EcoDIS

Disease ecology in a modified world:

Linking combined environmental stressors, population dynamics and movement ecology to understand the circulation of infectious agents

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The Mediterranean Sea, a threatened ecosystem

A major reservoir of marine and coastal biodiversity

→ 28% endemic species, 7.5% of the world's marine fauna, 18% of world's marine flora.
www.unep.org

Natural stressors:

- environmental variation
- food resources
- competition
- predation
- parasites & pathogens

+

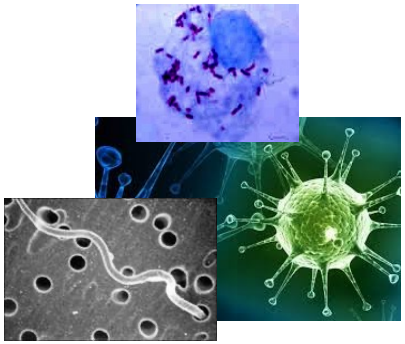
Human-derived stressors:

- climate change
- commercial fishing
- human densities (habitat loss)
- invasive species
- pollutants (eg., MTE, POPs, plastics, …)

Cumulative and interactive effects on biodiversity ?

Halpern et al., 2015; Avery-Gomm et al., 2018

Negative feedback loop ?



Parasite/pathogen transmission

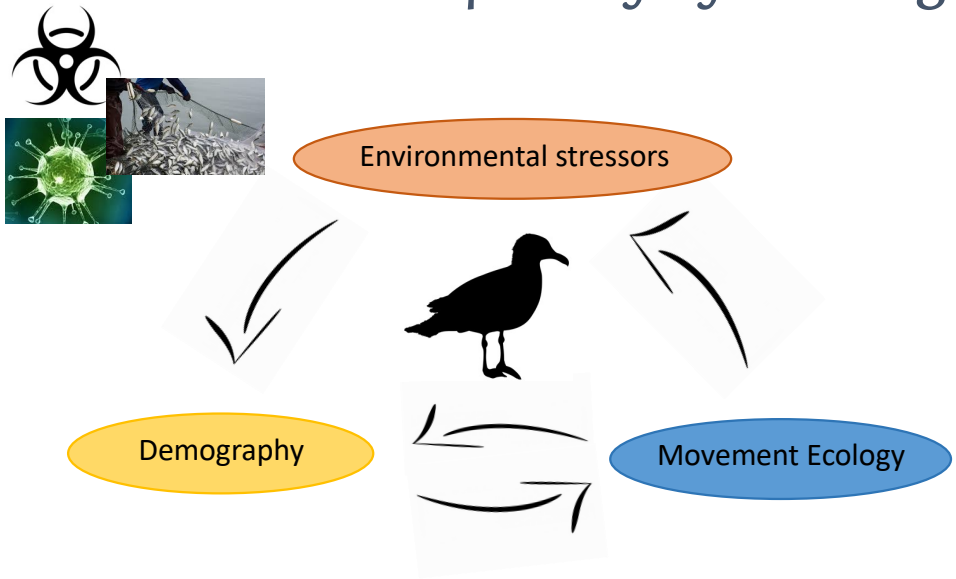
Prospecting / dispersal

Low reproductive success

Environmental stressors

EcoDIS: Context & Objectives

How do combined stressors interact with demography and movement to alter in the spread of infectious agents at different spatial scales ?



Yellow-legged gull
Larus michahellis

Known pathogens
Influenza
Meaban virus
Enterobacteria (AB resistant)
Campylobacter
Toxoplasma
Tick-borne agents
… ?

Objective 1: Mapping pollution and parasites in seabird colonies across the western mediterranean

Objective 2: Assessing impact on seabird demographics & movement

Objective 3: Dissemination risk at different spatial scales

Expertises

- Ornithology
- Demographic modeling
- Biologging
- Ecotoxicology
- Chemistry
- Parasitology/Microbiology
- Population genetics
- Molecular epidemiology

The consortium

Tour du Valat

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LIENSs UMR 7266

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Boudjéma SAMRAOUI
Laid Touati

Conservatoire du littoral

Collettività di Corsica
Collectivité de Corse
Uffiziu di l'Ambiente di a Corsica
Office de l'Environnement de la Corse

Parcs nationaux

Parc naturel régional de la Narbonnaise en Méditerranée

Objective 1:

Mapping pollution and parasites in seabird colonies across the western Mediterranean

Year 2021

- 2021
- 2022?

Samples:

- Environment

[soil, bolus, ticks]

- Birds

[blood, feathers, swabs, + cadavers]

Analyses in progress..

YLG feeding regimes (LIENSs, University of Barcelona):

- anthropogenic versus natural food sources
  - Boluses
  - Regurgitates
  - Stable Isotype analyses (C, N, S) on feathers, blood

MTE pollution (LIENSs):

- assessed in collected soil, feather, blood and parasite samples

Talk : Gauthier Poiriez

Plastics (ECCC, IMRCP):

- Macro & large microplastics (1-5mm) characterized in nest, bolus and feces
- Small microplastics (<1mm) in animal tissues
- Plastic additives in blood, tissues (eg. phthalate ester plasticizers, SDPAs, BZT-UVs)

PhD : Florence Droguet

Parasites (MiVEGEC, Tour du Valat, Oniris):

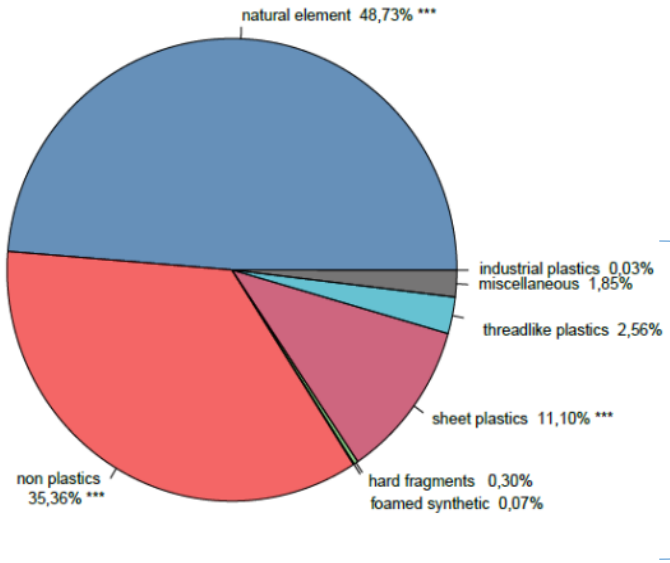
- blood, fecal and tick samples
  - Bacteria + viruses: metabarcoding
  - Blood parasites
  - Endoparasites in animal tissues (necropsies) + barcoding on eggs in fecal samples

PhD : Thibaut Langlois

Necropsies (MiVEGEC, Tour du Valat):

- Diverse tissues from adult and juvenile birds (n=38)

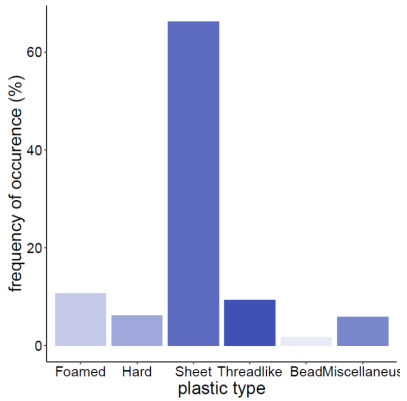
Plastic ingestion over the breeding season



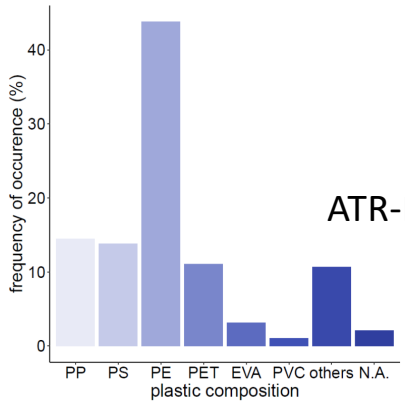
Plastics
15,89%

Carteau 2020 (n=143)

66% sheet plastic



44% PE



ATR-FTIR

Pre-hatching	Post-hatching
(n=82)	(n=61)
2.26 (1.95-2.61) →	0.76 (0.60-0.97)

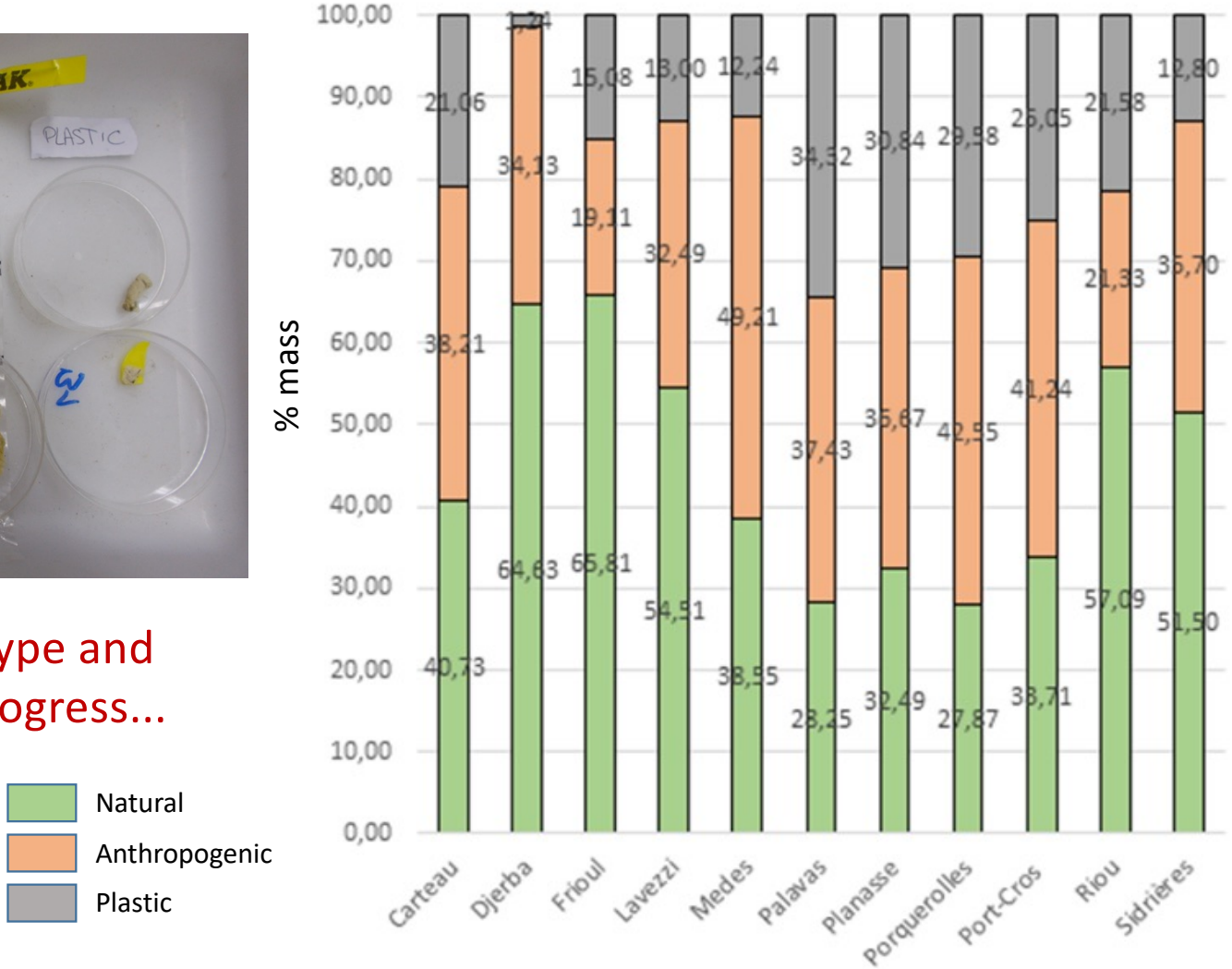
Plastic items/bolus

→ dominated by food packaging

Inter-colony variation in plastic ingestion ?

n = 281 boluses

Analyses of number, type and origin per colony in progress...



Microplastic accumulation ?



N= 38 YLG

LMP (1-5 mm) = large microplastics

↓

Isolation

↓

ATR-FTIR

SMP (0,001-1 mm) = small microplastics

↓

Digestion

↓

Filtration

↓

Cryo-milling

↓

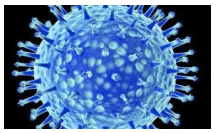
Pyrolysis-gc-ms

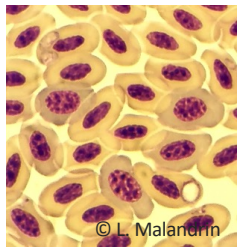
Results coming soon !

Parasites & pathogens

- Observe and quantify
- Identify
- Analyse spatial structure







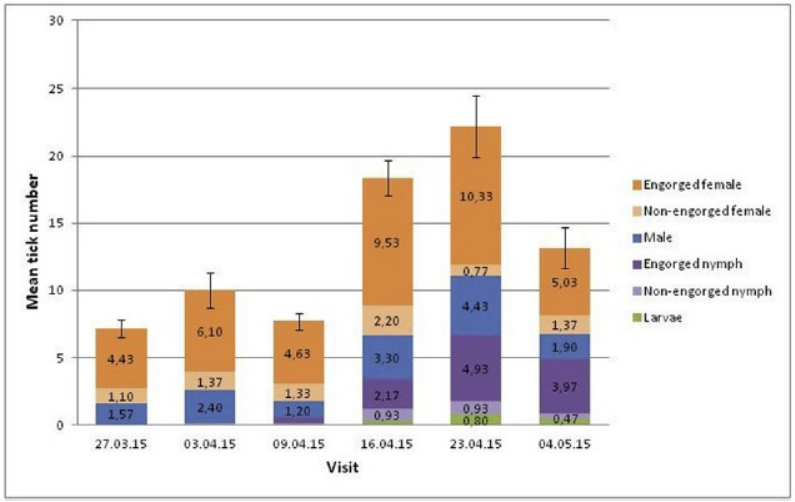
Ornithodoros (Carios) maritimus : Colonial seabird tick

- Soft tick (Family *Argasidae)*
  → *O. capensis* s.l. species complex
- Colonial seabirds of the Mediterranean and North Atlantic coast
- Polyphasic cycle: 3 developmental stages (larvae, nymph, adult), with 3-4 nymphal instars
- Short and numerous blood meals (minutes to a few hours) at night
- Endophilic life style

Ticks prevalent & abundant within YLG colonies

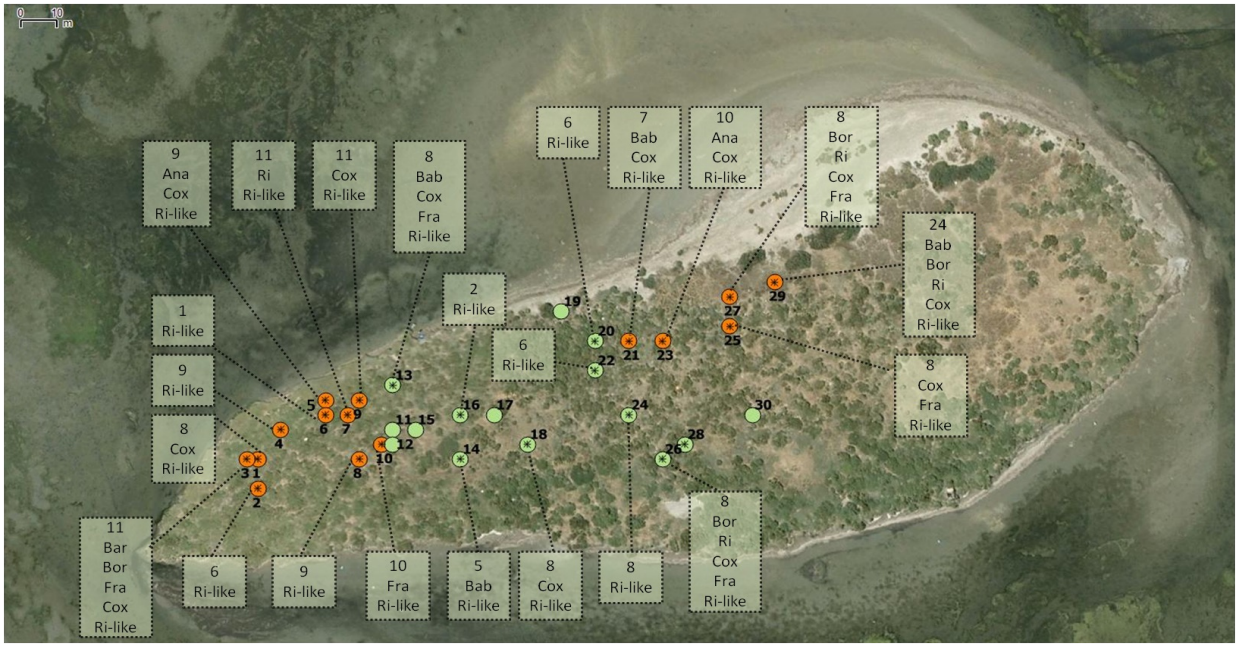
Presence of *O. maritimus* in western Mediterranean YLG colonies (19/23 = 82,6%)

Seasonal changes in abundance of different life stages of *O. maritimus* at the Carteau YLG colony (Dupraz et al. 2017)



Diversity of tick-borne infectious agents (Dupraz et al. 2017, IJP)

- Bacteria: *Anaplasma spp*, *Bartonella henselae*, *Borrelia spp*, *Coxiella spp*, *Francisella spp, Rickettsia spp.*
- Protozoa: *Babesia sp*
- Virus: Flavivirus, proche à West Nile

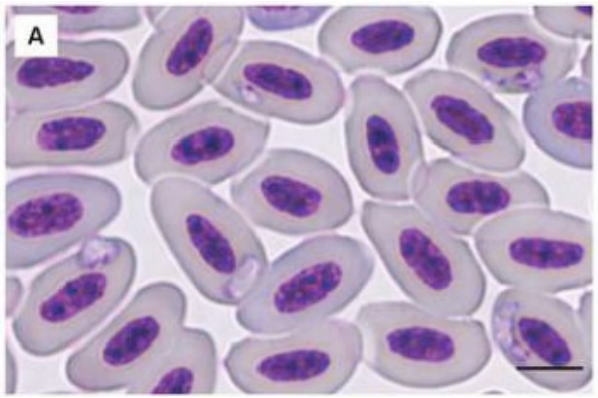


Other infectious agents and other locations ?

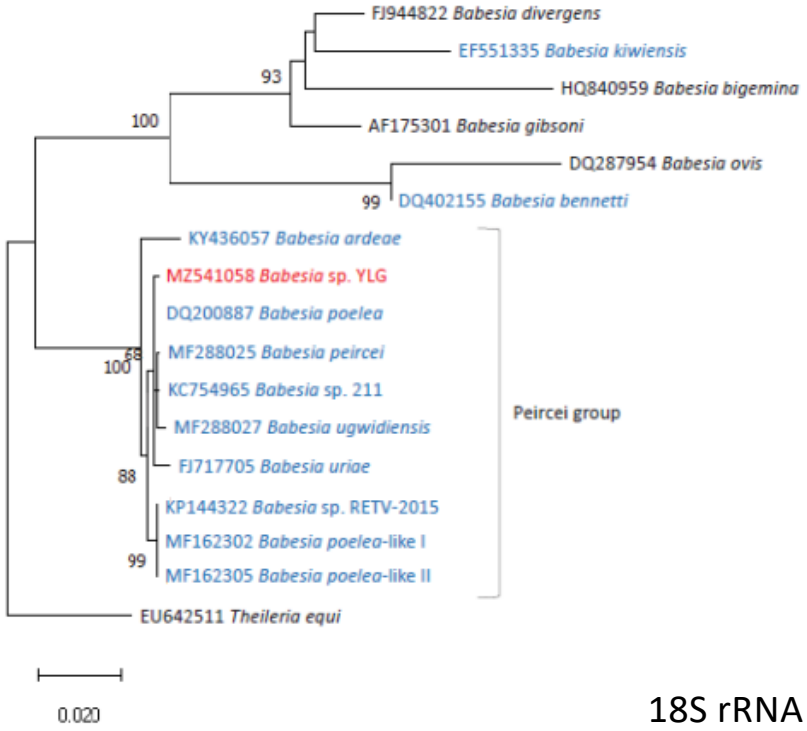
Babesia sp. YLG, a new member of the Peircei group

(Bonsergent *et al*. 2021 TTBD)

Molecular (18S rRNA, COX1) and morphological characterisation



High prevalence in chicks (Carteau 2019 – 85%; 2020 – 58%)
High intensities of infection (up to 20% of erythrocytes)
No obvious clinical signs



18S rRNA

Tick-borne ? *Inter-colony variation?*

Objective 2:

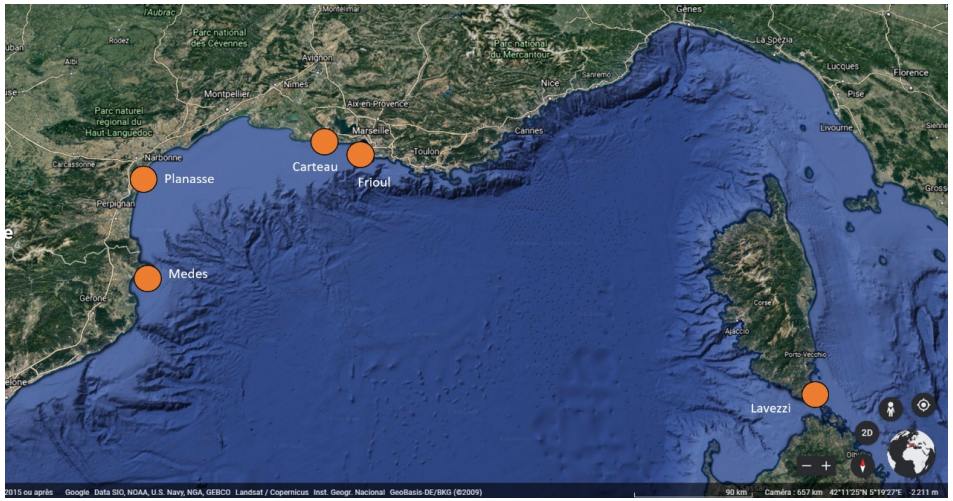
Assessing impact on seabird demographics & movement

3 years: 2022, 2023, 2024

Within colony demography [N = 5 YLG colonies]

Effect pollutants + parasites on seabird fitness (growth and survival estimates) ?

Simple cumulative? Synergistic ? Interactive (beneficial) ?



30 nests per colony:

- ~one visit per week (2-3 hours)
- Adult captures (5-10 GPS trackers)
- Chicks followed individually (5-10 GPS trackers)
- Nest condition (ticks, bolus, macroplastics)
- Collect cadavres

All Years

Seabird movement & dispersal

Population genetic structure of YLGs [CEFE]

- 9 Microsatellites
- 2 mtDNA genes

(add to existing dataset of 18 locations, only 6 within Mediterranean Sea)

- Comparison with parasite/pathogen structure (WP5)

GPS trackers [TdV, MiVEGEC, UB]

- Adults + juveniles
- Continuous data on date, time, location per individual recovered via GSM cellular network (>20g)
  (longevity 2- 3 years)
- Carteau, Medes in 2021; other colonies in 2022
  (Follow all types of movement + associated behaviours)

Multistate CMR modeling [CEFE]

- Historical ringing data (N. Sadoul)
- New data (survival, recruitement, movement)

OrniTrack-20 - solar powered GPS-GSM (4G)

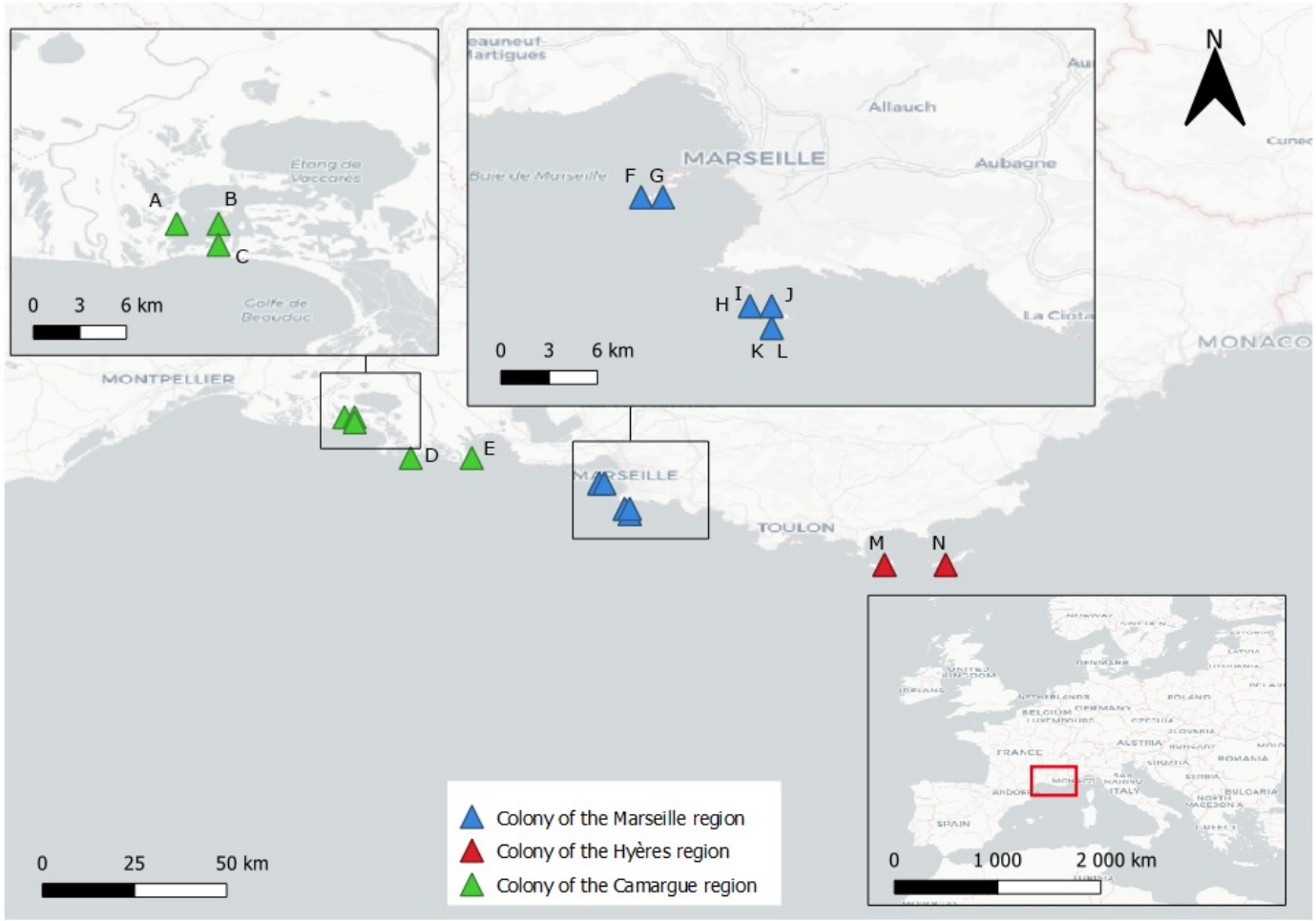
Intercolony differences in survival and movement

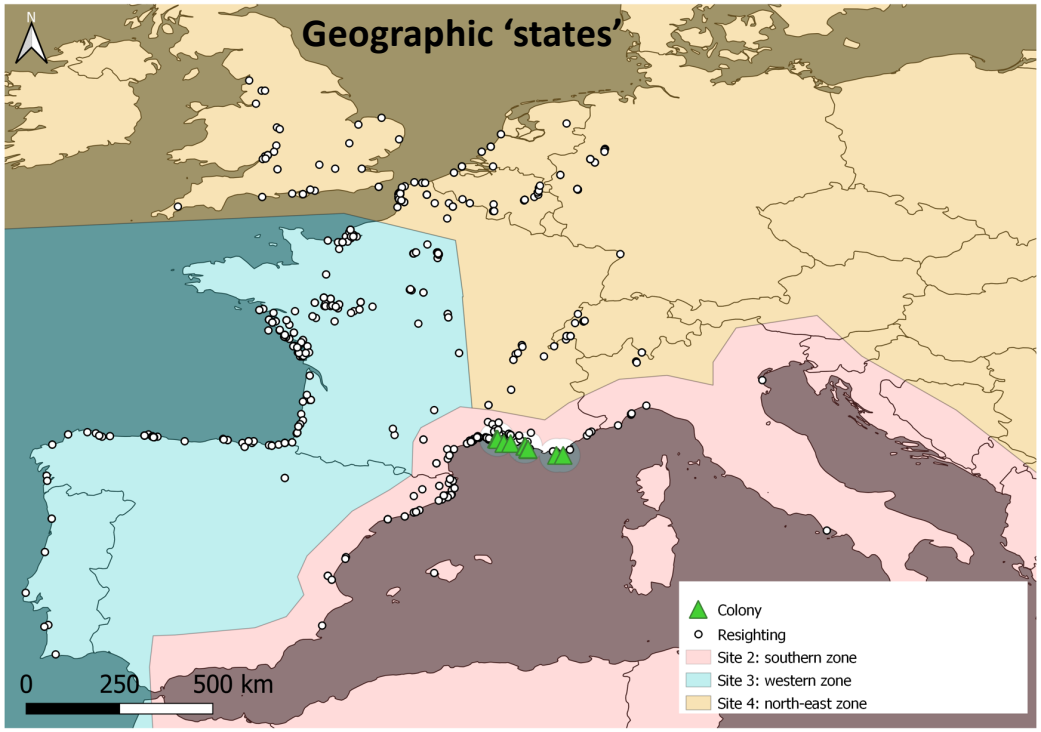
Data

- 5158 individuals
- 14 different colonies
- ringed between 1999 -2004
- Resighting data until 2011

Multi-event CMR model (Pradel 2009)

- calculate age-specific movement probabilities among geographical ‘states’ (accounting for detection and survival probabilities)
- Model selection procedure from 42 alternative models





Survival ?

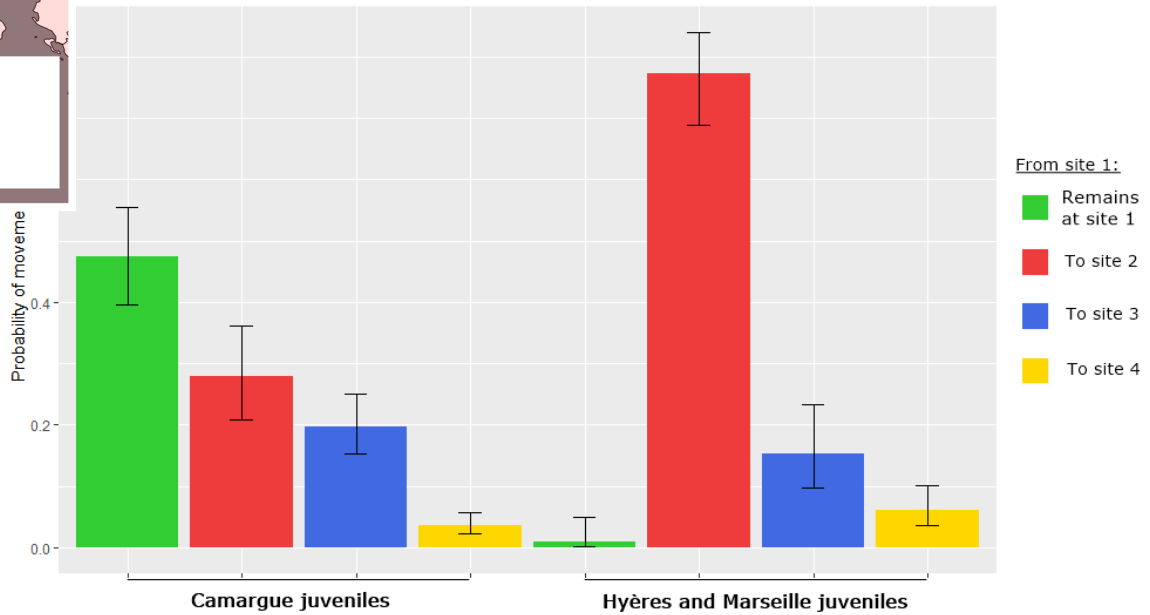
Adult: Hyères/Marseille **0.84** [0.80-0.86]
Camargue **0.89** [0.87-0.90]

Juvenile: Hyères/Marseille **0.43** [0.45-0.51]
Camargue **0.83** [0.72-0.92]

Movements ?

>76% Adults sedentary Post-fledgling

New data ?



Impacts - Perspectives

1. Distribution of pollutants in the Mediterranean Sea
   - Origins and movements

2. Diversity and distribution of seabird parasites and pathogens
   - Public health risks?

3. Seabird ecology and effect of combined stress on demography
   - Control strategies – nuisance species / zoonoses

Interactions with wildlife managers

8 – 10 nov 2021: Atelier « *Combined effects of pollutants and parasites on seabird health and population dynamics* » à la Tour du Valat

RÉGION SUD PROVENCE ALPES CÔTE D'AZUR

Version 2 - nov 2022 !

Tour du Valat

cnrs

OFB OFFICE FRANÇAIS DE LA BIODIVERSITÉ

Questions ?

Data for 2021:

OrniTrack-20 - solar powered
GPS-GSM (4G)

Carteau

6 adults; 3 fledglings

Adults - 2 dead, 1 defective,
- 1 Orléans, 1 Toulouse, 1 near Carteau (29/09/2021)

Juveniles - 1 dead
- 2 near Millau (29/09/2021)

Medes

5 fledglings

- 2 dead
- 2 defective loggers
- 1 alive? (not emitting)

Workshop overview

Objectives:

→ better understand the status of seabird populations in relation to pollution/infectious agents and to seabird/human society conflicts

→ develop a synergy in terms of methodologies used to advance scientific and management objectives

→ open up an exchange between researchers and managers

- researchers can benefit from the practical knowledge of managers and better appreciate field-based priorities,
- managers can participate in research actions and integrate results more into management strategies

	Lundi 8 Novembre	Mardi 9 Novembre	Mercredi 10 Novembre
Matin	Arrivée	Session Suivis de l'exposition des oiseaux marins aux polluants et au pathogènes	Sessions d'échanges : Quelles synergies et quelles priorités communes entre recherche et gestion
12h	Déjeuner – Cantine TdV	Déjeuner – Cantine TdV	Déjeuner – Cantine TdV
Après-midi	Accueil – Fonctionnement des populations d'oiseaux marins et pollution en Méditerranée	Session autres suivis en cours et enjeux de terrain	Départ

Colonie	Nombre de bolus	Nombre de plastique	Nombre moyen de plastique par bolus
Carteau	143	263	1.84
Djerba	16	19	1.19
Planasse	16	69	4.31
Medes	15	27	1.80
Palavas	15	21	1.40
Porquerolles	15	56	3.73
Port-Cros	15	65	4.33
Sidrières	15	79	5.27
Frioul	12	35	2.92
Lavezzi	10	32	3.20
Riou	9	58	6.44
Total	281	724	2.58

Table 2: Timing of the different ringing operations and number of chick ringed in the studied Yellow-legged Gull colonies. The different colony regions are highlighted in different colours: green: Camargue colonies, blue: Marseille colonies, orange: Hyères colonies.

Colony	1999	2000	2001	2002	2003	2004	Total number of ringed individuals
Besson	0	323	349	284	0	0	956
Flamants	180	232	149	172	0	0	733
Banaston	183	0	0	0	0	0	183
Salin de Giraud	472	397	0	0	0	0	869
Pégoulier	0	0	0	200	196	0	396
Pomeges	0	0	51	15	191	0	257
Ratonneau	0	0	16	0	0	0	16
Jarre	112	0	0	0	0	0	112
Plane	202	59	154	111	181	0	707
Riou	34	23	122	66	140	0	385
Jarron	4	0	0	0	0	0	4
Congloue	0	63	0	0	0	0	63
Bagaud	0	78	58	28	42	44	250
Porquerolles	67	50	56	54	0	0	227

Population genetic structure of *O. maritimus* in the north-western Mediterranean (Master's project: E. CONTE)

- Sampling:

2012-2015

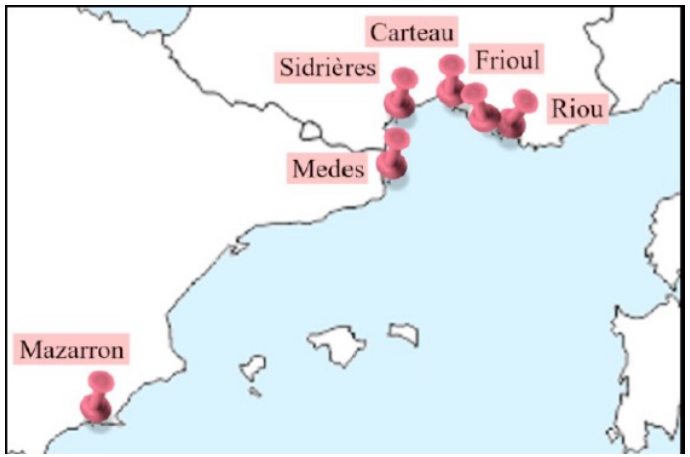
6 colonies, avg. 27 ticks/colony

N_{total} = 162 adult ticks

SNP markers

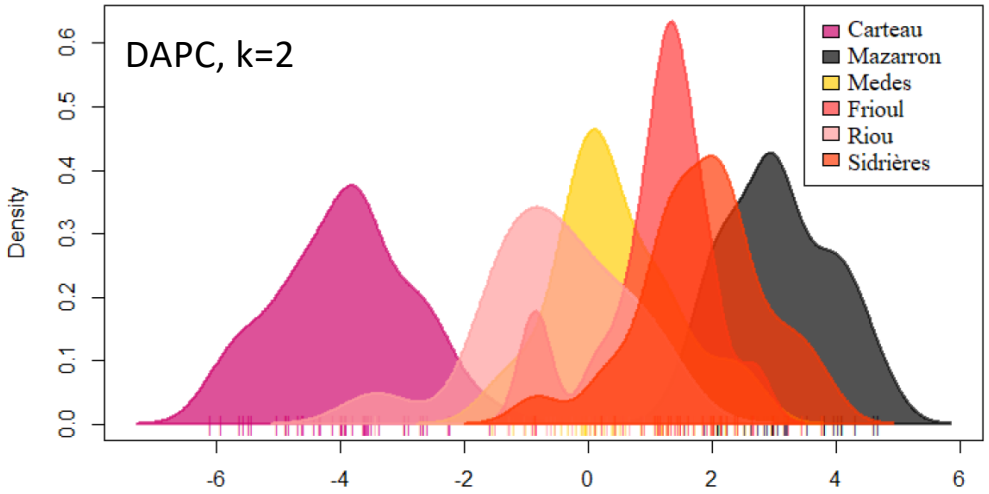
- 53 markers

Population genetic structure of *O. maritimus*

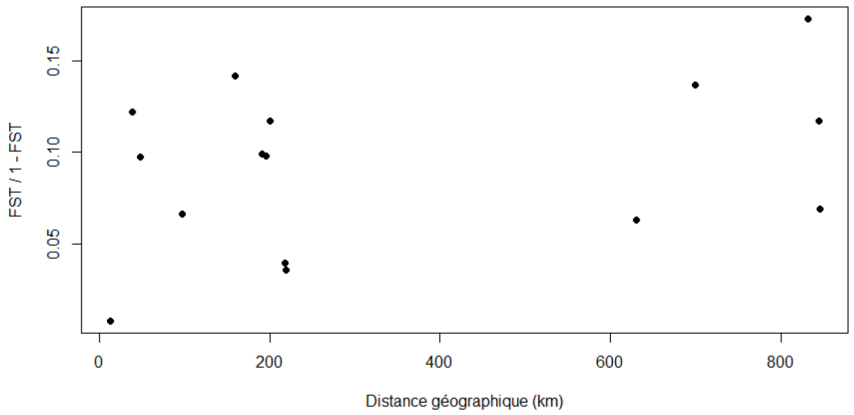


No linkage disequilibrium among markers
No deviation from HW equilibrium
avg F_{IS} = 0.036 (±0.012), P > 0.05

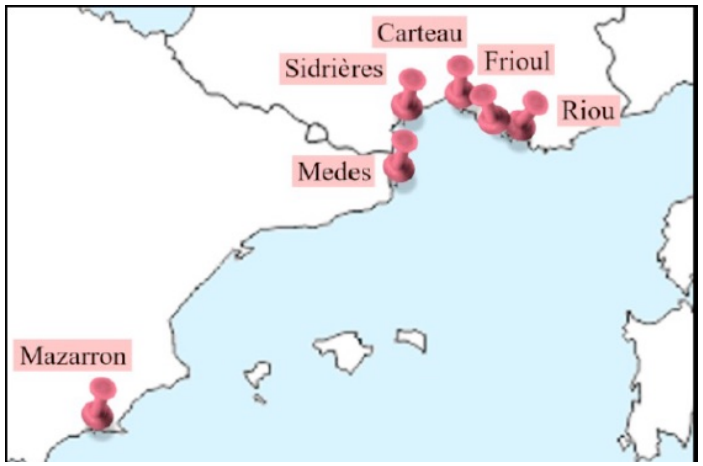
Significant structure among colonies
FST = 0.10 (±0.011), P < 0.001

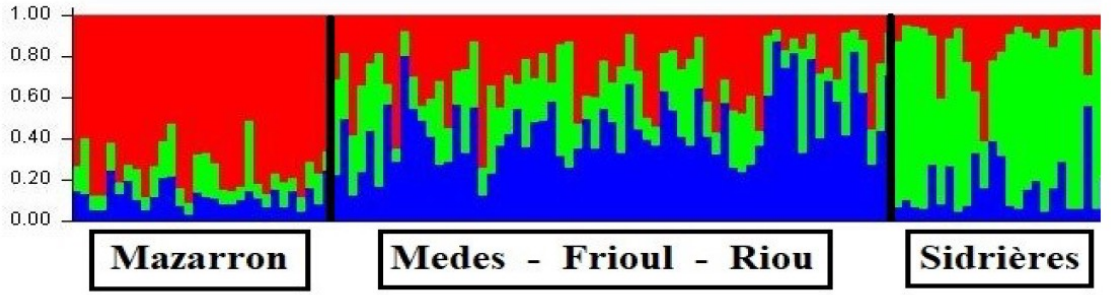


No pattern of isolation by distance (P=38)



Population genetic structure of *O. maritimus* (without Carteau)

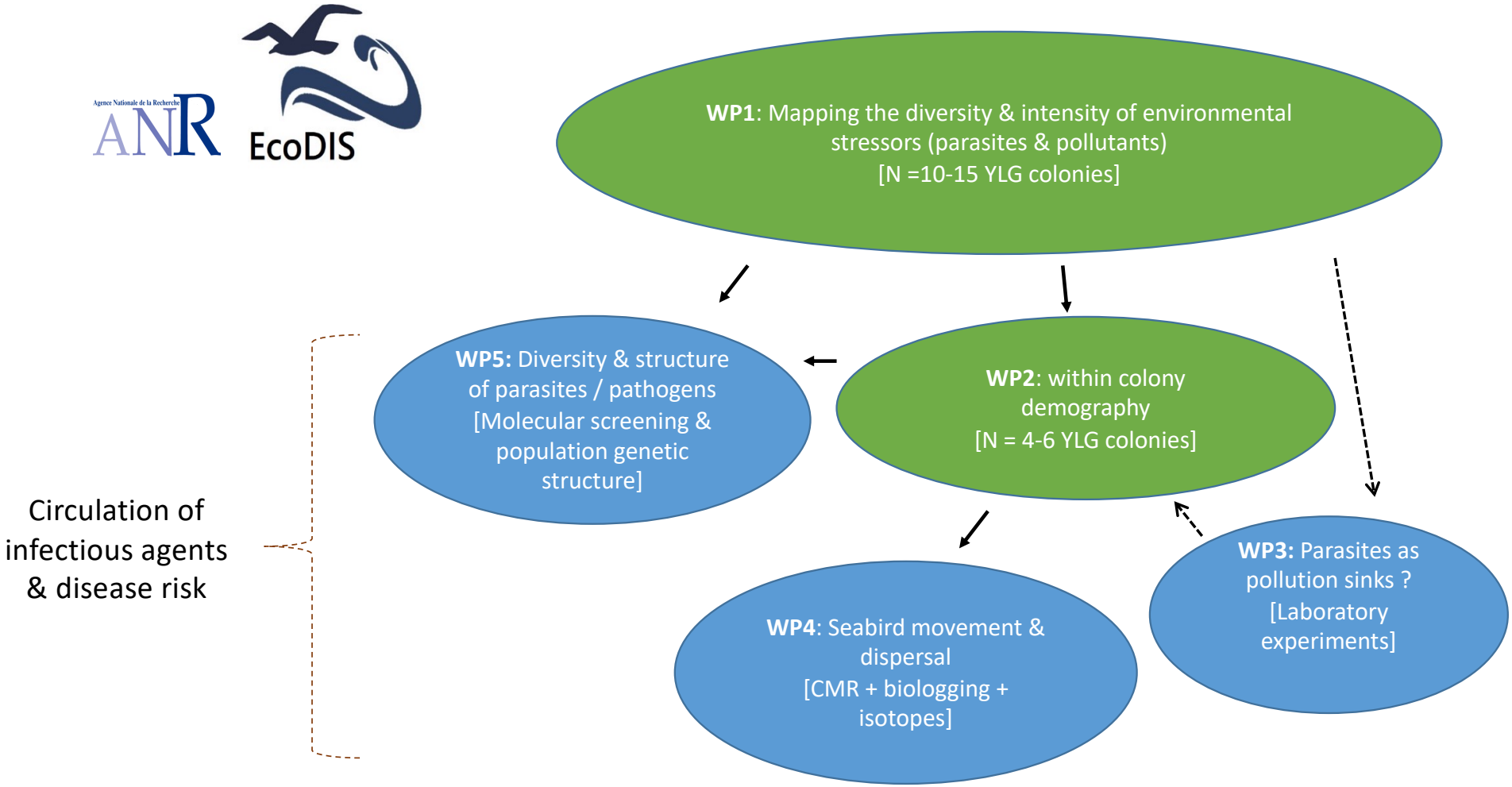




Cluster analysis in STRUCTURE without Carteau (k=3)

Significant structure still present, but not based on coastal distance.

Tick survival or gull movement patterns ?


EcoDIS
WP1: Mapping the diversity & intensity of environmental stressors (parasites & pollutants) [N =10-15 YLG colonies]
WP5: Diversity & structure of parasites / pathogens [Molecular screening & population genetic structure]
WP2: within colony demography [N = 4-6 YLG colonies]
WP4: Seabird movement & dispersal [CMR + biologging + isotopes]
WP3: Parasites as pollution sinks ? [Laboratory experiments]
Circulation of infectious agents & disease risk