

# Sous les tortues, la plage

université  
PARIS-SACLAY

FACULTÉ  
DES SCIENCES  
D'ORSAY

Marc GIRONDOT



- Laboratoire Ecologie, Systématique, Evolution
  - Université Paris Saclay, CNRS et AgroParisTech
- Equipe Processus Ecologique et Pressions Anthropiques
  - Stratégies de conservation des tortues marines (1985)
  - Adaptation des reptiles au changement climatique (1989)
  - Evolution des tissus minéralisés (1994)
  - Réponse des organismes aux pollutions dans les milieux naturels (2005)
  - Statistiques et modélisation (2010)

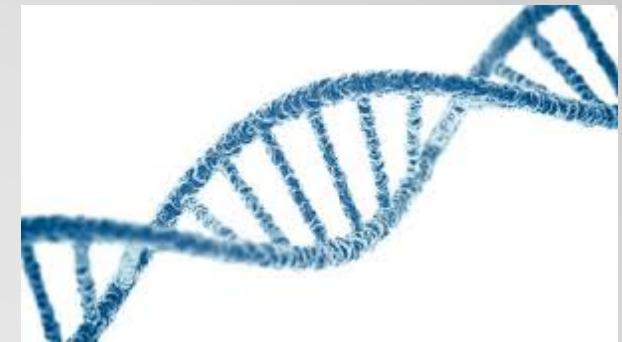
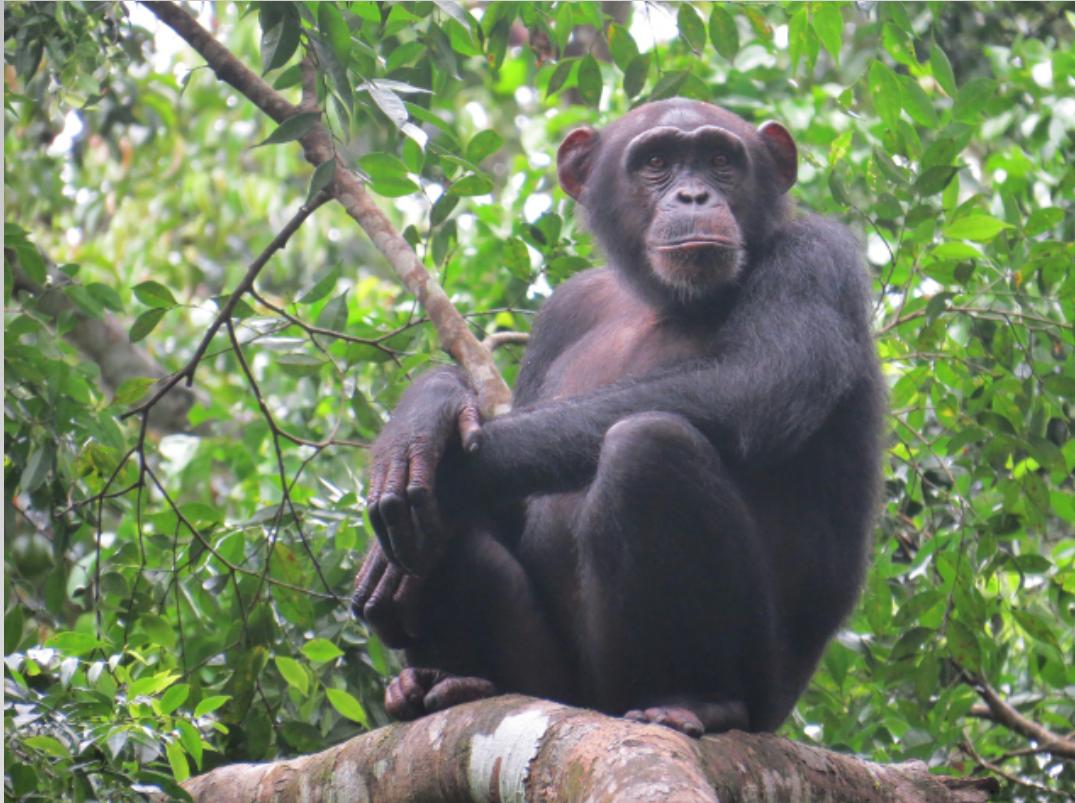


# Marc Girondot, Professeur

97 publications de rang A



Digressions: Qu'est-ce qu'un animal ?



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X



Digressions: Qu'est-ce qu'un animal ?



X



**Un animal est-il toujours un animal s'il n'a plus de fonction écologique ?**

**La fonction écologique de l'animal devrait faire partie intégrante de la définition d'un animal.**

At sea



On the beach



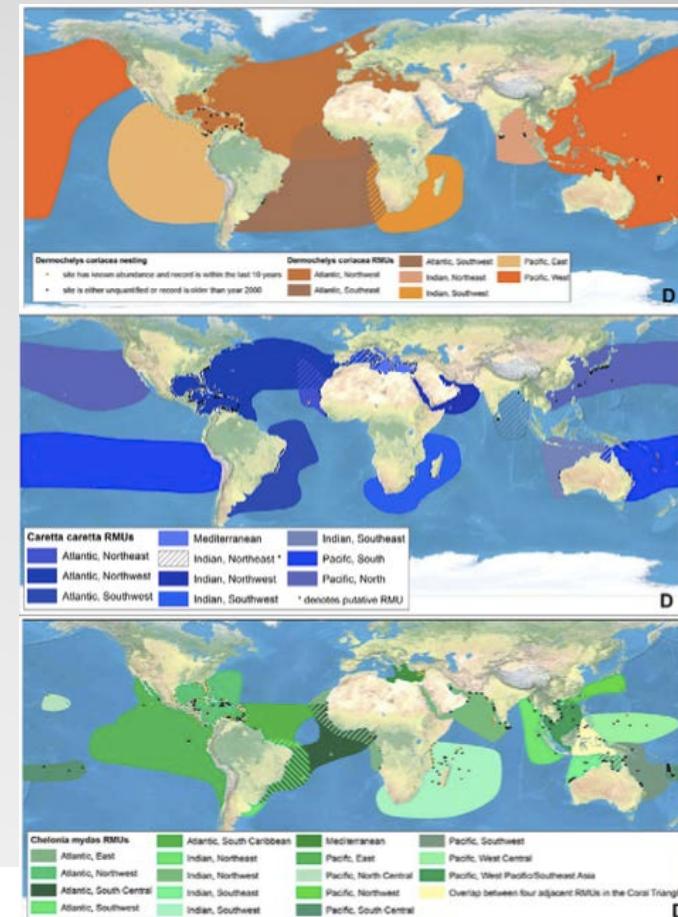
- De nombreux outils en terme de protocoles et d'analyses des données sont disponibles.
- Cependant, ils doivent être utilisés toujours pour répondre à une question qui aura été préalablement clairement formulée.
- Ainsi on évitera les surprises d'avoir des données soient ininterprétables, soient qui ne permettent pas de répondre à la question posée.

"Appeler un statisticien après que l'expérience est terminée, c'est comme lui demander de faire une autopsie ; il pourra seulement déterminer la cause de l'échec de l'expérience."

Ronald A. Fisher

# Nécessité d'avoir des espèces indicatrices de l'état des écosystèmes

- Les espèces utilisant divers habitats peuvent permettre d'avoir une information rapide et globale sur l'état de la planète.



# Tortues marines : 7 espèces



Tortue imbriquée: *Eretmochelys imbricata*



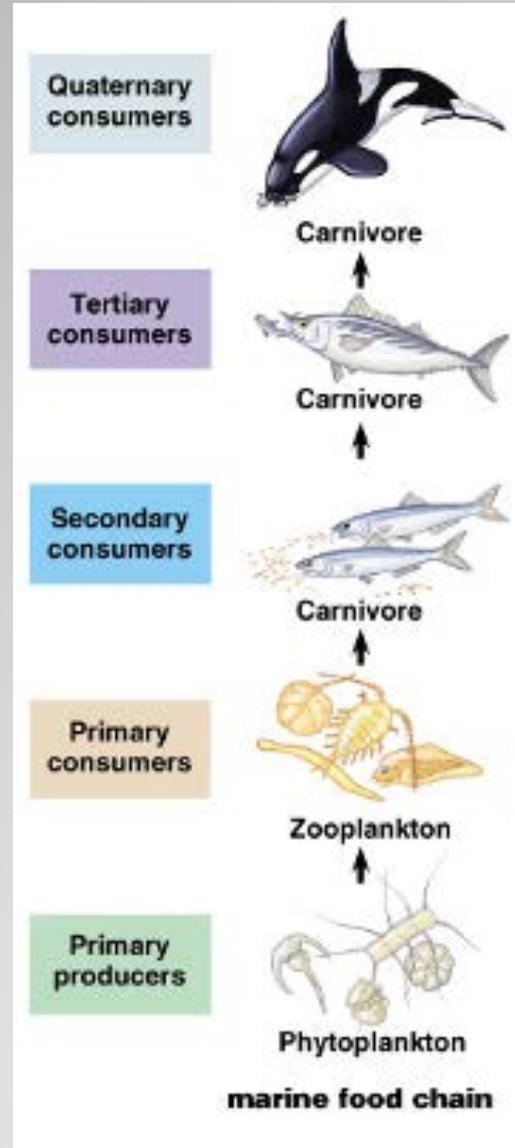
Caouanne: *Caretta caretta*



Tortue verte: *Chelonia mydas*



Tortue luth: *Dermochelys coriacea*



Caouanne: *Caretta caretta*

Tortue luth: *Dermochelys coriacea*

Tortue imbriquée: *Eretmochelys imbricata*

Tortue verte: *Chelonia mydas*

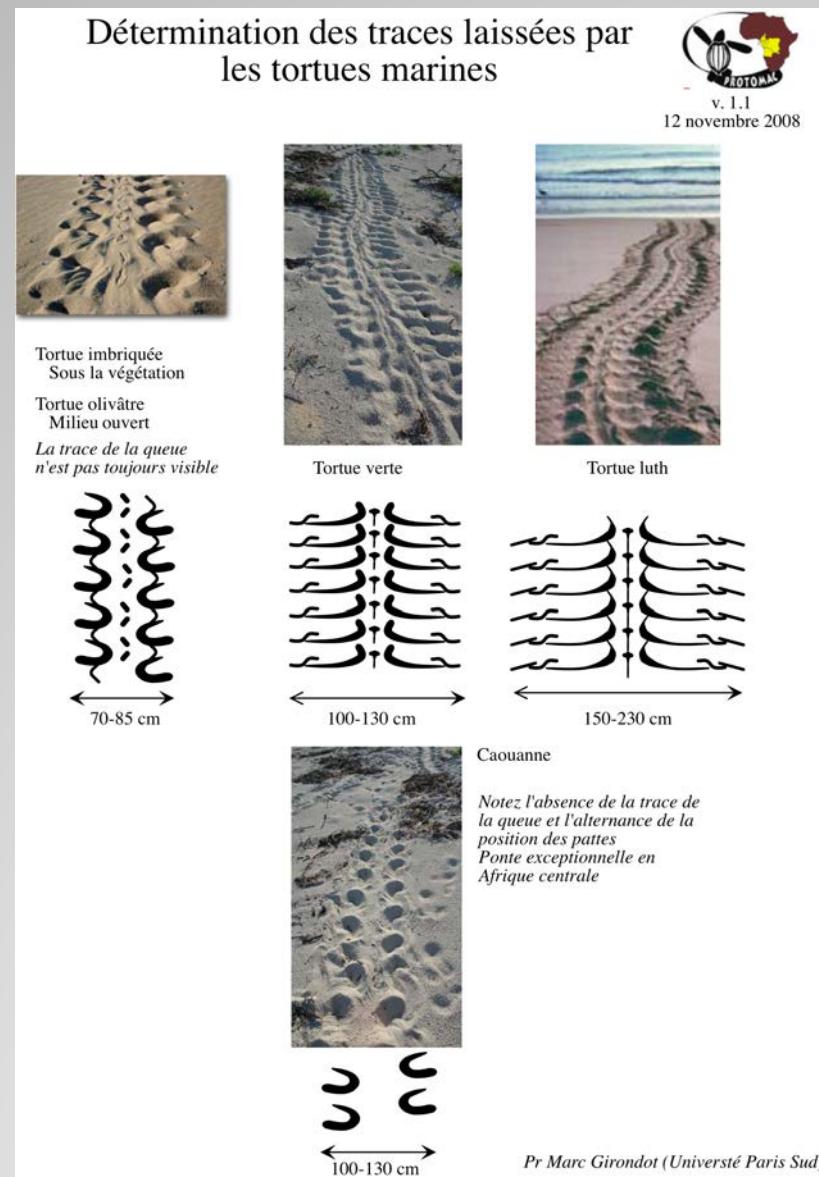


## Espèce indicatrice

# Espèce indicatrice



# Why monitor beach?



- Identification of species, is possible from the tracks on the beach

- The advantage of track counts over nest counts is that it is easier and give higher figures and then is better for statistics.

## Identification of biological activity

Détermination des traces laissées par les tortues marines

v. 1.1  
12 novembre 2008

Tortue imbriquée  
Sous la végétation  
Tortue olivâtre  
Milieu ouvert  
*La trace de la queue n'est pas toujours visible*

Tortue verte

Tortue luth

70-85 cm

100-130 cm

150-230 cm

Caouanne

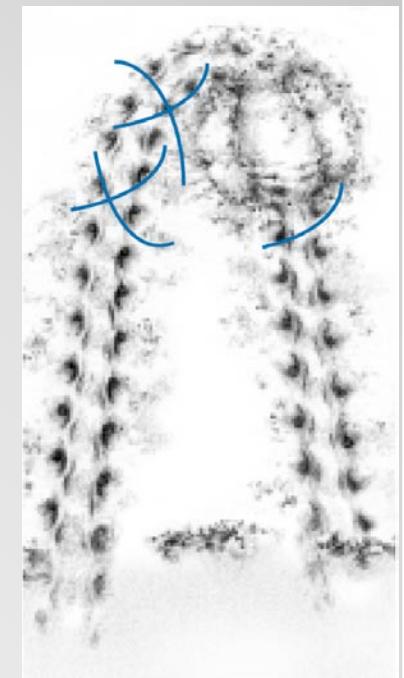
*Notez l'absence de la trace de la queue et l'alternance de la position des pattes  
Ponte exceptionnelle en Afrique centrale*

100-130 cm

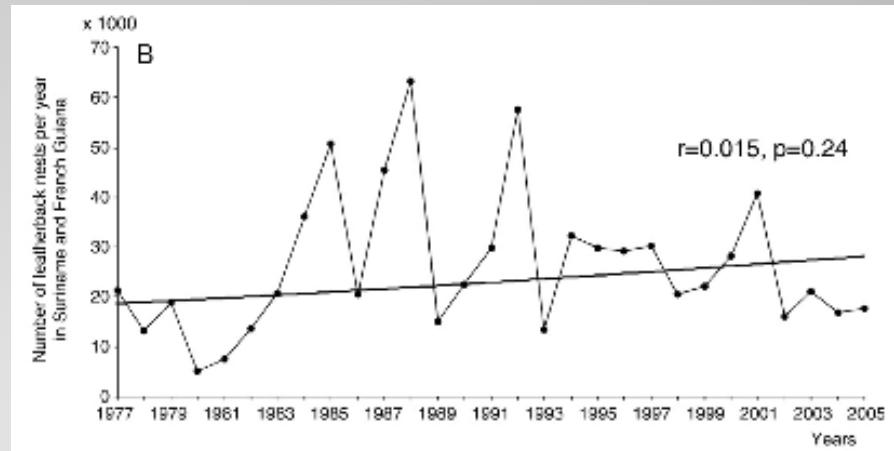
Pr Marc Girondot (Université Paris Sud)

- What is the error about the identification of species?
  - Measure of track could be a solution
- What is the error about date determination?
  - Mark the track to say it has been counted

These errors exist and it is important that they are evaluated.



- The tendency on the biological activity measured from number of tracks can be used to define a trend.



- To use these data to evaluate the status of a population, it is necessary to optimize the capacity to detect a trend with the fewer information as possible.
  - Minimize the number of days on the beach during a nesting season
  - Minimize the number of years to detect a tendency

## Biological activity as an index

- A sampling is a measure of fragment of a biological system to capture its properties to answer a clear and precise question:
- The sampling methodology will depend on:
  - The objectives of the study,
  - The spatio-temporal requirements of the study,
  - The internal structure of the studied system.

Girondot, M. (2010) Estimating density of animals during migratory waves: application to marine turtles at nesting site. *Endangered Species Research*, 12, 85-105.

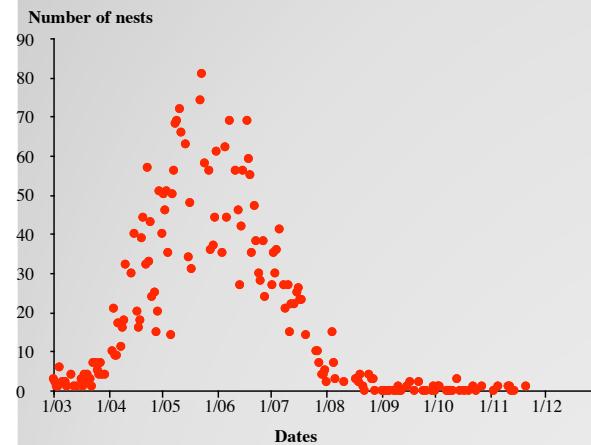
## What about sampling?

# Partial monitoring of nesting season

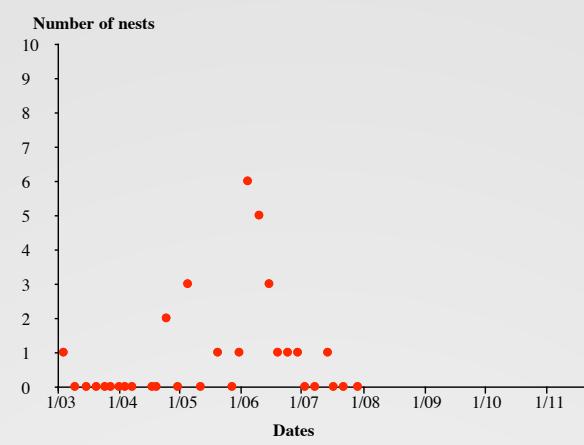
- Often the nest number for a nesting beach is not known for all the season because all nights have not been monitored.
- Data must be corrected for monitoring effort.

## Leatherbacks nest number (2002)

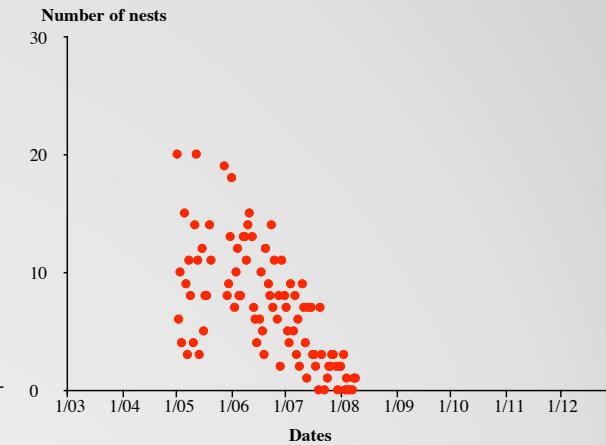
Ya:lima:po-Awa:la



Farez



Irakumpapy I



Percentage of 2002 nights monitored

56%

10%

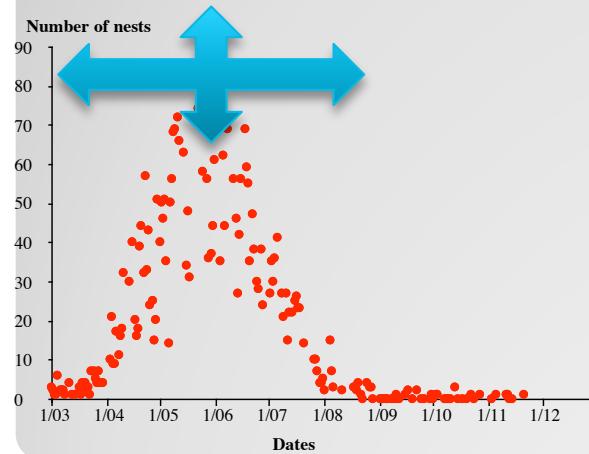
30%

# Enhance the information

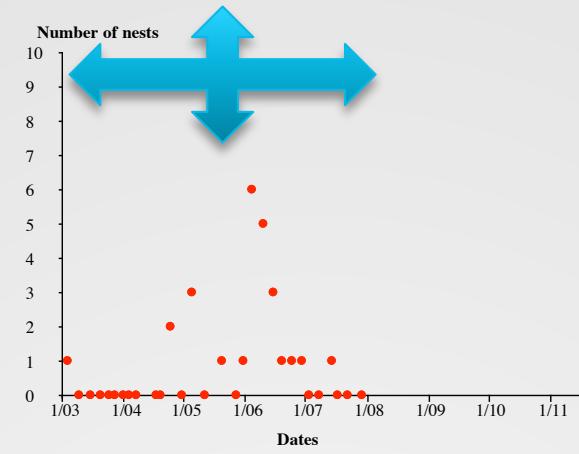
- When the monitored beaches are in the same region for the same species, it is possible to hypothesize that nesting season is the same for all the beaches. Thus each beach brings information on the entire system.

## Leatherbacks nest number

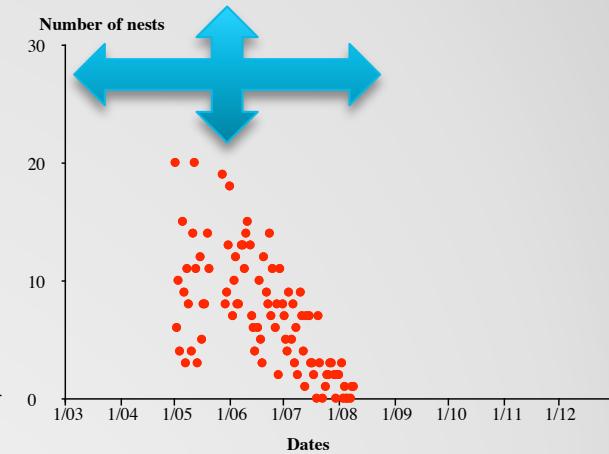
Ya:lima:po-Awa:la

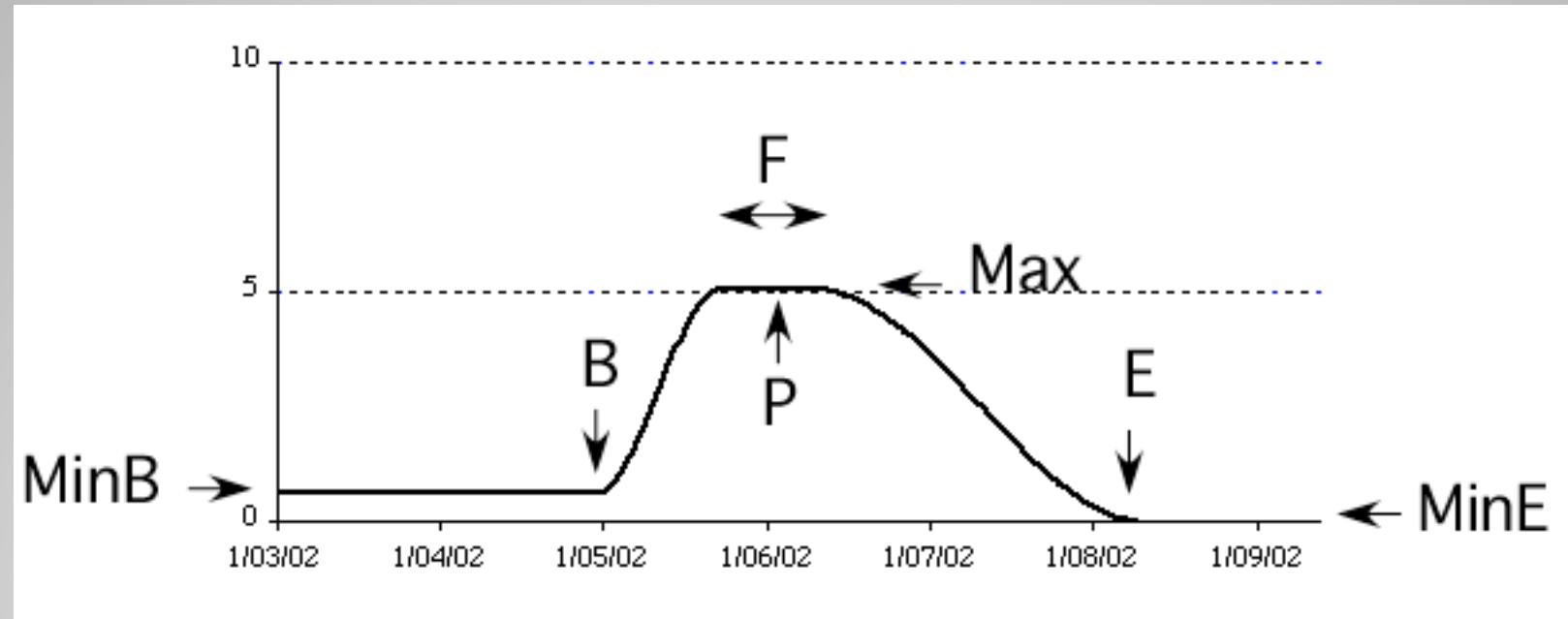


Farez

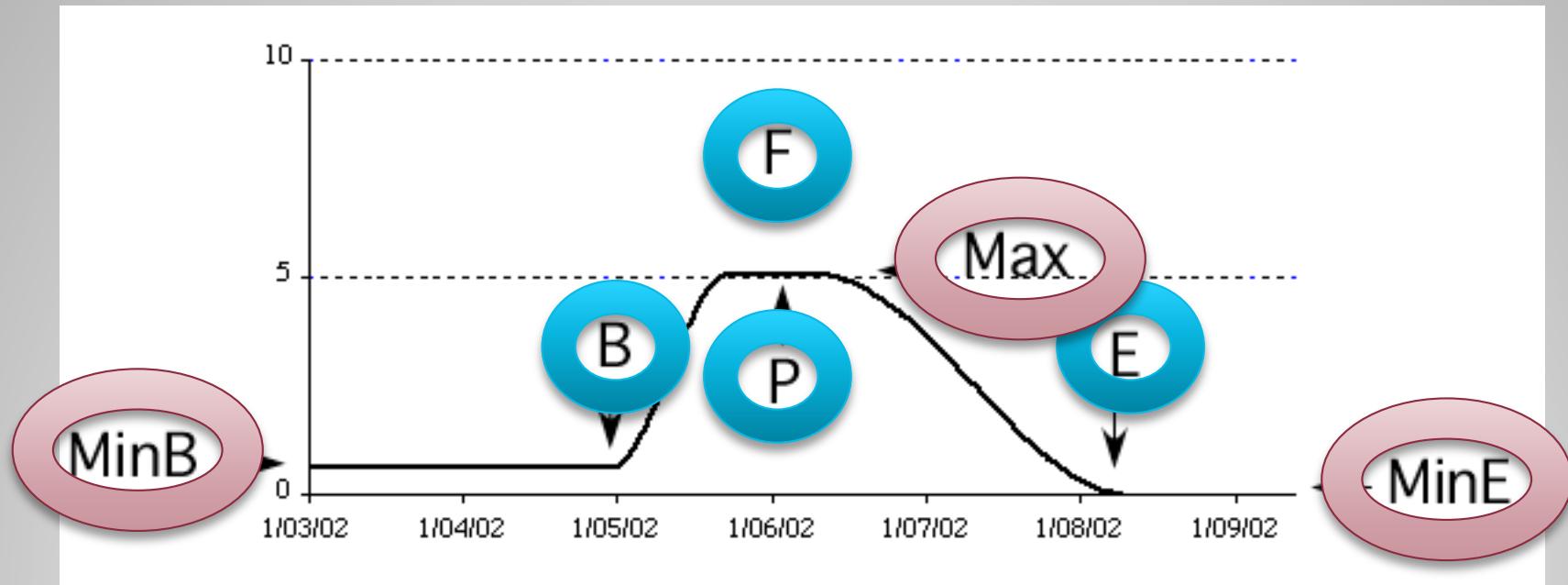


Irakumpapy I

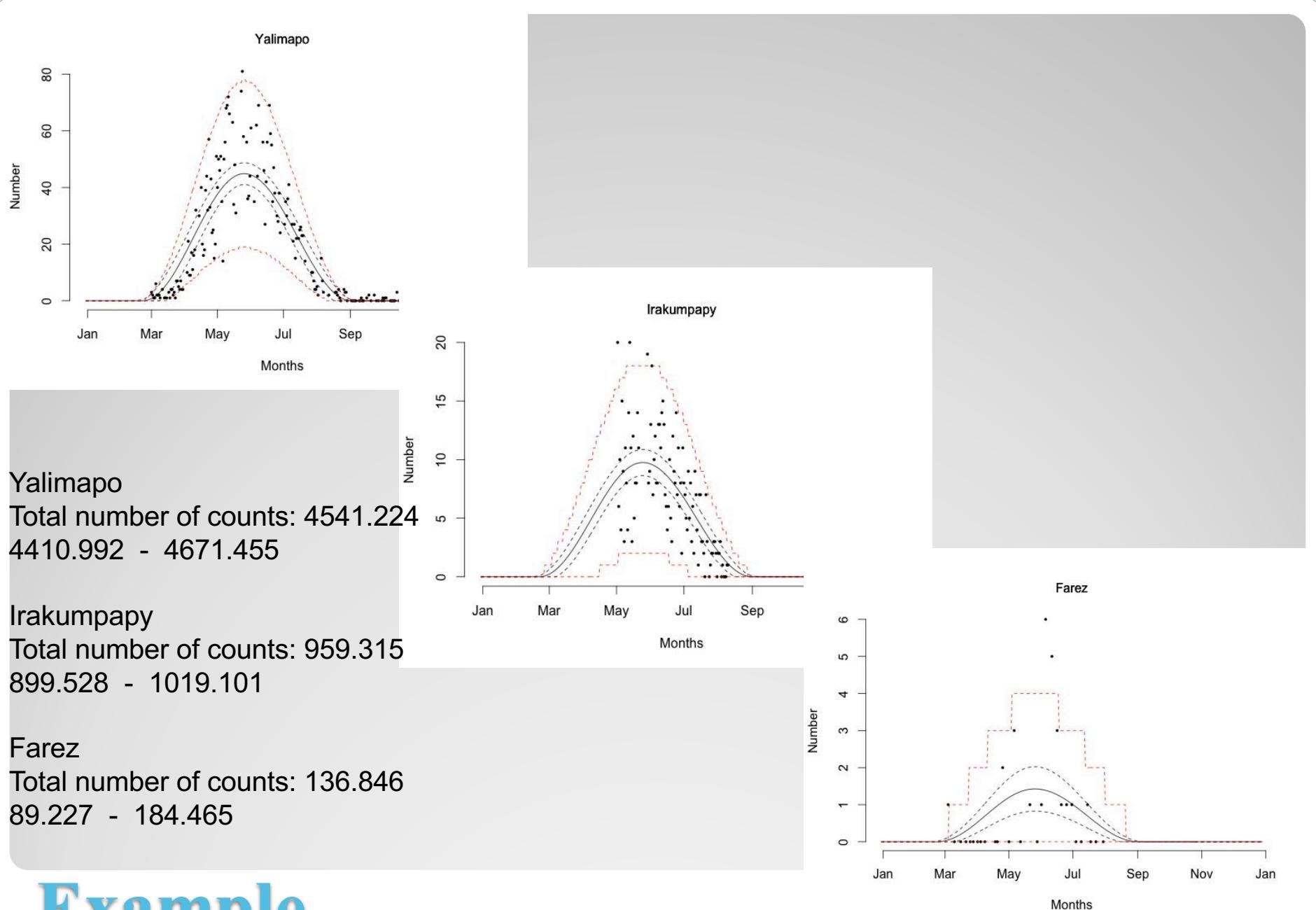




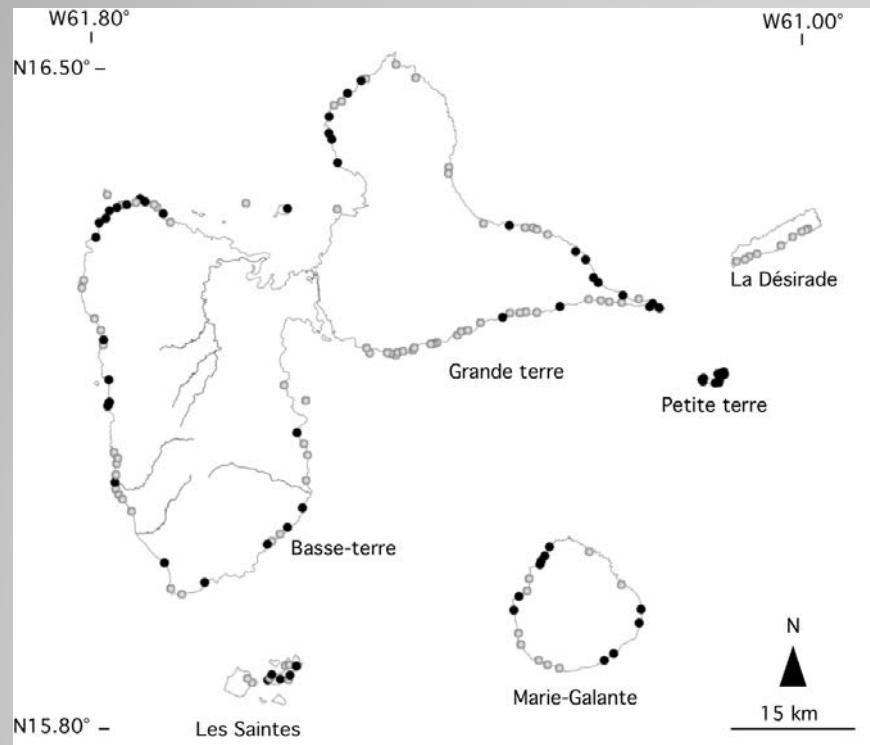
Beach monitoring  
**Mathematical description of nesting season**



Beach monitoring  
**Mathematical description of nesting season**



# Example



Partial monitoring has been done for 60 nesting beaches with 4 persons. A similar shape model of nesting season has been chosen for all these beaches (**B, P, F and E parameters**).

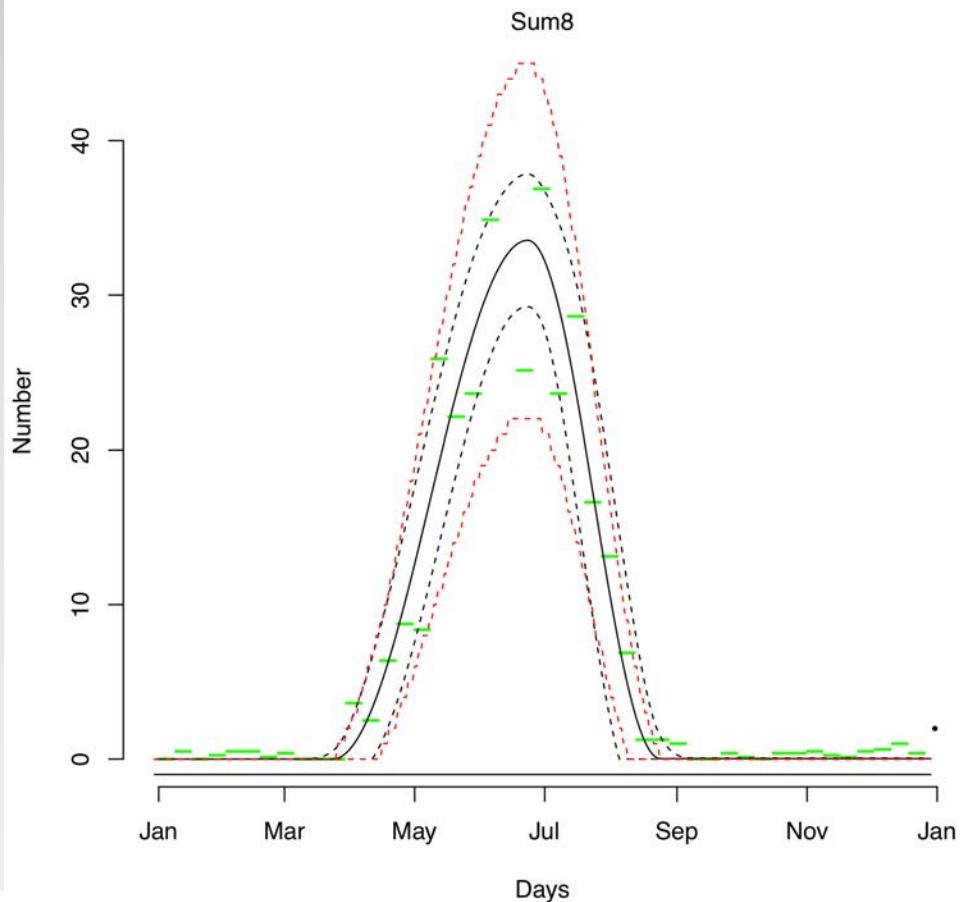
The **Max, MinB and MinE** parameters are specific of time series.

Ex 3 Ilets 2007, 851 tracks  
d'imbriqués (IC 95% 731- 971)

## Example of beach monitoring Example in Guadeloupe

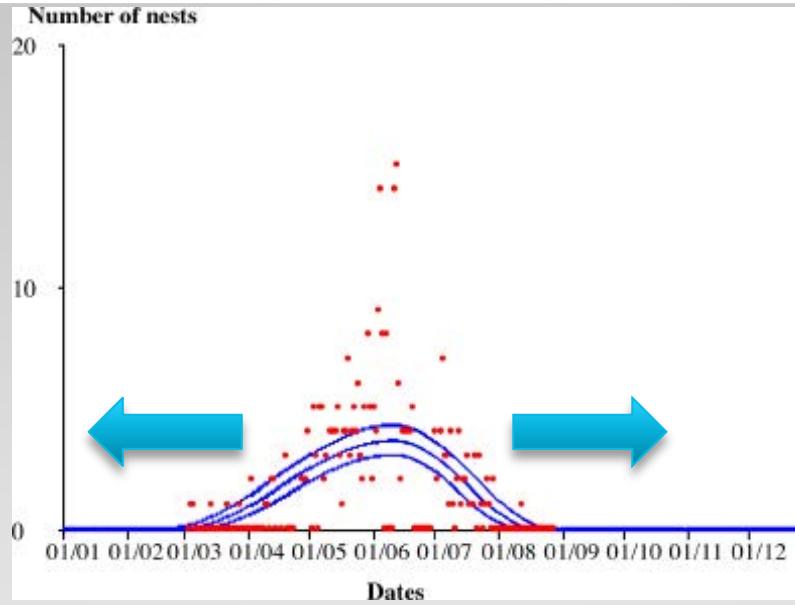
During monitoring, it is often difficult to date with precision the age of a track. It is possible to manage such uncertainty.

	Night 1	Night 2	Night 3
Number of nest per night	2	0	0
	1	1	0
	1	0	1
	0	2	0
	0	1	1
	0	0	2



## Date of nesting is not always known with precision

Girondot, M. (2017) Optimizing sampling design to infer marine turtles seasonal nest number for low- and high-density nesting beach using convolution of negative binomial distribution. Ecological Indicators, 81, 83–89.



Simulations results indicates that the most difficult parts of the nesting season to define are the begin and the end.

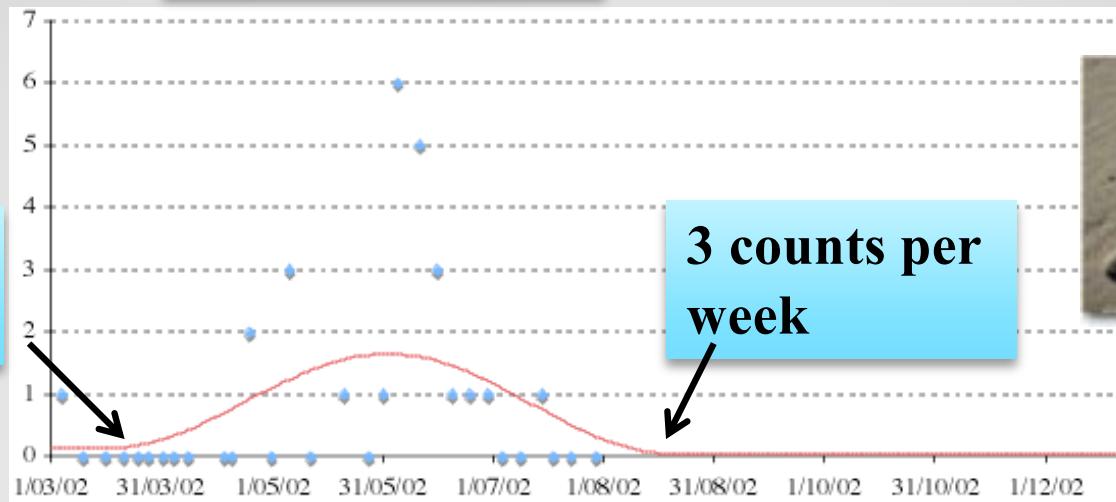
Unfortunatly, these early and end nesting season are often poorly monitored because few individuals are observed:

It is important to clearly define the objective of the work

## Beach monitoring

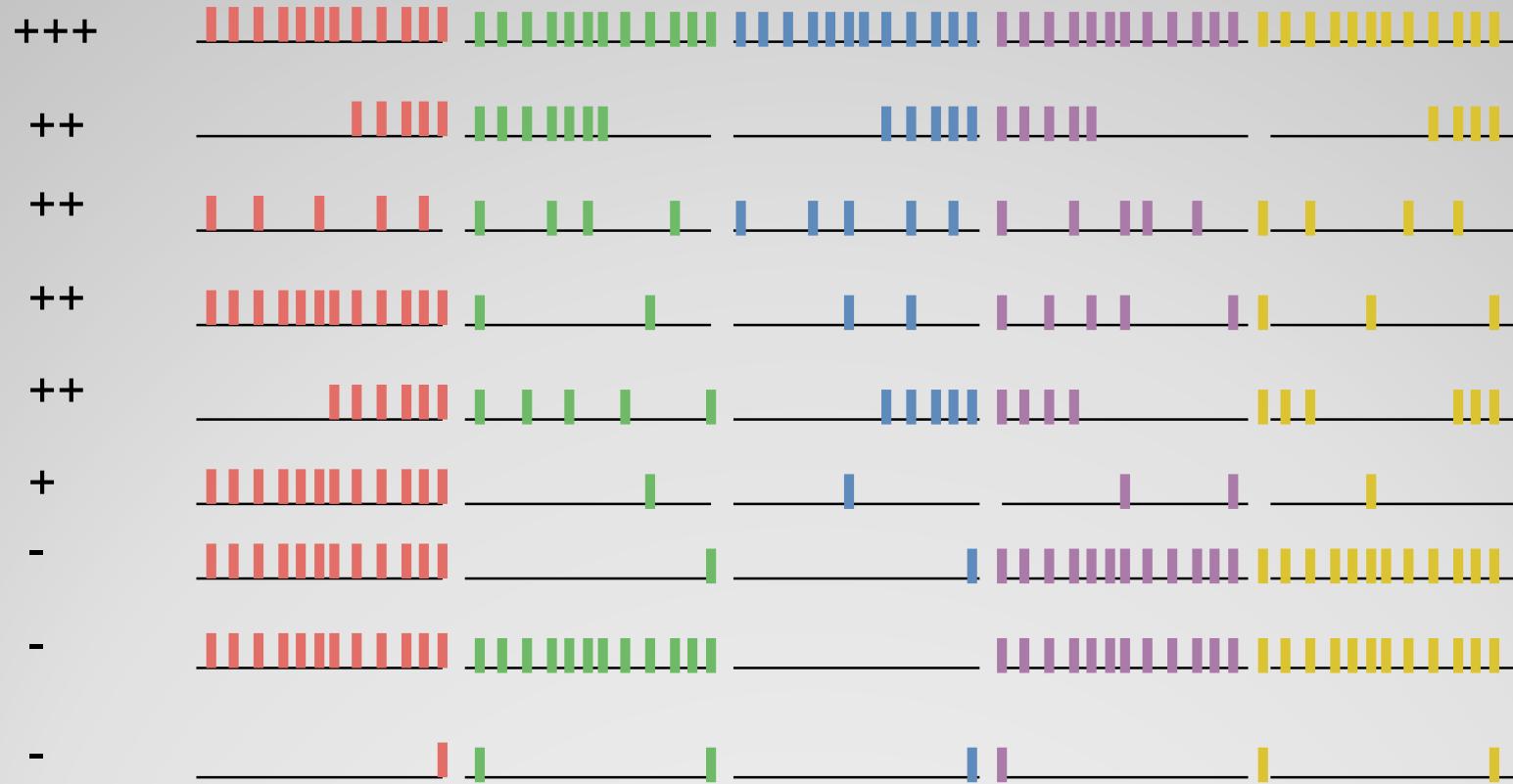
**3 counts per week**

**1 count per week around peak of nesting**



**IUCN recommandation**

- Let imagine 5 sites with monitoring along the year

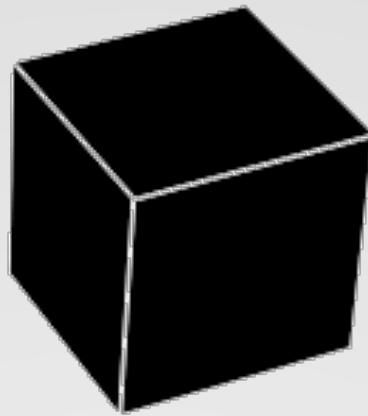


- The method is very robust on change in monitoring strategies until #20% of nights are monitored **but the quality of field data is of prime importance.**

- How to aggregate these values to give a global view for the status of this “population” taking into account different quality of information and even missing values?
- When information is completely missing, we have still information because it is based on a timeseries and in a place that have been monitored for other years.

	Matapica (EST)	Galibi (West)	Yalimapo	Irakompapi	East
1967	80	10		20000	
1968	190	10		20000	
1969	296	9		20000	
1970	242	13		20000	
1971	242	43		20000	
1972	341	39		20000	
1973	626	274		?	?
1974	643	142			
1975	989	636			
1976	560	110			
1977	2958	2607	14833		
1978	1691	469			
1979				13986	
1980		?		2729	
1981		?		4539	
1982				9500	
1983				14381	
1984	2252	5039		28675	
1985	5666	6735		38326	
1986	1469	2130		15825	
1987	4148	5668		33706	
1988	2506	8930		48358	
1989	1192	1540		8764	
1990	1182			15138	
1991	1482		?	21075	
1992	2732			43412	
1993		607	9025		
1994		1456	26962	3000	
1995		1176	22581	3000	
1996		2048	23249	3000	
1997		2516	14318	7000	
1998		1470	7398	9000	1000
1999		2000	11381	5000	1170
2000	3000	7469	11047	6000	1139
2001	3700	26750	10191	11941	2800
2002	738	10079	4700	1648	426

## Aggregate beach timeseries

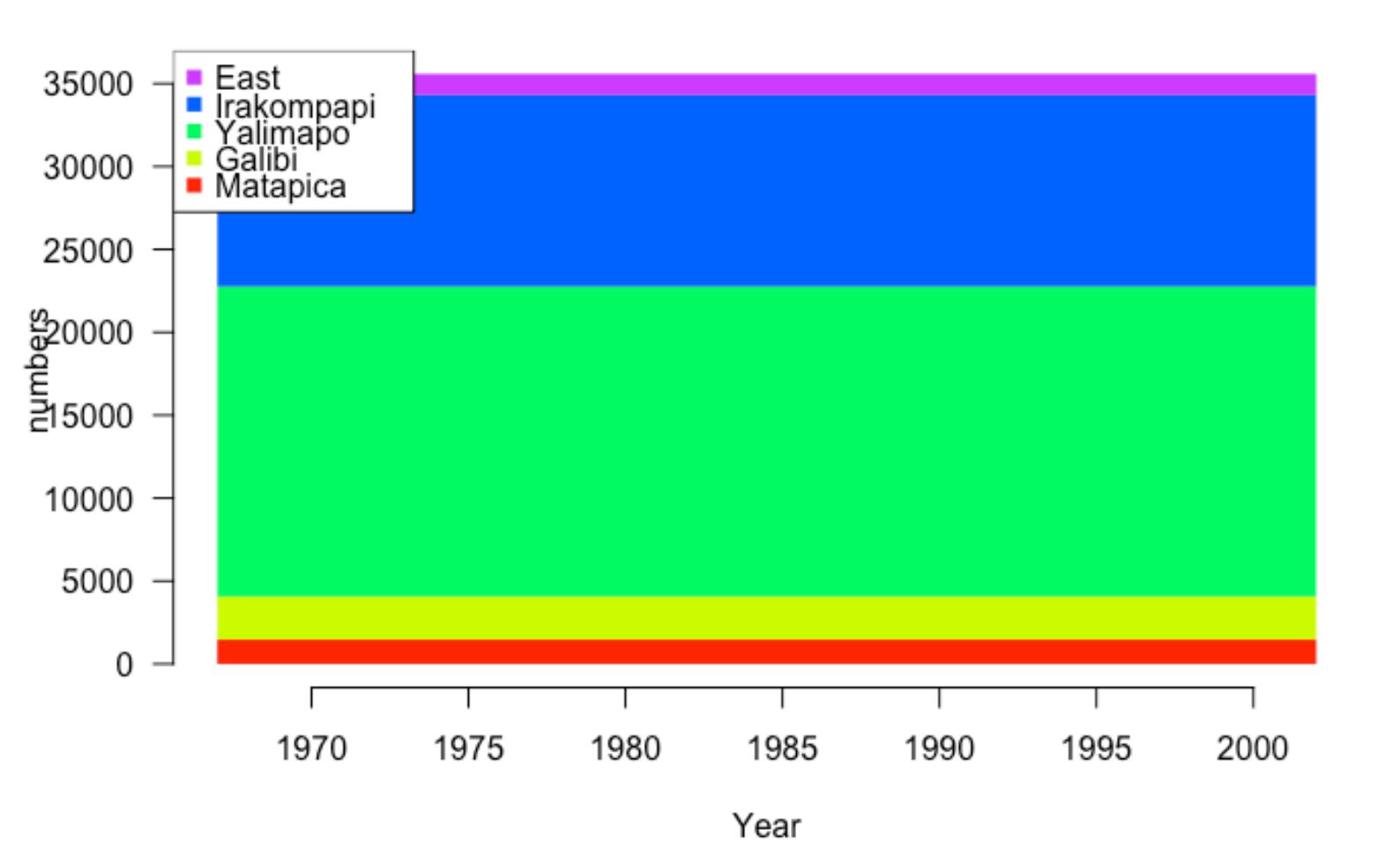


The model

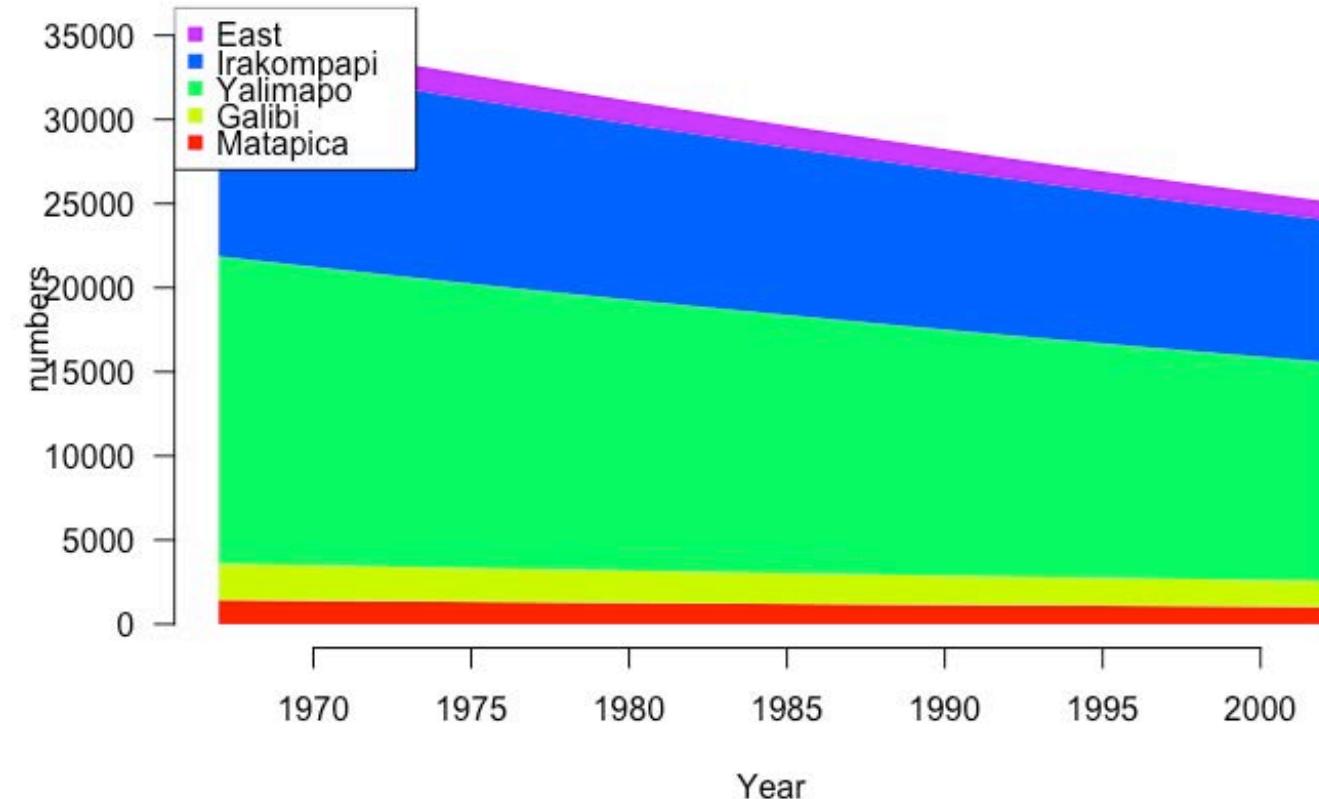


- Maximum likelihood and error from Bayesian statistics
- Temporal model can be constant, exponential or year-specific
- Spatial model is of order 0 (constant relative frequency for use of beaches), 1 (monotonic increasing or decreasing) or 2 (with peak)

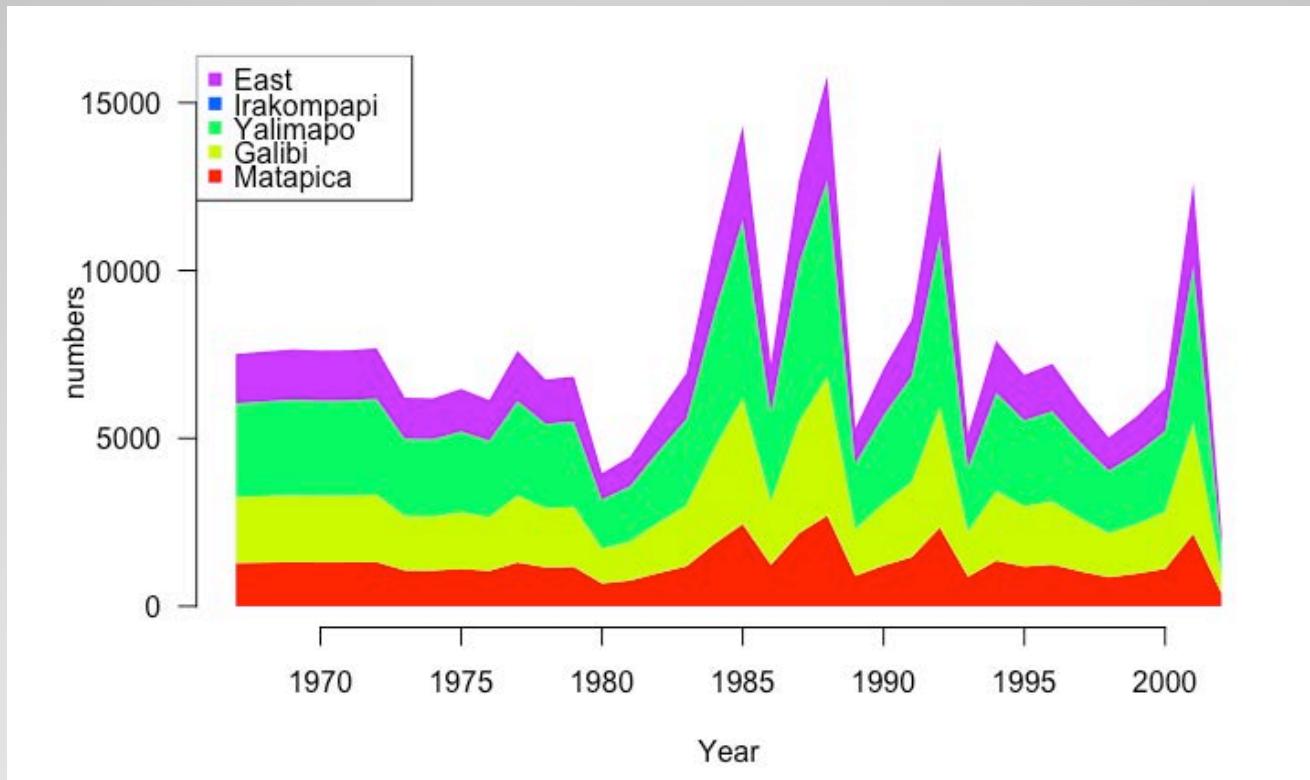
## The model



**Stable trend and constant relative frequencies**

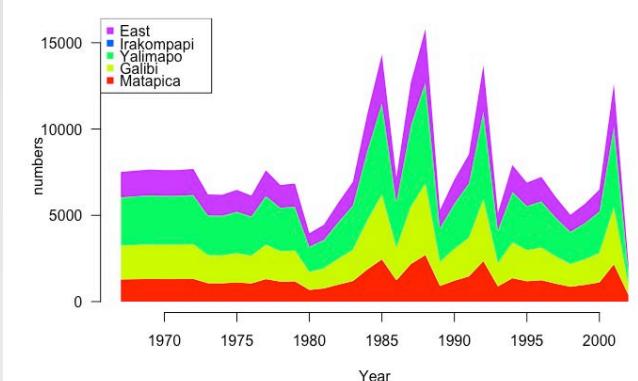
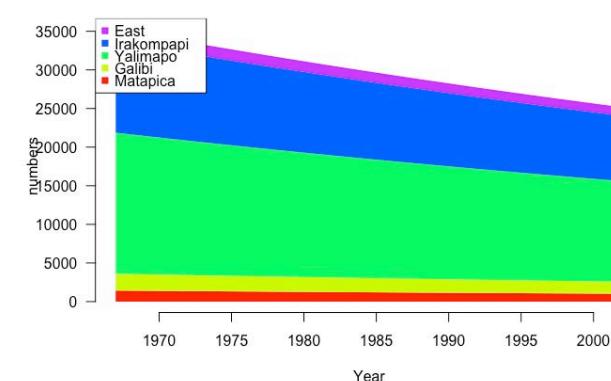
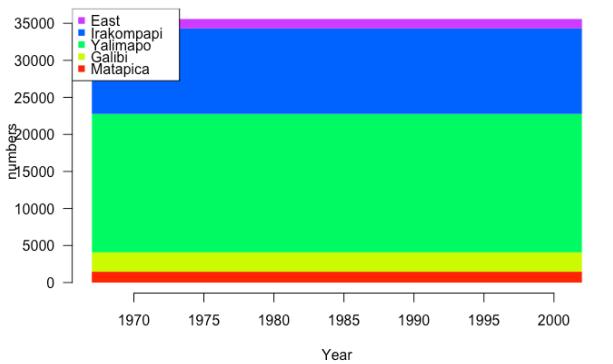


**Exponential trend and constant relative frequencies**

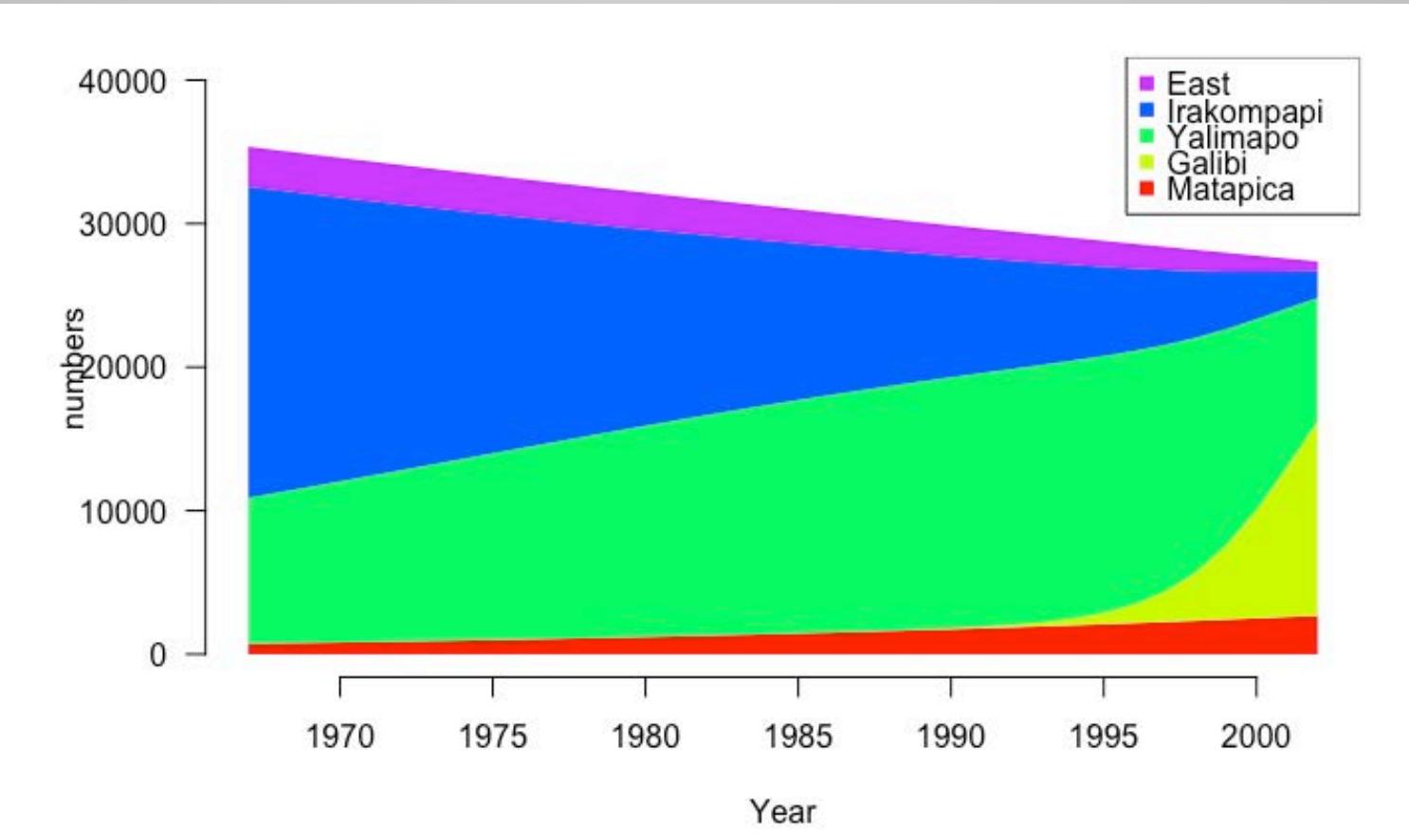


**Year-specific numbers and constant relative frequencies**

	AIC	$\Delta AIC$	Akaike_weight
Stable	1916.847	9.989639	6.727380e-03
Trend	1906.857	0.000000	9.932726e-01
YearSpecific	1976.454	69.597035	7.660629e-16

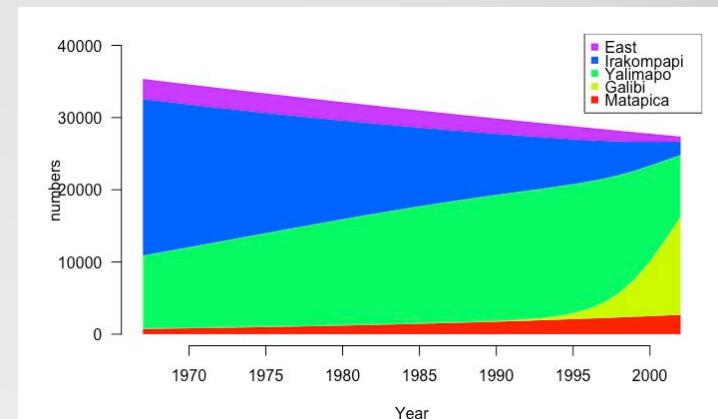
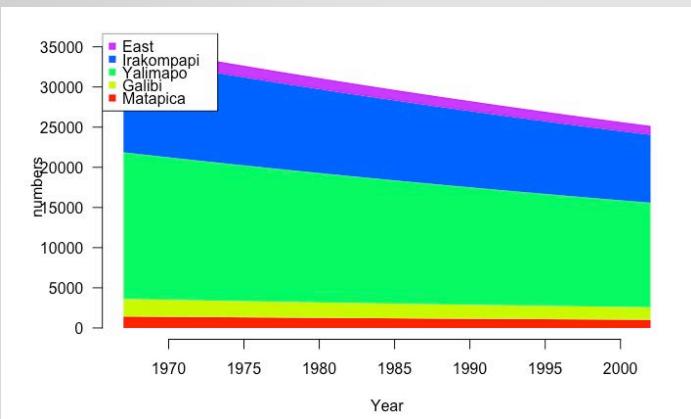


## Comparison of models



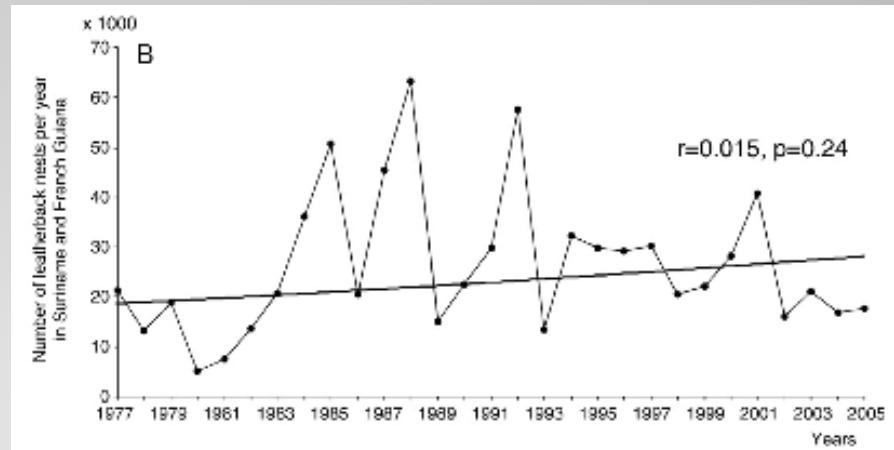
Exponential trend and first-order relative frequencies

	AIC	$\Delta AIC$	Akaike_weight
ConstantRF	1906.857	41.08226	1.199777e-09
FirstOrderRF	1865.775	0.00000	1.000000e+00



## Comparison of models

- The tendency on the biological activity measured from number of tracks can be used to define a trend.



- Biological activity is not a direct measure of number of individuals.**

## Biological activity as an index

- Nombre de jours entre deux pontes
- Nombre de jours entre deux tentatives de pontes
- Nombre de pontes par an et par femelle
- Nombre d'années entre deux saisons de pontes

**What we should know to convert the  
measures of biological activity into female  
counts ?**

## 1. Tagging



## 2. Releasing

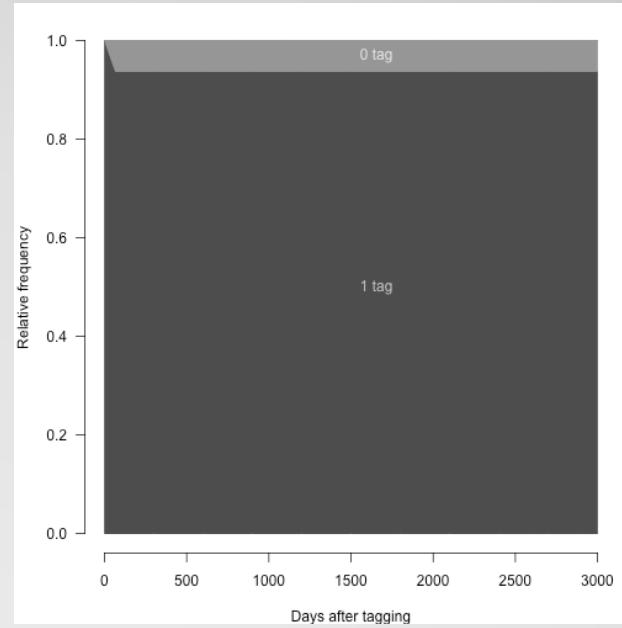
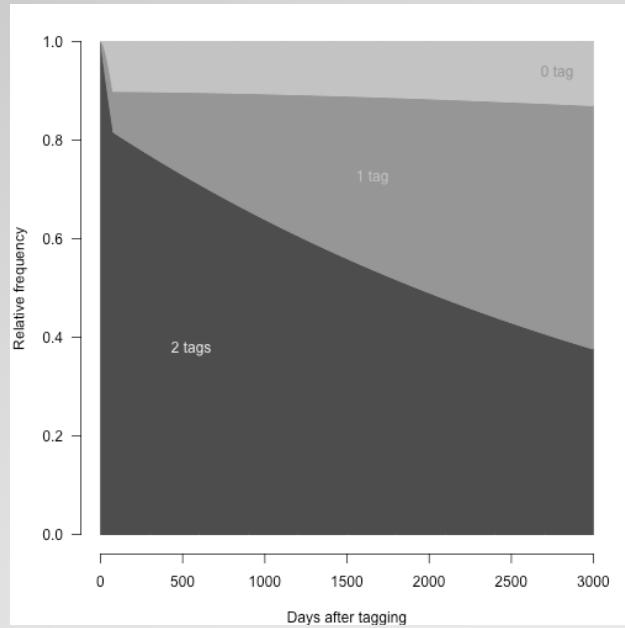


## 3. Monitoring all the subsequent observations



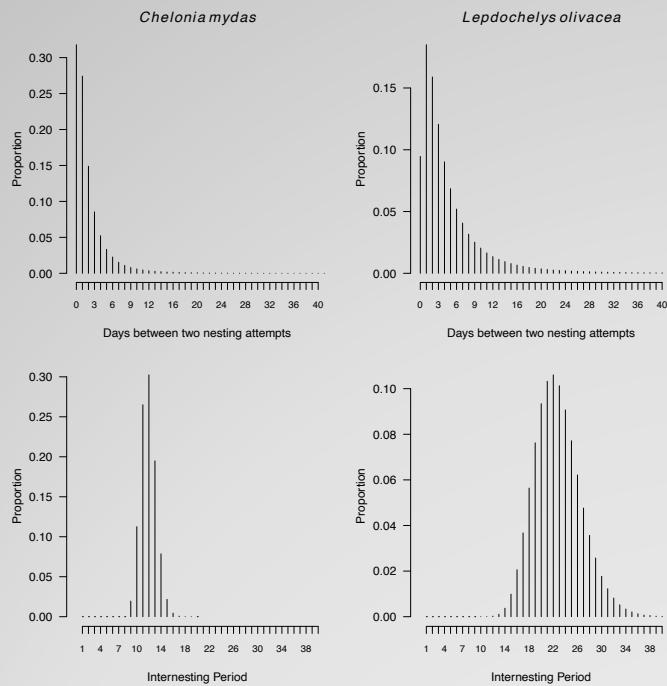
**Capture-Mark-Recapture**

- To know how tags are lost!



Pfaller, J.B., Williams, K.L., Frick, M.G., Shamblin, B.M., Nairn, C.J. & Girondot, M. (2019) Genetic determination of tag loss dynamics in nesting loggerhead turtles: A new chapter in “the tag loss problem”. *Marine Biology*, 166, 97.

## Why tagging turtles?



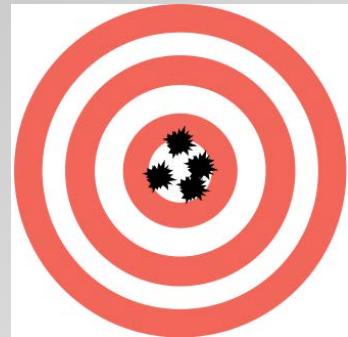
Number of days after an aborted nesting attempt

Tagloss creates a lack of precision but not a bias.

Number of days before return after nesting

Hancock, J., Vieira, S., Lima, H., Schmitt, V., Pereira, J., Rebelo, R. & Girondot, M. (2019)  
Overcoming field monitoring restraints in estimating marine turtle internesting period by modelling individual nesting behaviour using capture-mark-recapture data. Ecological Modelling, 402, 76-84.

## Retour en intrasaison



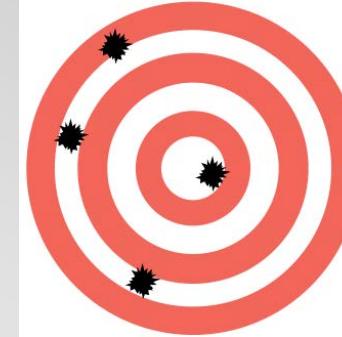
Precise  
Not bias



Not precise  
Not bias



Precise  
Biased

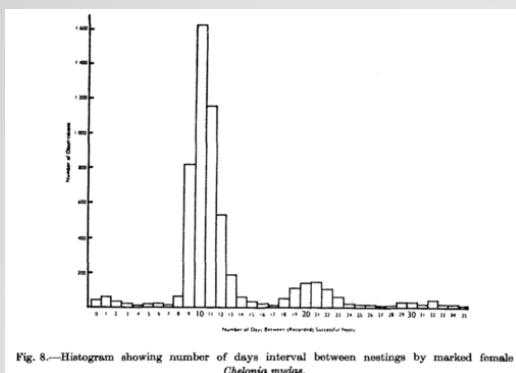


Not precise  
Bias

Precision is assessed with a confidence interval or a credibility interval.

## Bias and precision

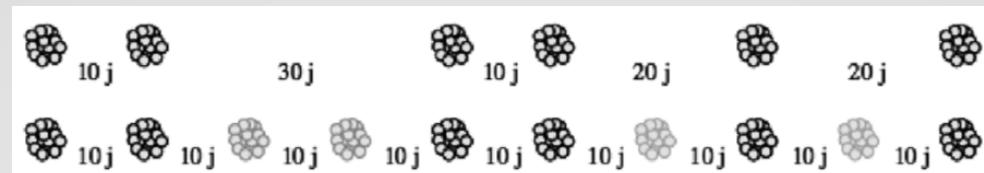
- As early than in the 30s, it was recognized that females come on the beach to nest several time with more or less regular nesting interval.
- Moorehouse, F.W., 1933. Notes on the green turtle, *Chelonia mydas*. Reports of the Great Barrier Reef Committee 4, 1-22.



- Distribution of number of days between two observations of tagged green turtles
- Hendrickson, J.R., 1958. The green sea turtle, *Chelonia mydas* (Linn.) in Malaya and Sarawak. Proceedings of the Zoological Society of London 130, 455-535.

## Nesting behavior of marine turtles

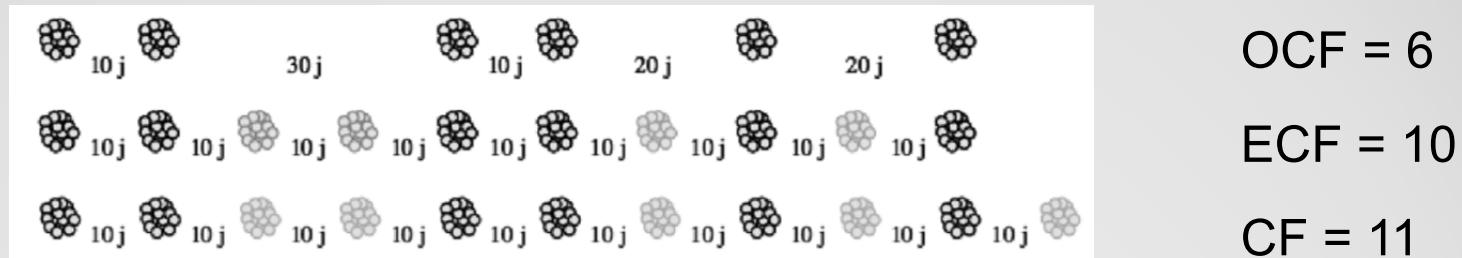
- From this observation, Frazer and Richardson (1985) derived new clutch frequency (CF) statistics:
- OCF being the Observed CF for each female: how many times each female was observed nesting;
- ECF being the Estimated CF for each female when missing observations were added.



- Frazer, N.B., Richardson, J.I., 1985. Annual variation in clutch size and frequency for loggerhead turtles, *Caretta caretta*, nesting at Little Cumberland Island, Georgia, USA. Herpetologica 41, 246-251.

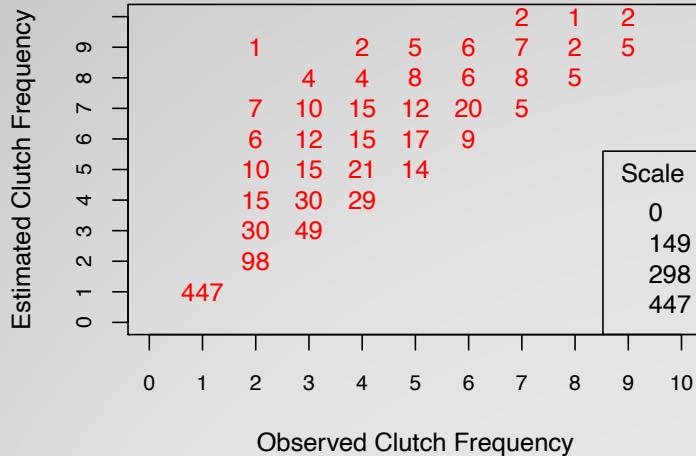
## ECF from OCF

- From this definition, it follows that  $\text{ECF} \geq \text{OCF}$ .
- However, a strong hypothesis is done when ECF is used as an estimate of true CF:
  - First and last nests must have been observed



## Statistical properties of ECF

## Leatherbacks in Ya:lima:po in 2012

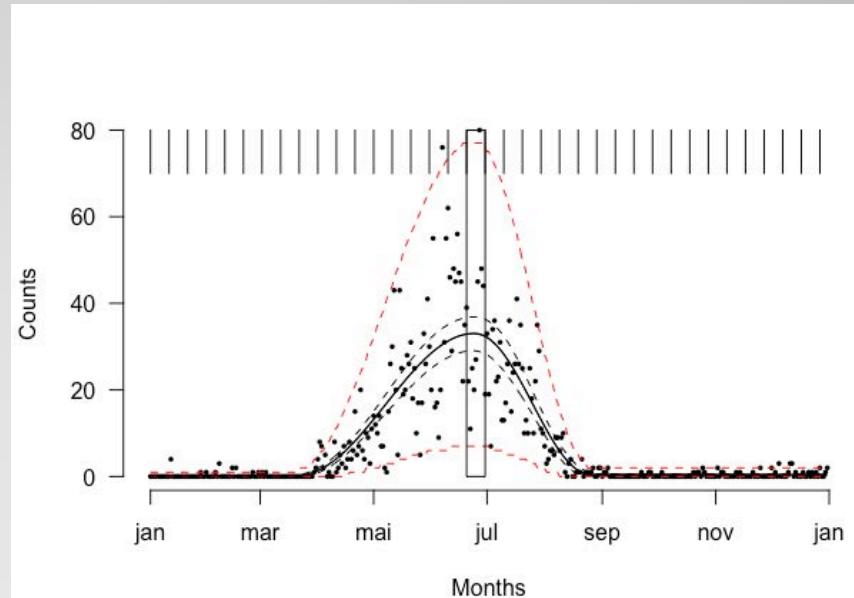
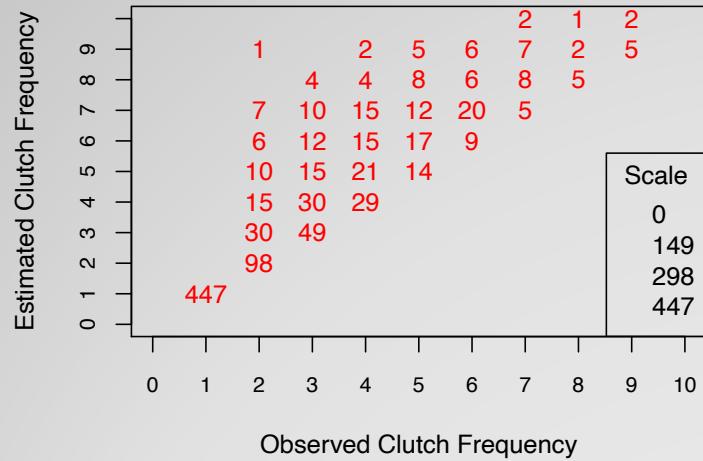


Note the high frequency of females of the (OCF=1, ECF=1) category which cannot be handled in stopover CMR models.

Rivalan, P., Pradel, R., Choquet, R., Girondot, M., Prévot-Julliard, A.-C., 2006. Estimating clutch frequency in the sea turtle *Dermochelys coriacea* using stopover duration. Marine Ecology-Progress Series 317, 285-295.

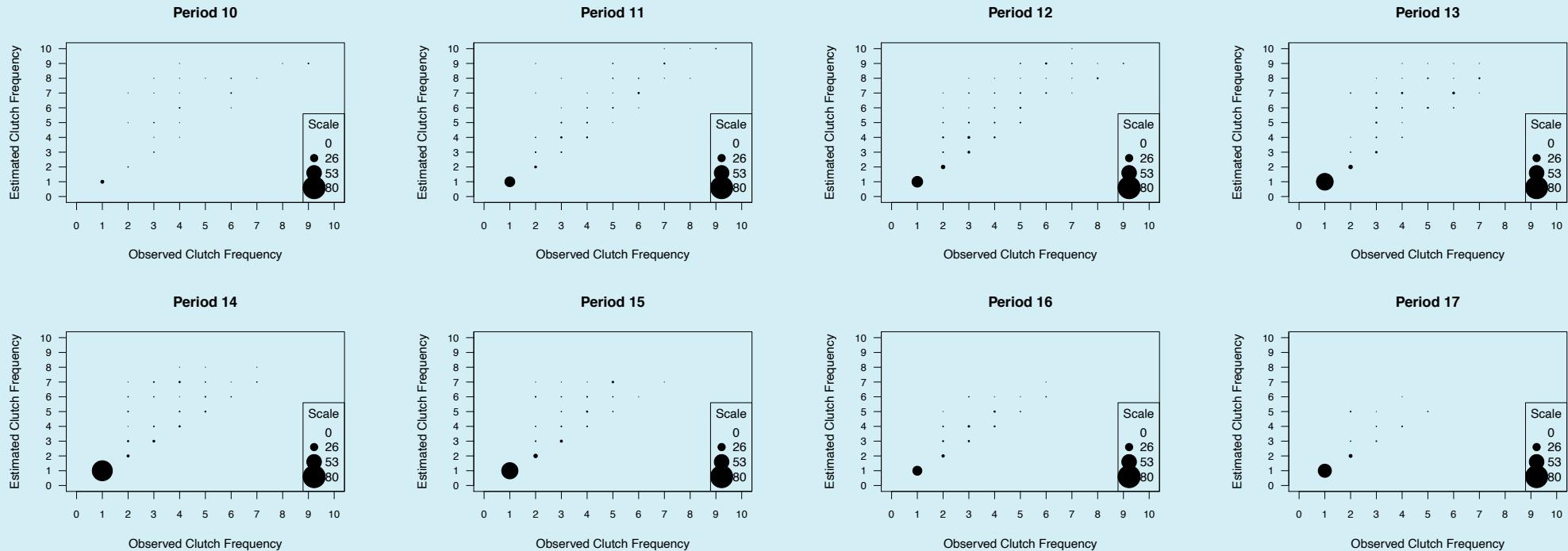
## Stopover with Capture-Marquage-Recapture

## Leatherbacks in Ya:lima:po in 2012



**Splitting OCF-ECF tables by the period of first observation for each female**

## Leatherbacks in Ya:lima:po in 2012



**Splitting OCF-ECF tables by the period of first observation for each female**

- The probability associated with each combination of (OCF, ECF, Period) was explicitly written and the parameters are fitted using classical non-linear optimization.

## The model

- The probability associated with each combination of (OCF, ECF, Period) was explicitly written and the parameters are fitted using classical non-linear optimization.

## The model

$$\begin{aligned}
 & W_0 + W_1 + \dots + W_t = \ln(R_2), L_3 = \ln(R_3) \\
 & L_1 = \ln(R^1), Y_2 = \frac{1}{T_1} \\
 & Y_3 = \frac{1}{T_2}, Y_4 = \frac{1}{T_3} \\
 & CR = \frac{Y_2 - Y_1}{L_2 - L_1} \\
 & EV_j = \sum_{j=1}^t \gamma^{t-j} W_j \\
 & \max(R^{\frac{Y_2}{L_2}})(L_1 + L_2) \\
 & \Rightarrow C = \frac{R^{\frac{Y_2}{L_2}}}{(L_1 + L_2)} \\
 & \Rightarrow B = Y_2 - C(Y_1, O) \\
 & \Rightarrow A = Y_1 - L_1(B) + W_5 \\
 & \sum_{j=1}^t \gamma^{t-j} W_j
 \end{aligned}$$

- The probability associated with each combination of (OCF, ECF, Period) was explicitly written and the parameters are fitted using classical non-linear optimization.

Available as a  package « phenology » in CRAN



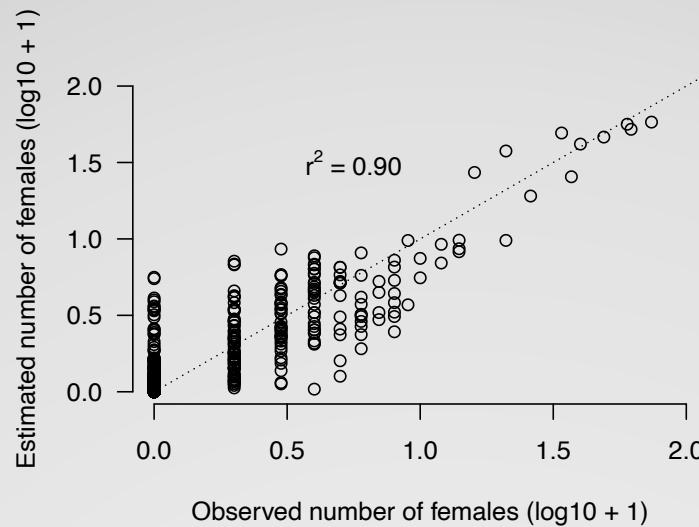
## The model

## Leatherbacks in Ya:lima:po in 2012

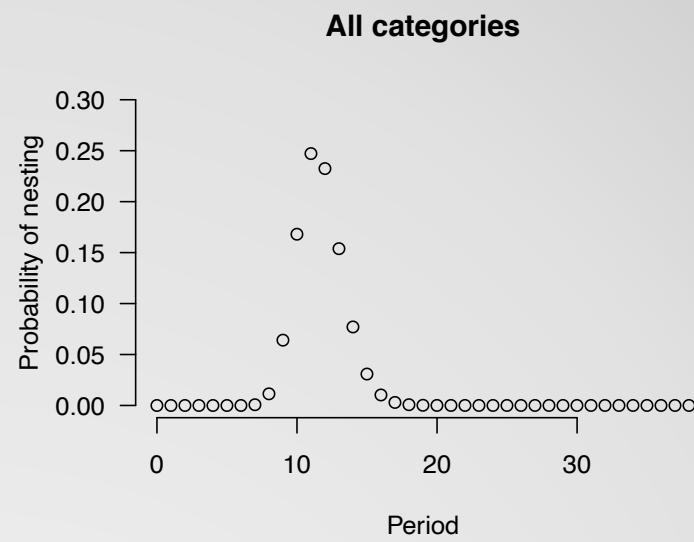
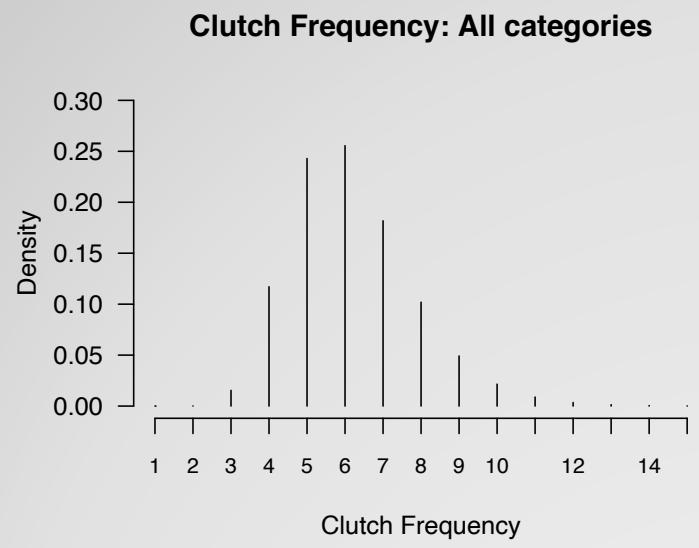
	AIC	$\Delta AIC$	Akaike Weight
1 category	9 226	206	0
2 categories: ≠ Clutch Frequencies	9 115	95	0
2 categories: ≠ Nesting seasons	9 198	78	0
2 categories: ≠ Capture probabilities	9 019	0	1

**Different models corresponding to different behaviors can be tested**

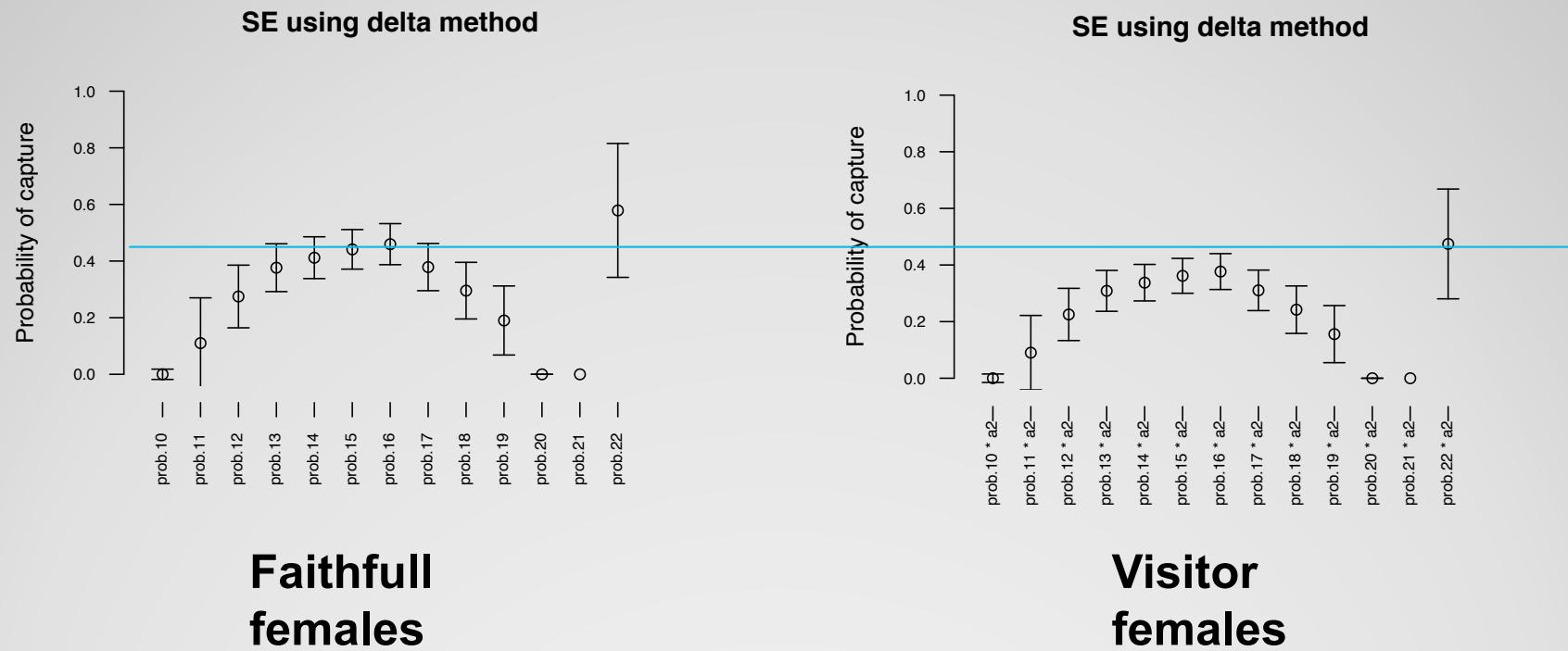
## Leatherbacks in Ya:lima:po in 2012



**Results: 2 categories of females different by their capture probabilities**



**Results: one category of CF and nesting season**



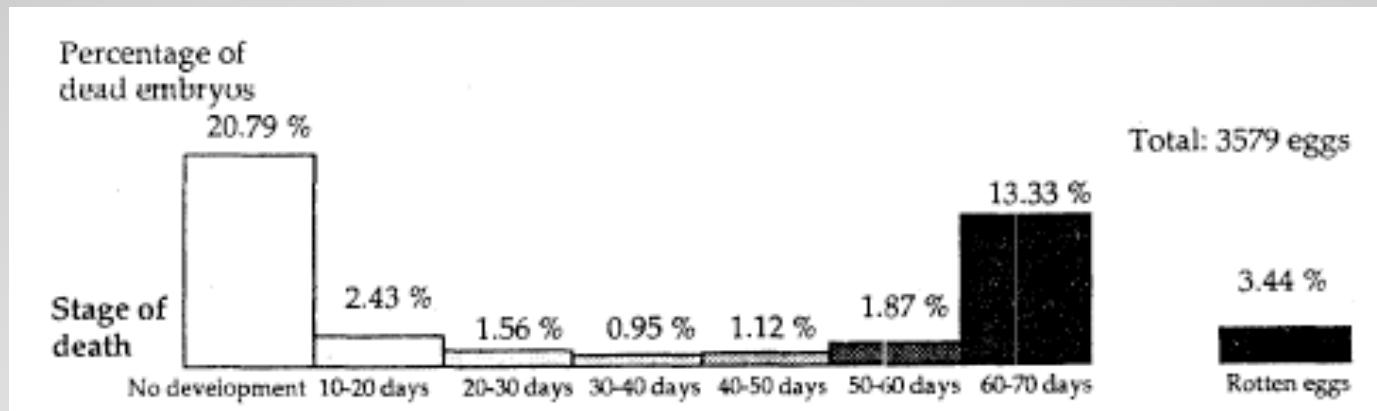
## Results: 2 categories of capture probabilities

- Splitting the OCF-ECF table into periods when each female was seen for the first time permits to generate **more information from the same data**;
- The 3D tables (OCF, ECF, period) allow to fit **a period-specific capture probability** as well as **the distribution of first nesting by the females**;
- Using this new formulation of CF model, we show that the two categories of leatherback females did **not differentiate by CF** as previously thought, but **by capture probability**:
  - Some females are *faithful* to the monitored nesting beach and others are just *visitors* to this beach.



# Nest monitoring

- A la fin de l'incubation, en déterrant le nid, on peut établir la réussite d'incubation et caractériser le stade de développement des œufs non-éclos



- Il est alors possible d'identifier l'origine de la mortalité embryonnaire

- Caut, S., Guirlet, E. & Girondot, M. (2010) Effect of tidal overwash on the embryonic development of leatherback turtles in French Guiana. *Marine Environmental Research*, 69, 254-261.
- Caut, S., E. Guirlet, P. Jouquet, and M. Girondot. 2006. Influence of nest location and yolkless eggs on hatching success of leatherback turtle nests in French Guiana. *Canadian Journal of Zoology-Revue Canadienne de Zoologie* 84:908-915.

## Suivi d'un nid

- L'incubation d'un nid est un processus dynamique.
- Le taux de mortalité à un stade dépend de ce qui s'est passé auparavant lors de l'incubation.

- |           | Nid 1    | Nid 2    |
|-----------|----------|----------|
| • Stade 0 | 10 (14%) | 50 (72%) |
| • Stade 1 | 20 (28%) | 10 (14%) |
| • Eclos   | 40 (56%) | 10 (14%) |
- Le taux de mortalité au stade 1 est plus fort pour le nid 1 ? **Non**

## Suivi d'un nid

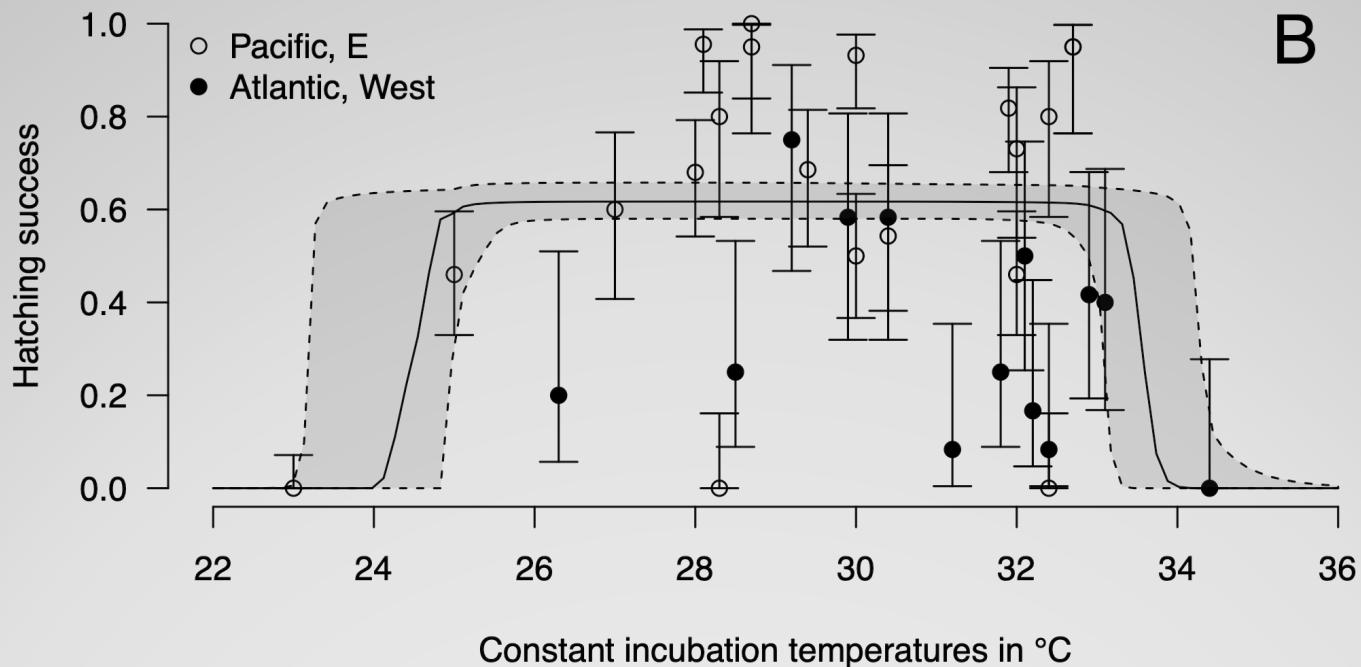
- L'incubation d'un nid est un processus dynamique.
- Le taux de mortalité à un stade dépend de ce qui s'est passé auparavant lors de l'incubation.

	Nid 1	Nid 2
• Stade 0	10 ( $10/70=14\%$ )	50 ( $50/70=72\%$ )
• Stade 1	20 ( $20/60=33\%$ )	10 ( $10/20=50\%$ )
• Eclos	40	10

- Le taux de mortalité au stade 1 est plus fort pour le nid 2

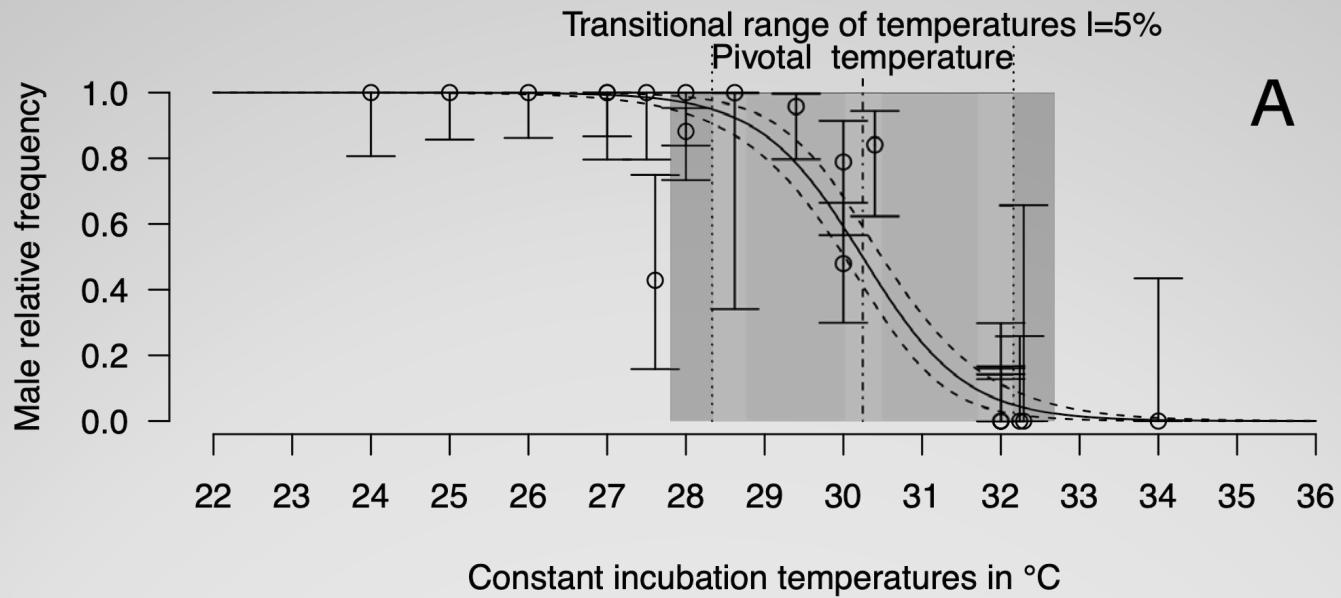
## Suivi d'un nid

B



Mérida, A.M., Helier, A., Cortés-Gómes, A.A., Guillon, J.-M. & Girondot, M. (Submitted) Hatching success rather than temperature-dependent sex determination as the main driver of Olive Ridley (*Lepidochelys olivacea*) nest density in the Pacific Coast of Central America. Sexual Development.

Hatching success as function of temperature

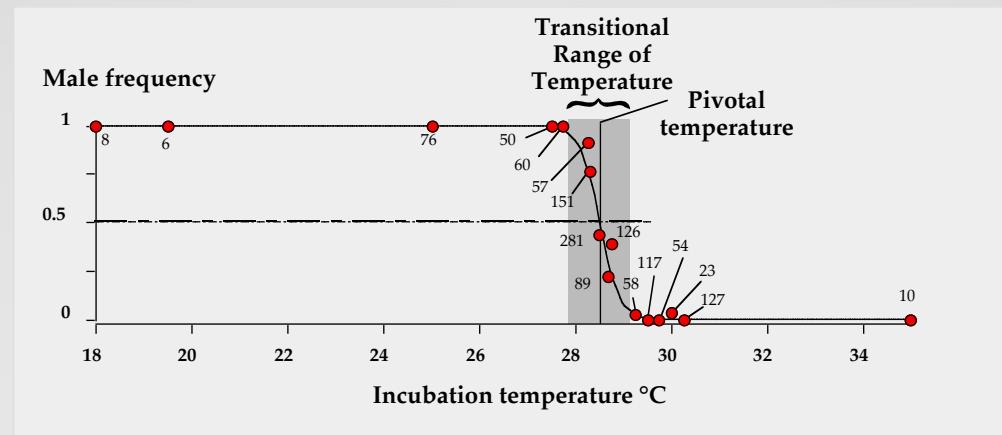


Mérida, A.M., Helier, A., Cortés-Gómes, A.A., Guillon, J.-M. & Girondot, M. (Submitted) Hatching success rather than temperature-dependent sex determination as the main driver of Olive Ridley (*Lepidochelys olivacea*) nest density in the Pacific Coast of Central America. Sexual Development.

## Sex ratio as function of temperature

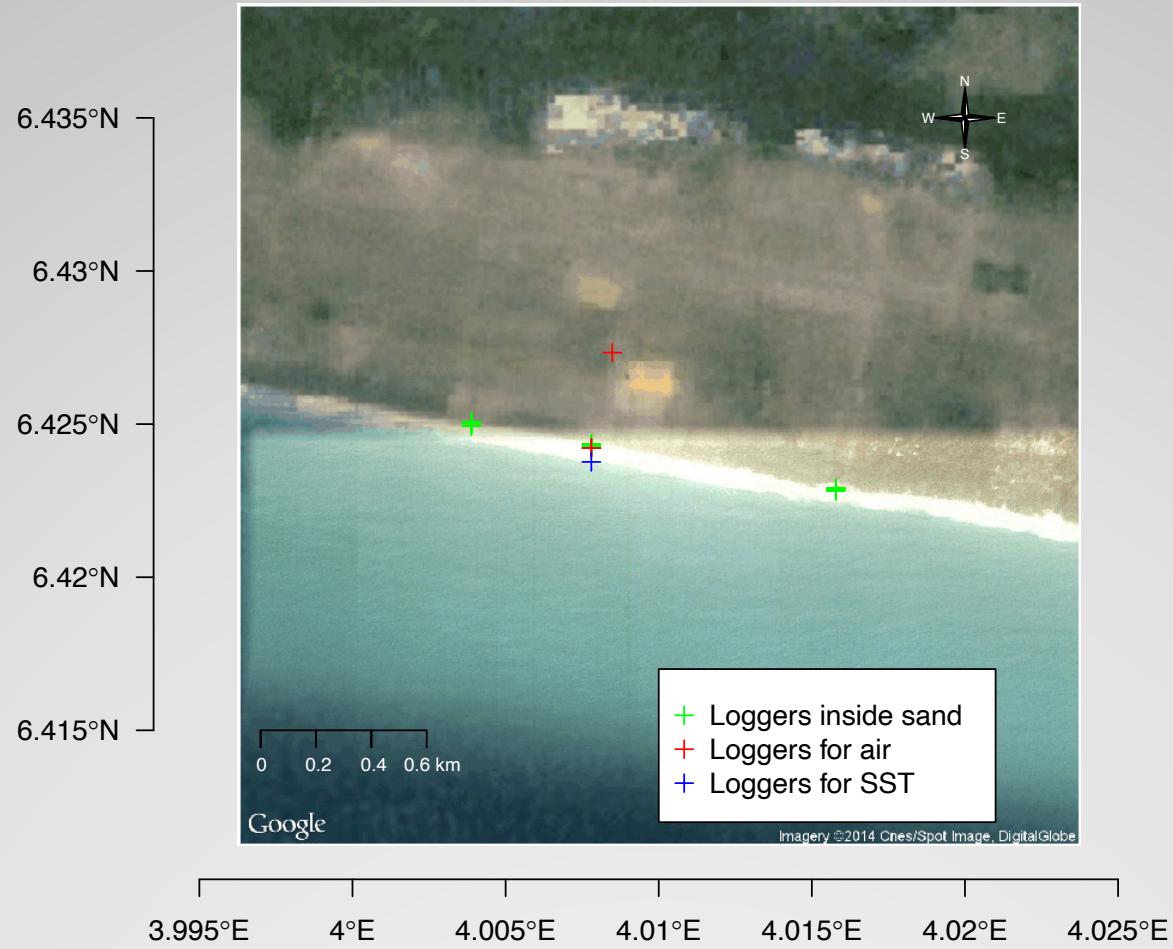
We must have information about beach ecosystem that can be easily monitored and interpreted both at the level of physical characterization of ecosystem and for marine turtles:

- Temperature is the easiest physical parameter that can be measured in a granulose media like sand
- Incubation of eggs and hatching success is linked to temperature
- Sex ratio of marine turtles is linked to temperature



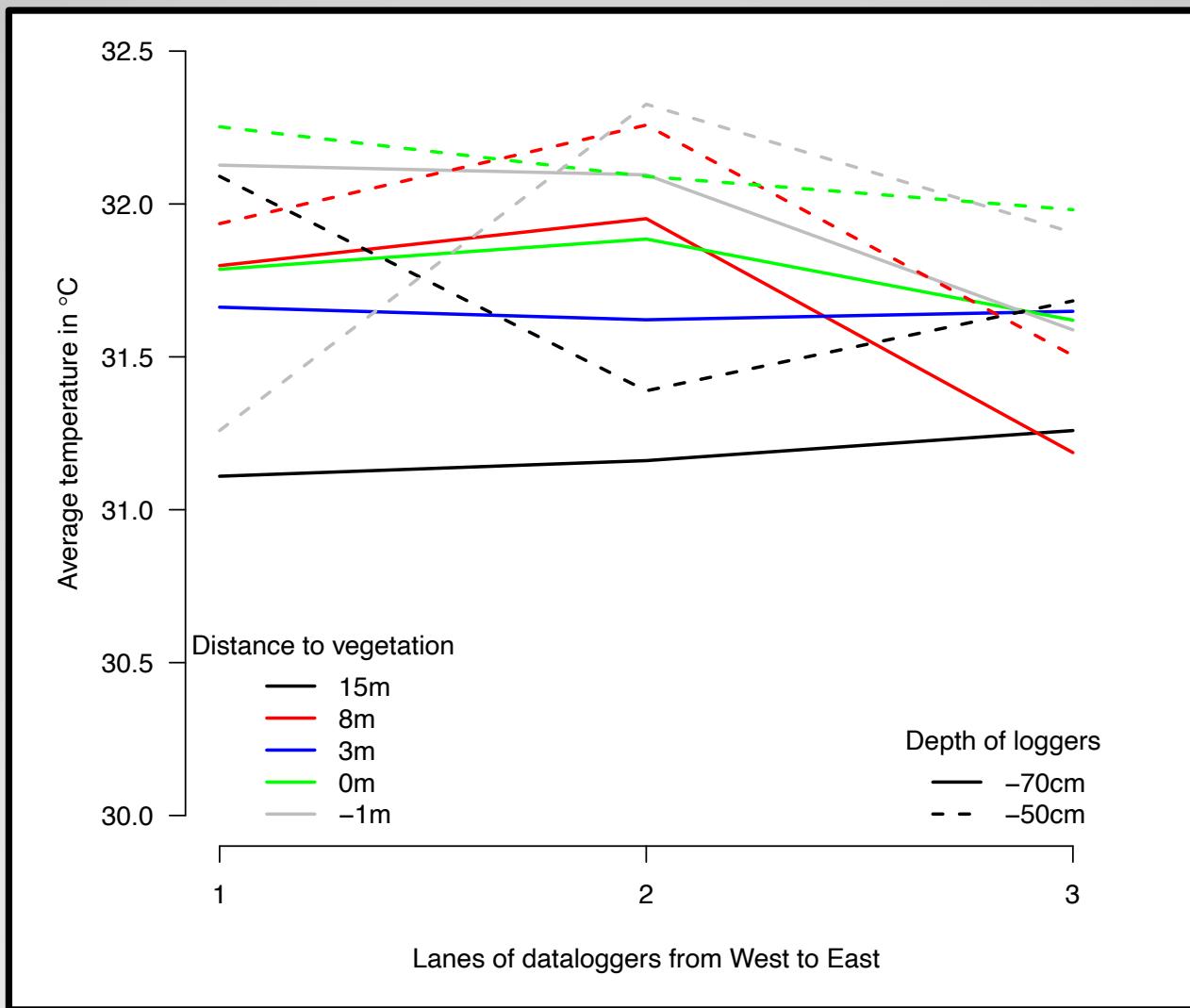
Compilation of artificial incubation for 1293 eggs at 16 different incubation temperatures

## Physical beach characterization



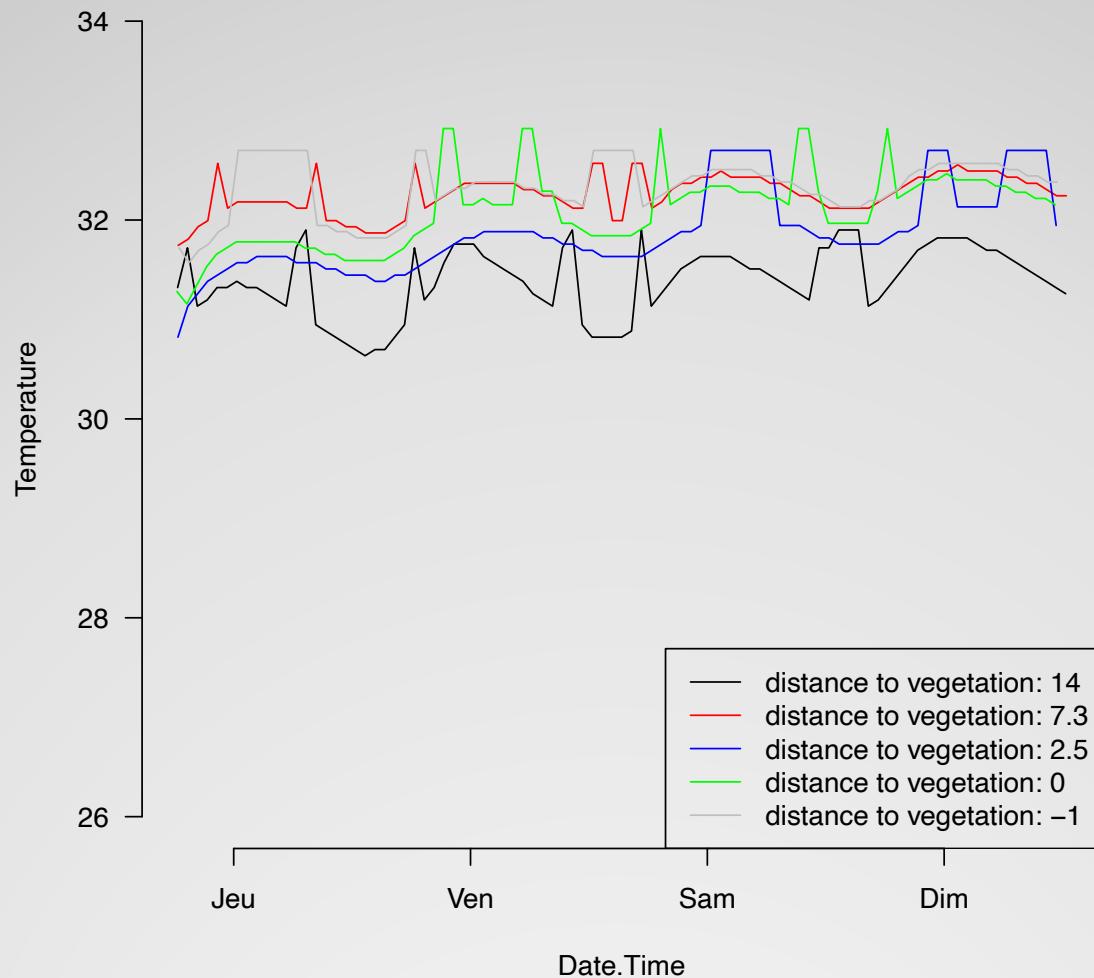
# Dataloggers in Lekki beach, Nigeria

### Average temperature according to distance of vegetation



# Lane effect on sand temperature

**Line, latitude 6.42422 longitude 4.00780; Depth=-50**



## Logger information

How to integrate thermal heterogeneity in nesting site?

Scale of difference is important

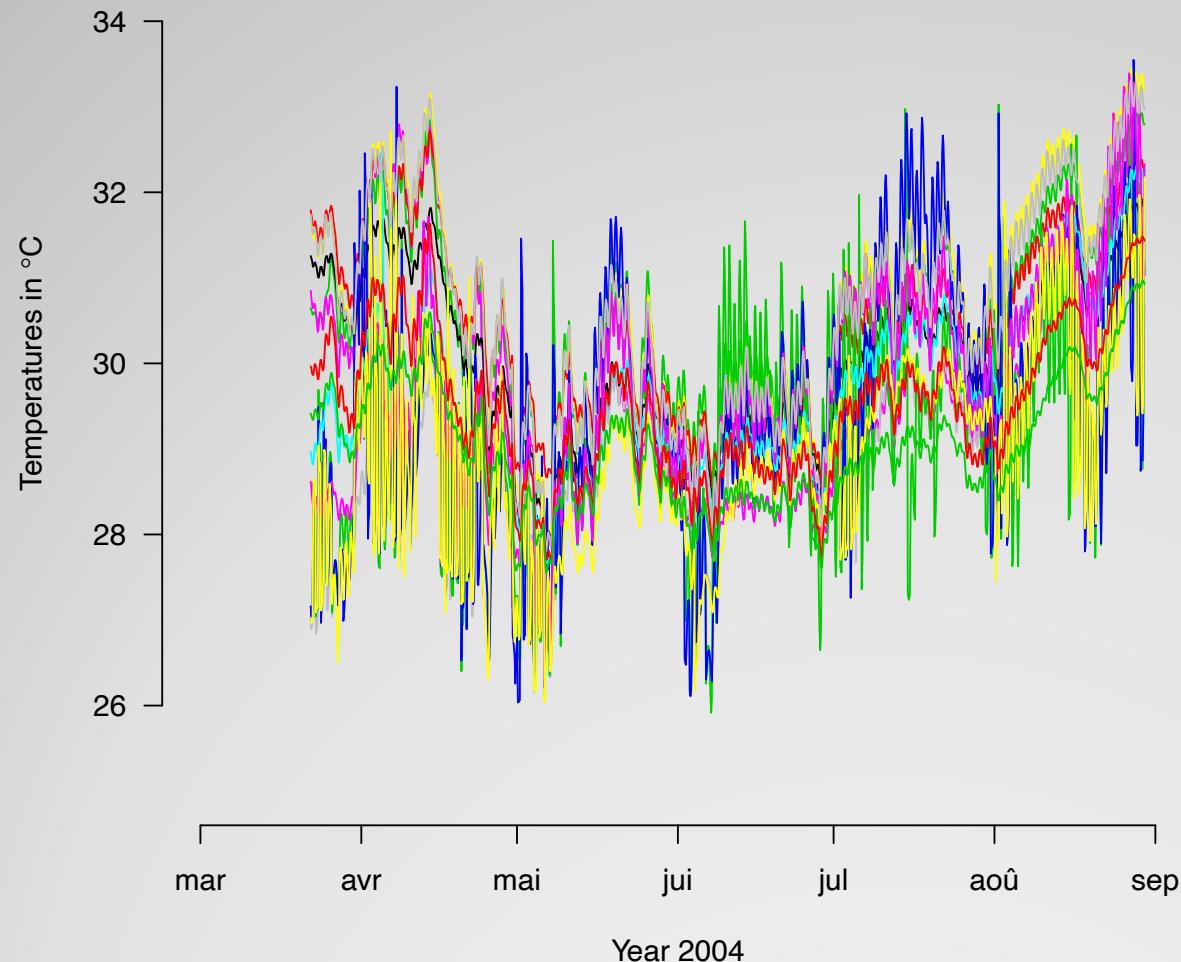
- It is recognized since very long time that temperature is not homogeneous in an ecosystem, mainly due to cooling due to shade



## Scaling the thermal heterogeneity



# Scaling the thermal heterogeneity



- Based on temperature recording, thermal heterogeneity in soil at very small scale (10m) can be very large (up to 3°C) even in the absence of shading difference

## Scaling the thermal heterogeneity

- Based on temperature recording, thermal heterogeneity in soil at very small scale (10 m) can be very large (up to 3° C) even in the absence of shading difference
  - *Physics of thermal properties of soil is very complex. Energy transfer depends on soil structure and composition. Particularly moisture in soil have a very complex interaction with energy loss and will change over time.*

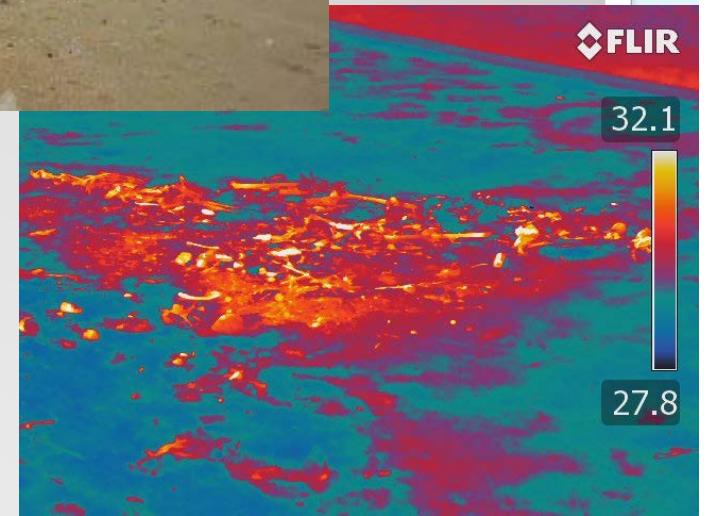
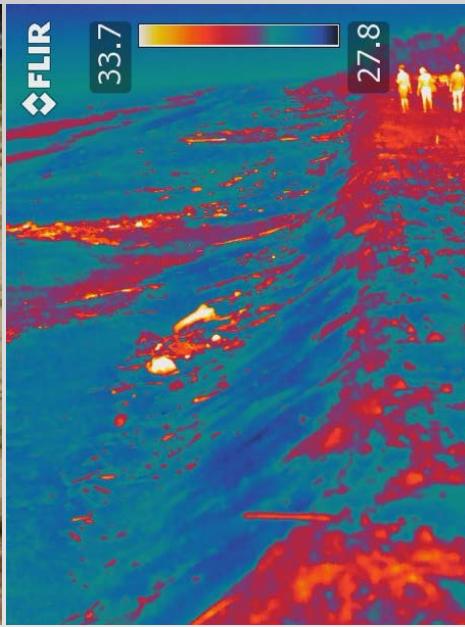
## Scaling the thermal heterogeneity

- Thermal properties of sand (thermal conductivity, thermal diffusivity) are determined by the physical properties of substrate
- When plastics are mixed to sand, what is the change of thermal properties of sand and then the temperature?



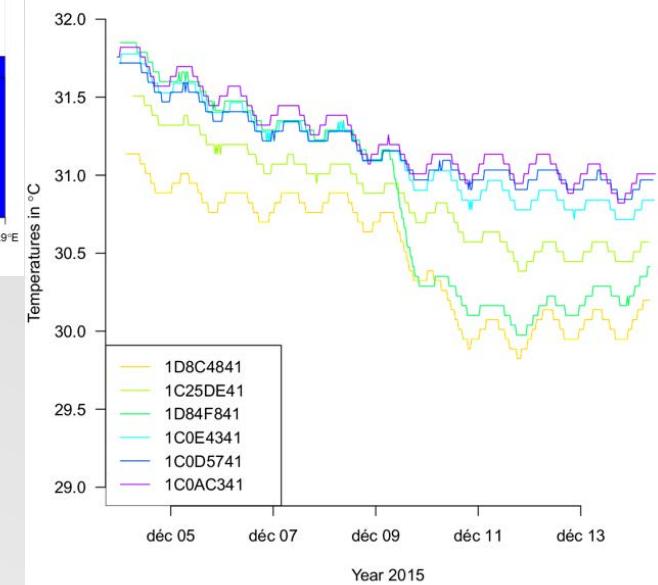
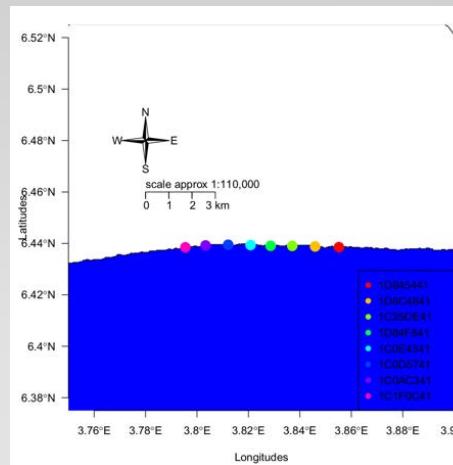
Adegbile, O.M. & Girondot, M. (2019) Plastic debris and sand temperature in a sea turtle nesting beach in West Lagos coast, Nigeria. 39th International Sea Turtles Symposium. Charleston, SC.

**Plastic in sand changes the physical properties of sand: thermal pollution?**



# Survey using infrared camera

- Temperature data loggers were deployed along the Eleko beach in Lagos Nigeria between at 50 cm depth and 3 m from vegetation at varying distances to determine the heterogeneity of the sand temperatures.
- Sand temperature heterogeneity can be as large as  $1.5^{\circ} \text{ C}$  but the closer the dataloggers are, the most similar are the temperatures.

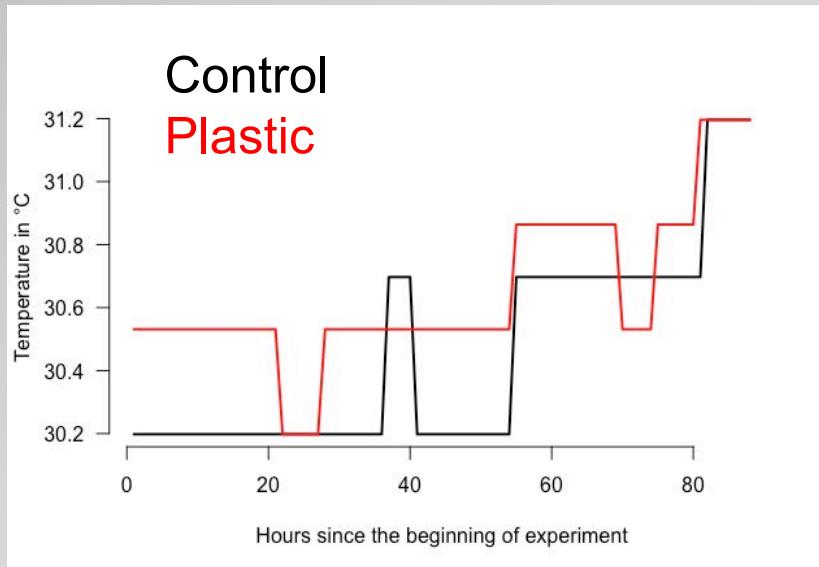


## Heterogeneity of temperatures in absence of plastic

- 2 replicates of temperature recorded at 50 cm depth in sand without plastics (C1 & C2) or with plastic (P1 or P2) at the top for a 5 day period (experiment 1) or 3 days (experiment 2). Each control and experiment dataloggers were localized at 1 m distant apart.
- Temperatures were recorded each hour.



**Experiment to analyze if plastics in sand can have an impact for marine turtles**



- In the 4 experiments, the temperature recorded by datalogger with plastic was always warmer than the temperatures recorded by datalogger without:
  - $\Delta T = +0.036^\circ \text{ C}$  (SE  $0.014^\circ \text{ C}$ )
  - $\Delta T = +0.353^\circ \text{ C}$  (SE  $0.021^\circ \text{ C}$ )
  - $\Delta T = +0.186^\circ \text{ C}$  (SE  $0.028^\circ \text{ C}$ )
  - $\Delta T = +0.418^\circ \text{ C}$  (SE  $0.026^\circ \text{ C}$ )

## Results of experiments

- Climatic models use a 25km x 25km grid to give estimate of past and future climate
- This scale is not relevant at all to take into account thermal micro-habitat.

## Scaling the thermal heterogeneity

- Temperature recorded in beach shows large variation even at <10 m spatial scale
- Nyctemeral rythm can be observed even at -70 cm but it depends on quality of sand (humidity, content in organic matter)
- Plastic pollution on the beach changes the thermal properties of sand and induces an increase of temperature

## Summary of beach temperature

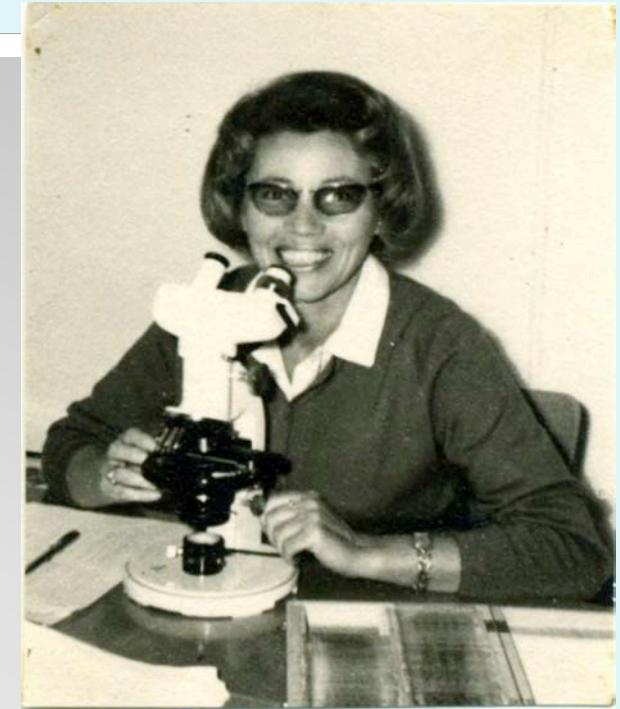
**What about sex ratio ?**

- Charnier M, 1966. Action de la température sur la sex-ratio chez l'embryon *d'Agama agama* (Agamidae, Lacertilien). C. R. Soc. Biol. Paris 160: 620-622.



## Découverte de TSD chez les reptiles

Gabon, mai 2008



Madeleine Charnier, 1919-2002



# TSD chez les chéloniens

- Pieau C, 1969. Sur une anomalie des conduits génitaux observée chez des embryons de Tortue grecque (*Testudo graeca* L.) traités par le benzoate d'oestradiol. C. R. Acad. Sci. (Paris) 268: 364-367.
- Pieau C, 1970. Effets de l'oestradiol sur l'appareil génital de l'embryon de tortue mauresque (*Testudo graeca* L.). Arch. Anat. Microsc. Morph. Exp. 59: 295-318.
- Pieau C, 1971. Sur la proportion sexuelle chez les embryons de deux Chéloniens (*Testudo graeca* L. et *Emys orbicularis* L.) issus d'oeufs incubés artificiellement. C. R. Acad. Sci. Paris 272(D): 3071-3074.
- Pieau C, 1972. Effets de la température sur le développement des glandes génitales chez les embryons de deux Chéloniens, *Emys orbicularis* L. et *Testudo graeca* L. C. R. Acad. Sci. Paris 274(D): 719-722.



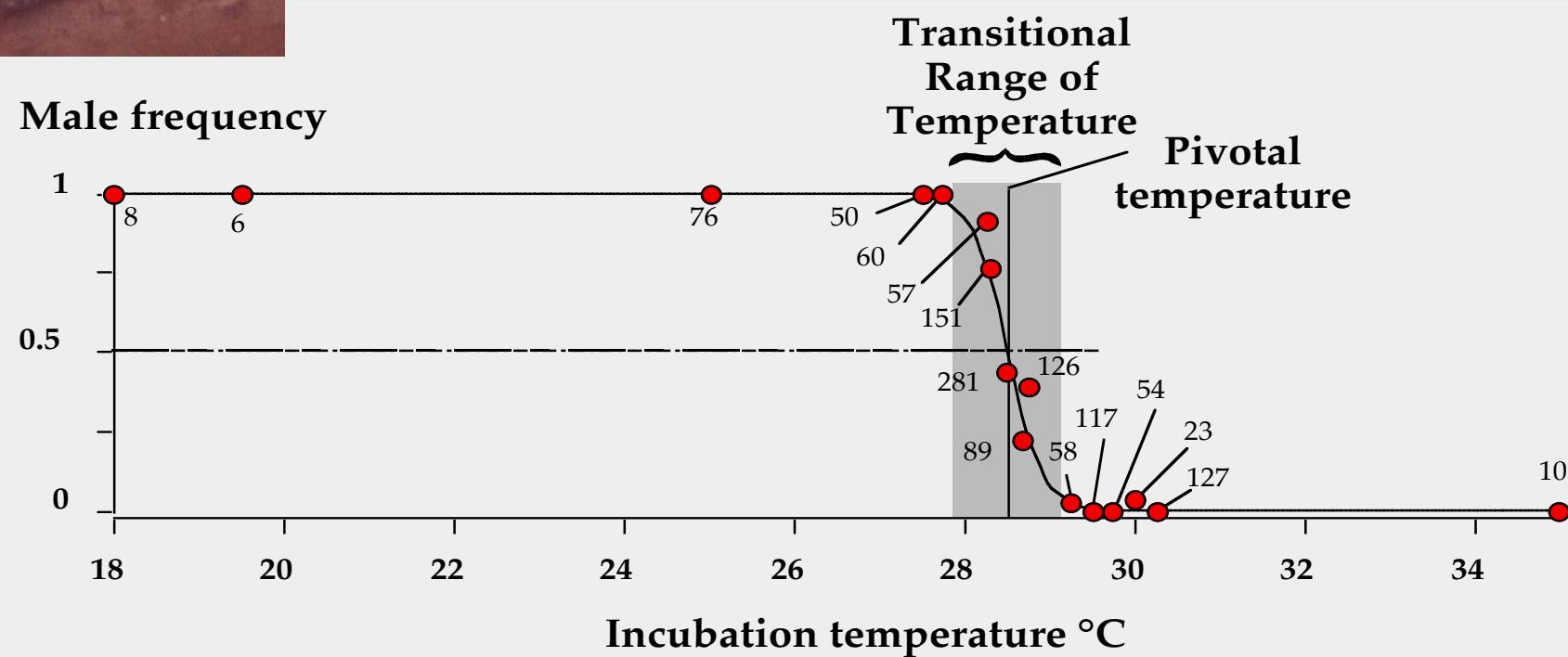
*Emys orbicularis*



*Testudo graeca*

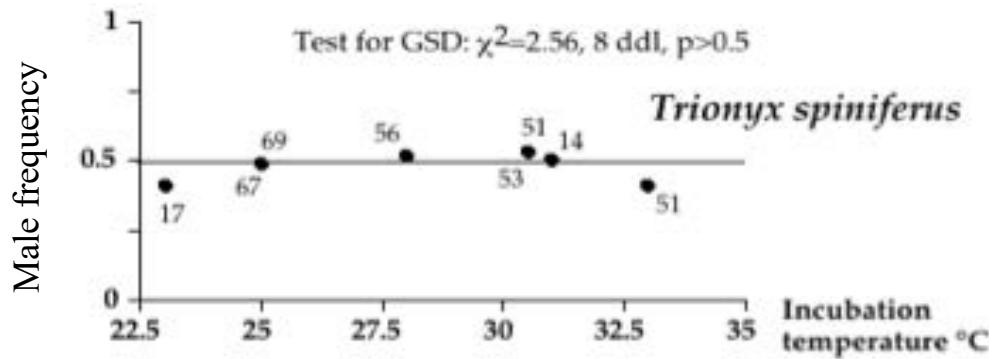


# Sex determination upon constant incubation temperatures in *Emys orbicularis*

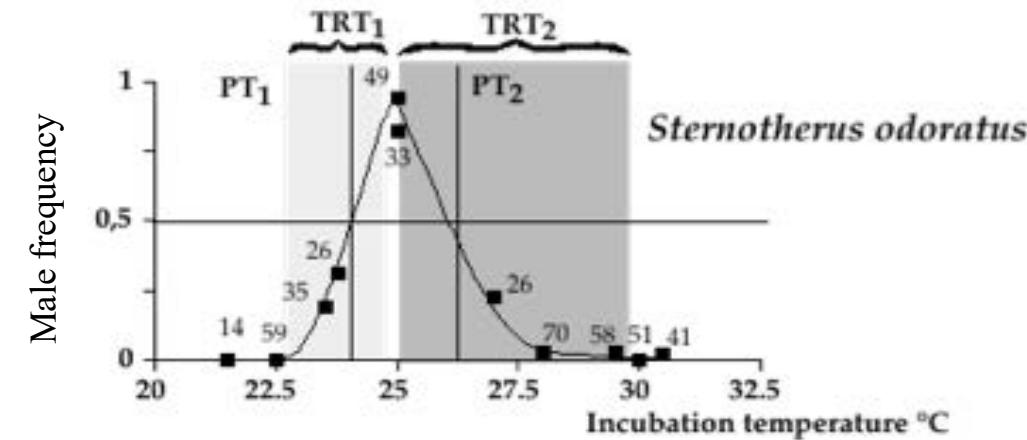
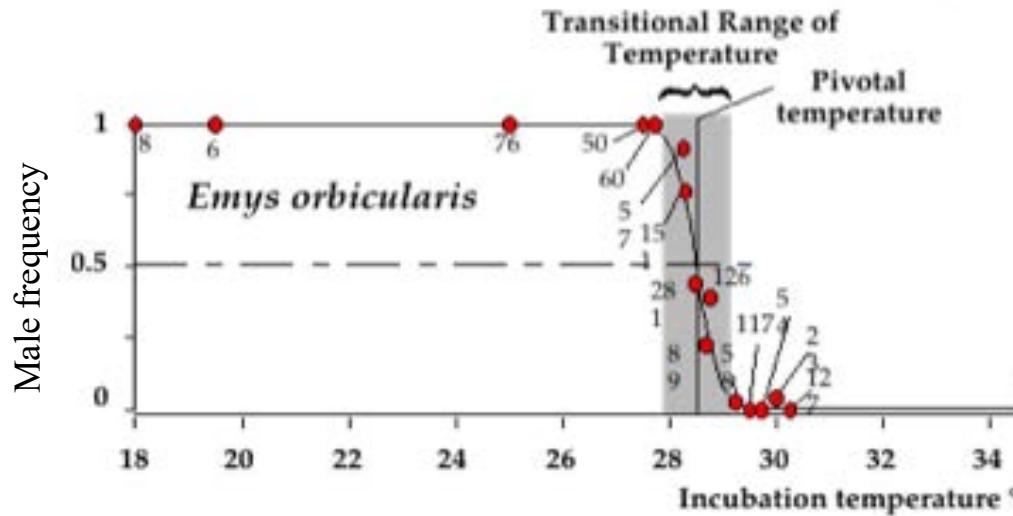


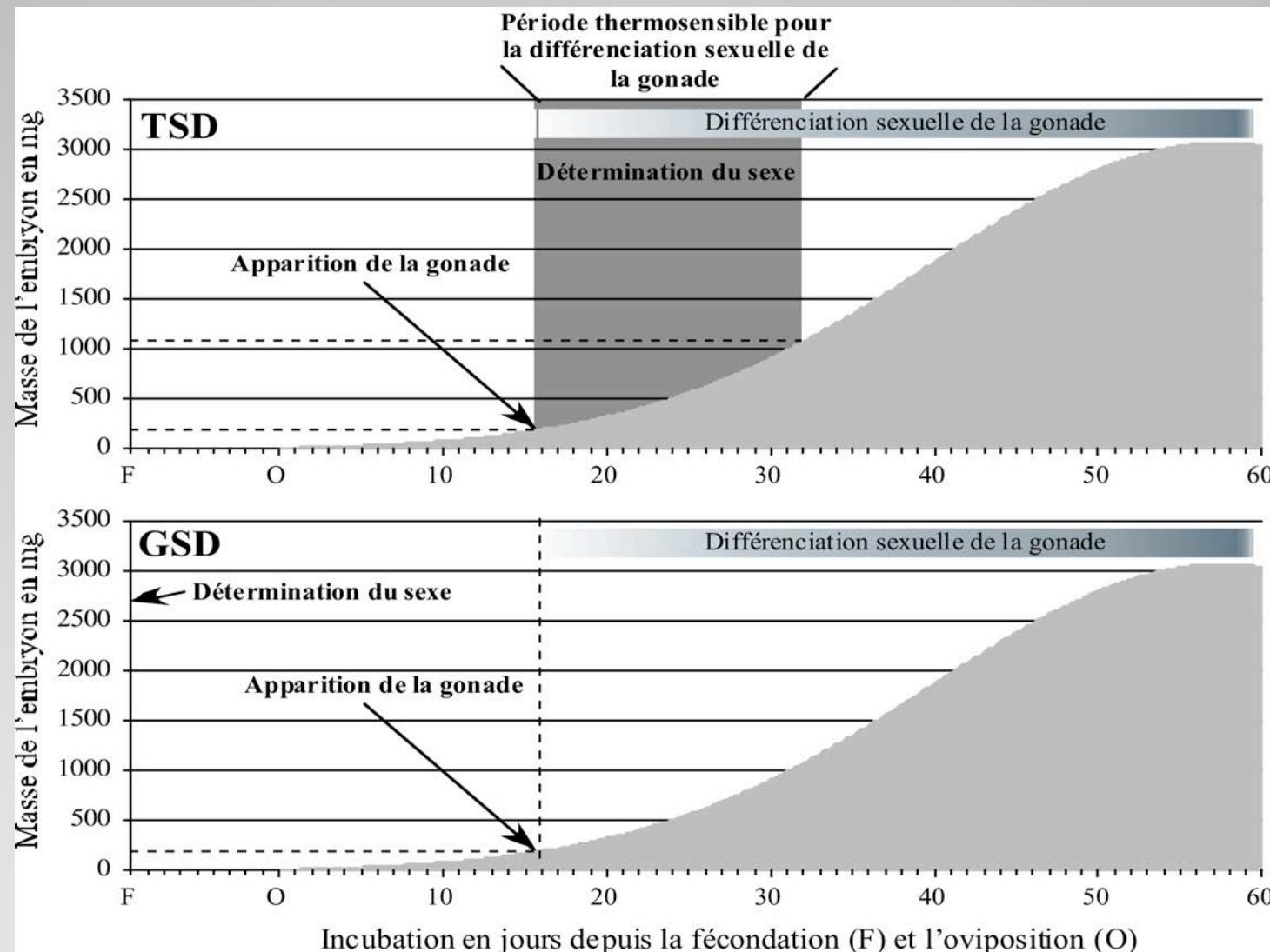
Compilation of artificial incubation for 1293 eggs at 16 different incubation temperatures

GSD

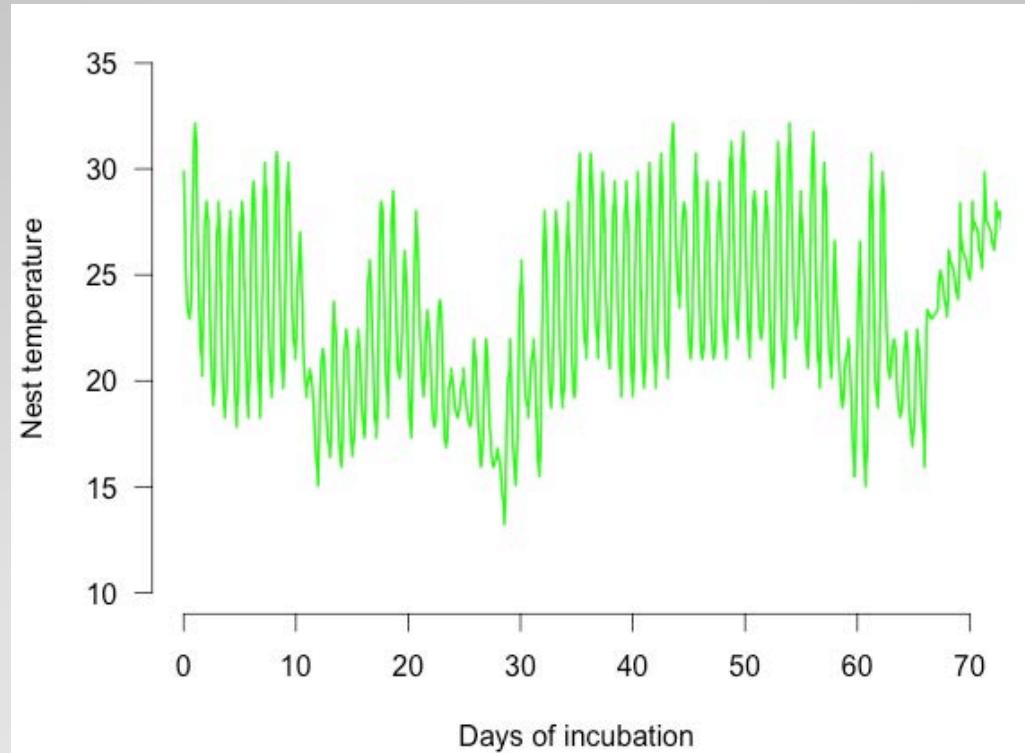


TSD





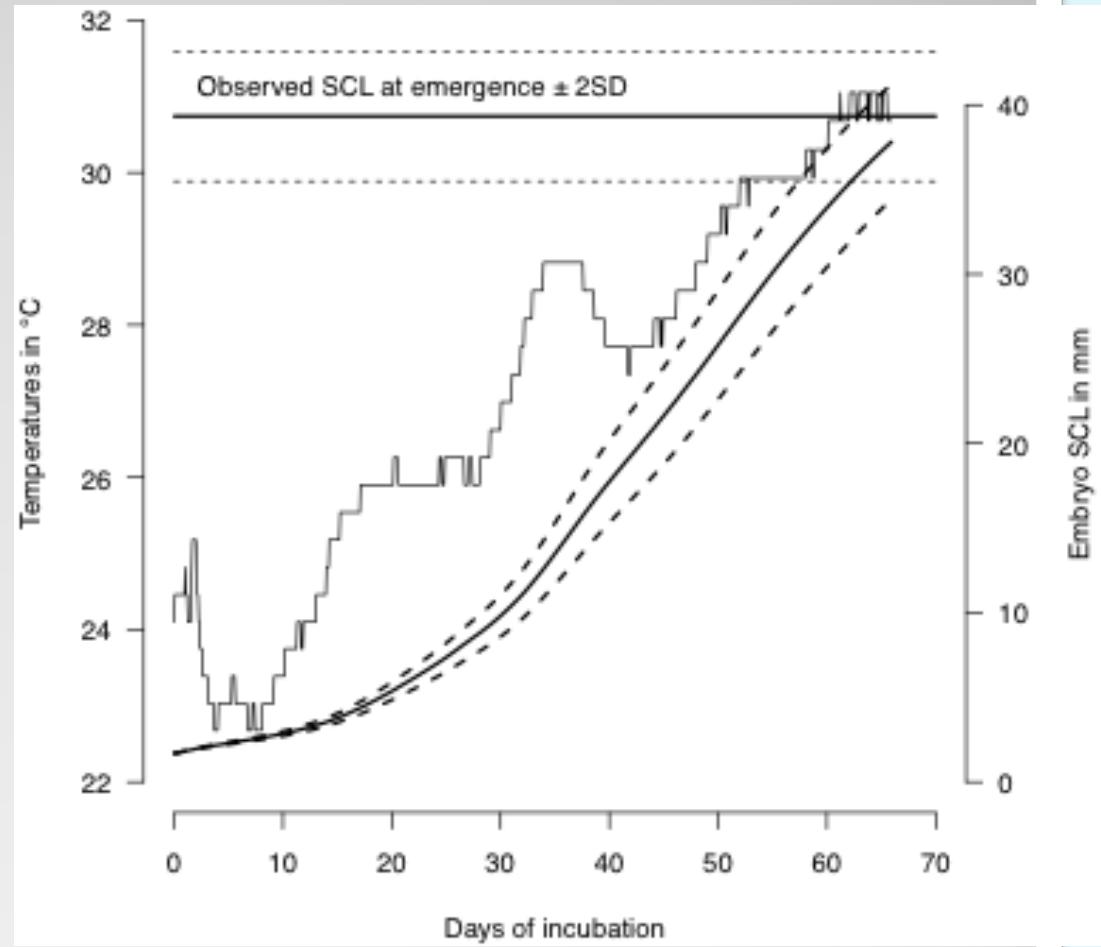
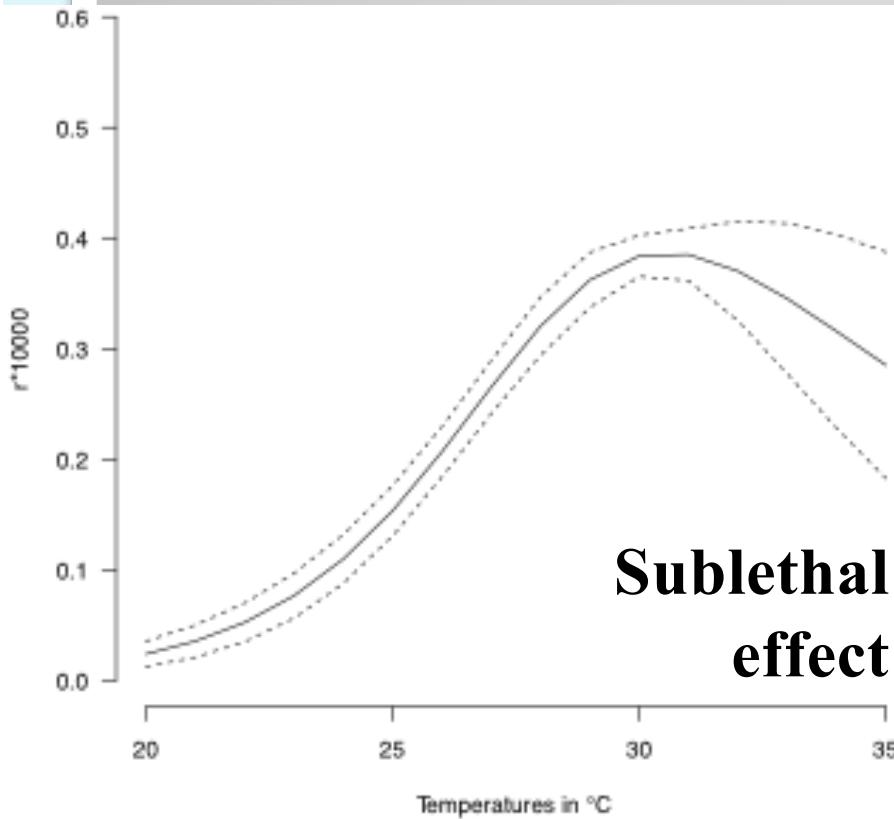
# Development



- To define the position of TSP, we need to have a model of embryonic growth dependent on temperature.

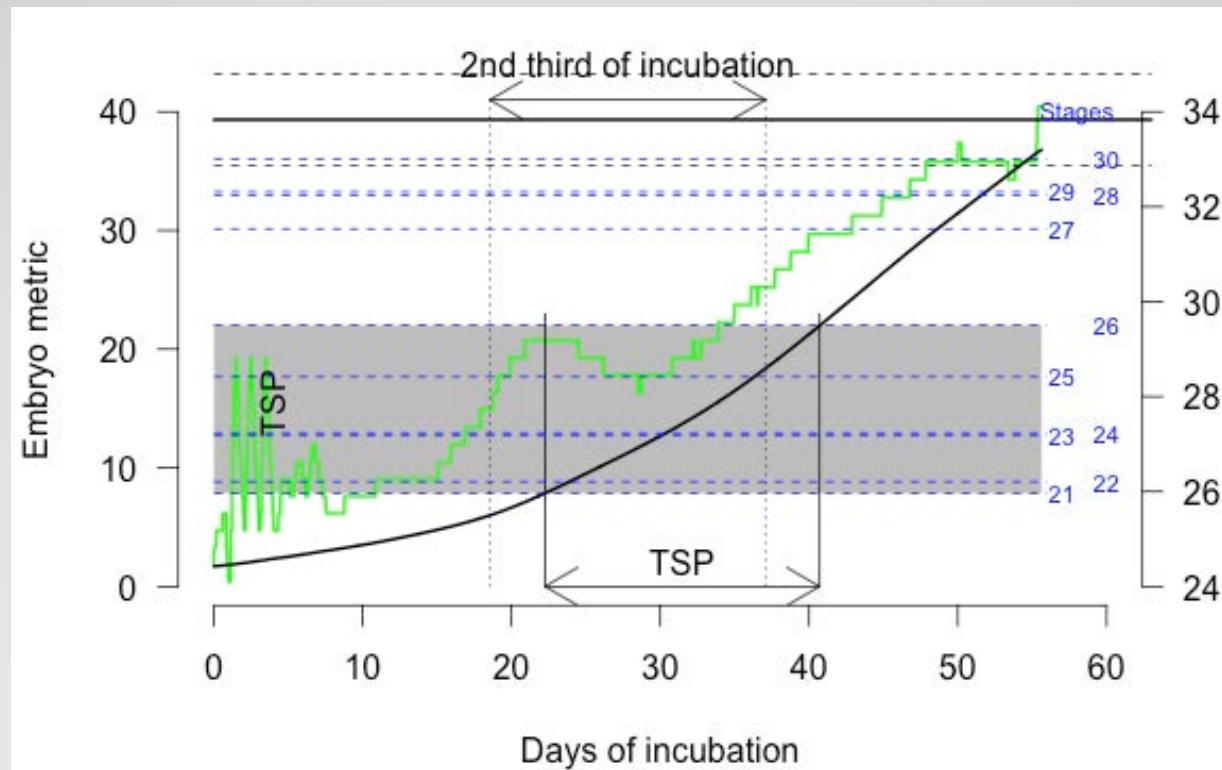
## How to define the position of TSP?

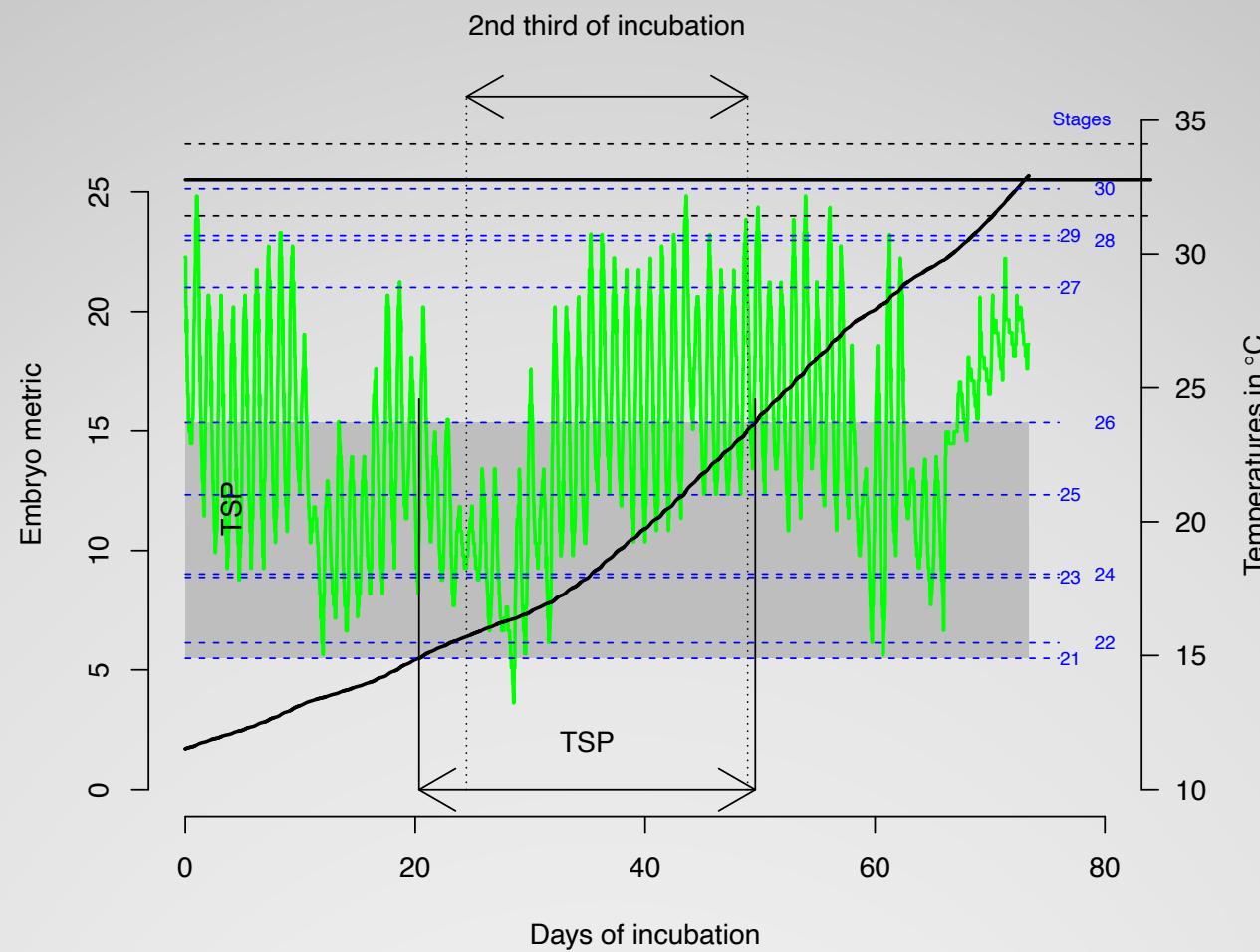
# Results



**Example of modeled embryo growth with varying temperature**

# Embryonic growth and TSP



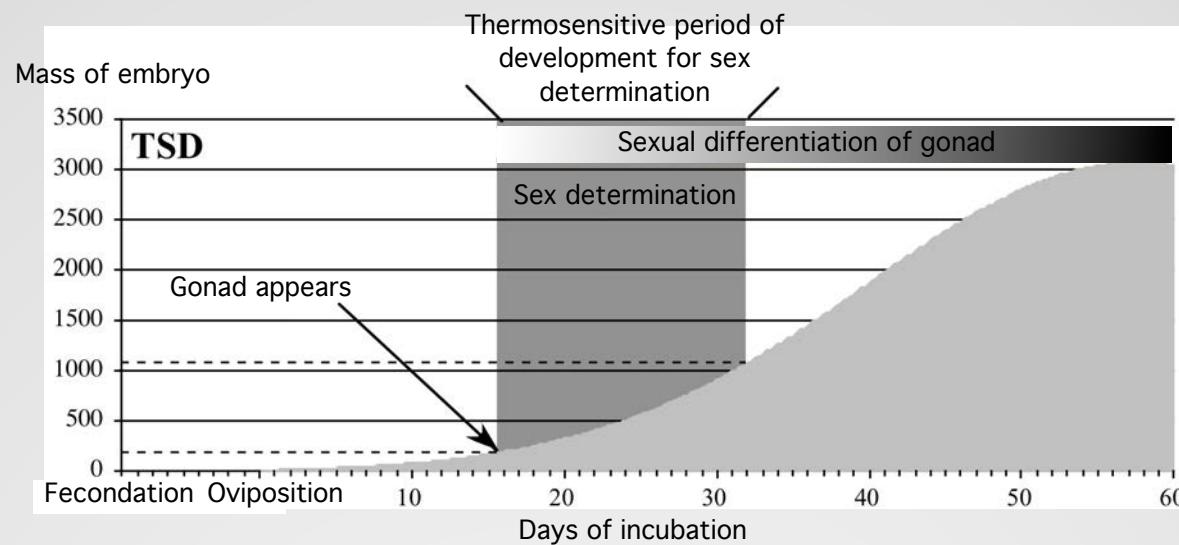


# TSP at non-constant temperature

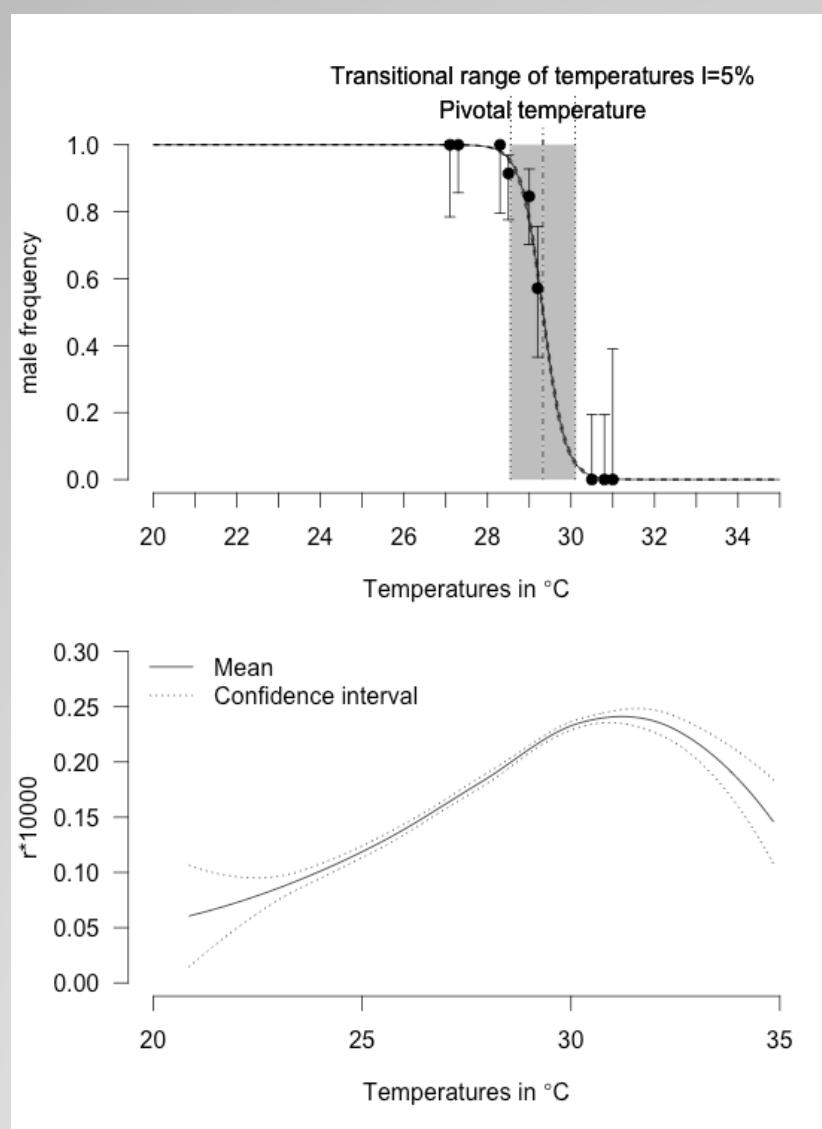
- Rate of development in reptiles is dependent on integrative cumulated effect of temperature during development.
- For species with TSD, sex is also dependent on integrative cumulated effect of temperature during thermosensitive period of development for sex determination.
- Then, it has been proposed to use the incubation length as an index of sex ratio.

**Incubation length proxy...**

- However, the development is dependent on temperature during the entire incubation whereas sex is dependent on temperature only during the so-called TSP, at the middle-third of incubation.

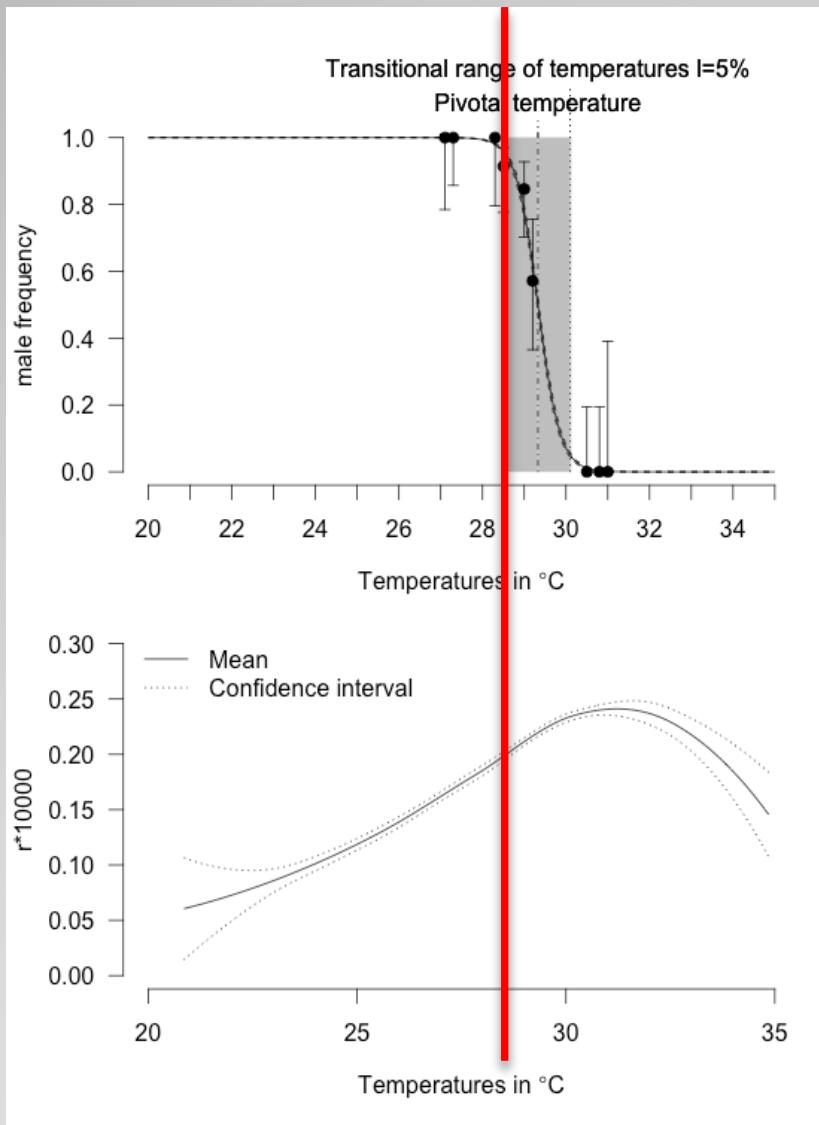


**But...**

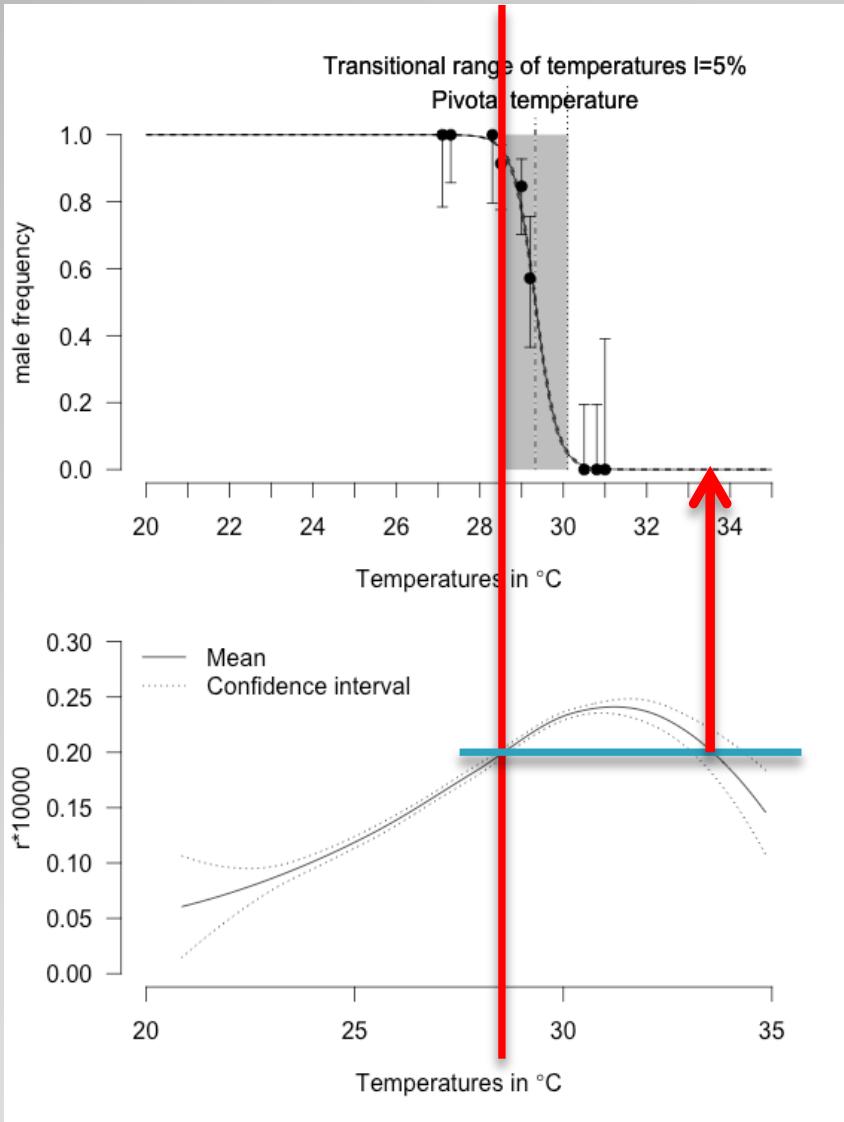


## Another problem

- TSD reaction norm and embryo growth reaction norm are not parallel



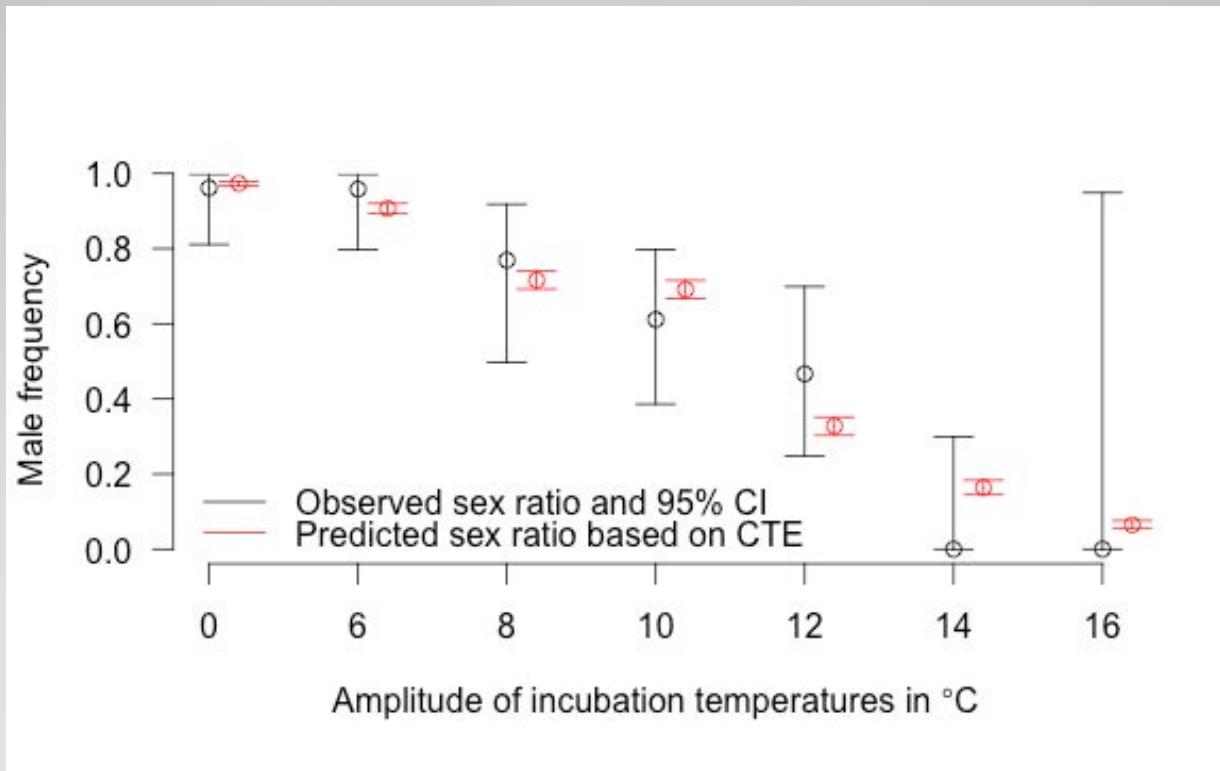
- TSD reaction norm and embryo growth reaction norm are not parallel



- TSD reaction norm and embryo growth reaction norm are not parallel
- For a same incubation length, 100% males or 100% females can be obtained !

- Using an embryonic growth rate model, we can estimate when is the TSP;
- But how to estimate sex ratio based on temperatures within TSP?
- Based on observations, Pieau (1974) has proposed that the more embryo develops at one temperature, the more this temperature will influence the sex
  - But rate of development is not-constant, then we must weight the contribution of each temperature during TSP by its impact for growth of embryo ...

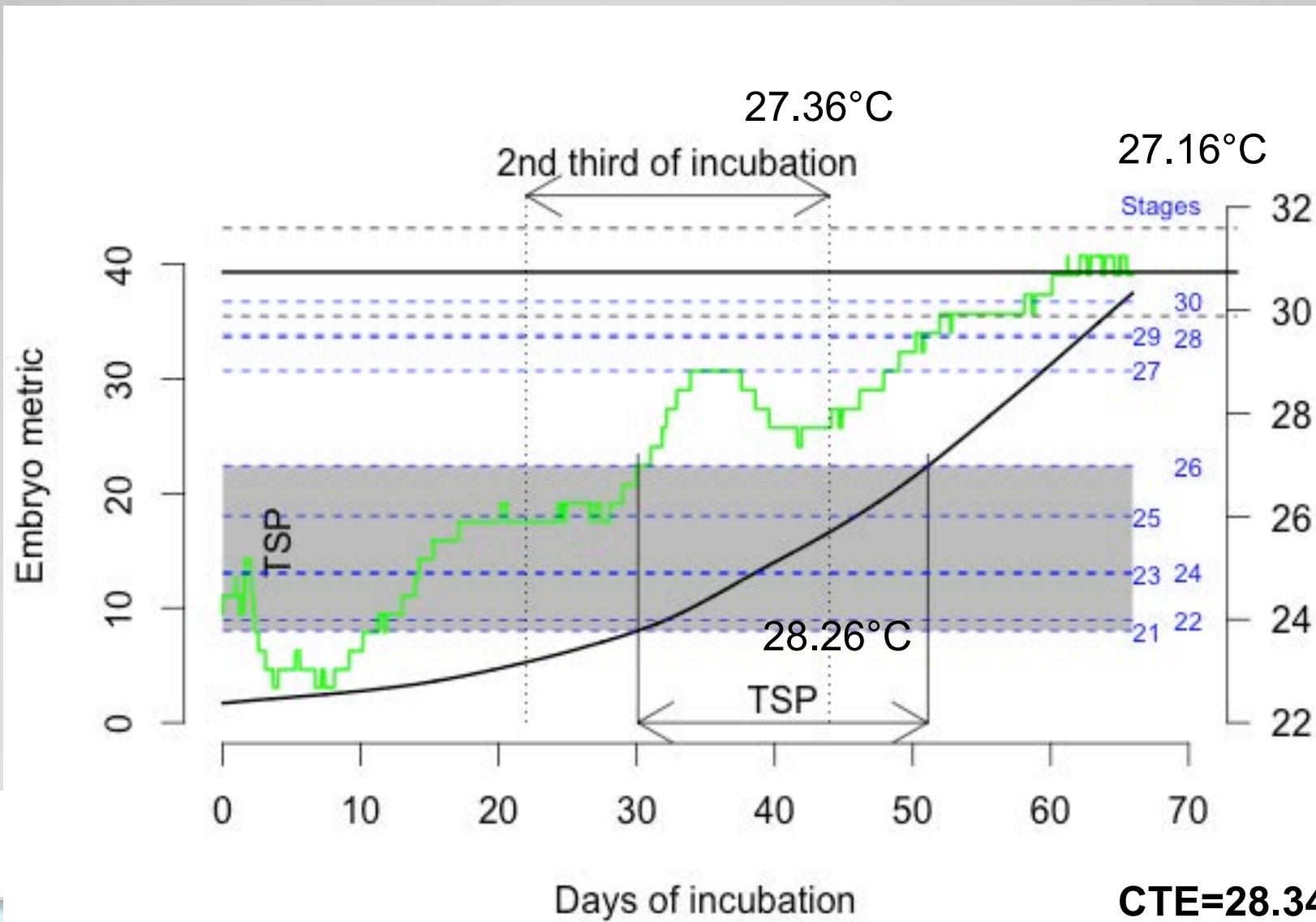
## Constant-temperature equivalent



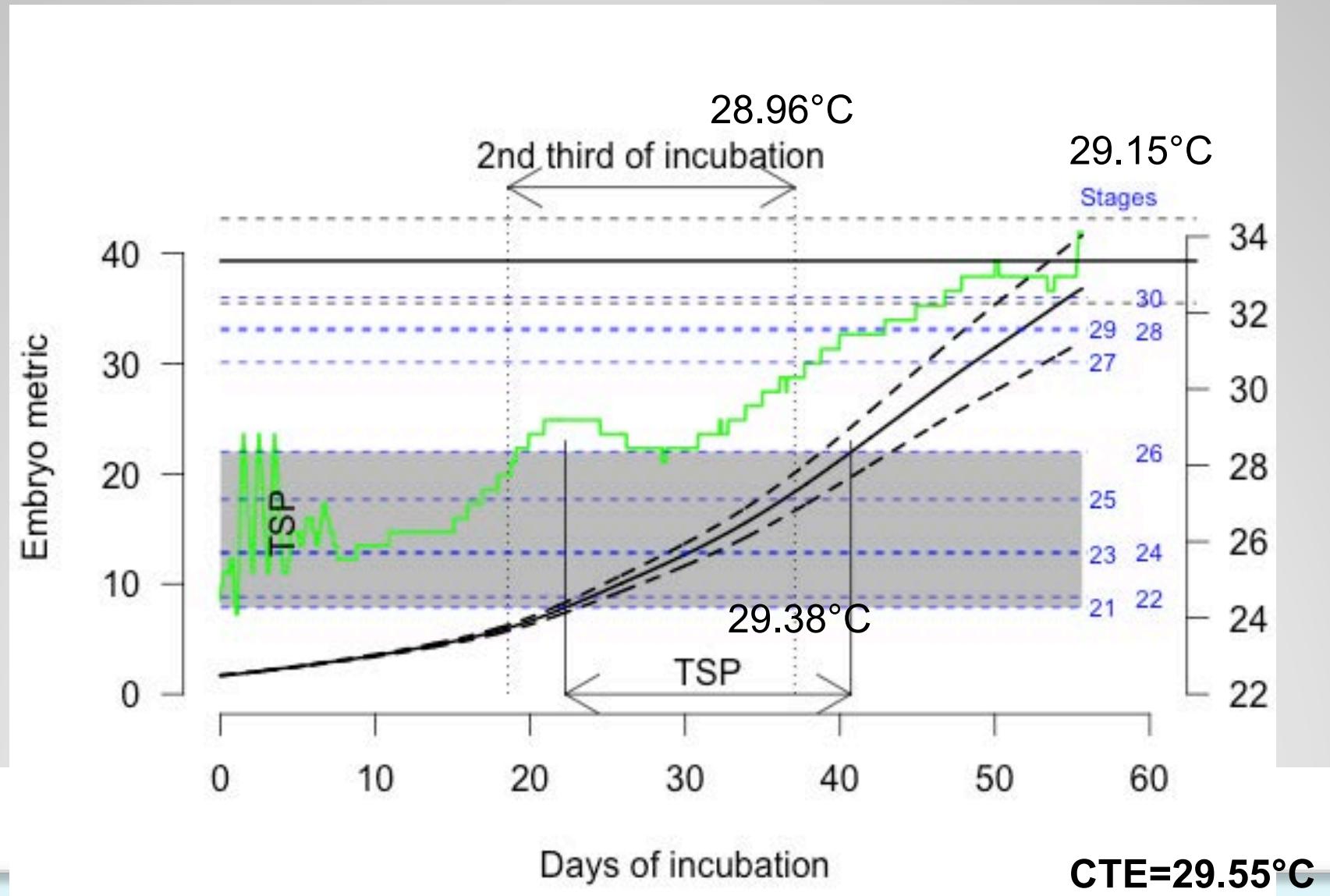
Monsinjon, J., Lolavar, A., Guillon, J.-M., Wyneken, J. & Girondot, M.  
(Submitted) Thermal reaction norm for sexualization: the missing link to predict the sex ratio of reptiles with temperature-dependent sex determination.

**Prediction based on STRN model**

# Example nest DY.1



# Example nest DY.26



- There are no simple way to estimate sex ratio from temperature:
  - Most published papers about sex ratio estimated from field temperature are wrong !

## Conclusion

- Using only temperature recorded in # 20 nests permit to estimate with good precision the reaction norm of embryo growth according to temperature.
- Using the growth model, it is possible to delimitate the thermosensitive period for sex determination
- If sex is known for # 10 individuals from these nests, it is possible to calibrate the CTE function and then estimate sex ratio for nests for which only temperature is known.

## Conclusion

- Une approche orchestrée d'événements interdépendants

## Gestion de projet

- Un événement conduit à un autre
- Ils peuvent être multiples, et se chevauchent pour former des modèles complexes
- « tâche » ou « événement » :
  - Unité de travail définissable, divisible, reliée à un projet et qui peut ou non inclure des sous-tâches.
- Pour comprendre l'articulation entre eux:
  - Graphiques
  - Logiciels de gestion de projet

## Gestion de projet

## **Un résultat défini**

**objectif obscur = résultats nébuleux**

**objectif précis = résultat spécifique.**

1 objectif majeur/projet = plusieurs objectifs intermédiaires

1 objectif intermédiaire par « événement » (tâches et sous-tâches,...)

Toujours la même intention : **atteindre l'objectif défini dans les délais tout en respectant le budget.**

- Il y a un responsable pour chaque sous-tâche qui s'assure que le travail est fait dans les temps
  - Il y a un contrôleur qui vérifie que le responsable est bien actif
- Régulièrement il y a des points d'étapes qui permettent de vérifier si des tâches ont pris du retard
  - Présentation de délivrables intermédiaires
- Les points d'étape sont prévus initialement dans le projet
- Le projet est en constante évolution

## Gestion de projet

## La planification du projet

*Le document de base du projet est le Plan. Il vit, respire et change en même temps que les événements progressent ou échouent.*

- répartition des tâches entre les membres de l'équipe
  - identification des objectifs intermédiaires (les « buts »)
  - description des événements marquants (ou tâches)
  - recensement des ressources et des moyens
- ... Dès que le projet démarre, le Plan de Projet se trouve modifié.**

*« N'importe quel plan vaut mieux que pas de plan, car sans plan vous n'irez nulle part ».*

## Le contrôle

- Surveillance de la progression du projet
- Le responsable de projet :
  - examine en permanence les résultats accomplis à la date considérée.
  - vérifie la conformité de ces résultats avec le Plan de projet
  - suggère et/ou apporte les modifications utiles
  - étudie la prochaine action à engager
  - surveille les éventuels obstacles qui pourraient survenir (moral et motivation de l'équipe, blocages extérieurs,...)
  - contrôle le suivi budgétaire
    - (un atout comportemental majeur : la tenacité!)*

# **Qu'est-ce qui fait un bon responsable de projet ?**

- Un acteur, non un spectateur
- Porter plusieurs casquettes en permanence
- Appliquer des principes pour se diriger



**Chaque tâche est suivie sur le même modèle**

- Identifying need
- Writing proposal
- Sending proposal
- Securing funds
- Field work – many sub tasks
- Managing data – many sub tasks
- Analysing data – many sub tasks
- Writing report
- Sending report

**Project management applied to marine turtles monitoring**

**Quality norm: ISO9001**

La qualité repose sur 7 principes de management:

- I. Orientation client
- II. Prise de décision fondée sur des preuves
- III. Responsabilité de la direction
- IV. Implication du personnel
- V. Approche processus
- VI. Gestion des relations avec les parties intéressées
- VII. Amélioration

## **LES PRINCIPES DE MANAGEMENT DE LA QUALITE**

- Les décisions efficaces se fondent sur l'analyse de données et d'informations.
- L'analyse des faits, des preuves et des données conduit à une plus grande objectivité et à la réduction de l'effet d'incertitude.
- Plus la direction possède d'éléments tangibles et plus la prise de décision est qualitative.

## **PRISE DE DECISION FONDEE SUR DES PREUVES**

- Un système de management est constitué de processus qui interagissent les uns avec les autres.
- Le pilotage de ces interactions permet à un organisme d'atteindre ses objectifs par la compréhension des conséquences de ces interactions sur les autres processus.
- Un résultat escompté est atteint avec plus d'efficacité et d'efficience si les activités et les ressources afférentes sont gérées comme un processus.
- Identifier, comprendre et gérer des processus corrélés comme un système contribue à l'efficacité et l'efficience de l'organisme à atteindre ses objectifs.

## APPROCHE PROCESSUS

- Il convient que l'amélioration continue de la performance globale soit un objectif permanent de l'organisme.
- L'amélioration est l'activité visant à améliorer les performances pour satisfaire aux exigences du client et accroître la satisfaction du client.

Démarche d'amélioration continue:

1. Identification des non conformités
2. Identification des causes
3. Identification des solutions
4. Suivi de l'efficacité des solutions

## AMELIORATION

Interactions avec d'autres processus

**Agir-**  
Apporter des améliorations, si nécessaire

**Planifier le processus-**  
(l'étendue de la planification dépend du RISQUE)

**Eléments d'entrée**

**Eléments de sortie**

**Réaliser-** Mettre en œuvre le processus

**Vérifier-Surveiller/mesurer les performances des processus**

**LA ROUE DE DEMING**

Interactions avec d'autres processus

- Written procedures is the basis of quality management
  - Regularly the written procedures must be audited and changed if necessary
- Verification of the quality of the work/data
  - It is important that procedure of verification is written
- Analyze the data when they are collected
  - Do not wait because you can detect some problems
- Secure data
  - You must invest !

## What should be done