

A primer on Ecological Statistics



Tiago A. Marques





Tiago André Marques

@TiagoALOMarques



Today I'll represent [@CEstatisticAUL](#) in CMAFclO ([@FC_UL](#) maths research group) open day with "A primer on Ecological Statistics". Other talks seem rather purer (!) with "Riemann Hypothesis", "Robin Laplacian", "Jordan arrays", "Narayana identity" or "non-archimedean fields" (1/3)



8:17 AM · Sep 9, 2020 · Twitter Web App



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@TiagoALOMarques

Almost like a clash of civilizations, akin to "Close Encounters of the Third Kind", different languages and ways of communication. Yet, we are all scientists, so I am hoping that it will be an interesting experience and I thank Luis Gouveia for the opportunity to engage. (2/3)



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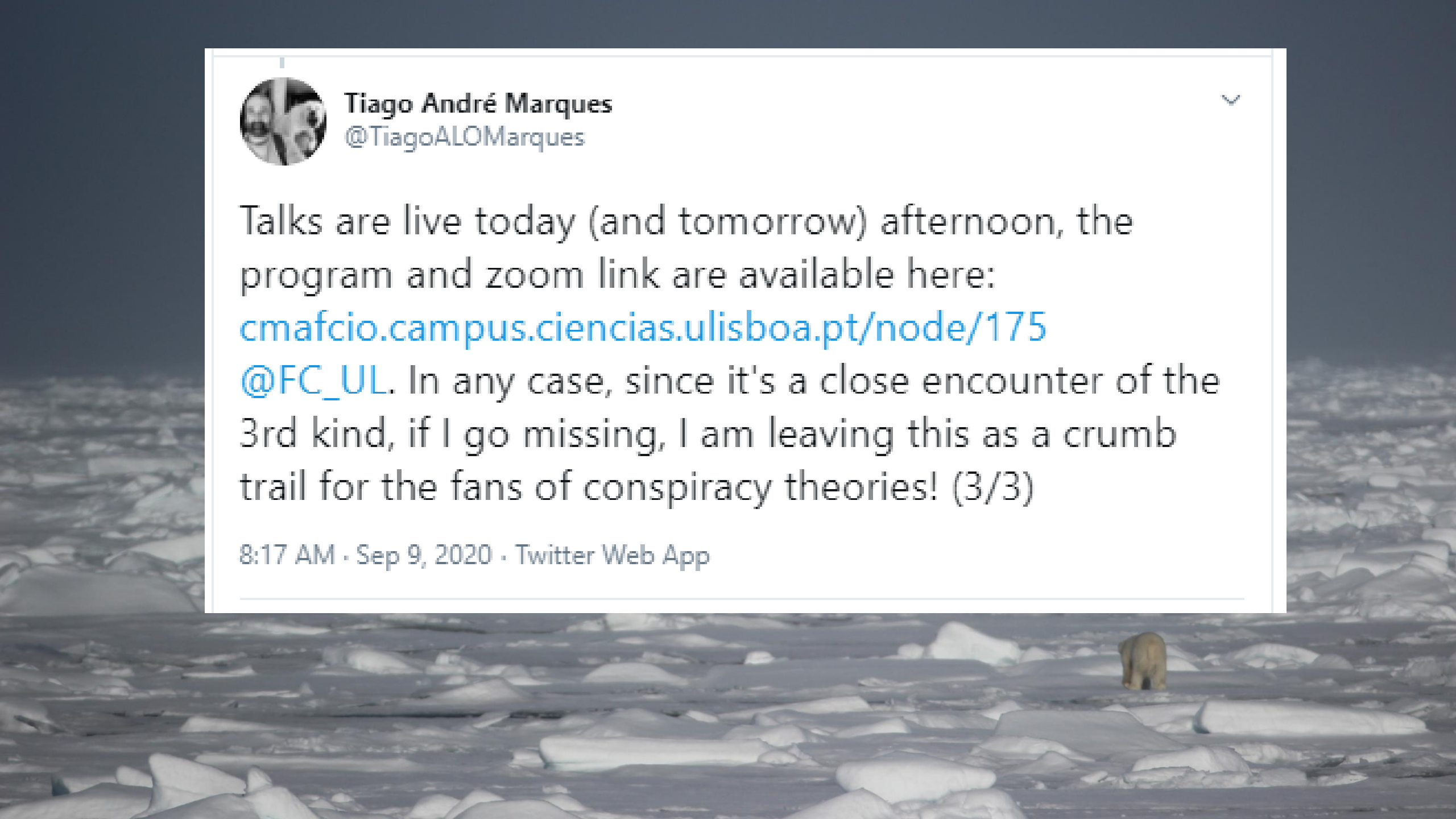


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Talks are live today (and tomorrow) afternoon, the program and zoom link are available here: cmafcio.campus.ciencias.ulisboa.pt/node/175 @FC_UL. In any case, since it's a close encounter of the 3rd kind, if I go missing, I am leaving this as a crumb trail for the fans of conspiracy theories! (3/3)

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GlobalChangeBiology

@GlobalChangeBio

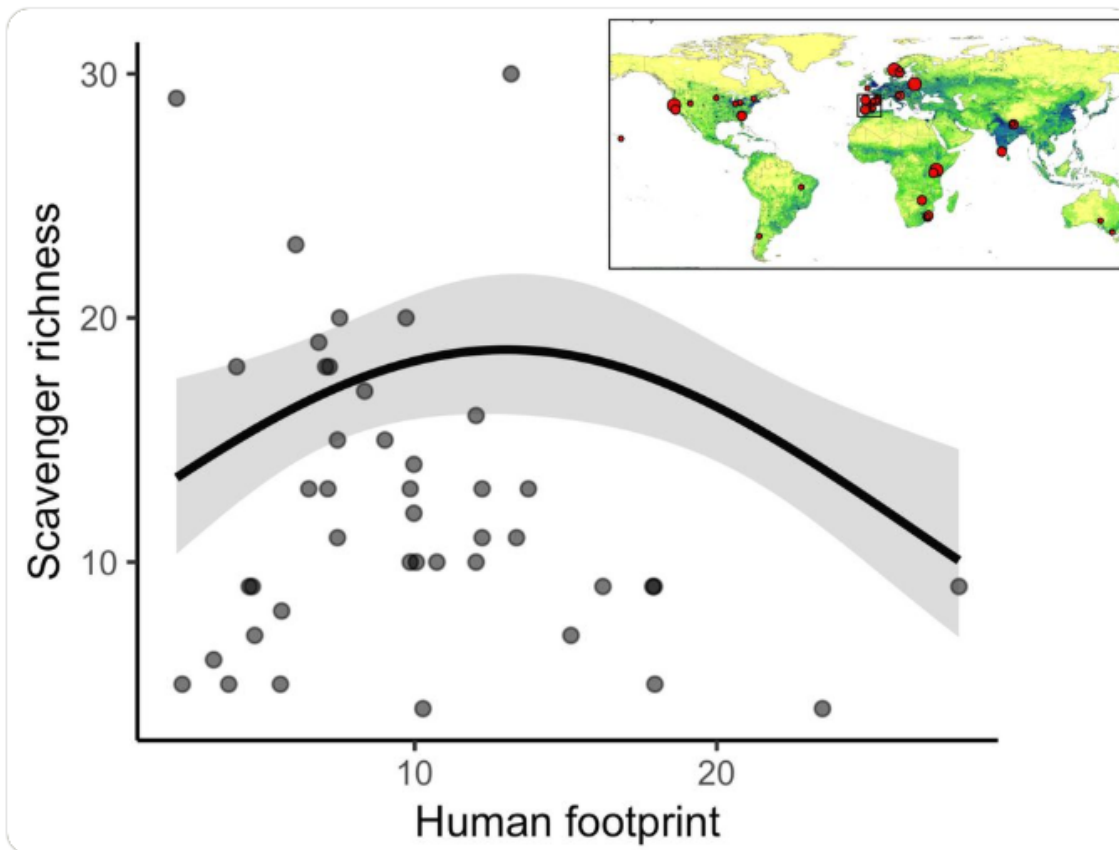
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EARLY VIEW


Scavenging in the Anthropocene: Human impact drives vertebrate scavenger species richness at a global scale

 buff.ly/2LtWnSx



PRIMARY RESEARCH ARTICLE

Scavenging in the Anthropocene: Human impact drives vertebrate scavenger species richness at a global scale

Esther Sebastián-González , Jomar Magalhães Barbosa, Juan M. Pérez-García, Zebensui Morales-Reyes, Francisco Botella, Pedro P. Olea, Patricia Mateo-Tomás, Marcos Moleón, Fernando Hiraldo, Eneko Arrondo, José A. Donazar, Ainara Cortés-Avizanda, Nuria Selva, Sergio A. Lambertucci, Aishwarya Bhattacharjee, Alexis Brewer, José D. Anadón, Erin Abernethy, Olin E. Rhodes Jr, Kelsey Turner, James C. Beasley, Travis L. DeVault, Andrés Ordiz, Camilla Wikenros, Barbara Zimmermann, Petter Wabakken, Christopher C. Wilmers, Justine A. Smith, Corinne J. Kendall, Darcy Ogada, Evan R. Buechley, Ethan Frehner, Maximilian L. Allen, Heiko U. Wittmer, James R. A. Butler, Johan T. du Toit, John Read, David Wilson, Klemen Jerina, Miha Krofel, Rich Kostecke, Richard Inger, Arockianathan Samson, Lara Naves-Alegre, José A. Sánchez-Zapata ... [See fewer authors](#) ^

First published: 25 May 2019 | <https://doi.org/10.1111/gcb.14708>



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Tiago André Marques @TiagoALOMarques · 19h

When more authors than data points can't avoid a disaster...



andy royle @andyroyle_pwrc

Polynomial regression for the win twitter.com/globalchangebi...



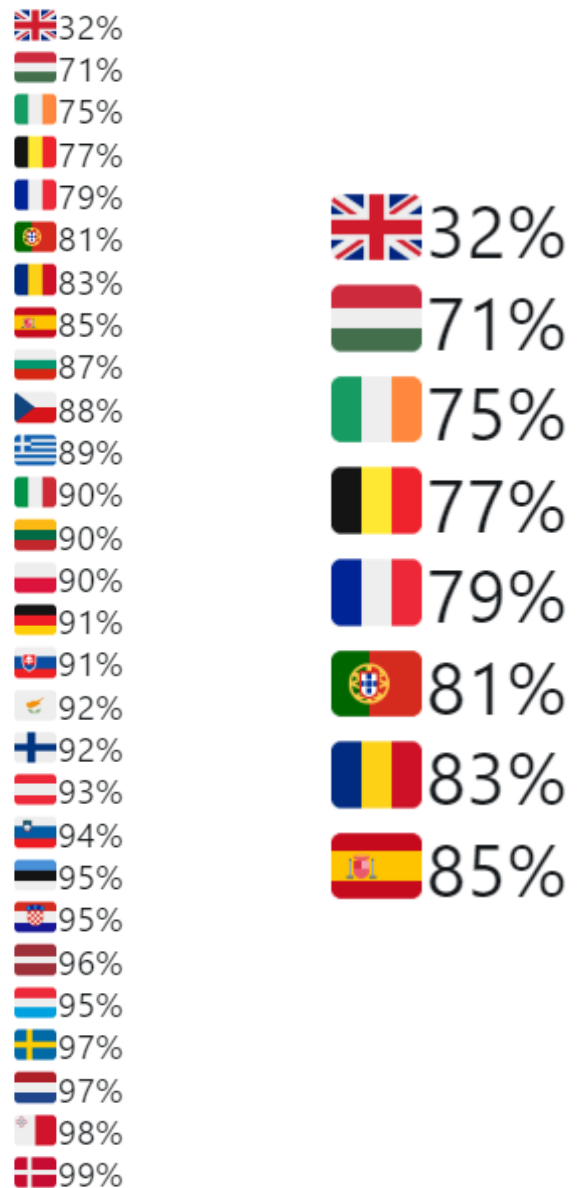
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% of people aged 15 - 30 who say they can read & write in at least one foreign language:



People tend to overinterpret numbers

So many filters...

- Self reported values
- No reported variance

Variance propagation in multi-stage analysis




Most of my work revolves around...

- Estimation of animal abundance
- Distance sampling
- Passive acoustic density estimation
- Using statistics for improved ecological inferences

Statistics & Ecology



Context: Who am I ?

- 1998: **Biology** degree at DBA (then D7A) FCUL
 - Around 2001 - Monitor @ Departamento de Matemática, FCUL
 - 2002: MSc in Probability and **Statistics** @ DEIO, FCUL
 - 2007: PhD in **Statistics** @ University of St Andrews(UStA)
 - Research Fellow/Senior Research Fellow @ School of Maths and **Stats** @ UStA
 - Member of *Centro de Estatística e Aplicações*, UL
 - 2017/2019: *Professor Auxiliar convidado* @ D**Estatística**IO
 - 2018/2019: *Professor Auxiliar convidado* @ D**Biologia**A 
- (Responsible for *Modelação Ecológica* and *Ecologia Numérica*)

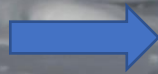
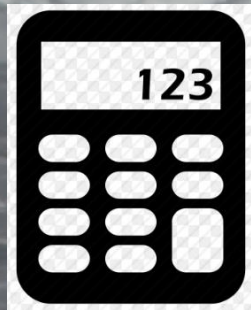
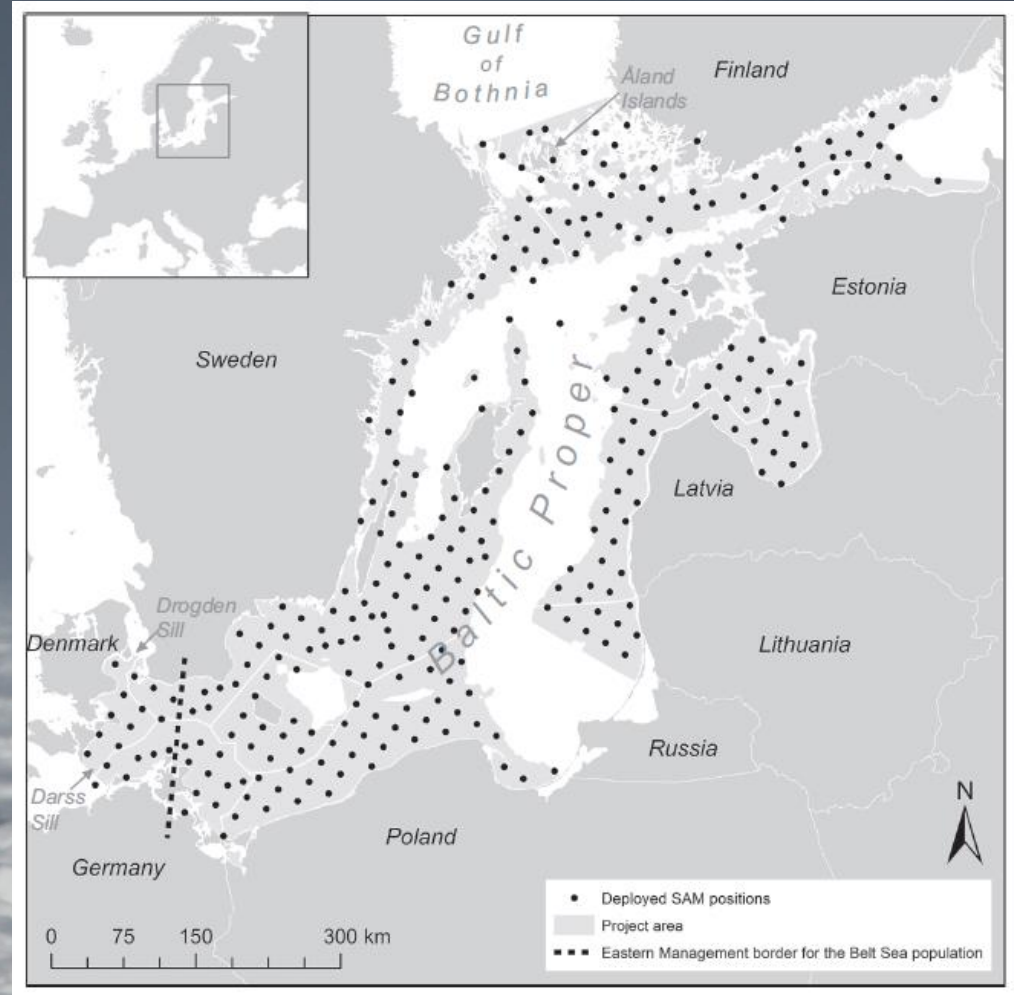


SAMBAH

Static Acoustic Monitoring of
the Baltic Sea Harbour
Porpoise – ultimate goal to
secure conservation of the
Baltic Sea harbour porpoise.

+/- 300 C-PODS

450 years of acoustic data!



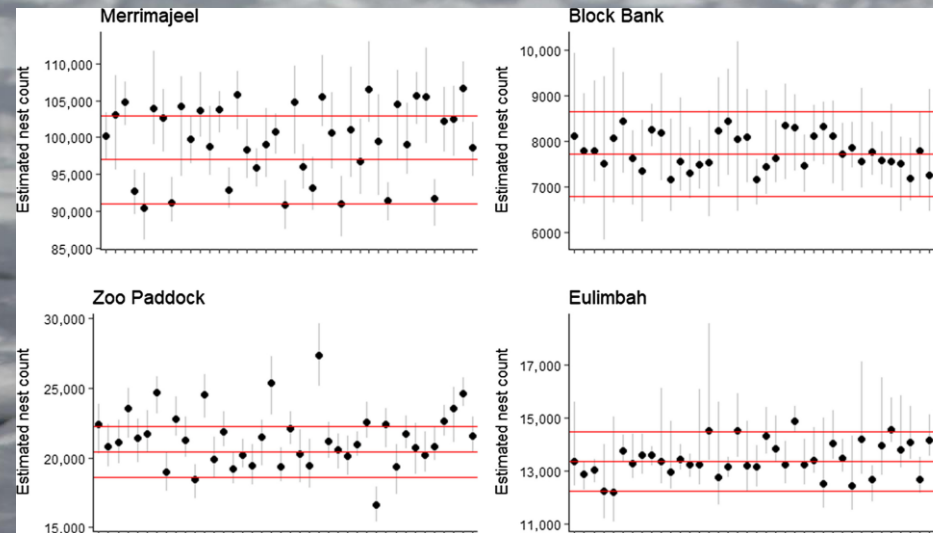


Monitoring large and complex wildlife aggregations with drones

Mitchell B. Lyons , Kate J. Brandis, Nicholas J. Murray, John H. Wilshire, Justin A. McCann, Richard T. Kingsford, Corey T. Callaghan

First published: 19 April 2019 | <https://doi.org/10.1111/2041-210X.13194>

“The smallest colony had a manual count of 7,717 nests and the largest colony had 96,989 nests, and with an estimated population of over 200,000 birds...”



Machine learning
random forest classifier

Acoustics, drones, camera traps, environmental DNA, biologging, citizen science, etc.

- All are based on new technological advances
- All generate massive amounts of data
- Require bespoke ways for
 - Data processing
 - Data analysis



Addressing statistical challenges of modern technological advances

ICMS, Bayes Centre, 47 Potterrow, Edinburgh EH8 9BT

24 - 28 June 2019

Summary



Technology and citizen science are introducing far-reaching changes to how biodiversity is monitored. Better models are needed to allow reliable inferences from the resulting data.



Addressing statistical challenges of modern technological advances

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24 - 28 June 2019



International Statistical Ecology Conference



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International Statistical Ecology Conference

<http://www.isec2020.org/>



Statistical ecology comes of age

Olivier Gimenez¹, Stephen T. Buckland², Byron J. T. Morgan³, Nicolas Bez⁴, Sophie Bertrand⁴, Rémi Choquet¹, Stéphane Dray⁵, Marie-Pierre Etienne⁶, Rachel Fewster⁷, Frédéric Gosselin⁸, Bastien Mérigot⁹, Pascal Monestiez¹⁰, Juan M. Morales¹¹, Frédéric Mortier¹², François Munoz¹³, Otso Ovaskainen¹⁴, Sandrine Pavoine^{15,16}, Roger Pradel¹, Frank M. Schurr¹⁷, Len Thomas², Wilfried Thuiller¹⁸, Verena Trenkel¹⁹, Perry de Valpine²⁰ and Eric Rexstad²

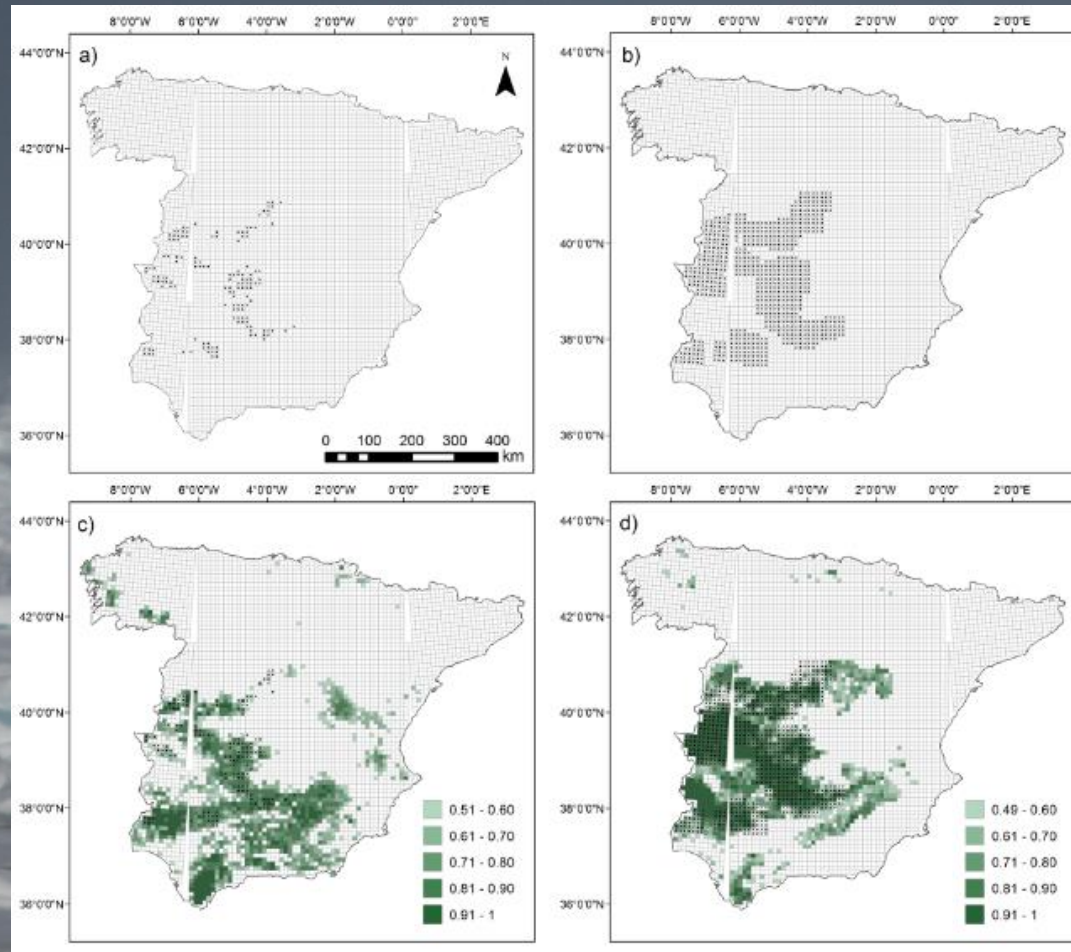
¹CEFE UMR 5175, CNRS, Université de Montpellier, Université Paul-Valéry Montpellier, EPHE, 1919 Route de Mende, 34293 Montpellier Cedex 5, France

²Centre for Research into Ecological and Environmental Modelling, University of St Andrews,

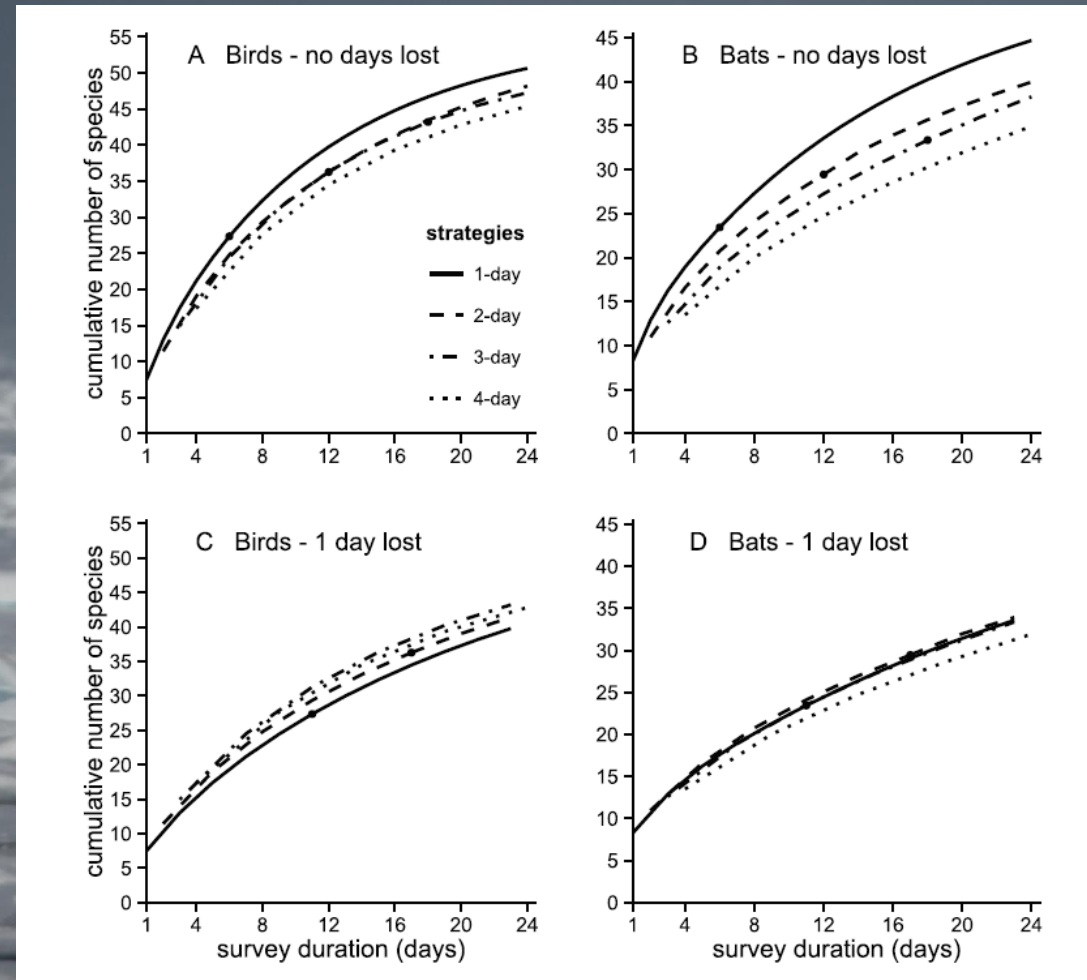
The desire to predict the consequences of global environmental change has been the driver towards more realistic models embracing the variability and uncertainties inherent in ecology. Statistical ecology has gelled over the past decade as a discipline that moves away from describing patterns towards modelling the ecological processes that generate these patterns. Following the fourth International Statistical Ecology Conference (1–4 July 2014) in Montpellier, France, we analyse current trends in statistical ecology. Important advances in the analysis of individual movement, and in the modelling of population dynamics and species distributions, are made possible by the increasing use of hierarchical and hidden process models. Exciting research perspectives include the development of methods to interpret citizen science data and of efficient, flexible computational algorithms for model fitting. Statistical ecology has come of age: it now provides a general and mathematically rigorous framework linking ecological theory and empirical data.



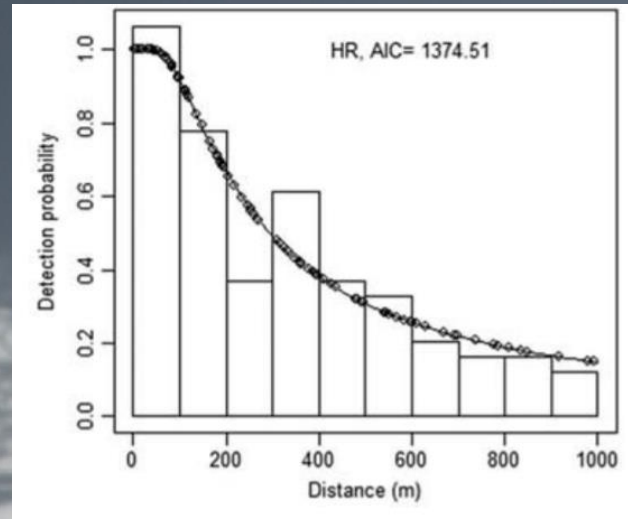
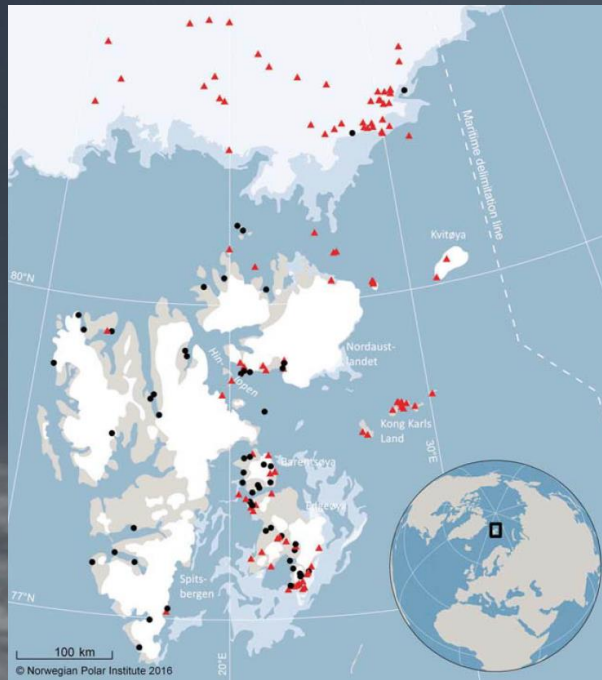
Species distribution modelling



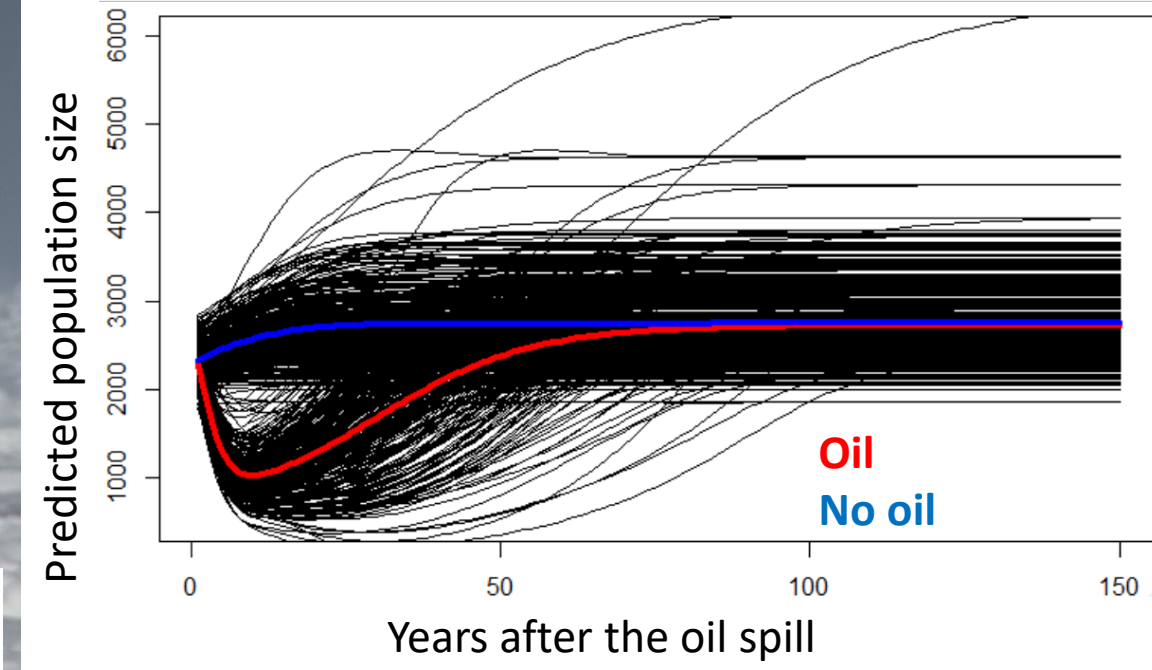
Measuring biodiversity



Investigating population dynamics



Ongoing CARMMA work (dolphins in GOM)

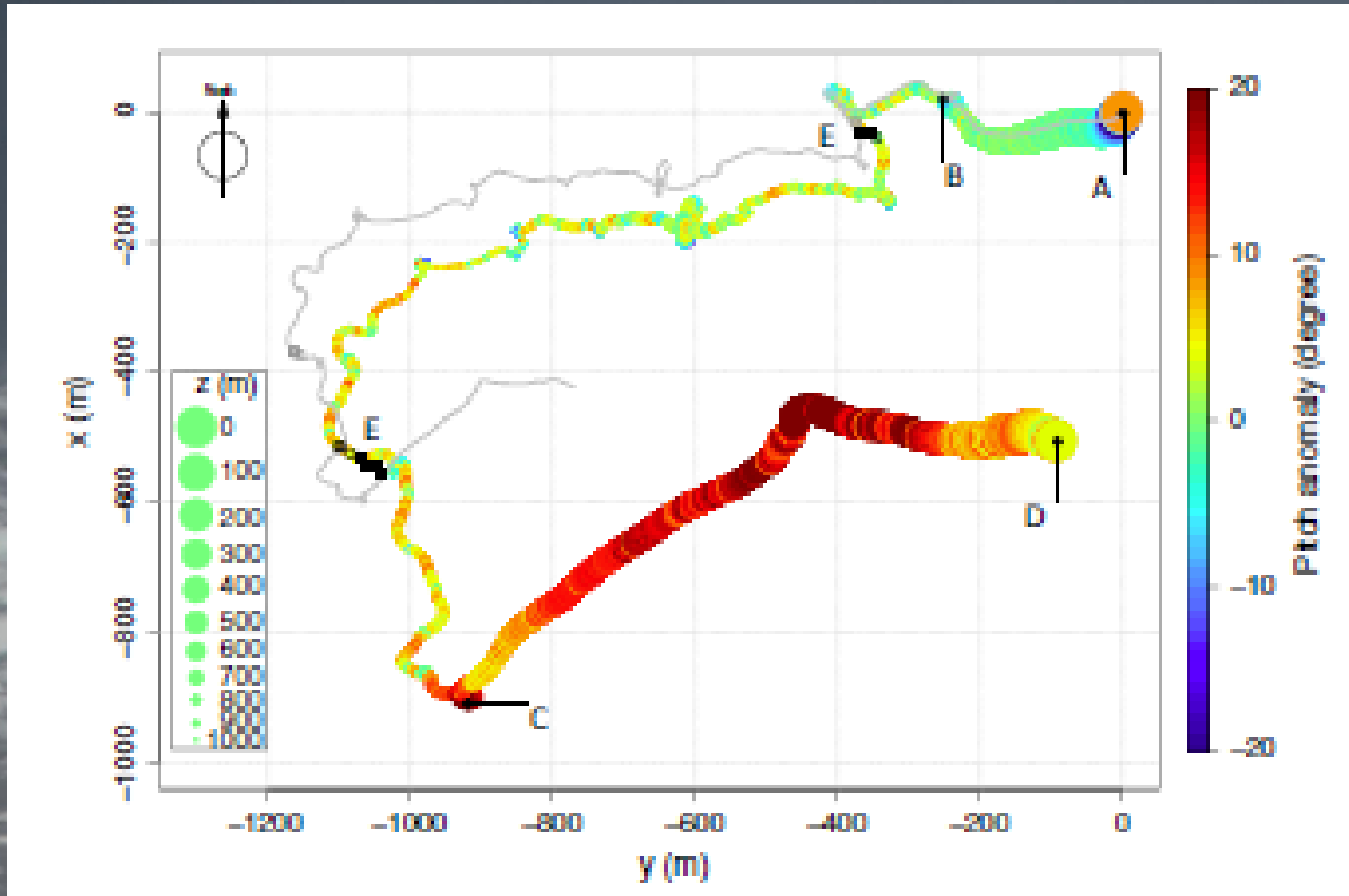


	2004		2015		Change, 2004 to 2015	
	\hat{N}	\hat{N} 95% CI	\hat{N}	\hat{N} 95% CI	$\Delta \hat{N}$	$\Delta \hat{N}$ 95% CI
Svalbard	241	(153, 329)	264	(199, 363)	23	(-97, 143)
Pack Ice	444	(282, 606)	709	(334, 1026)	265	(-117, 647)
Total	685	(501, 869)	973	(665, 1884)	288	(-349, 925)

Aars, J.; Marques, T.; Lone, K.; Andersen, M.; Wiig, Ø.; Fløystad, I. M. B.; Hagen, S. B. & Buckland, S. T. 2017 The number and distribution of polar bears in the western Barents Sea area. *Polar Biology*. **36**: 1374125

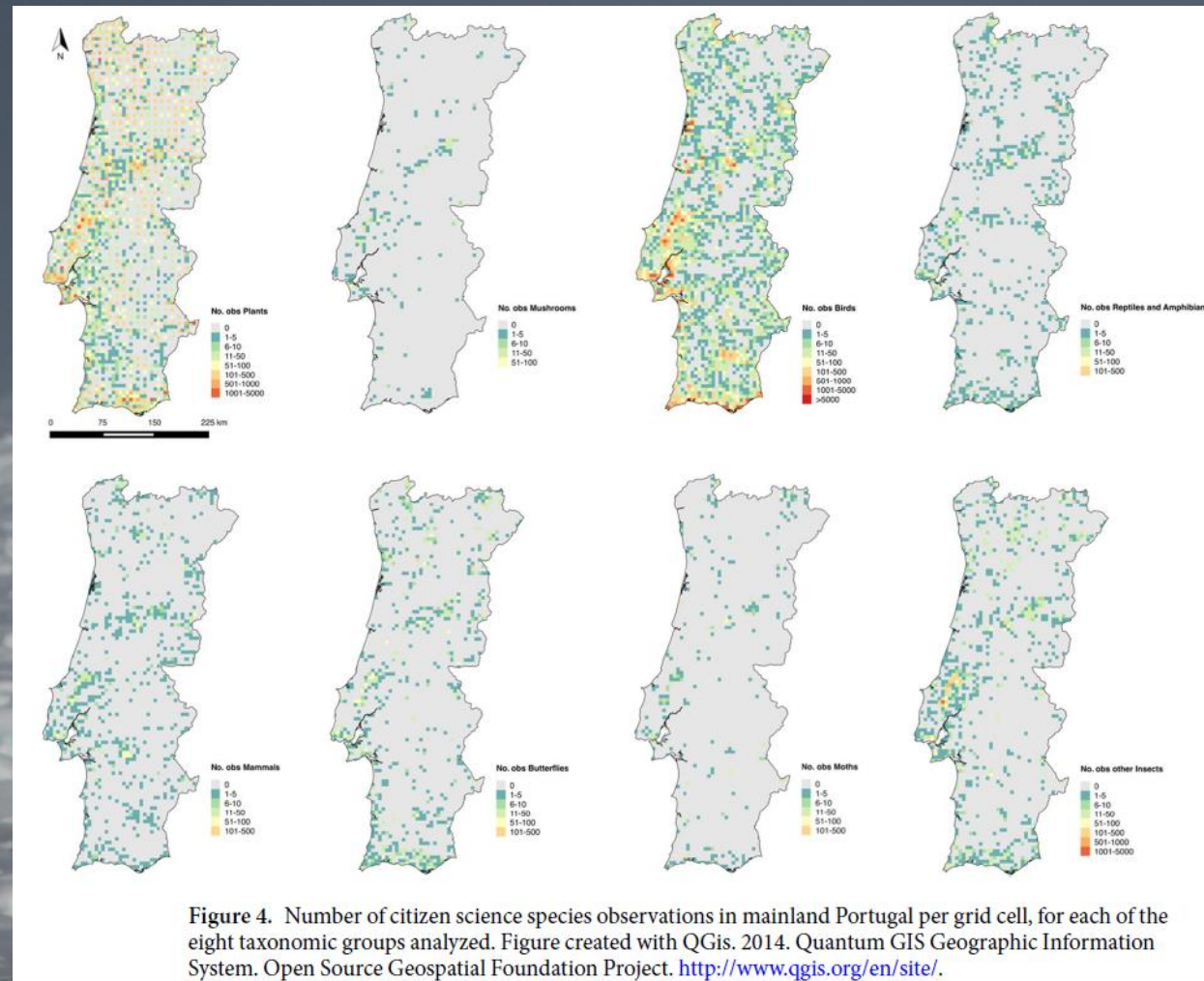


Understanding animal movements



Laplanche, C., Marques, T. A. & Thomas, L. 2015 Tracking marine mammals in 3D using electronic tag data. *Methods in Ecology and Evolution*. **6**: 987–996

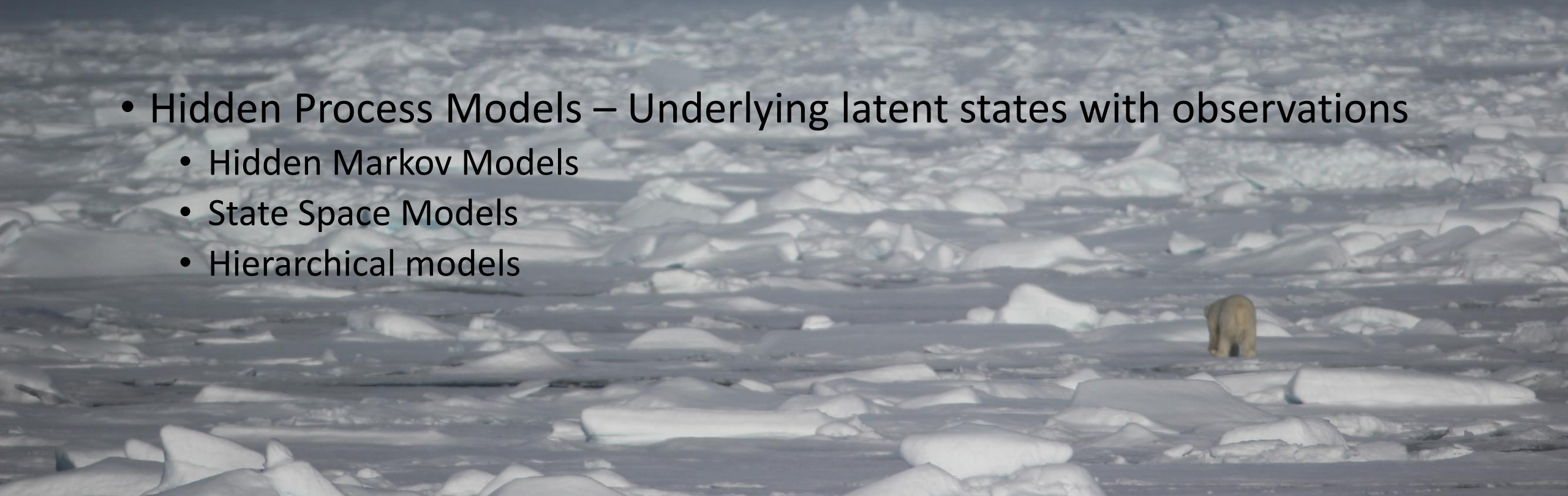
Interpreting citizen science data



Tiago, P., Ceia-Hasse, A. Marques, T. A., Capinha, C. & Pereira, H. M. (2017) Spatial distribution of citizen science casuistic observations for different taxonomic groups. *Scientific Reports*. 7: 12832

Methods

- Ecological statistics is moving away from modelling spatio-temporal patterns per se and towards modelling the ecological processes that generate those patterns.
- Hidden Process Models – Underlying latent states with observations
 - Hidden Markov Models
 - State Space Models
 - Hierarchical models



Flexible and practical modeling of animal telemetry data: hidden Markov models and extensions

ROLAND LANGROCK,^{1,5} RUTH KING,¹ JASON MATTHIOPOULOS,² LEN THOMAS,¹ DANIEL FORTIN,³ AND
JUAN M. MORALES⁴

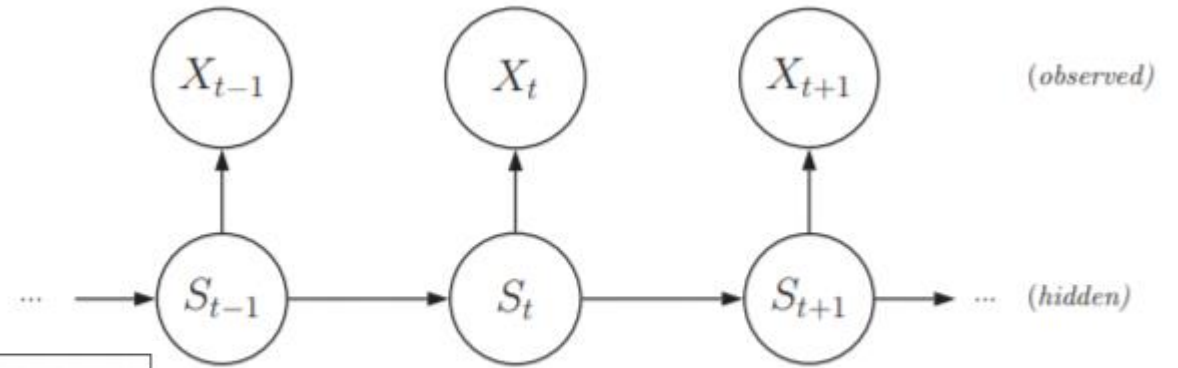
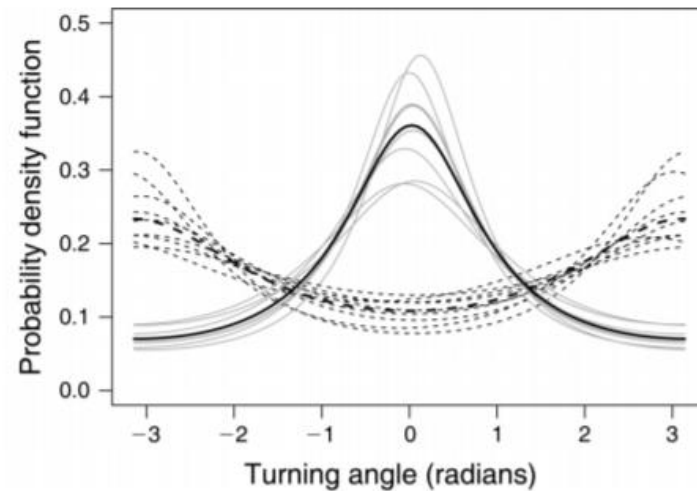
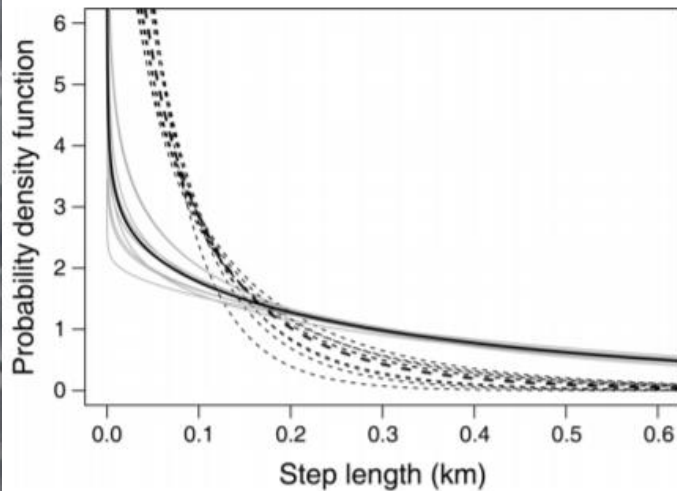
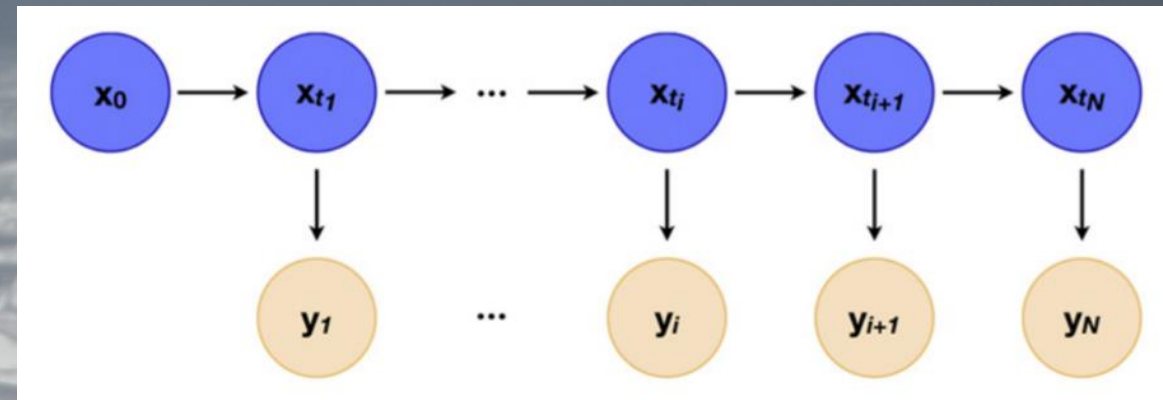
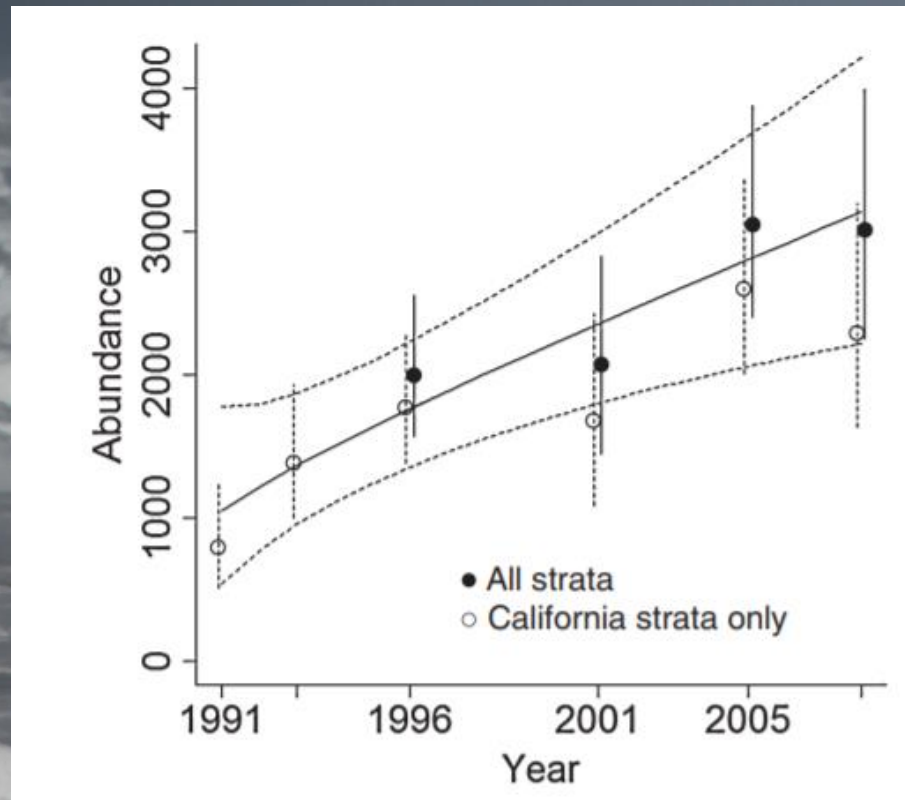


Figure 3. Dependence structure of an HMM.



Bayesian state-space model of fin whale abundance trends from a 1991–2008 time series of line-transect surveys in the California Current

Jeffrey E. Moore* and Jay Barlow



Jonsen et al. 2012 State-space models for bio-loggers: A methodological road map *Deep Sea Research Part II: Topical Studies in Oceanography* **88–89**: 34-46

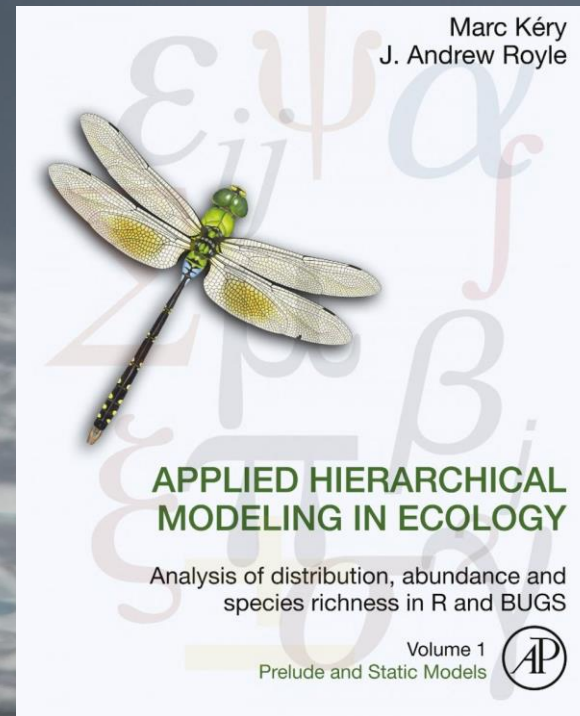
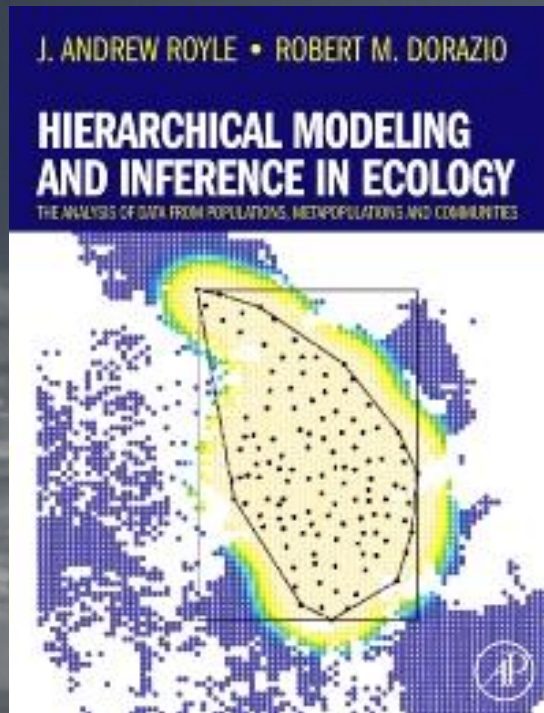


Hierarchical Models

Process-driven view

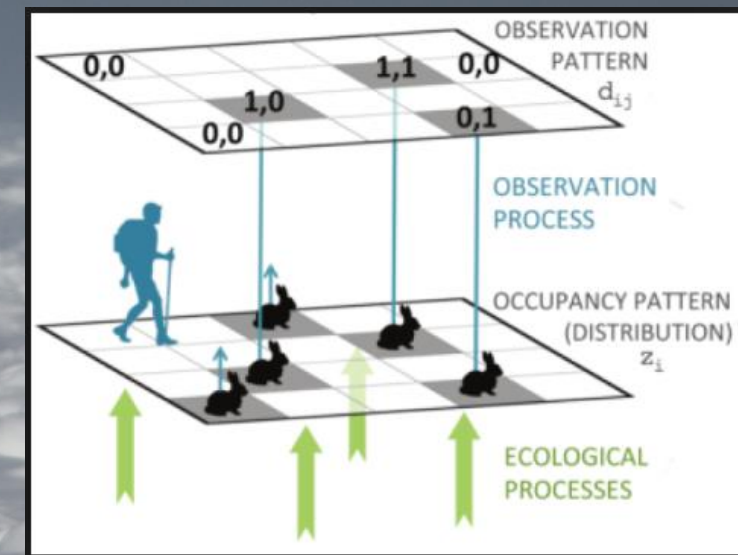
Observation-driven view

Hierarchical model



Process model

Observation model



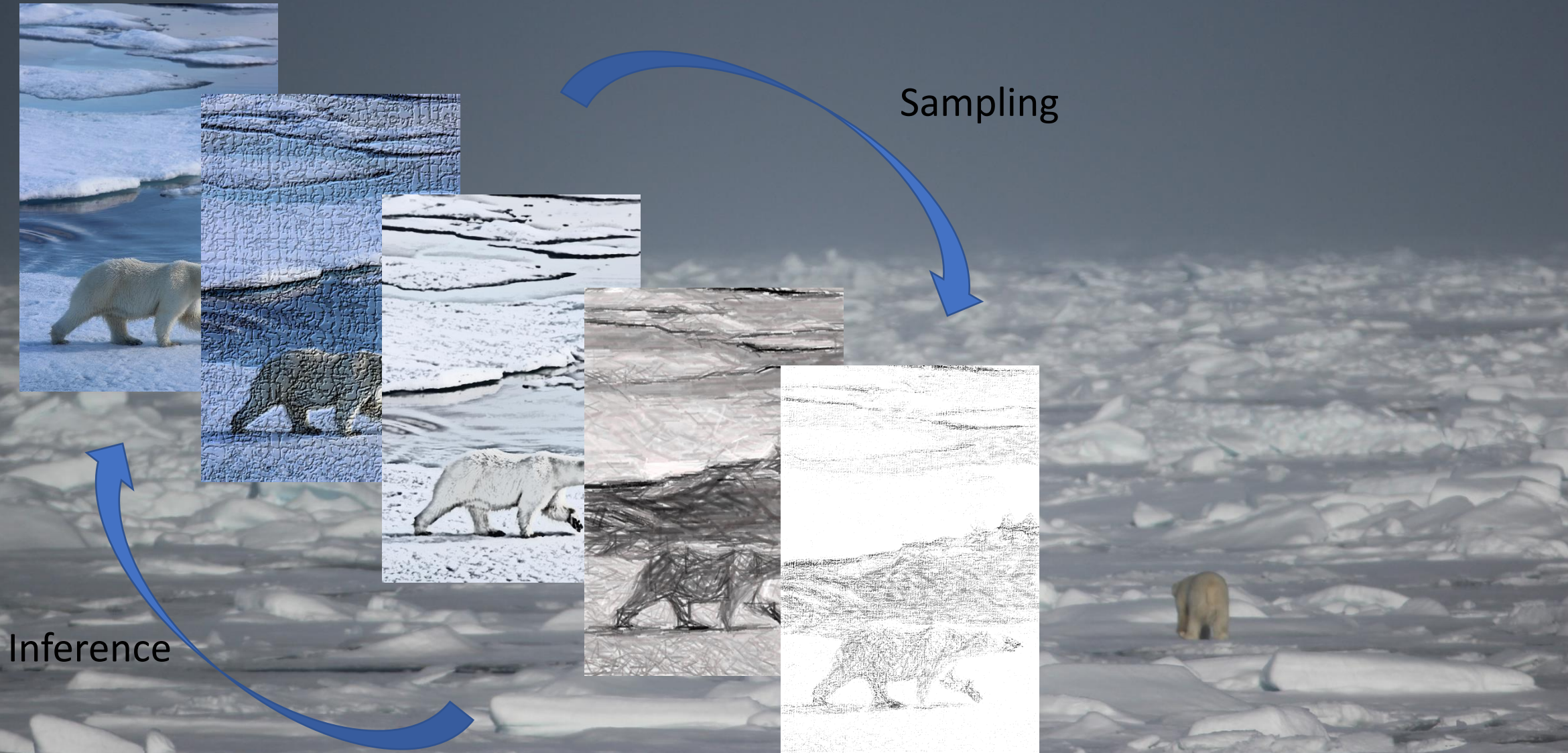
$$y_i | z_i \sim \text{Bernoulli}(z_i p)$$

$$z_i \sim \text{Bernoulli}(\psi_i)$$

$$\text{logit}(\psi_i) = \beta_0 + \beta_1 x_i$$

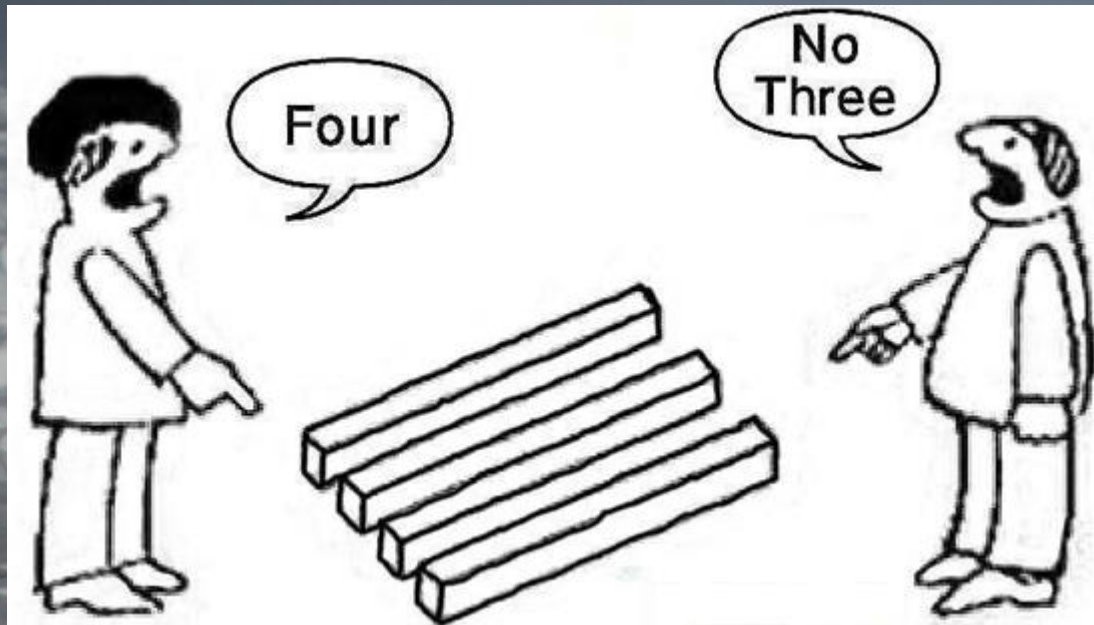
$$y_i | z_i \sim \text{Binomial}(J, z_i p)$$

REALITY, NATURE & FILTERS



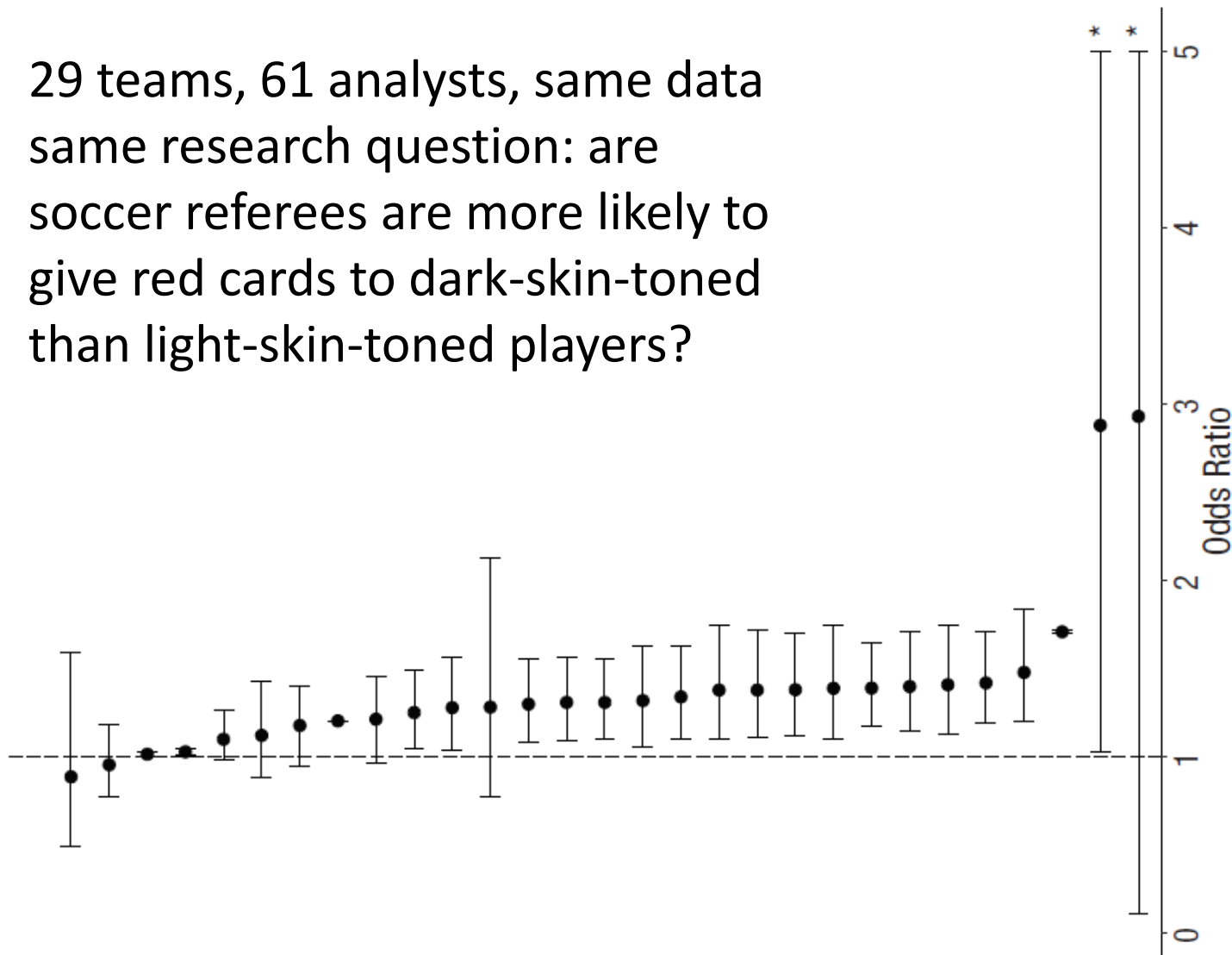
We want to make inferences about reality

- But what is reality?



'Truth isn't truth,' says Rudy Giuliani. But nonsense is still nonsense [source](#)

29 teams, 61 analysts, same data
 same research question: are
 soccer referees are more likely to
 give red cards to dark-skin-toned
 than light-skin-toned players?



Mario Balotelli, playing for Manchester City, is shown a red card during a match against Arsenal.

- Analytic approaches varied widely across teams
- 20 teams (69%) found a statistically significant + effect, and 9 teams (31%) did not observe a significant relationship.



What is (ecological) reality...?

- A response (acorn count), three designed effects (species, site, and year) and 7 environmental variables
- “explain variation in response variable (acorn count) using the predictors available”
- responses from a skilled average self-reported statistical expertise of 6.7 on scale of 1 [low] to 10 [high]) diverse group of 24 ecologists
- no two final models included exactly the same set of predictors
- not a single predictor was included in every final model

So whatever reality is... filters are hard to undo!

statistical significance
does not imply
biological significance

ACTA OECOLOGICA 34 (2008) 9–11



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Original article

Statistical significance and biological relevance: A call for a more cautious interpretation of results in ecology

Alejandro Martínez-Abraín*


EDITORIAL

 OPEN ACCESS

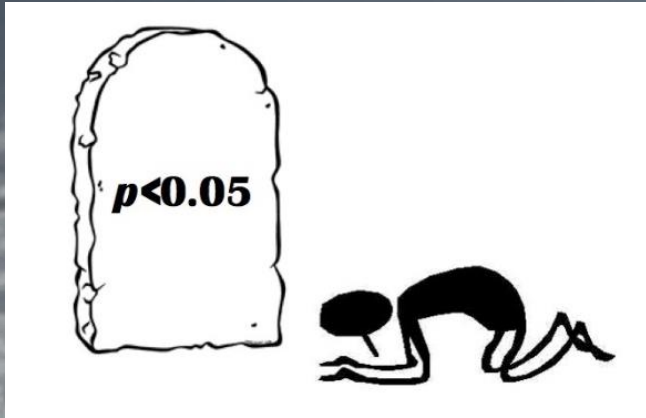
 Check for updates

Moving to a World Beyond “ $p < 0.05$ ”

Special issue: 43 papers on significance

“We conclude, based on our review of the articles in this special issue and the broader literature, that it is time to stop using the term “statistically significant” entirely. Nor should variants such as “significantly different,” “ $p < 0.05$,” and “nonsignificant” survive, whether expressed in words, by asterisks in a table, or in some other way.” 

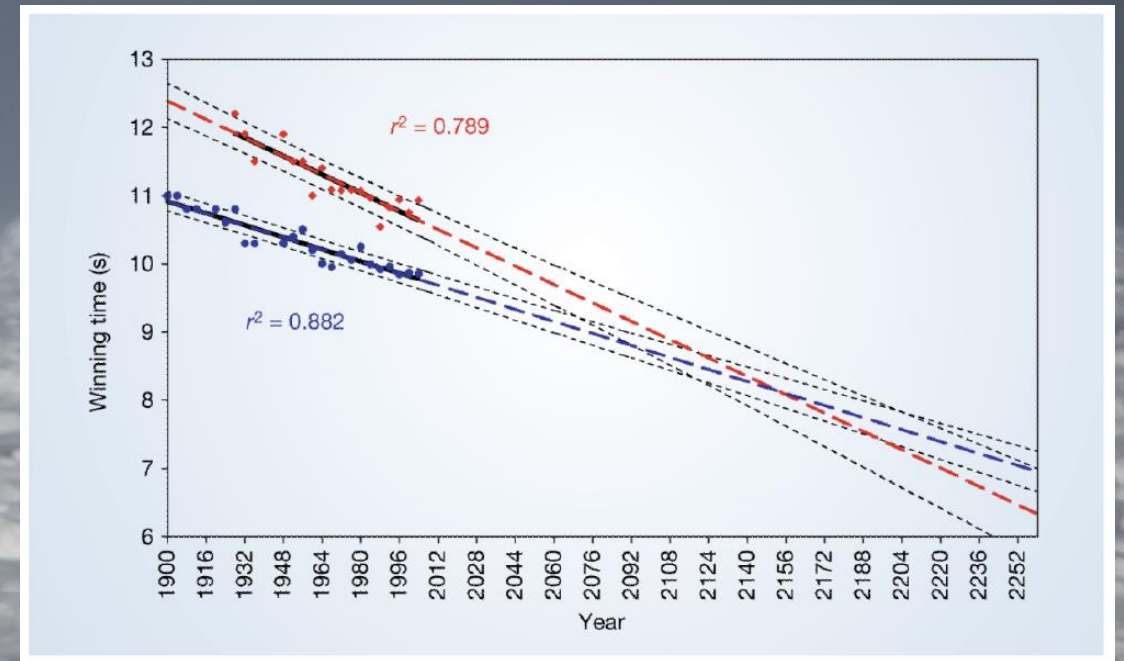
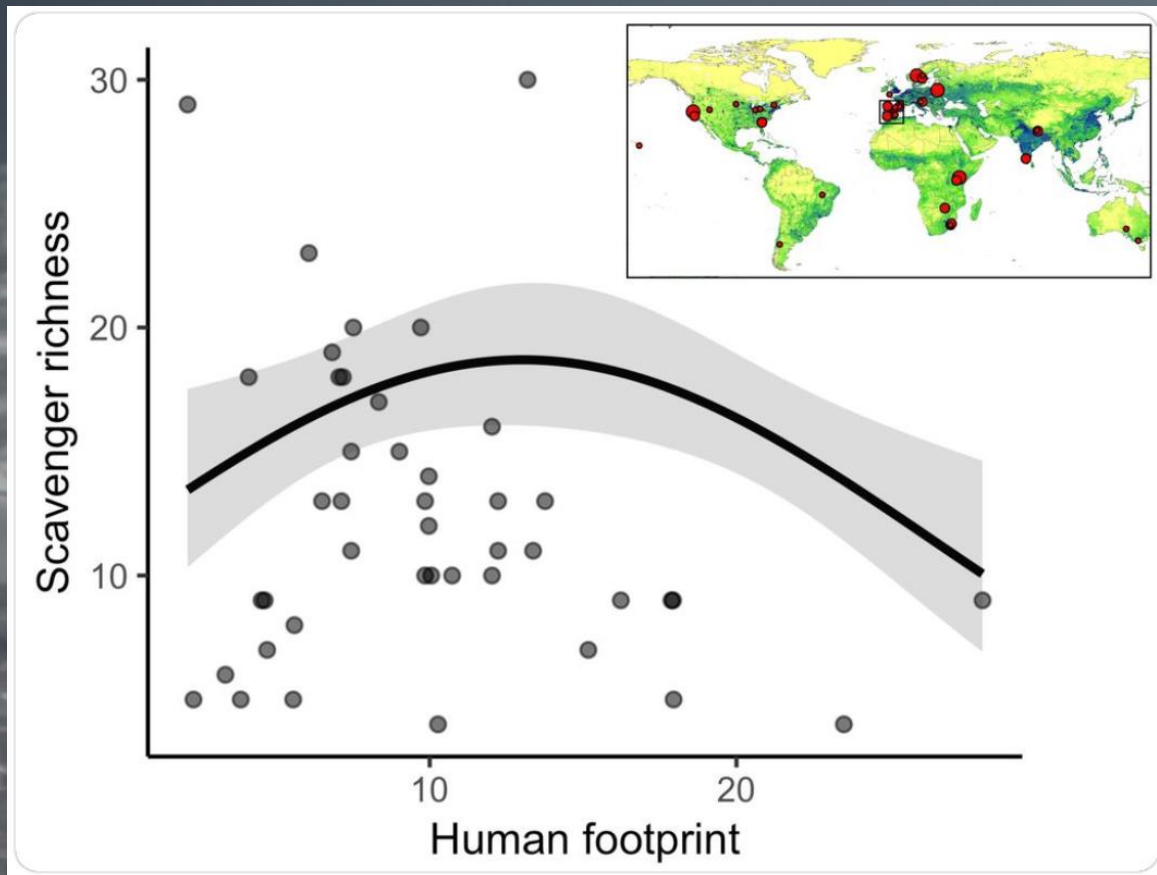
- It does not matter if you agree with progress, the only thing you can do about it is to adapt!
- Statistical significance is dead...



ANY CHANGE, EVEN A CHANGE FOR THE BETTER, IS ALWAYS ACCOMPANIED BY DRAWBACKS AND DISCOMFORTS. ARNOLD BENNETT



- An ecologist should know enough statistics to avoid major pitfalls, implement a set of standard methods and know when to ask for help
- But the key is to turn your brain on before turning your computer...





Lisete Sousa

esteve online hoje, às 15:21

Slides OK. Agora, na perspetiva dos matemáticos - provavelmente vão sentir falta de fórmulas. A apresentação que está a decorrer agora, tem muitas!

15:20

então pronto, em média temos formulas suficientes

15:20 ✓✓



A polar bear is swimming in dark, choppy water. To the right of the bear is a large, white, textured piece of ice. The bear's body is mostly submerged, with its head and part of its back visible above the surface. The water is dark blue/black, and the ice is bright white with some blueish tints from the water.

Thank you!
Any questions?

tiago@fc.ul.pt



[@TiagoALOMarques](https://twitter.com/TiagoALOMarques)