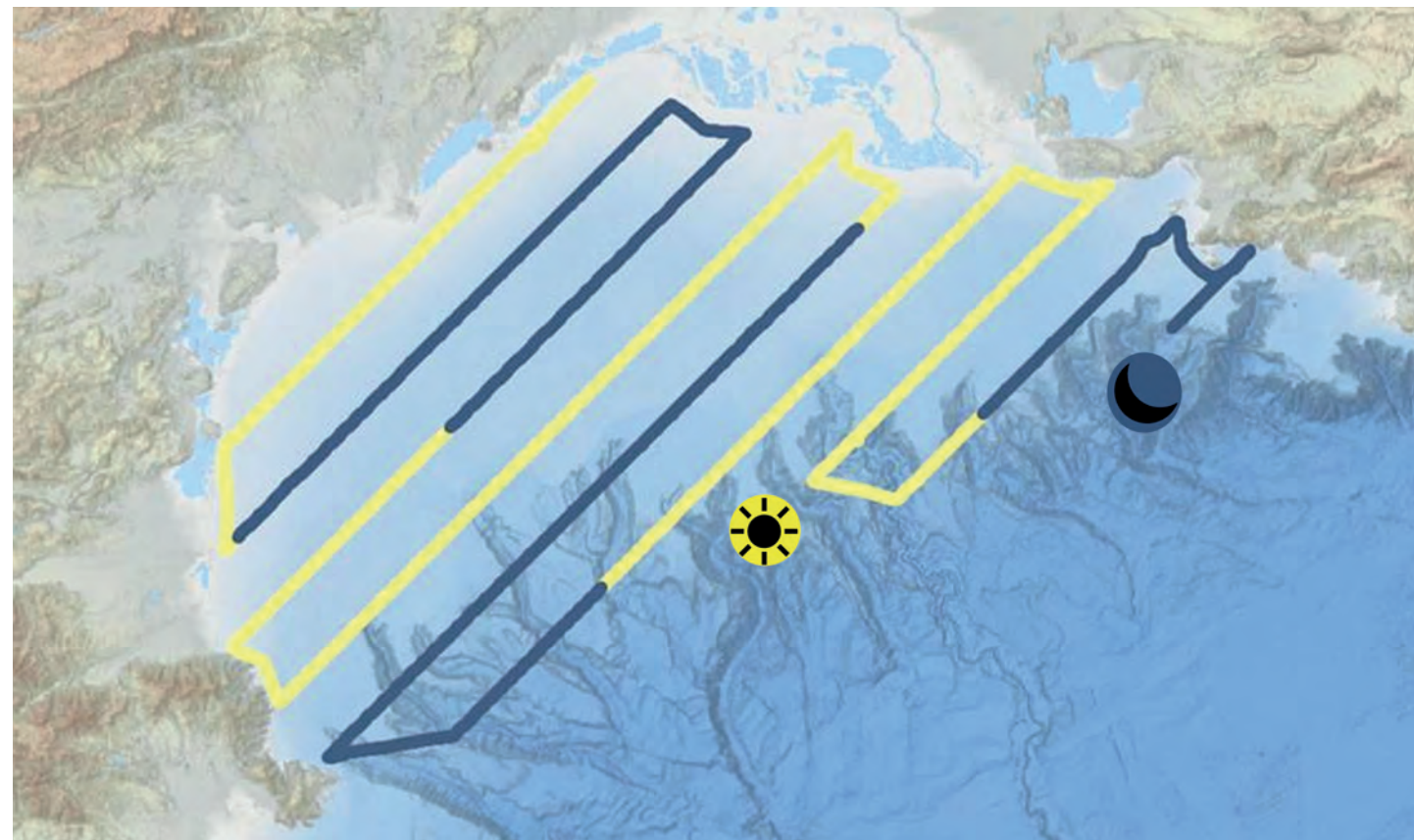
Contacts: ndelelis@biotope.fr (WP4 coordinator), yann.planque@france-energies-marines.org (project coordination), constance.audiffren@ofb.gouv.fr (project management)

Objectives

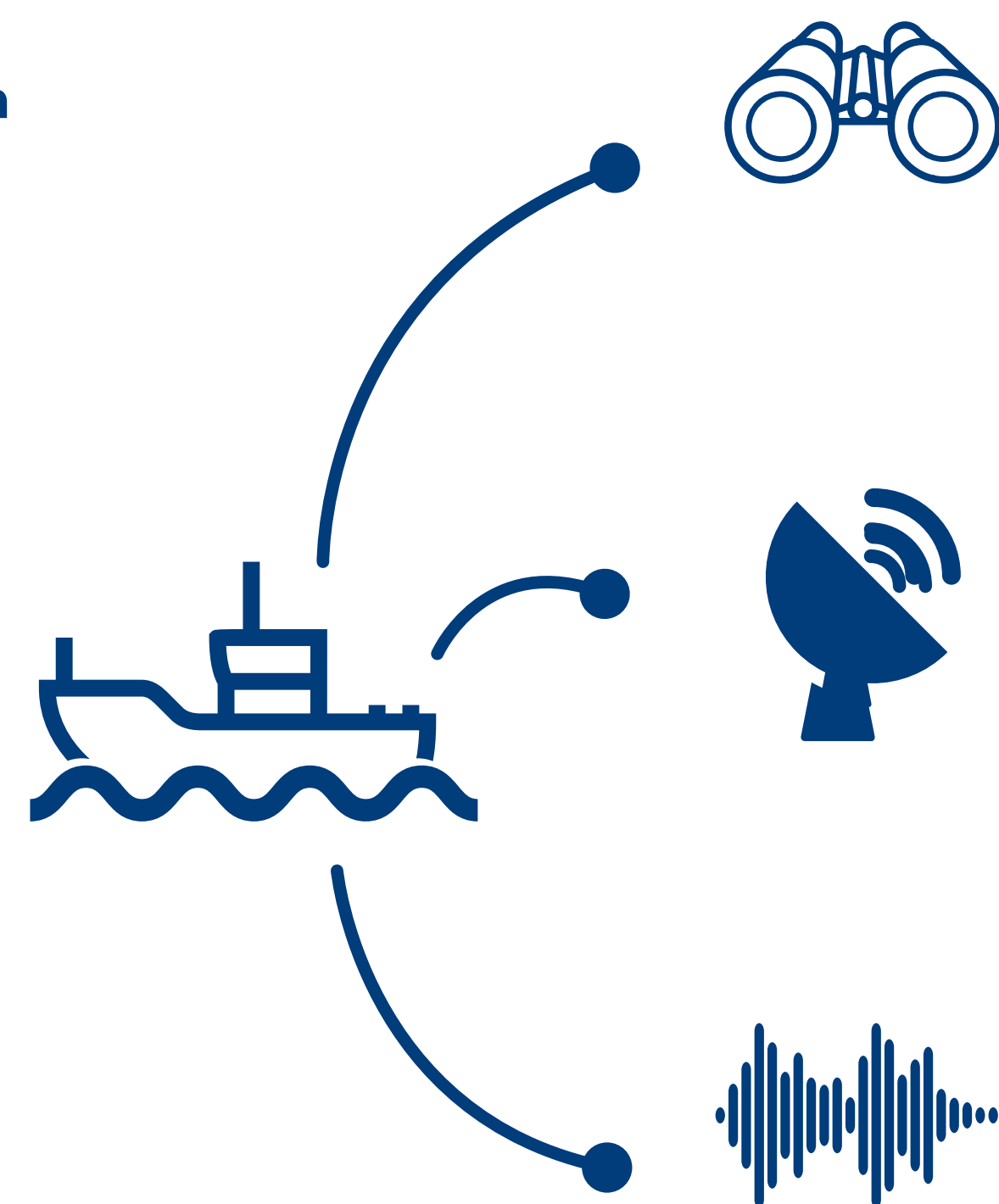
- Acquire data on marine megafauna through at-sea boat surveys to support the assessment of seabird distribution at sea
- Use complementary survey technologies to count both **seabirds** and **terrestrial migratory birds** in the Gulf of Lion, at day and at night

Methodologies

10 at-sea boat surveys conducted in the Gulf of Lion (4 in 2022, 4 in 2023, and 2 in 2024), during both spring and autumn migration periods



Transects realised by boat surveys at day and at night (example of day/night alternation carried out in March 2023)



Visual observations of seabirds and terrestrial migratory birds

- Number of birds per species
- Flight altitudes visually estimated

Onboard radars

- Horizontal radar: bird echoes (classification and selection) used to retrace bird tracks (flight directions)
- Vertical radar: identification of echoes to estimate Migration Traffic Rates (MTR ; nb birds.h⁻¹.km⁻¹) and flight altitudes

Acoustic recorders (bird and bat)

- Identification of bird species vocalisation
- Identification of bat species echolocation

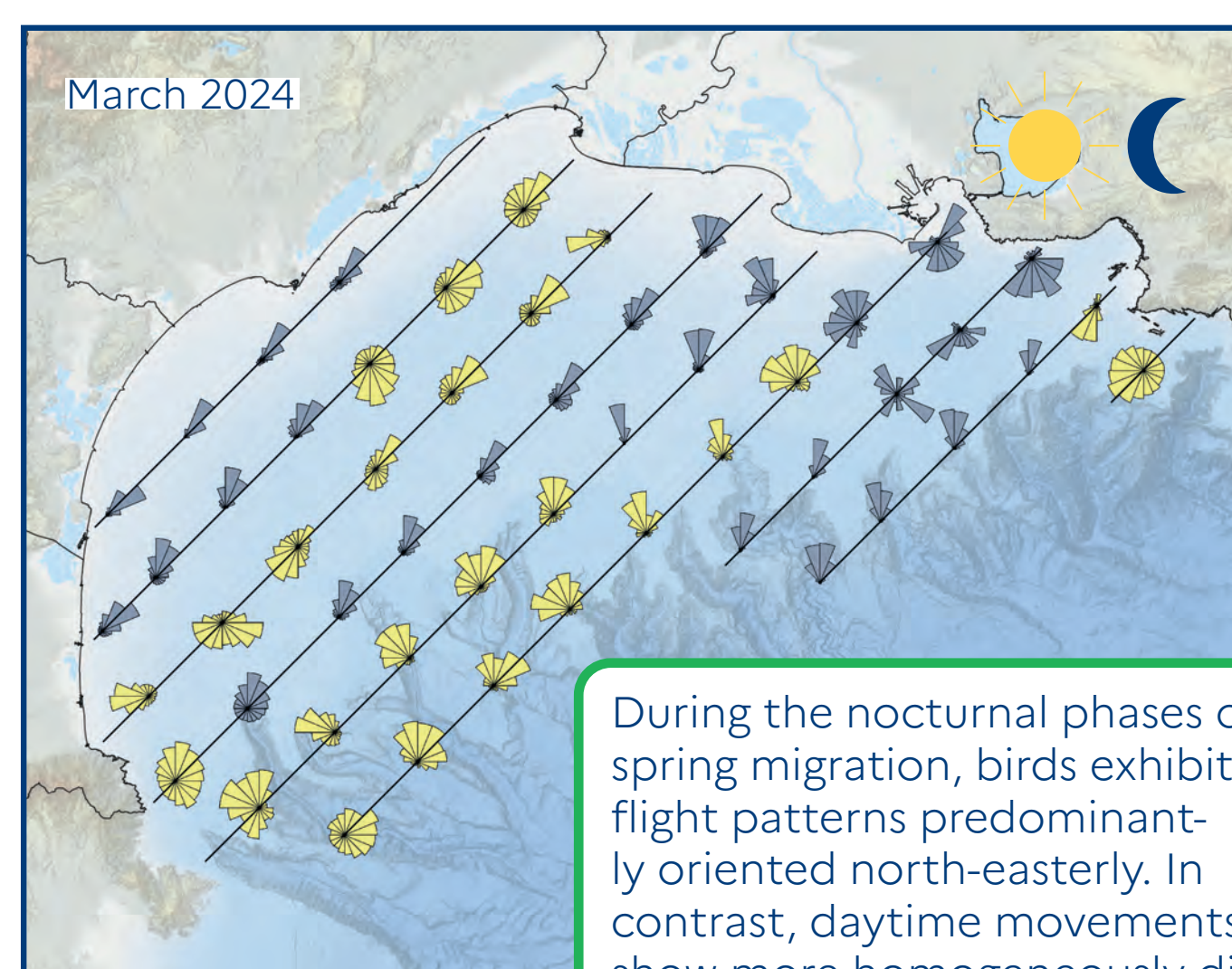
Examples of results



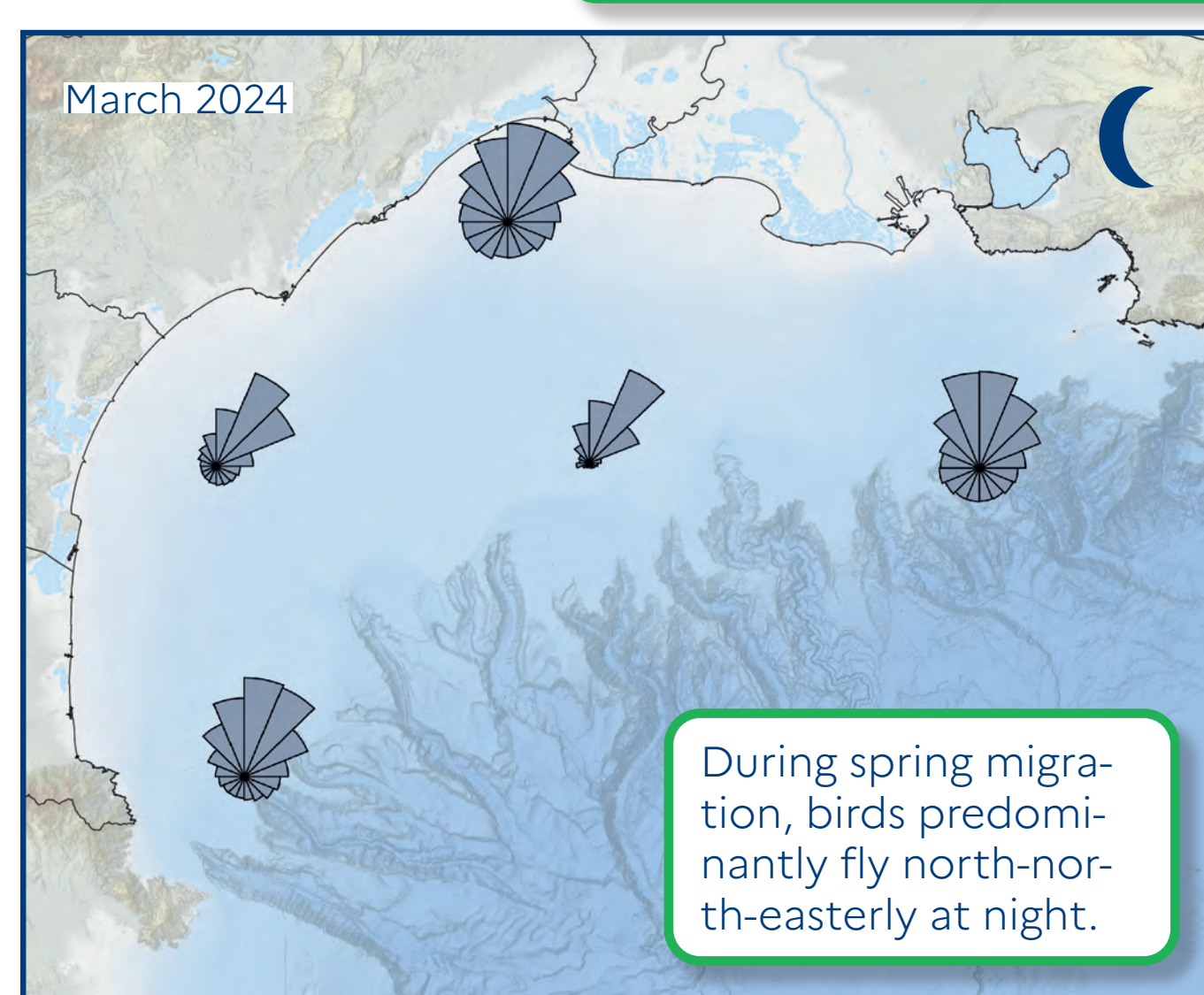
Onboard horizontal and vertical radars

Horizontal radar

Flight directions of birds detected during spring migration.



During the nocturnal phases of spring migration, birds exhibit flight patterns predominantly oriented north-easterly. In contrast, daytime movements show more homogeneously distributed flight directions.

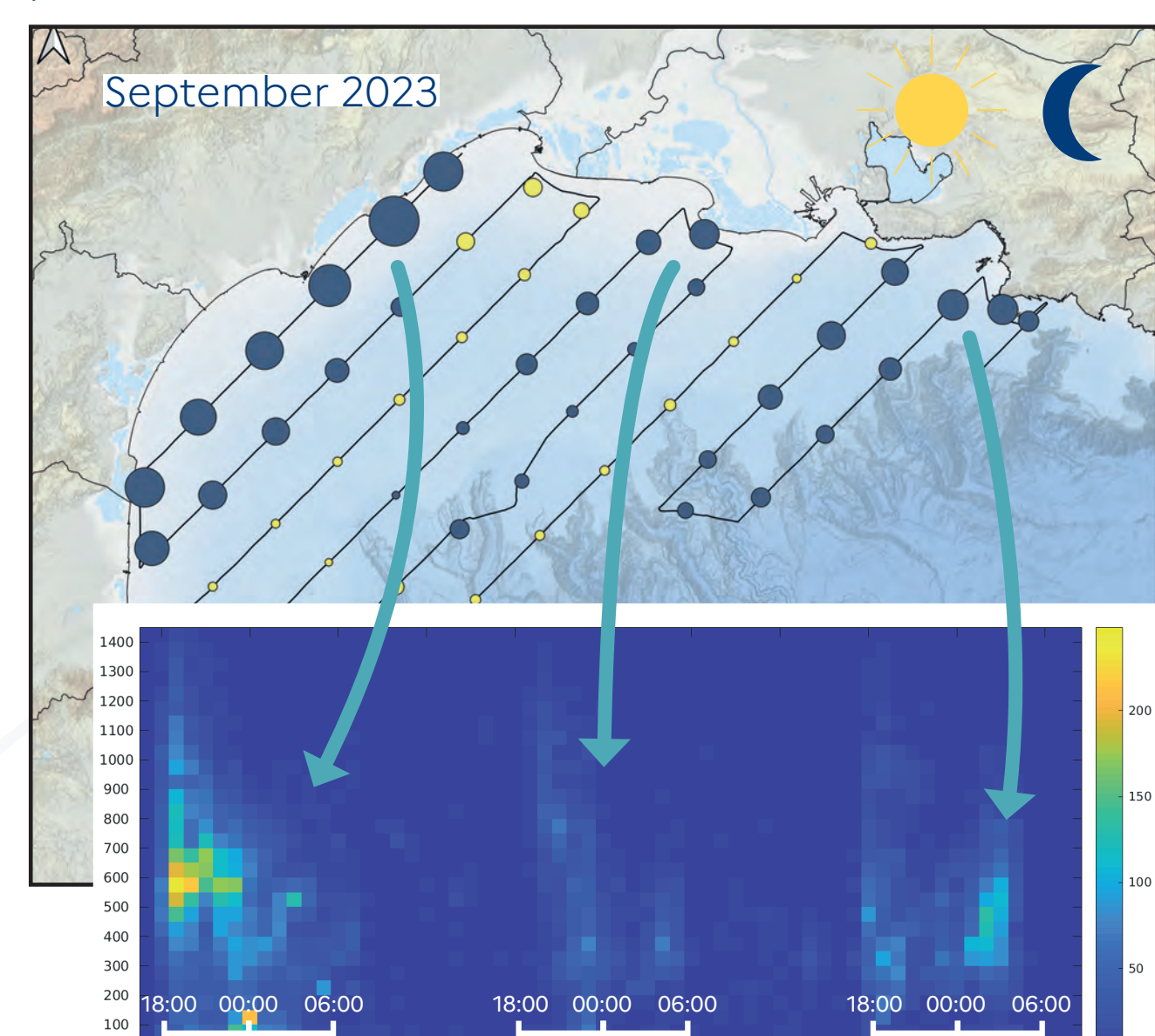


During spring migration, birds predominantly fly north-north-easterly at night.

Flight directions at night during spring migration

Vertical radar

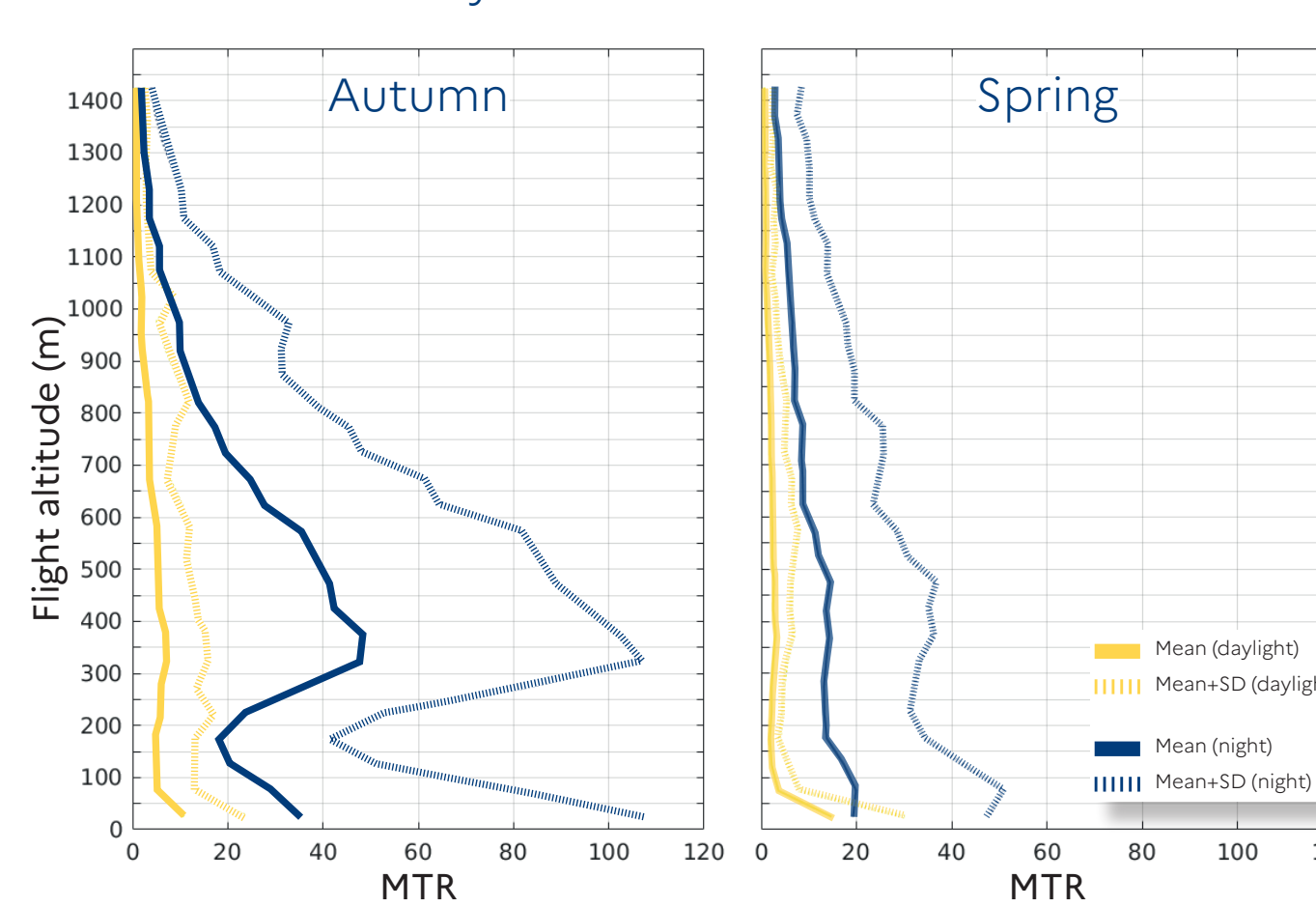
MTR of birds detected during autumn migration. Size of points are relative to MTR.



The highest Migration Traffic Rates (MTR) are recorded during nighttime.

Fly heights vary during and between consecutive nights.

MTR of birds in relation to flight altitudes (m) over consecutive days.



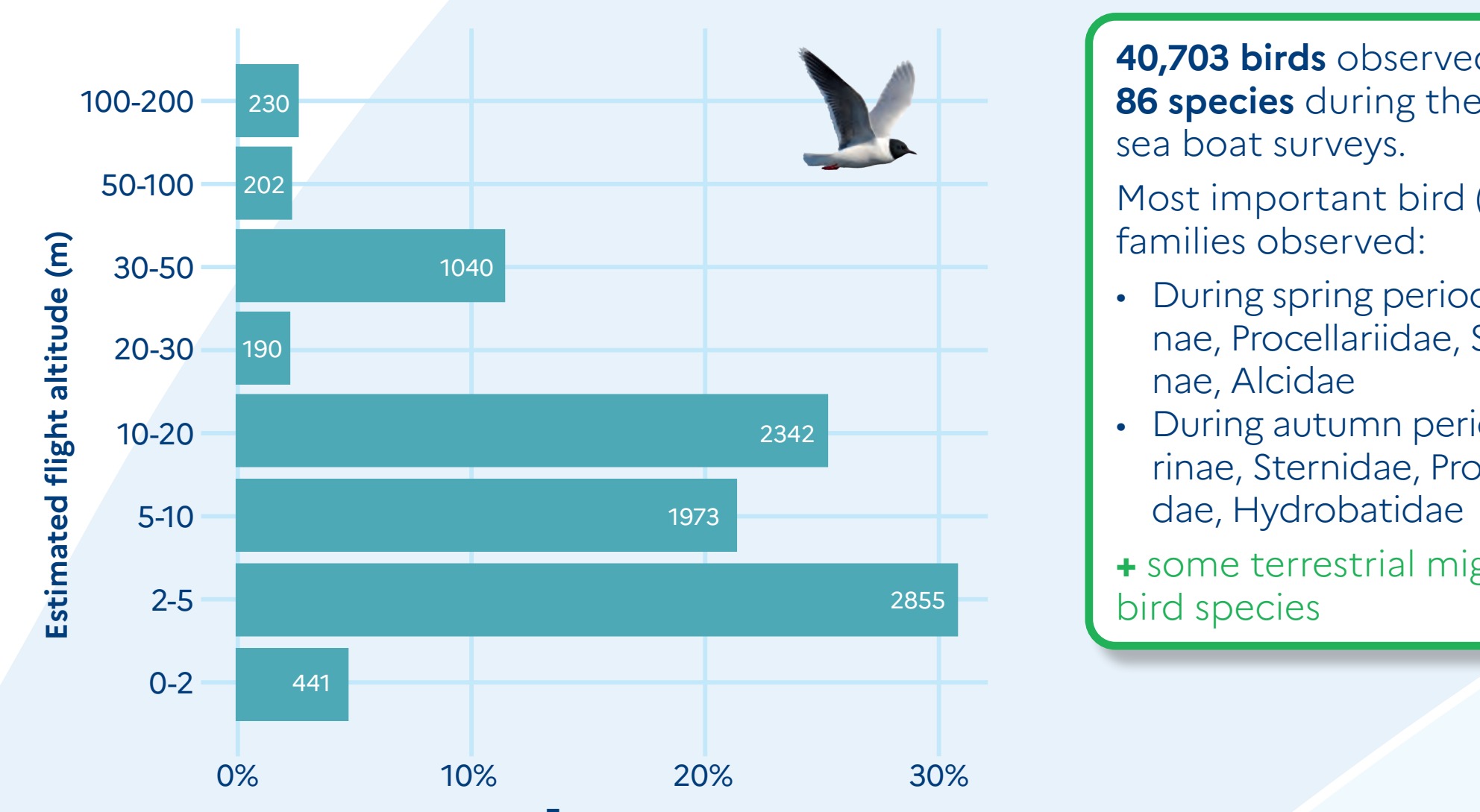
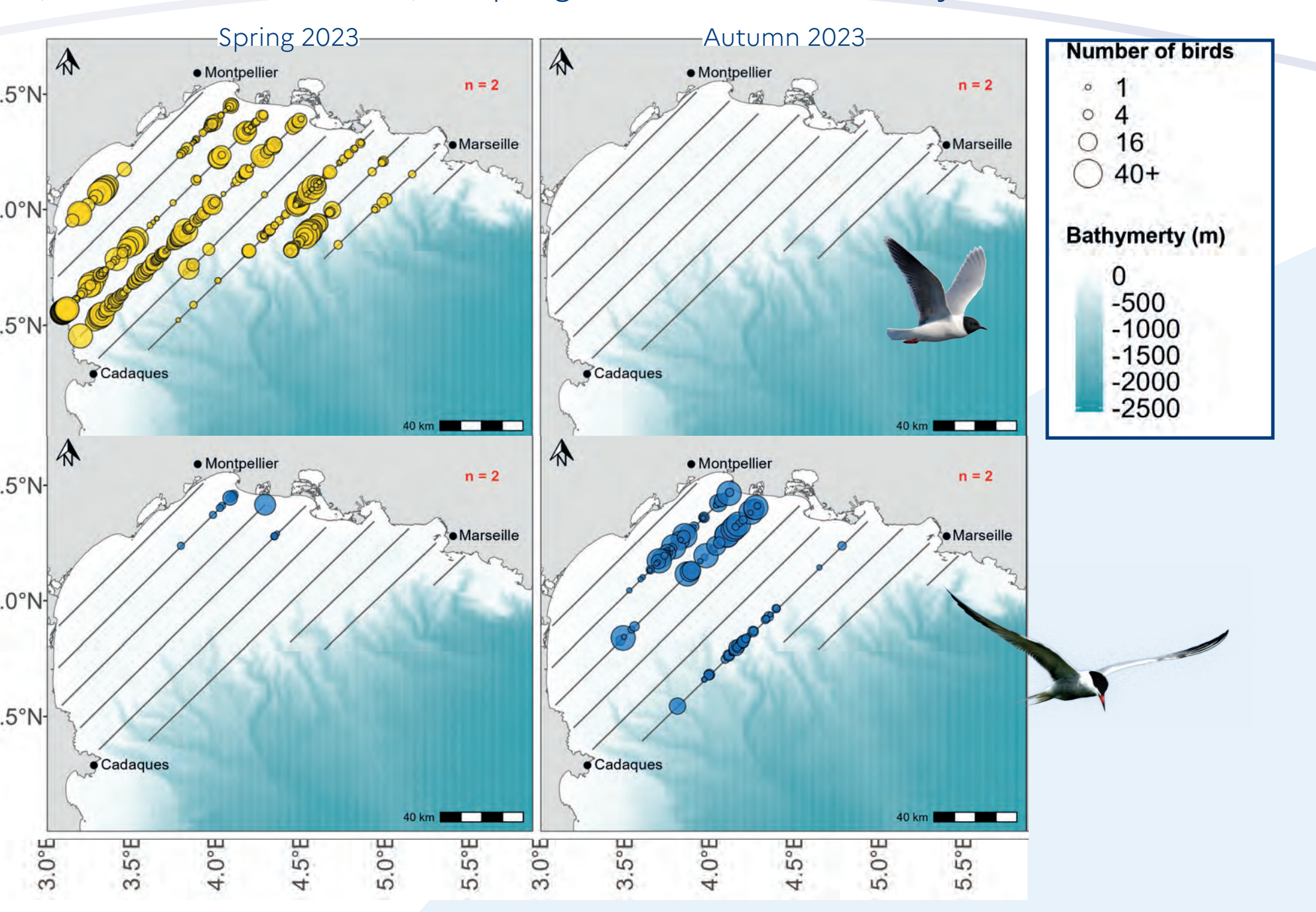
Daytime (yellow) and nighttime (blue) MTR distribution relative to altitude during autumn (left) and spring migration (right)

Highest MTR are recorded < 200 m for both seasons, either during day or night. Nocturnal MTR are also important between 200 and 600 m, especially during autumn migration.



Observation data on seabirds

Visual observations of **Little gulls** (*Hydrocoloeus minutus* ; top) and **Common tern** (*Sterna hirundo* ; bottom) on spring and autumn boat surveys of 2023.



Estimated flight altitudes of these Little gulls (up to 200m maximum)

40,703 birds observed from **86 species** during the 10 at-sea boat surveys.
Most important bird (sub-) families observed:

- During spring period: Larinae, Procellariidae, Sterninae, Alcidae
- During autumn period: Larinae, Sternidae, Procellariidae, Hydrobatidae

+ some terrestrial migratory bird species

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Coastal bird radar



VOGELWARTE.CH



Contributors to the WP5 Coastal bird radar: DELCOURT Vincent, SCHOPPER Hélène, SCHMID Baptiste, DAÏDÉ Cyprien

Contacts: vdelcourt@biotope.fr (WP5 coordinator), yann.planque@france-energies-marines.org (project coordination), constance.audiffren@ofb.gouv.fr (project management)

Objectives

- Collecting data on terrestrial migratory birds crossing the gulf of Lion with ornithological radars
- Description of flyways, number of birds, phenology, flight heights and directions of migrating birds

Methodologies

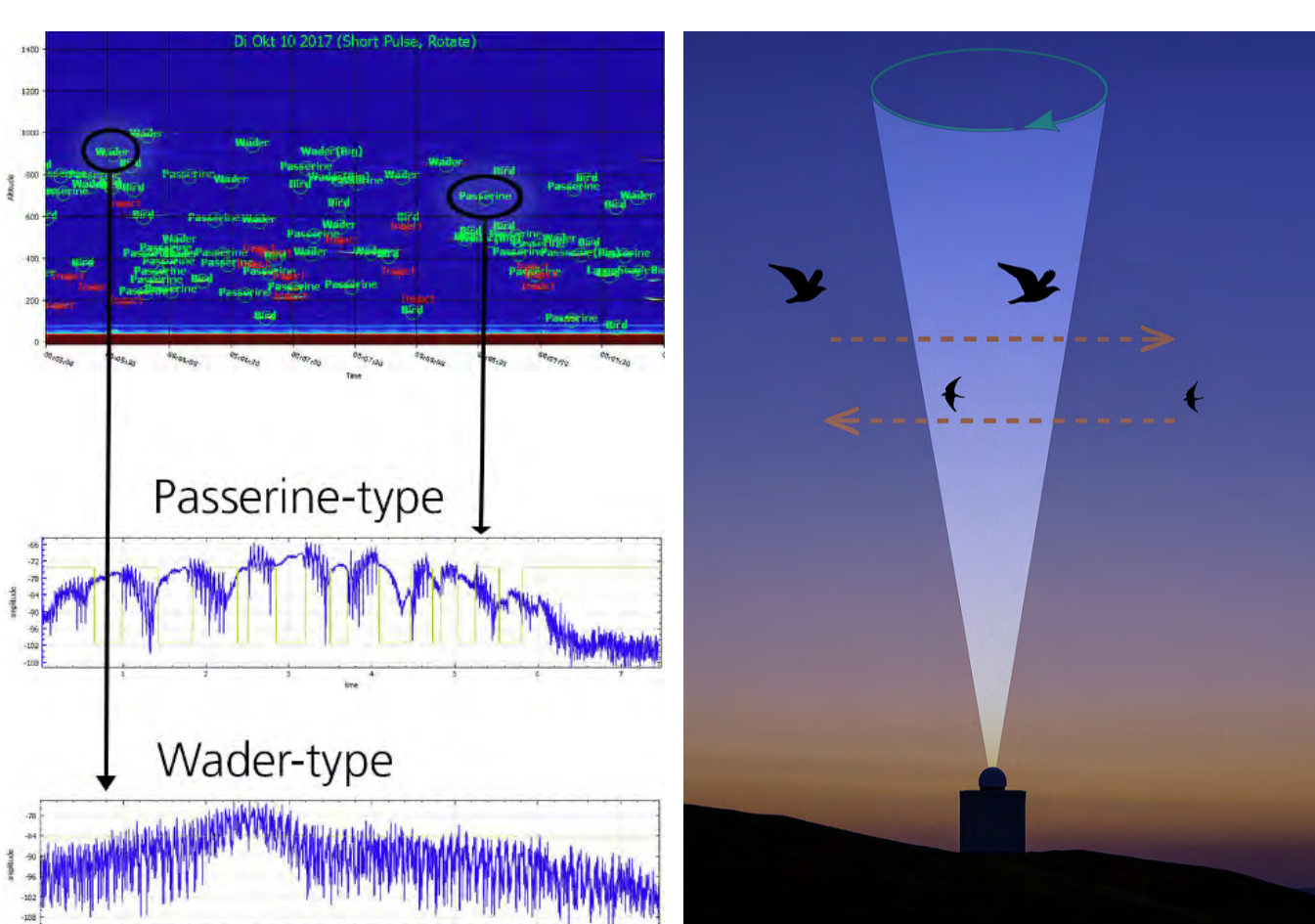
2 vertical looking radars (BirdScan MR1)



Detection of birds between 50m and 1500m of altitude

Data collected : fluxes (MTR - Migration Traffic Rate), flight heights, directions, speeds, wingbeat frequencies

Process of bird detection and classification



Vertical beam, data collection 24/7.

Each echo is located, classified regarding its features and registered in a database.

Deployment sites of BirdScan radars

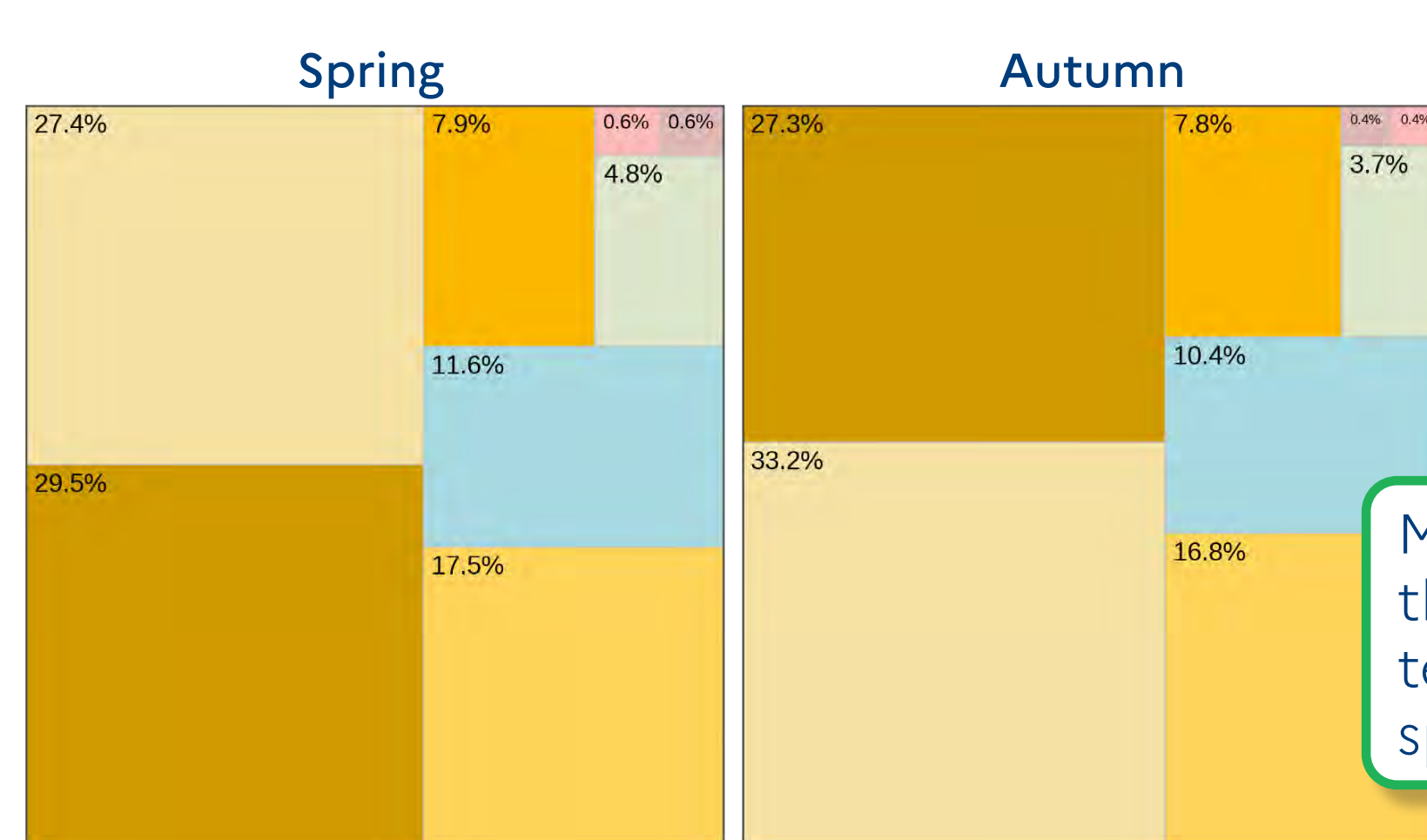


- 2022-2024:** 1 site with continuous recording (Camargue, La Palissade)
- 2022-2023:** 7 sites covered by a mobile unit
- 2024:** 1 site with continuous recording in the west (Agde)

→ 40 000 hours of survey

Examples of results

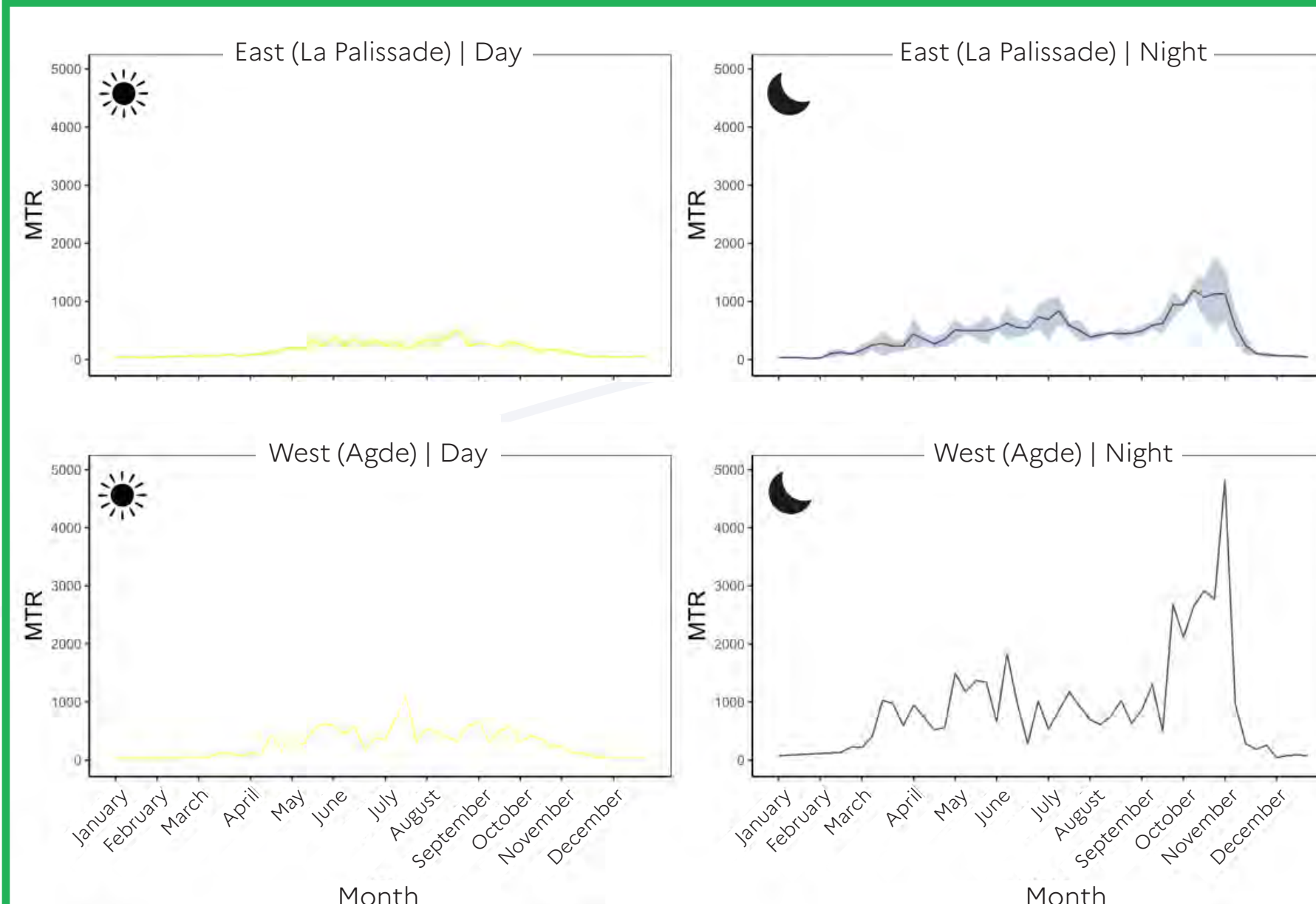
Which species?



Distribution of birds detected by radar and classified in categories (left : spring, right : autumn).

More than 80% of the birds detected are passerine species.

When?



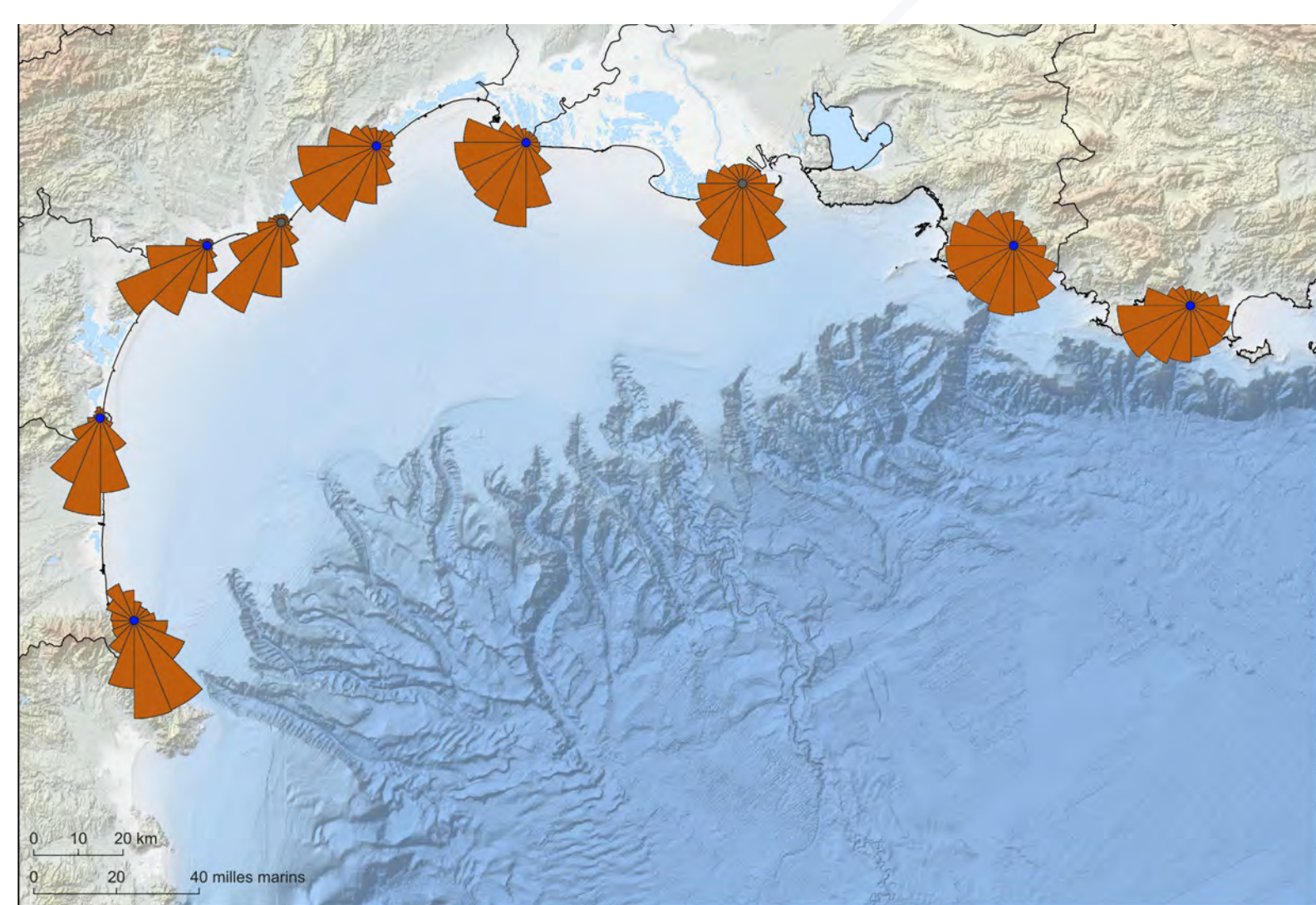
Yearly migration activity (MTR, in individuals.h⁻¹.km²) during day (left) and night (right), in the east (above) and in the west (bottom)

Migration is more important during the night (70%), in autumn, and in the west part of the Gulf of Lion.

How many birds?

Each year, between **45 to 90 millions** of birds cross the Gulf of Lion during spring migration below 1000m of altitude, and between **140 to 210 million** during autumn migration

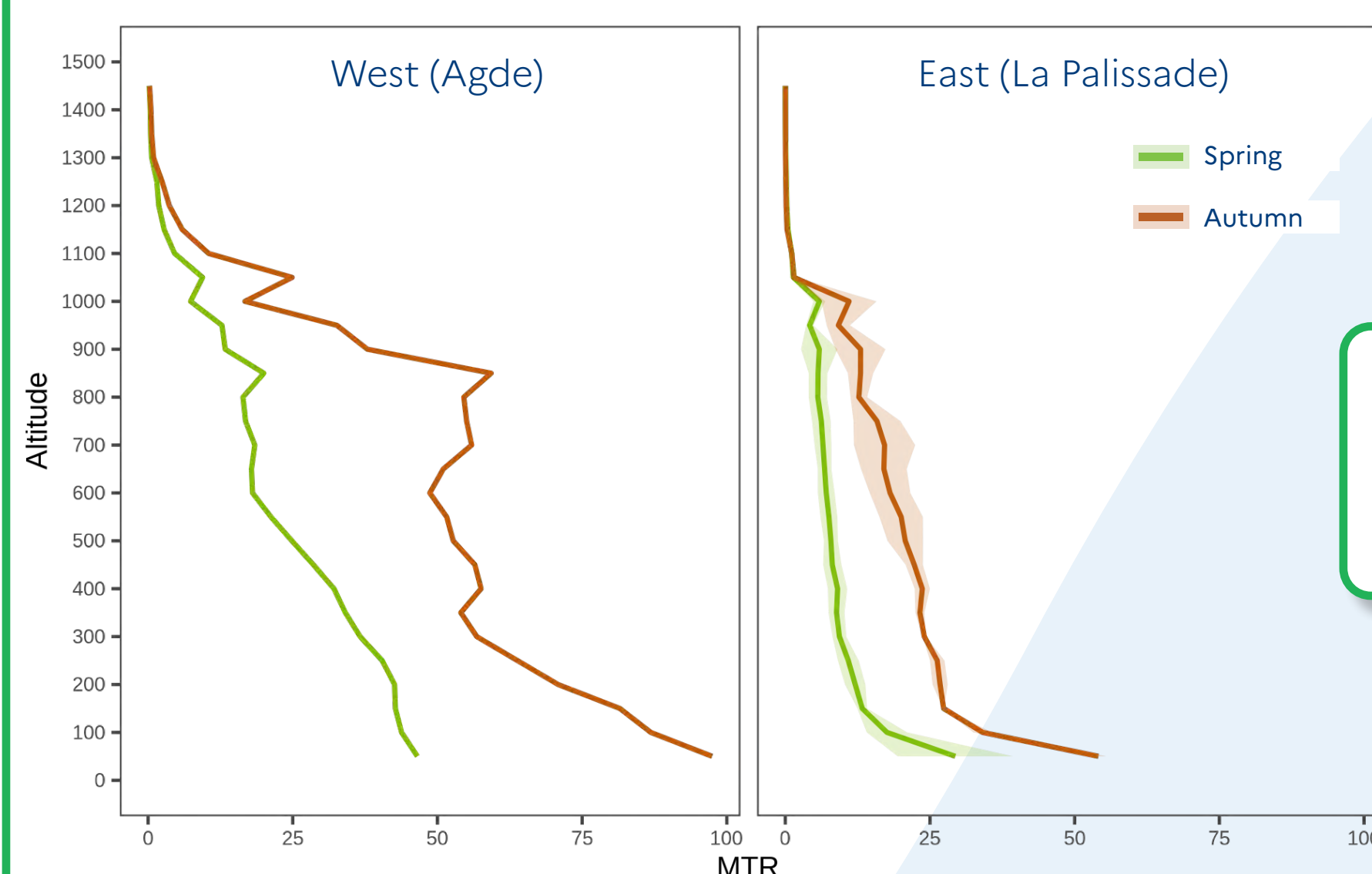
Where?



Flight directions of birds recorded during autumn migration (2022-2024)

Birds fly more along the coast in the western part than in the eastern part, where they cross the sea more frequently.

What height?



Flight heights of birds recorded in the west (left) and east (right), expressed as MTR (individuals.h⁻¹.km²). NB: above 1000 m the detection is weak.

Birds fly at various altitudes, but a high proportion migrate below 300m.

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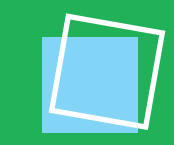
Combined analysis of data



Contributors to the WP6 Combined analysis of data: CANONNE Coline, QUEROUE Maud, ROQUES Sébastien, LAURET Valentin, SCHROLL Louis, CAT Victor, COURBIN Nicolas, PLANQUE Yann, CHAMPAGNON Jocelyn, DURIEZ Olivier, BESNARD Aurélien

Contacts: aurelien.besnard@cefe.cnrs.fr (WP6 coordinator), yann.planque@france-energies-marines.org (project coordination), constance.audiffren@ofb.gouv.fr (project management)

Objectives



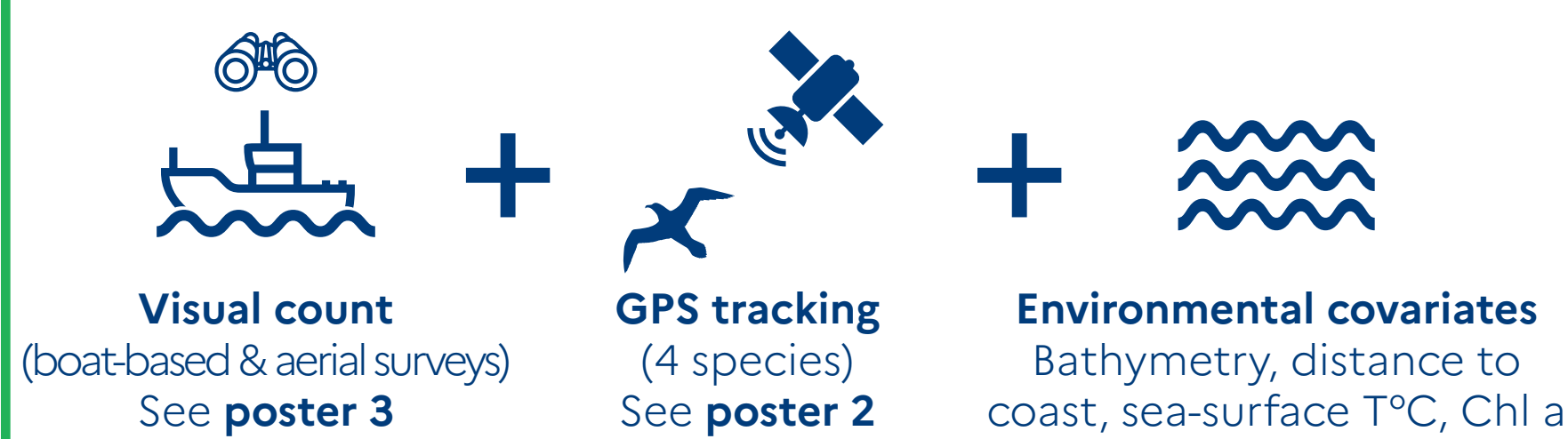
Develop methodologies for the combined statistical analysis of data acquired during MIGRALION (see posters 1, 2 & 4) to:

(1) Map the at-sea space-use of seabirds, (2) map the at-sea migratory flows of large terrestrial migratory birds, and (3) model the distribution of flight altitudes of large terrestrial migratory birds.

Methodologies used & integrated results

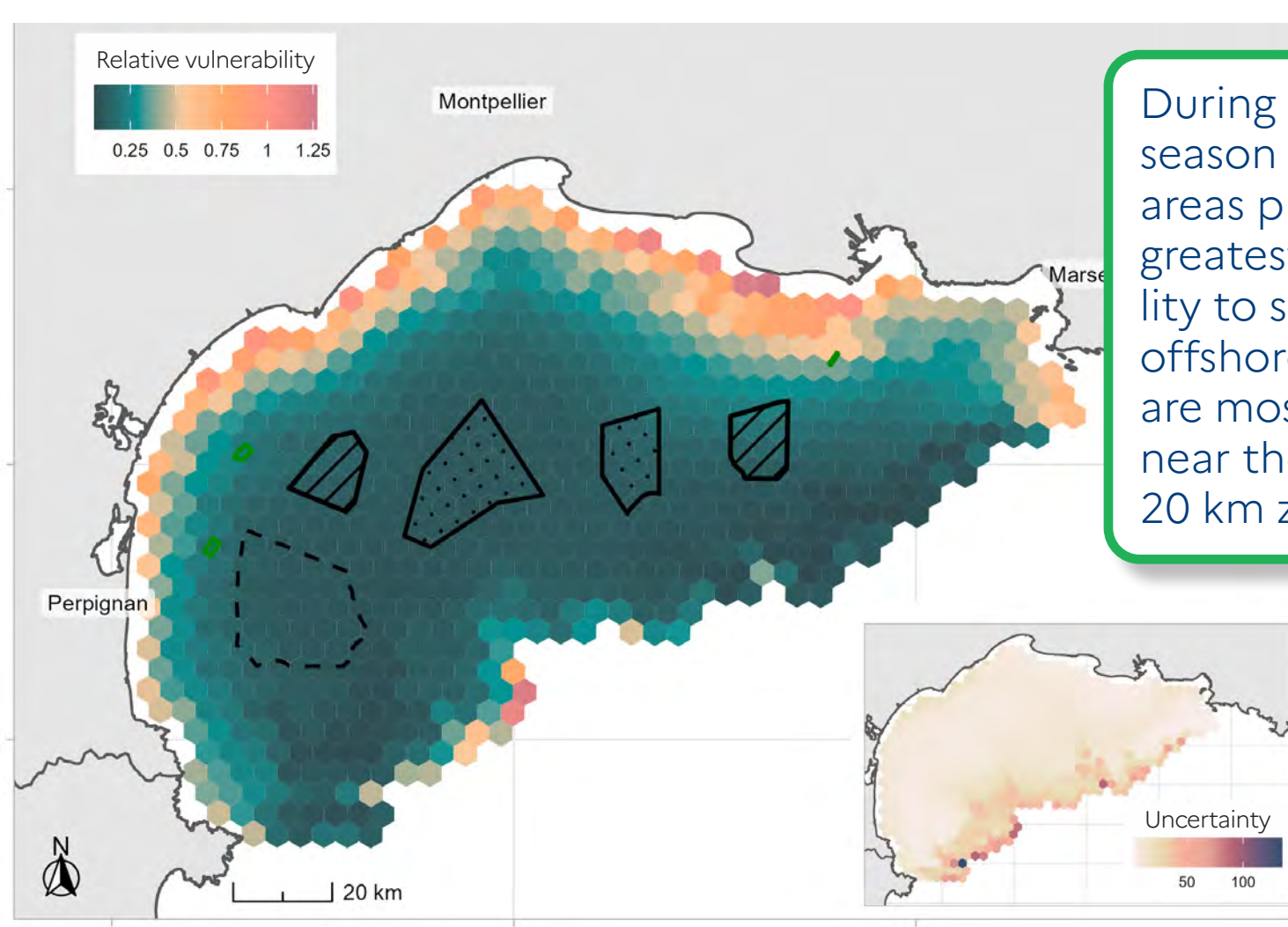


How do seabirds use the marine environment of the Gulf of Lion?

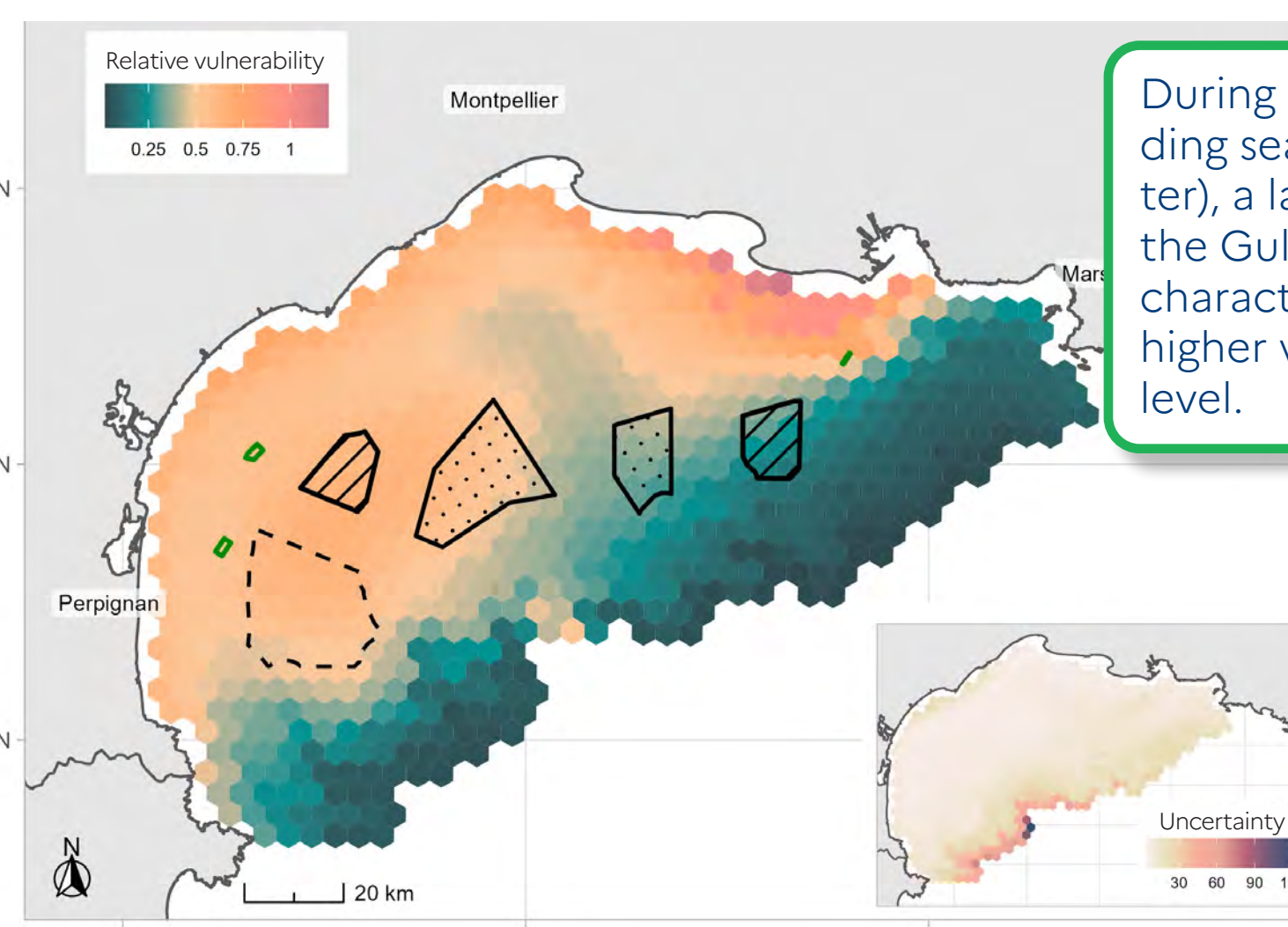


Integrated Inhomogeneous Poisson Point process (IPP) model
→ **Spatial relative space-use of seabird species**
Vulnerability index (Bradbury et al. 2014) based on:
collision risk + displacement risk + conservation score
→ **Spatial relative vulnerability to offshore wind farms**

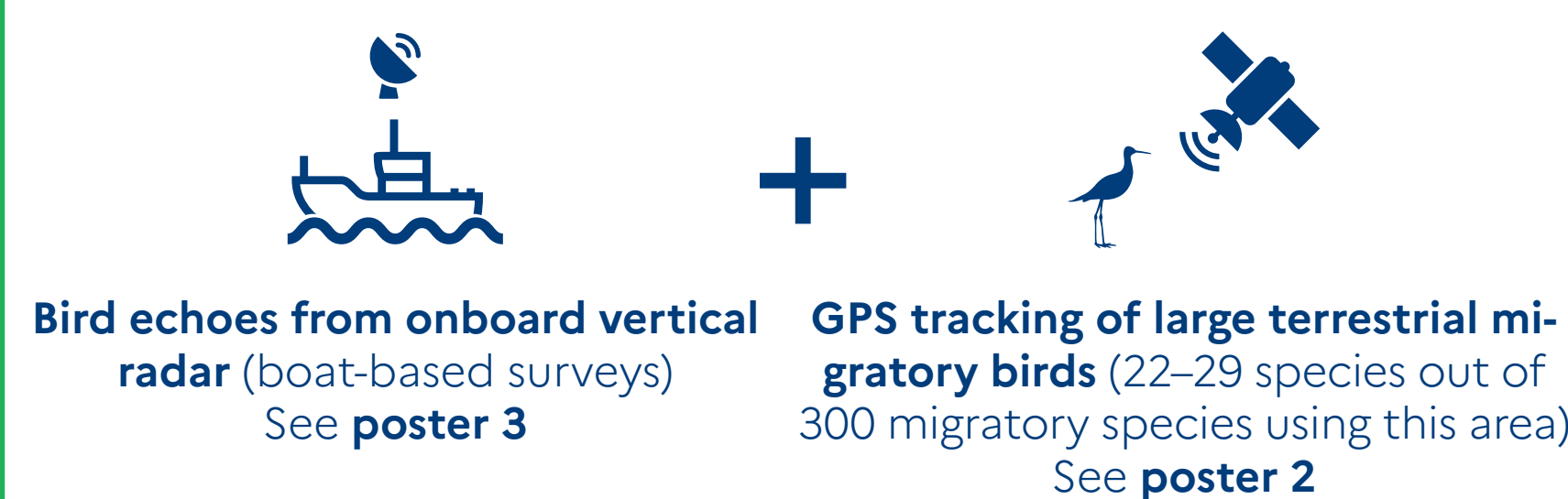
Breeding season (summer) – 7 breeding species



Non-breeding season (winter) – 11 wintering species

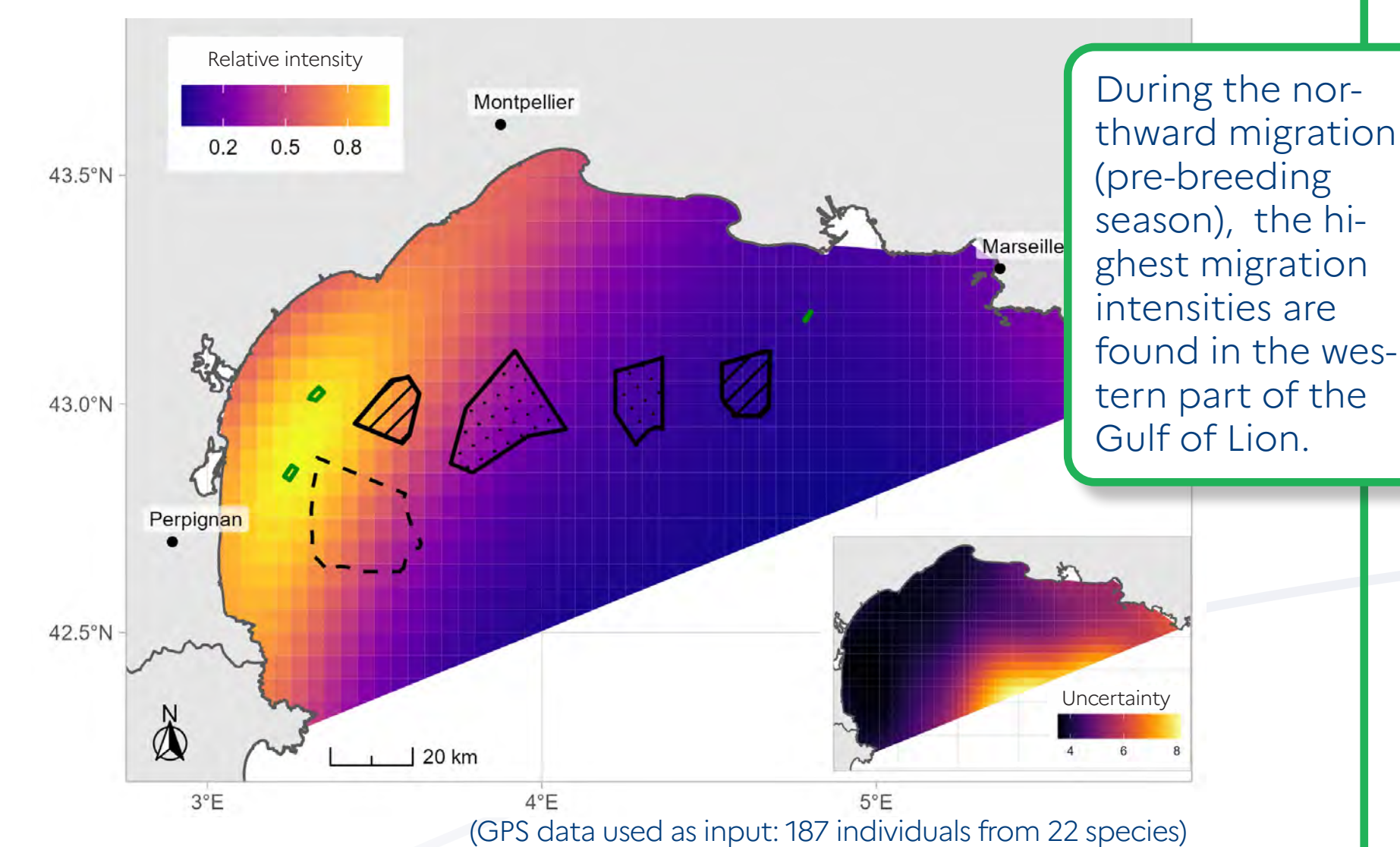


Which areas in the Gulf of Lion have the most intense migratory bird flows?

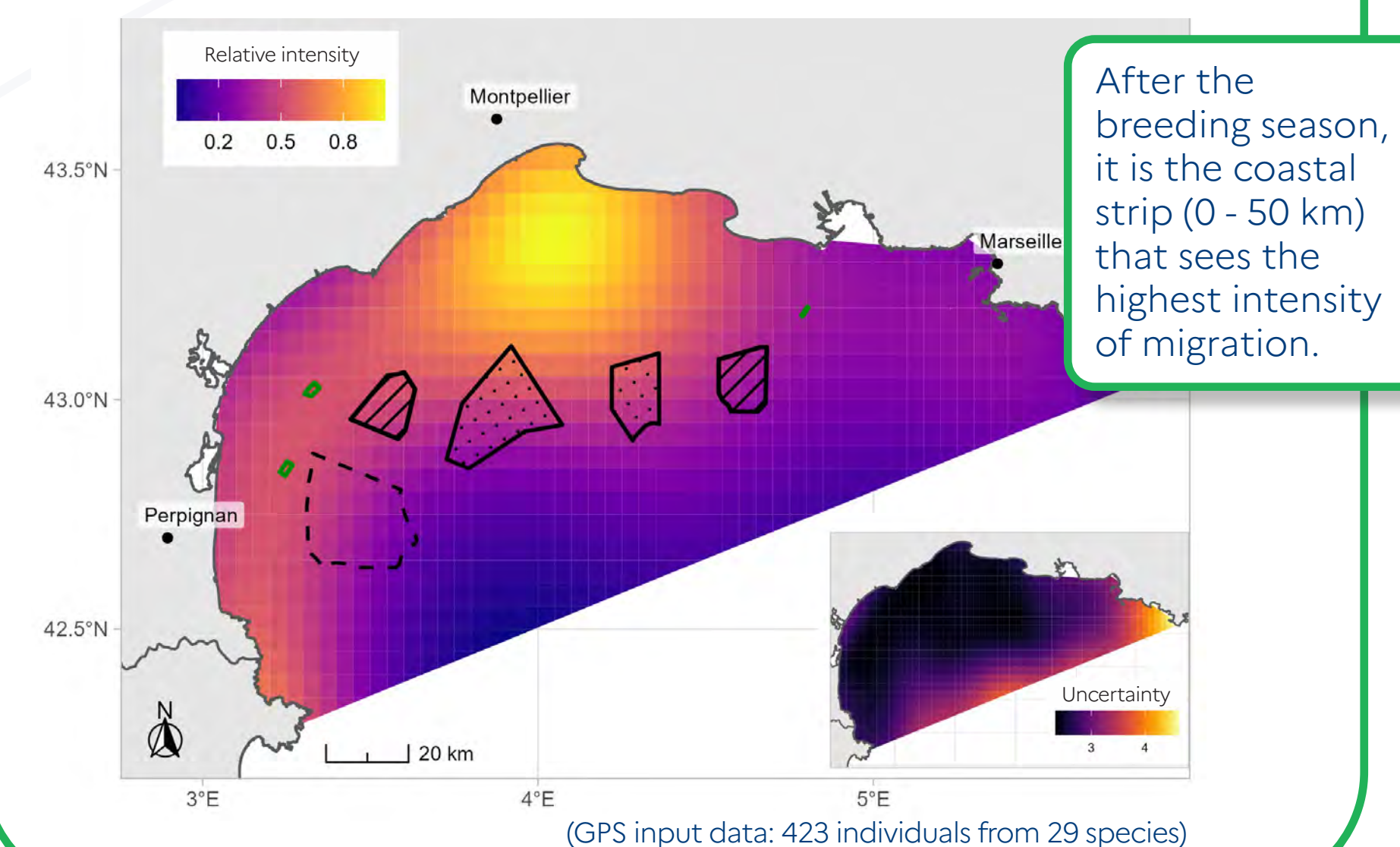


Integrated Inhomogeneous Poisson Point process (IPP) model
→ **Spatial relative intensity of migratory flows**

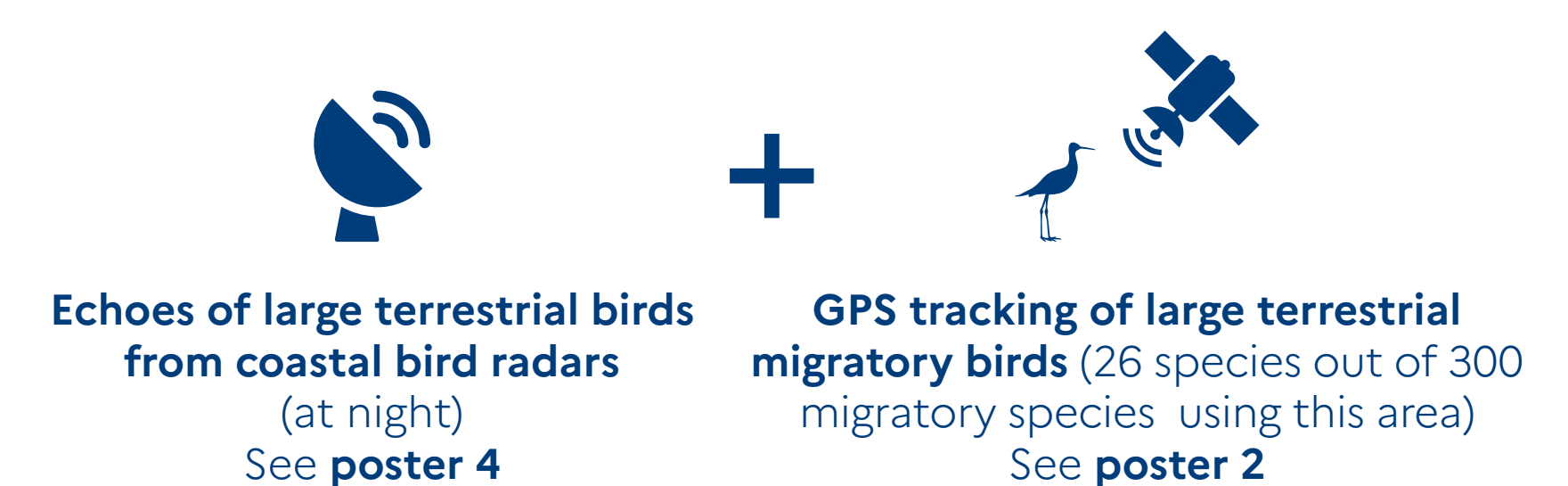
Pre-breeding season (January–June): northward migration



Post-breeding season (July–December): southward migration

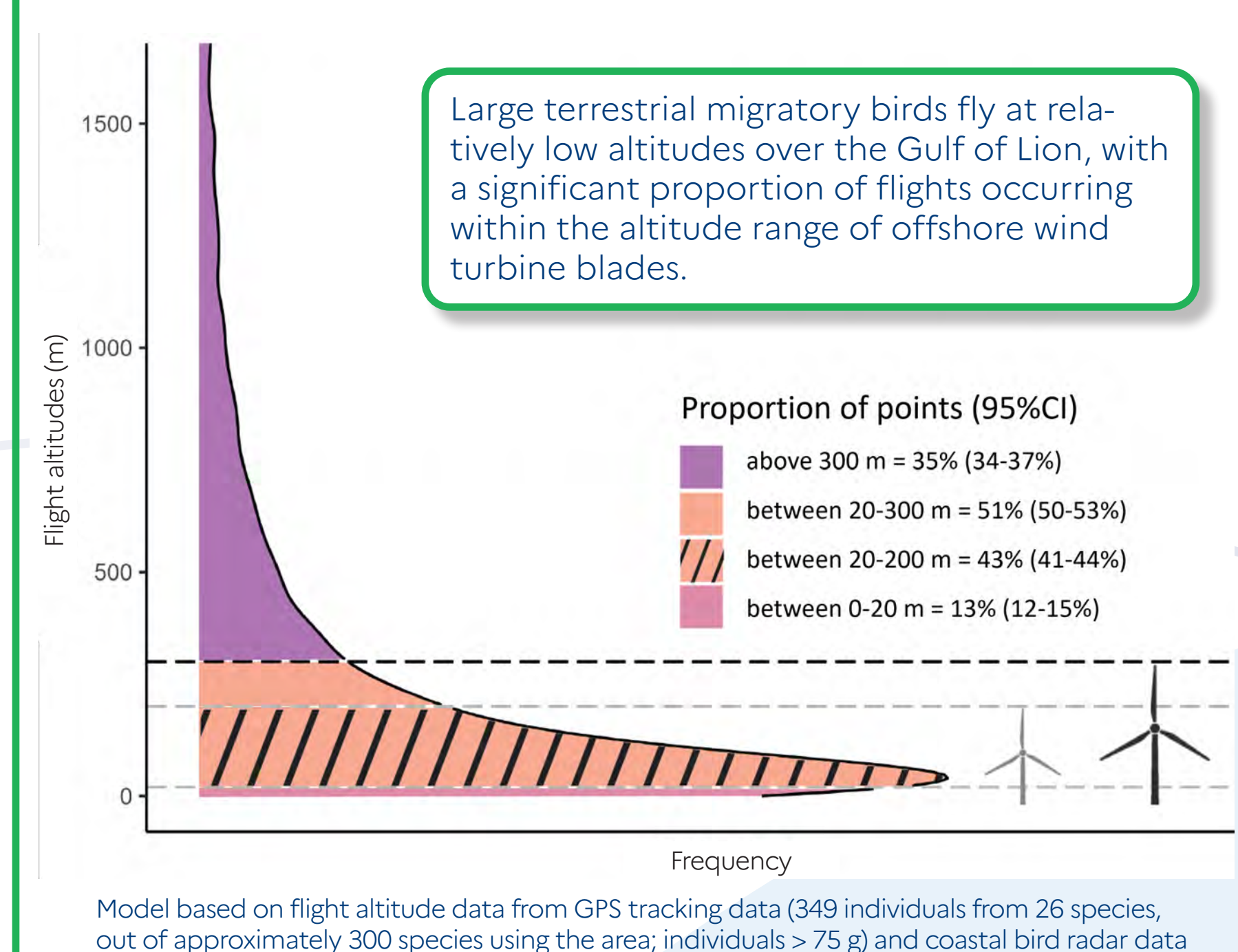


At what altitude do land migrants fly when crossing the Gulf of Lion?



Integrated state-space model (lognormal model dealing with measurement errors)
→ **Distribution of flight altitudes**

Flight altitudes of large terrestrial migratory birds during the post-breeding season: southward migration



Flight altitudes obtained during pre-breeding season are similar.

Offshore Wind Farms (OWFs)

- Pilot OWFs commissioned in 2024-2025
- Under development or in competitive tendering
- Priority areas over a 10-year horizon
- Priority area by 2050

Summary & perspectives

MIGRALION is an innovative research programme that stands out for the **unprecedented scale of avifauna data collected at sea** in the Gulf of Lion. For the first time in France, **complementary monitoring methods** were implemented **over several consecutive years**, and the resulting data were combined for a comprehensive analysis. MIGRALION provides **new knowledge** into the **areas used by seabirds at sea**, the **offshore migration flow areas of terrestrial migratory birds**, the timing of their presence, and their flight altitudes.

These key knowledge concerning the **areas of interaction with human activities (notably offshore wind energy)** provide a solid foundation for **addressing conservation challenges and adapting environmental measures** (avoidance). **This work deserves to be expanded to other species**, particularly regarding small terrestrial migratory birds and bats (which are underrepresented here), different age classes (e.g., juveniles), migration strategies, links with environmental conditions, and the finer-scale impacts of offshore wind farms on avifauna.

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