

PhD from French  
Polynesia University and  
École Pratique des Hautes  
Études



# Pink whiprays *Himantura fai* in French Polynesia:

case study of their feeding for  
tourism purpose

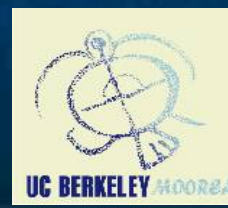
Presented by

**Cécile Gaspar**

October 24 th 2008

PhD Directors:

**Claude PAYRI et  
René GALZIN**



# Summary

1. Zusammenfassung der Ergebnisse der Analyse der Daten der letzten 12 Monate. Die Ergebnisse zeigen eine deutliche Steigerung der Umsätze in den letzten Quartalen, was auf eine erfolgreiche Marketingstrategie hinweist. Die Kundenzufriedenheit ist ebenfalls gestiegen, was auf eine Verbesserung der Servicequalität schließen lässt.



# Introduction and research topics

## Introduction and research topics

1/ Species and study zone

2/ Sting ray feeding activity

3/ Individual movement studies

4/ Genetic structure of polynesian population

General discussion

Conclusion and future research

### Global context:

- Global warming, species extinction, destruction of natural habitats...
- over 300 marine animals feeding sites in the world: modification of food resources by human. What is the definition of «ecotourism»?

### Local context:

- *Himantura fai* : first study on this species
- Involved in polynesian culture but no interest for human consumption
- Involved in tourism interest while marine reserve areas are created on Moorea
- More questions on the impact of feeding on wild animals

## Research topics





# Chapter 1 : Species and study zone

Introduction and research topics

1/Species and study zone

2/ Touristic ray feeding activity

3/ Study on individual movements

4/ Genetic structure of polynesian sting ray population

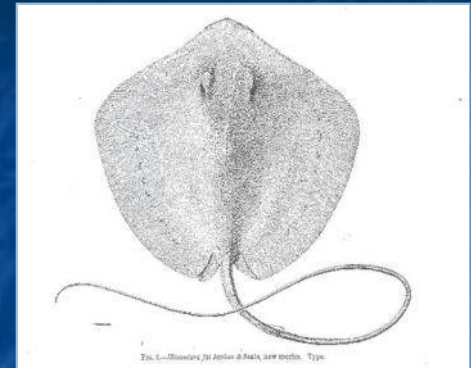
Discussion

Conclusion and future research

**Common names:**  
Sting ray, pink whipray  
*fai i'u, fai potaka, hai pink whipray...*

a/ selected species: *Himantura fai*

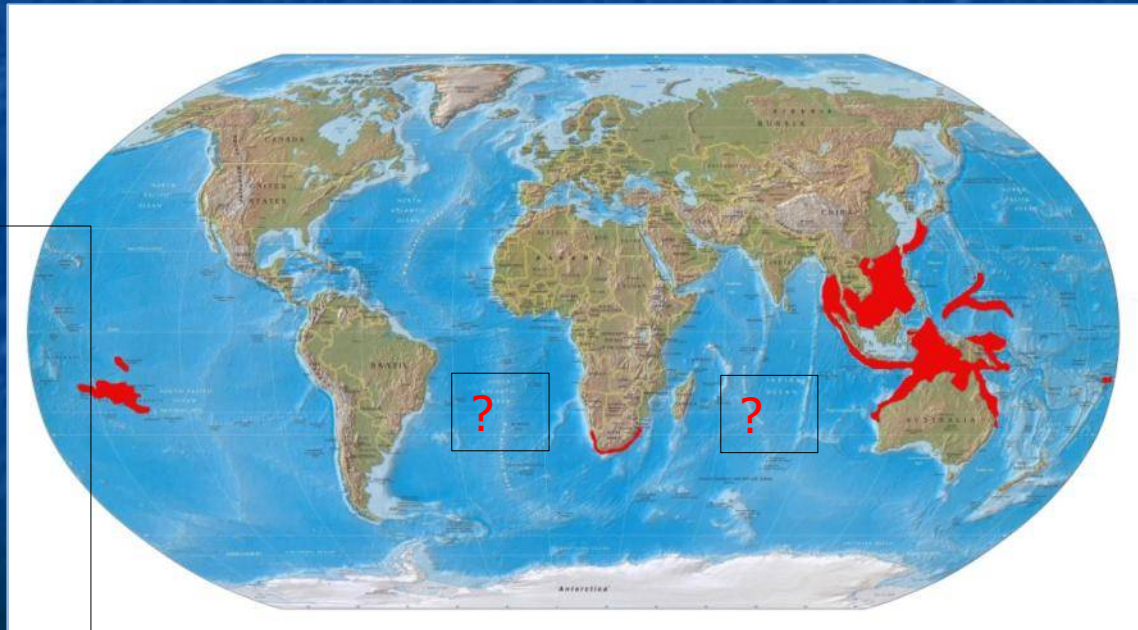
Class: Chondrichthyens  
Sub class : Elasmobranch  
Order : Rajiformes  
Family : Dasyatidae (sting rays)  
Sub family : Dasyatinae  
Genus : *Himantura*  
Species : *fai*  
Authors: Jordan et Seale 1906



**Identification in French Polynesia:**  
B. Seret, 1994

**Global distribution:**  
de 24° north to 26° south

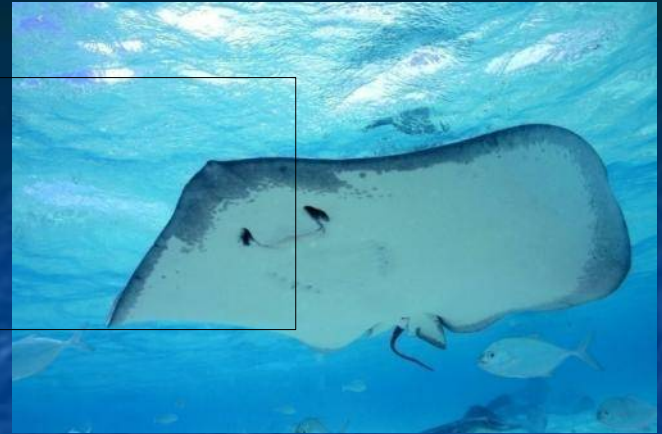
- South Africa
- Samoa
- Philippines
- Indonesia
- Marshall Islands
- Japon
- Caroline Island
- Australia
- Egypte
- Papoua New Guinea
- French Polynesia



# Anatomy



Disc shape  
Size 120 cm width  
Colour  
Skin marks



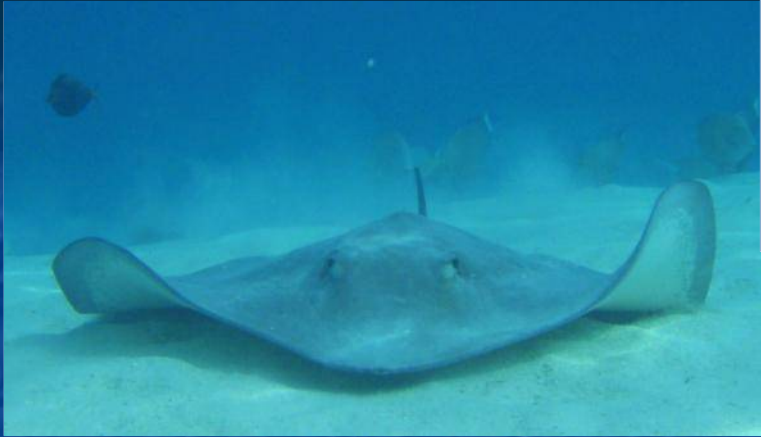
Sexual dimorphism  
Pterygopodes  
Pelvic fin  
Female size/male



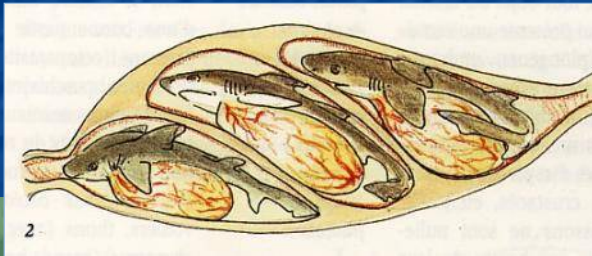
Spiracle  
Gills



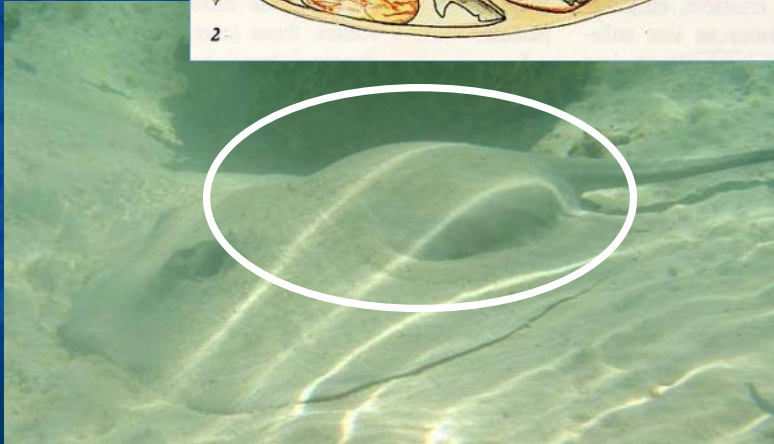
## Feeding and reproduction



- Diet (crustaceans, mollusks, worms, fish)
- Prey detection



- Internal fecondation
- Maturity age
- Ovoviviparity
- Gestation period
- Litter size
- Nursery sites
- Juvenile size and weight

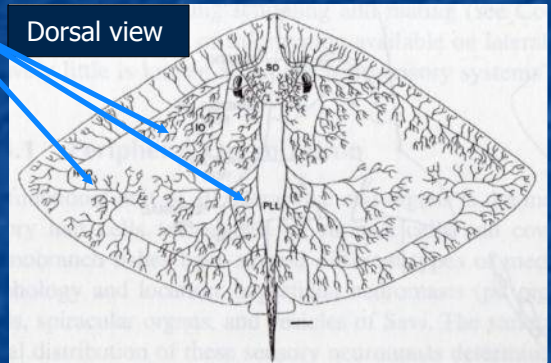
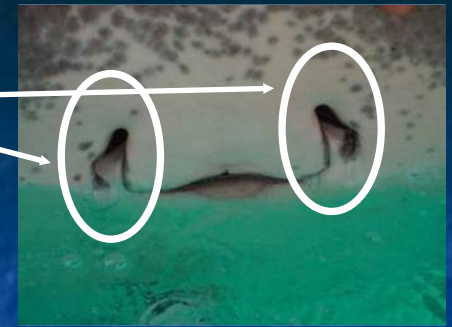


# Senses

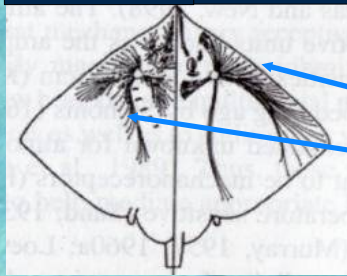
Olfaction : nostrils

Vision

Electro-location :  
ampullae of Lorenzini,  
electric field detection



Ventral view    Dorsal view

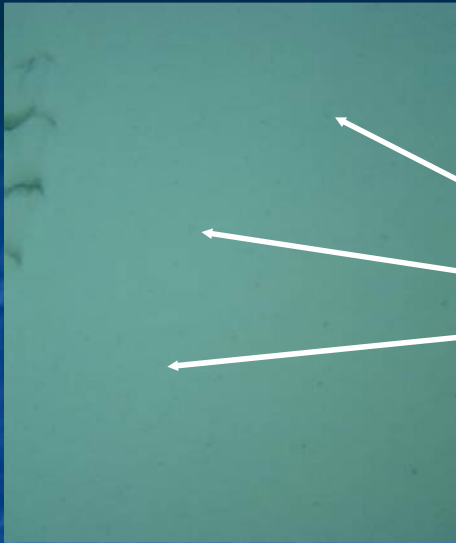


Mechano-reception:  
dorsal and ventral ligne,  
detection of pressure changes

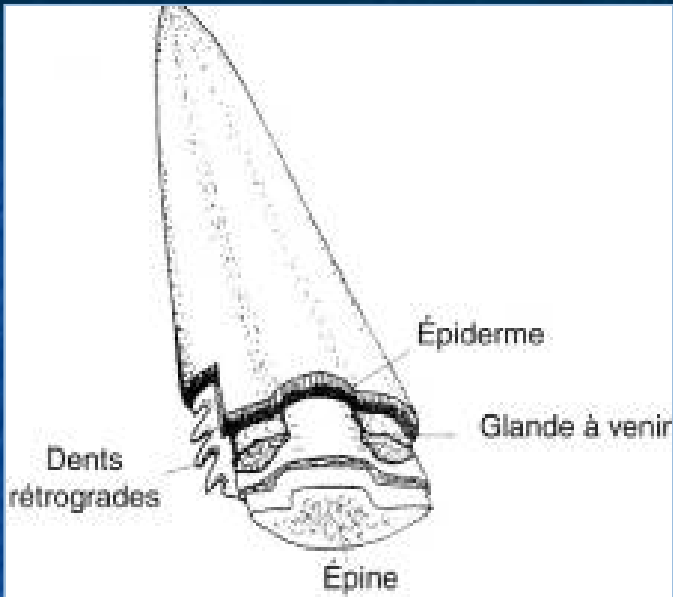
Taste

Hearing

Touch



## Sting and venom



- 1 or 2 stings, 10 to 30 cm length

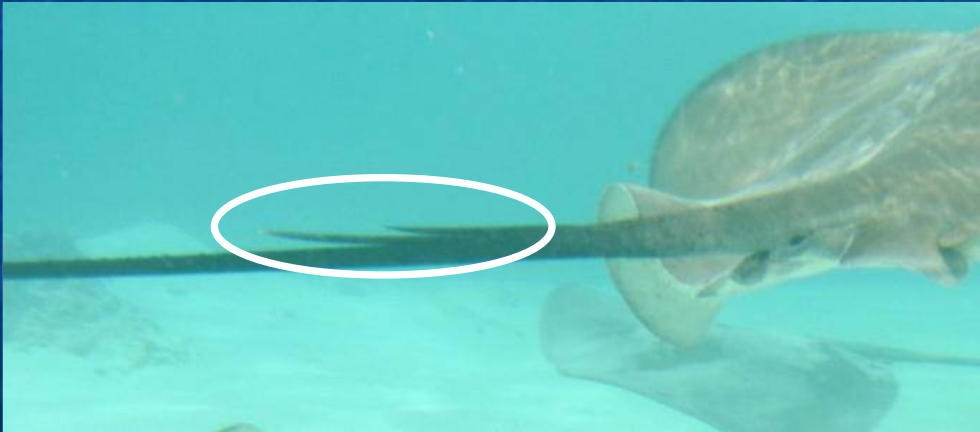
Cartilaginous

Venom gland on ventral side

- Venom sensible to heat

- Pain, oedema, inflammatory, necrosis

General symptoms



# *fai i'u* symbolism in French Polynesia

- Symbolism of wisdom and peace
- Traditionnal tatoos
- Legends and poems
- Sting used as tools by ancient Polynesian



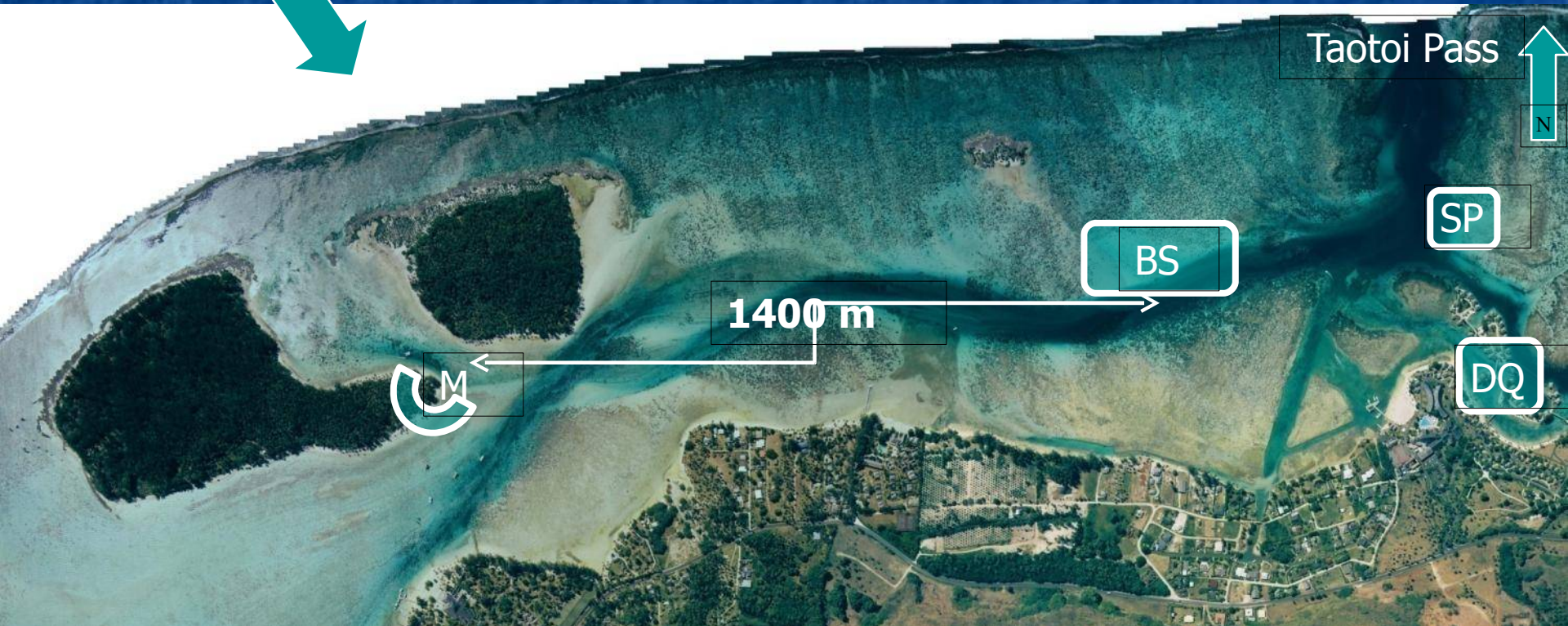


# Chapter 1 : Species and study zone

## b/ Study zone



French polynesia  
Moorea island  
Tiahura : 2,4 km<sup>2</sup>  
PGEM since 2004  
Coral zone  
Max depth: 8 m







# Chapitre 2 : Sting ray feeding activity

a/ marketing

Internet

Introduction and research topic

1/Species and study zone

2/ Sting ray feeding activity

3/ Study on individual movements

4/ Genetic structure of polynesian population

Discussion

Conclusion and future research

Albert Transport - Moorea / site à Moorea - Microsoft Internet Explorer

Fichier Edition Affichage Favoris Outils ?

Précédente Recherche Favoris

Adresse http://www.tahiti-vacances.com/activite/moorea/albert-transport/

Google s avec les raies à moorea Envoyer Mes favoris 90 bloquée(s) Orthographe Traduire Envoyer à Paramètres

SHRRE

## Tahiti Cruise & Vacation

Accueil Séjours Croisières Hôtels Activités Guide des îles Comparateur de prix Plus...

**Package Croisière**  
13 863 €

Bora Bora, Tahaa  
10 jours , 2 pers. [Plus !](#)

**Créez votre séjour !**

date d'arrivée\* jj/mm/aaaa

adulte(s) 2 ado(s) 0

enfant(s) 0 bébé(s) 0

[Démarrer](#)

[Contactez nos agents.](#)

### Albert Transport

#### Tour du lagon

Un nouveau jour au paradis... un magnifique lagon limpide, la brise agréable de l'océan, Moorea vu de la mer.

Venez profiter d'une sortie en toute sécurité sur notre bateau. Naviguez sur les vagues du plaisir dans un cadre exceptionnel avec les explications sur Moorea.



Découvrez le récif corallien de Moorea pendant une ballade de 6 heures. A bord du bateau ou dans l'eau, ne loupez pas l'opportunité de nourrir les raies et les requins. Nager parmi cette riche faune polynésienne est un souvenir à ne pas manquer !

Après tant d'émotions, une halte sur un îlot (Mcti) privé vous fera connaître la vie paisible des îles. Vous allez apprendre à préparer la noix de coco et à faire le " poisson cru " tahitien. Votre repas sera composé de ces préparations ainsi que de grillades marinées (poulet et poisson), riz et fruits. Bien entendu les boissons sont comprises.

A votre guise, vous pourrez explorer le lagon avec masque et tuba.

Terminé Internet

démarrer UDISK 2.0 (D:) Albert transport Albert Transport... Raies.doc - Micr... 10:23



**PIQUE NIQUE SUR LE MOTU,  
un Déjeuner sur un coin de paradis**



- Transfert au motu depuis l'hôtel
- Ou arrivée depuis le tour de l'île en bateau
- Pique nique sur place
- Rencontre avec les raies
- Plongée libre



**Indispensable**  
Maillot de bain

**OUVERTURE**

Tous les jours.  
Ou départ avec le tour de l'île en bateau  
Pique-nique sur le motu: Départ à 10h



**AQUABLUE**



Tous les jours  
sauf le dimanche

3 sorties par  
jours:

8h30  
10h30  
14h00.

Maximum:  
8 personnes.

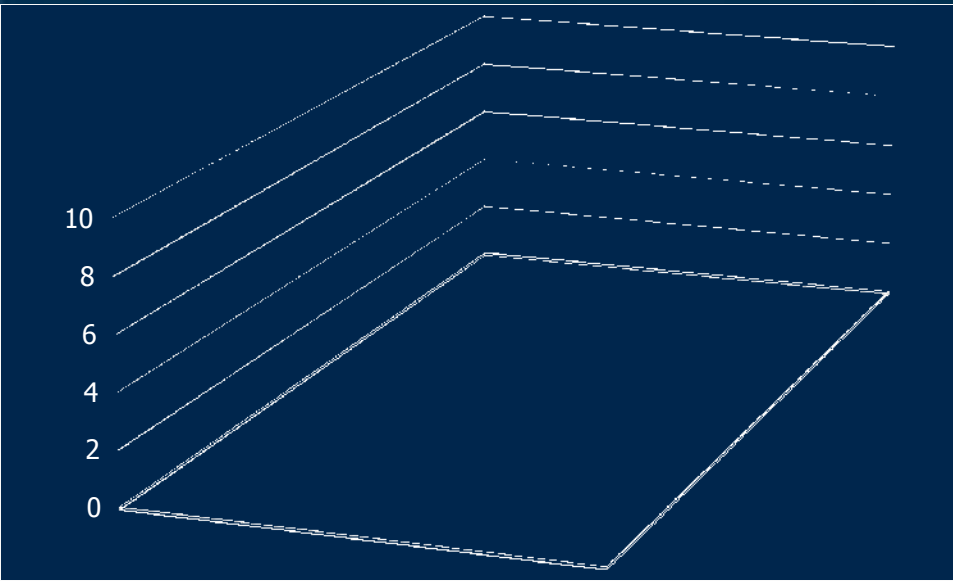


Pendant 30 minutes, explorez un monde marin et découvrez de nouvelles sensations à une profondeur maximum de 4 mètres. Nul besoin de savoir plonger ni même nager. La plongée casque s'adresse à tous!

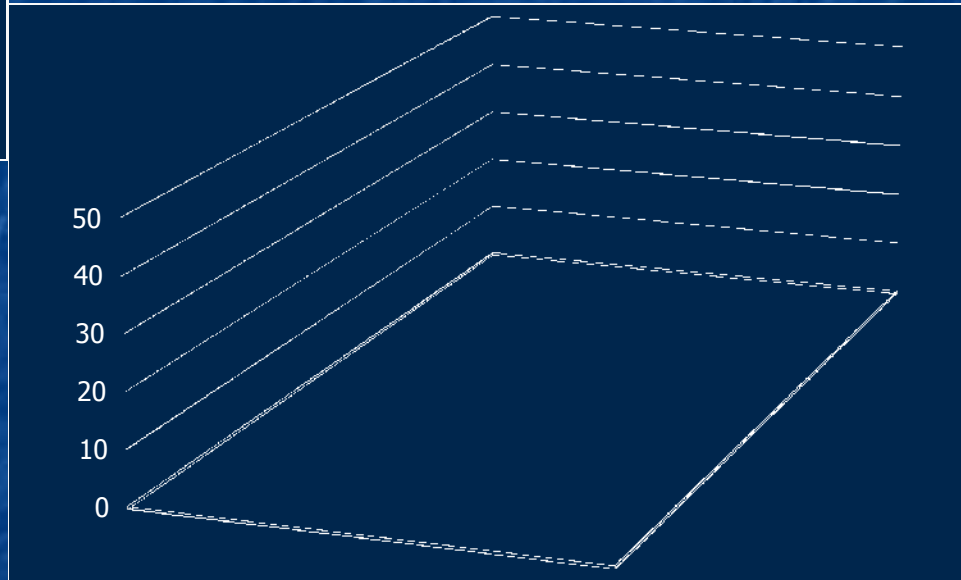
b/ activity description



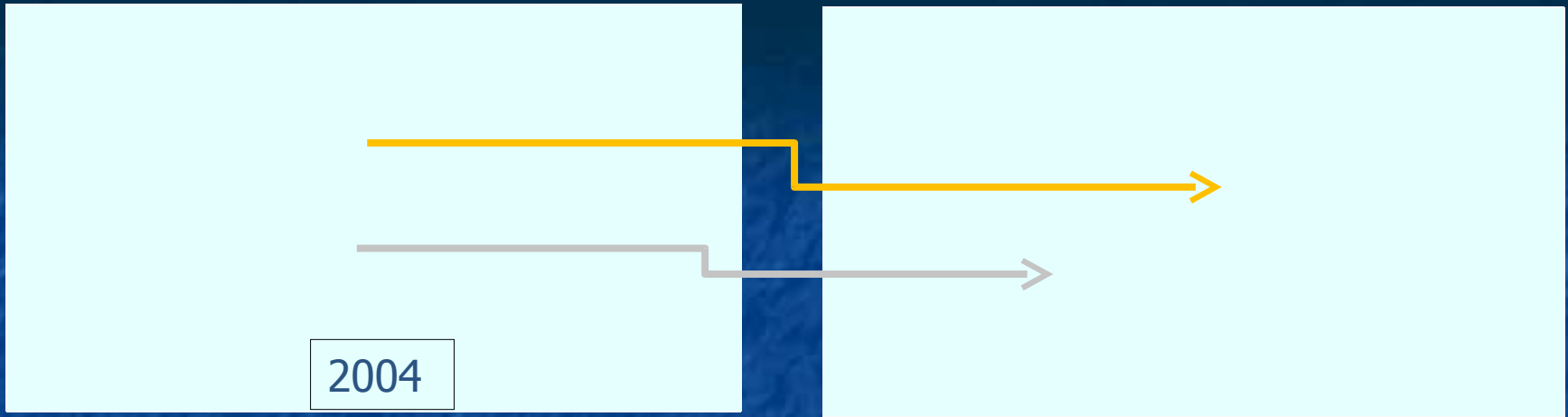
# c/ perception and social impact: 2004-2008



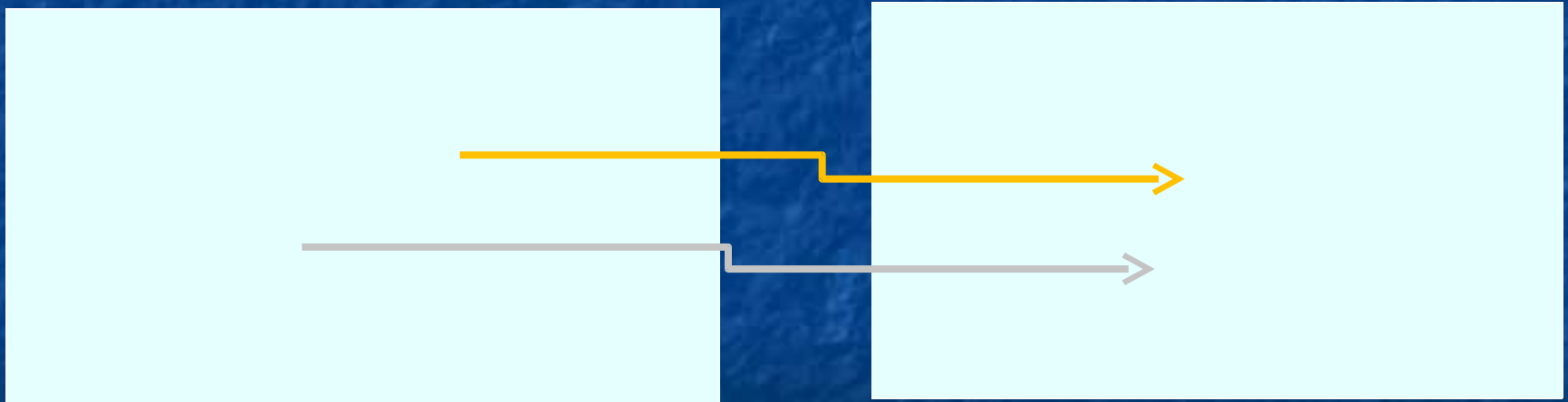
**Tourist** answers (n=41) to the question: « what attracts you in this activity? »  
2004 ● 2008 ●



**Resident** answers (n=77) to the question: « what attracts you in this activity? »  
2004 ● 2008 ●

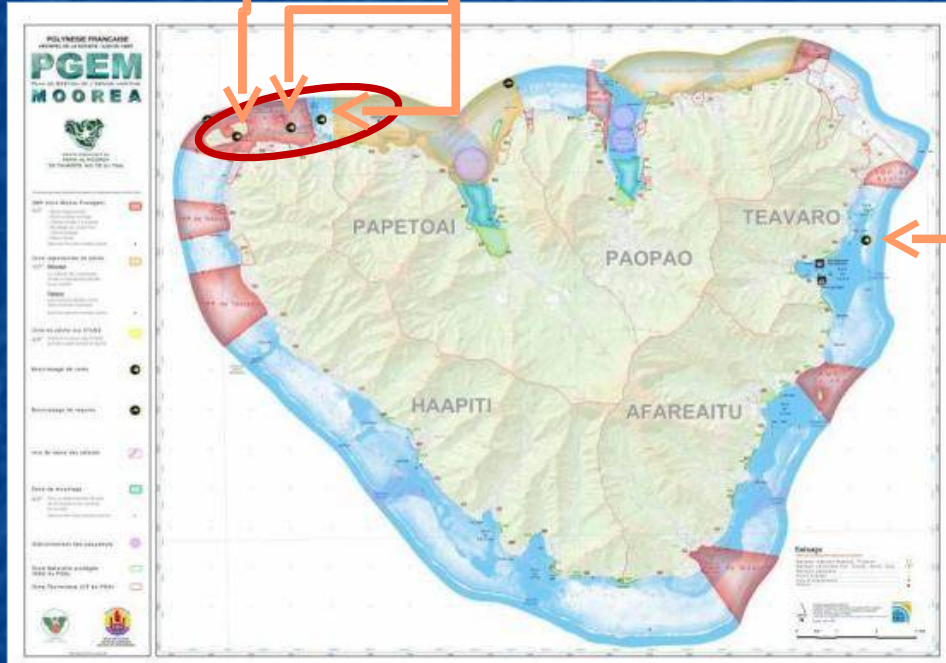


**Tourists** opinion on sting ray feeding in 2004 and 2008 (n=41)



**Resident** opinion on sting ray feeding in 2004 and 2008 (n=77)

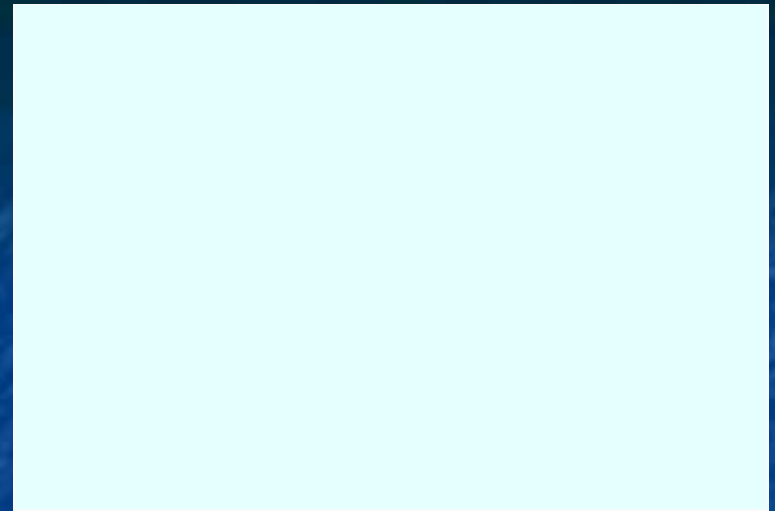
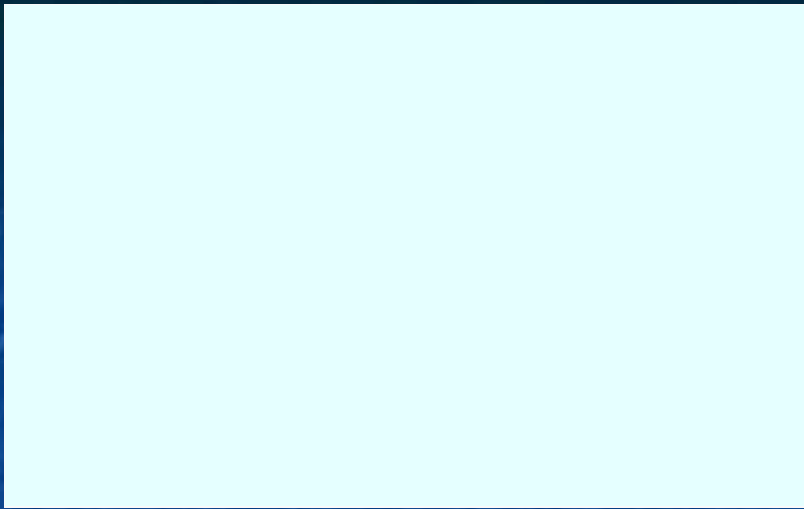
Plan de Gestion de l'Espace maritime (P.G.E.M)



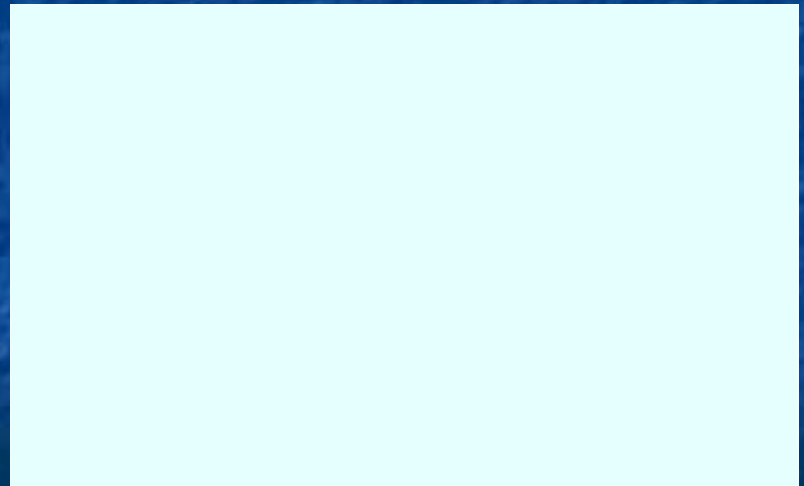
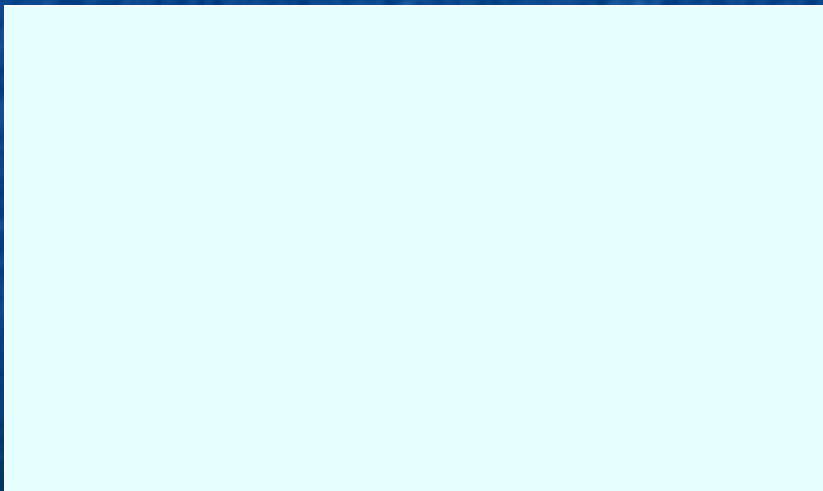
Authorized zones for sting ray feeding



- ❖ Role of PGEM: management tool since October 2004
- ❖ Presence of one full time coordinator since 2007
- ❖ Controls and communication of new rules
- ❖ Shark feeding forbidden in Moorea lagoon under fishermen pressure
- ❖ Rays: 4 authorized zones, guidelines



Tourist answers in 2004 and 2008 (n=41) to the question « Is it necessary to create guidelines to help maintain sting ray activity in the future? »



Resident answers in 2004 and 2008 (n=77) to the question « Is it necessary to create guidelines to help maintain sting ray activity in the future? »

Sting ray feeding guidelines summary

**Draft**

- ✓ 20 minutes per group on site, only one group simultaneously
- ✓ 10 visitors per guide in the water
- ✓ Less than 1 kg of fish per feeding; only the guide is feeding the animals
- ✓ Quality of the fish, small pieces, not carcass
- ✓ No left-over on the floor
- ✓ Educational message

✓High marketing value

✓Economic and social impact

but :

❖Safety measures?

❖Educative value ?

❖ Impact on the rays and their ecosystem?







# Chapter 3 : Study on individual movements

Introduction and research topics

1/ Species and study zone

2/ Sting ray feeding activity

**3/ Study on individual movements**

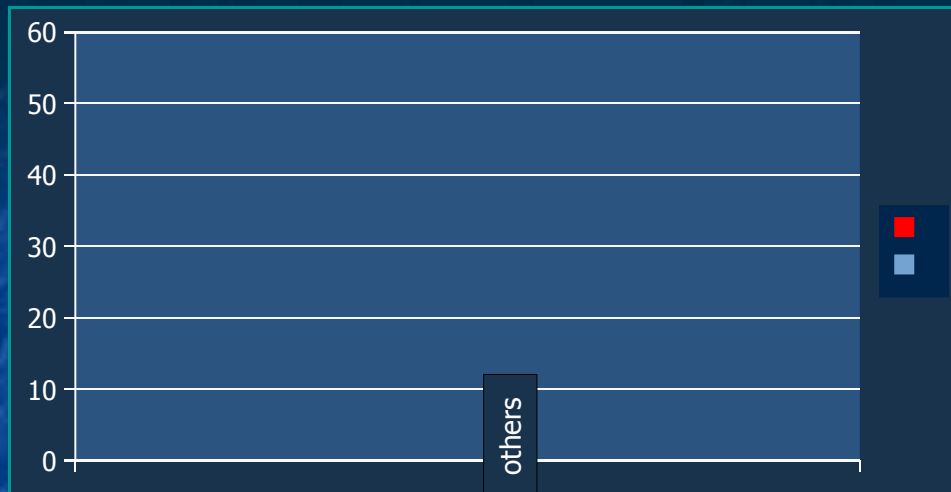
4/ Genetic structure of polynesian population

Discussion

Conclusion and future research



## a/ colour tagging: results and discussion



Total in june-july 2004: 58 individuals  
30 males et 28 females

- ✓ Good choice of method( spaghetti tag) → photo-identification not appropriated
- ✓ Confirmation of individual exchanges between feeding sites

→ But:



→ ✓ Touristic context → impact on visual aspect

→ ✓ Global sex-ratio even in the area → but not per site

# Acoustic telemetry: definition, types, methods

Choice :

- Tags V8 et V13
- Individuals
- Receivers VR2 positioning



Acoustic tag

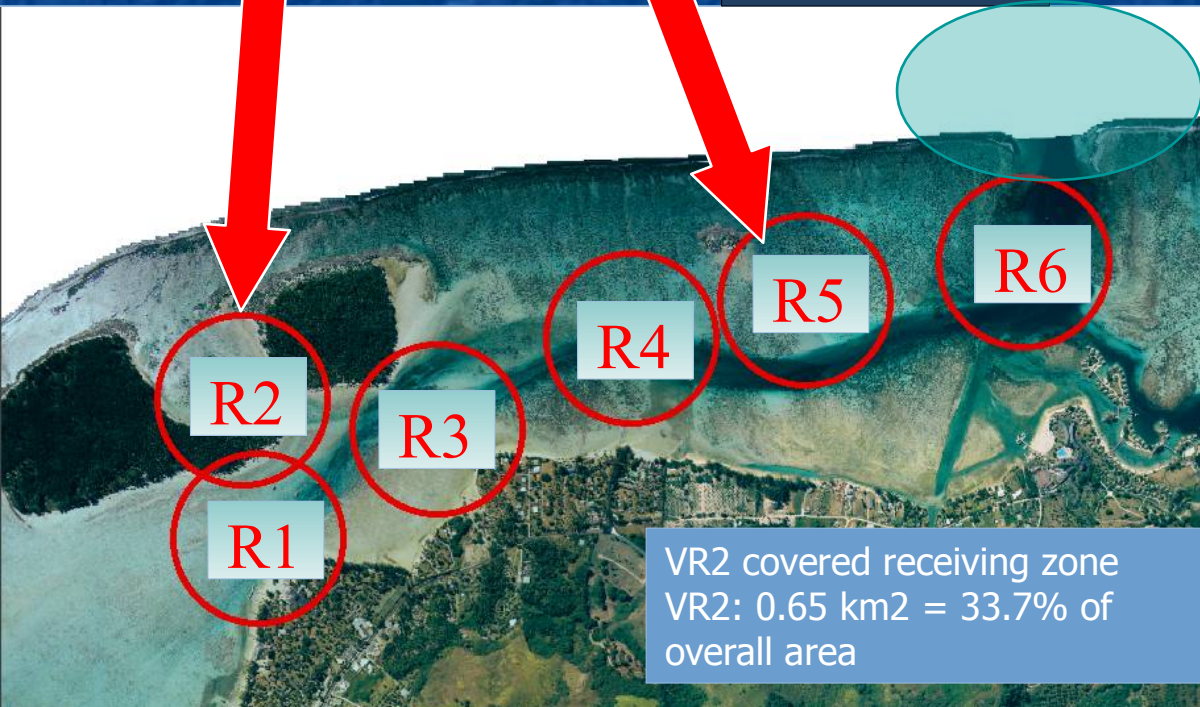


Receiver VR2



**Sand Bank Site**

**Motu site**



VR2 covered receiving zone  
VR2: 0.65 km<sup>2</sup> = 33.7% of overall area

Acoustic tags testing for receiving range:  
**202 meters**

Localisation of the 6 receivers in study zone

## b/ passive acoustic tagging: method- tag insertion



Collection of animals and set up on boat

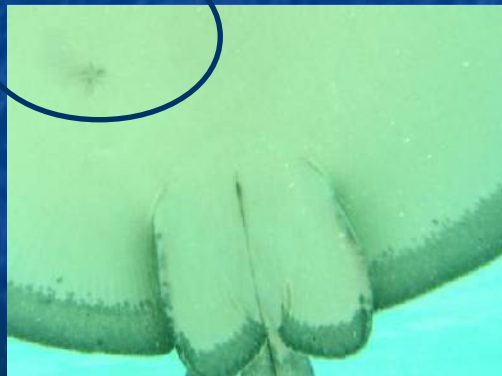


Incision of 1 cm, insertion of tag and suture



Total duration : max 5 min

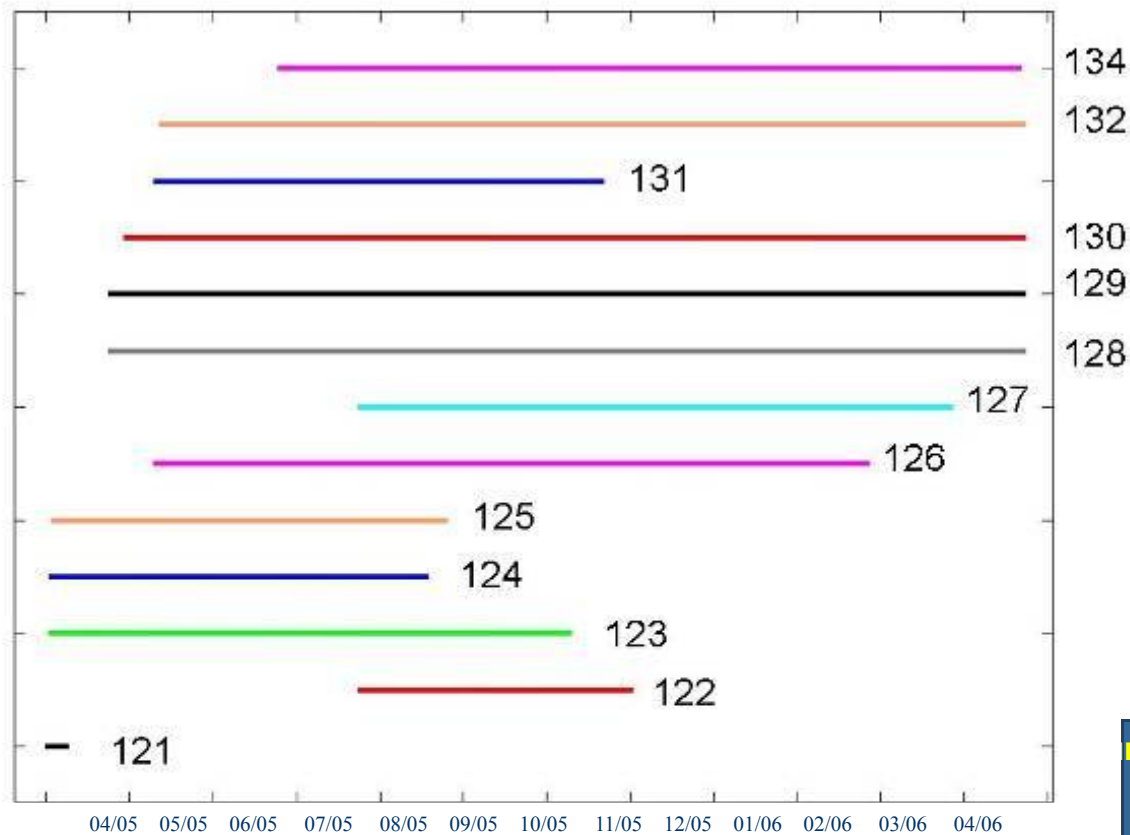
Choice of internal tagging: duration of emission, not touched by tourists, anterior studies



Control of scar region (D+7)

In-water observation of tagged individuals (D+15)

## b/ Passive acoustic tagging: results – emission duration



- 14 individuals tagged
- from March 30 th to July 24 th 2005
- 1 tag never emitted
- Short common emission period

### Number of rays with common emission period



## b/ passive acoustic tagging: all receivers results

Receiver	Total number of detections
R5	32 967
R2	24 130
R4	7 350
R3	5 592
R6	4 212
R1	1 306
Total	75 557

43,6 %

31,9 %

} > 75 %

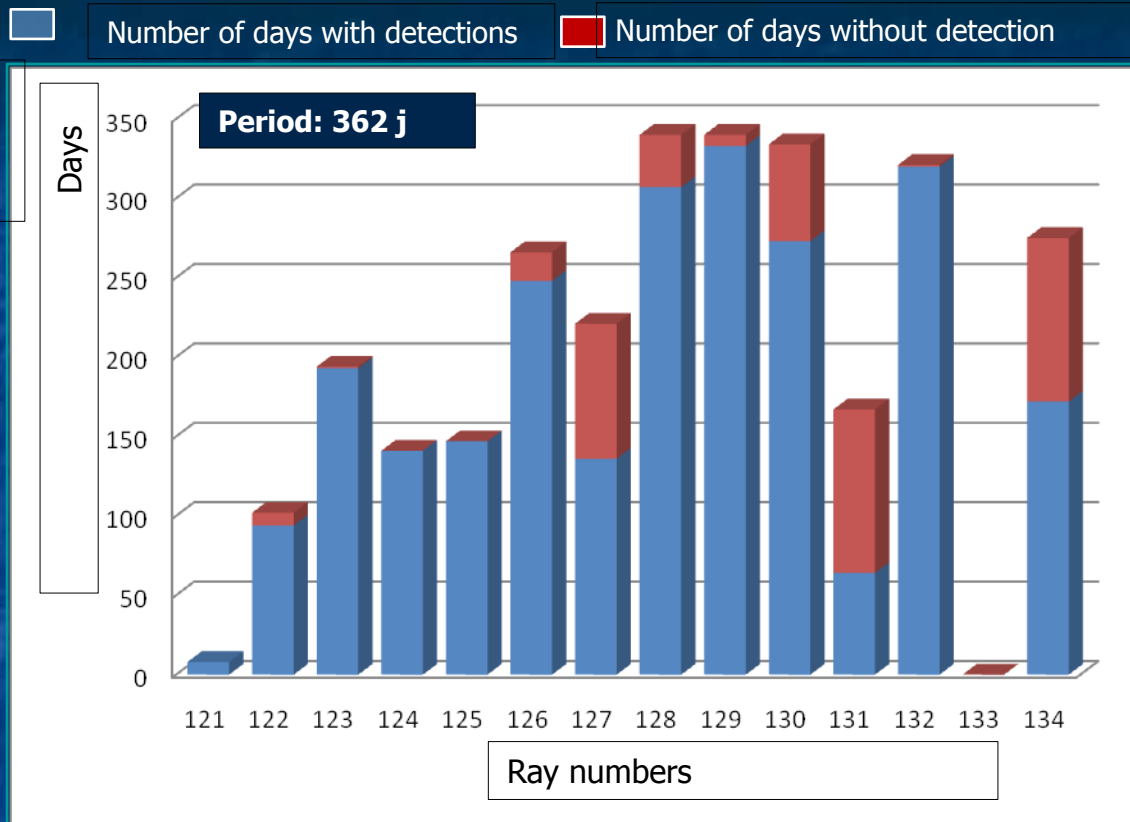
*Number of detections per receiver on total period*

Data given by receivers:  
time and dates of emission  
= treatment of data into  
duration of presence

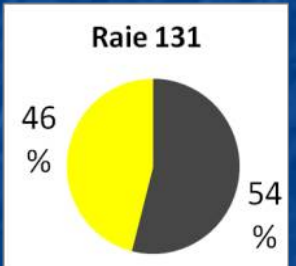
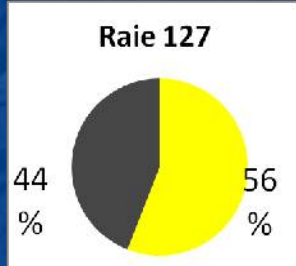
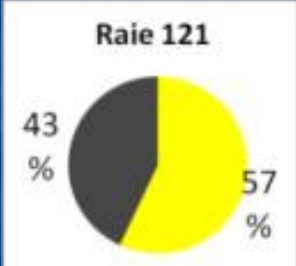
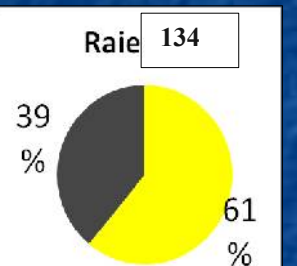
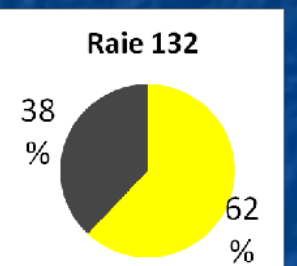
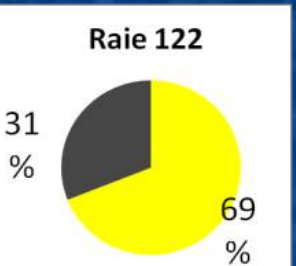
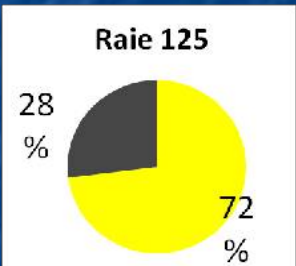
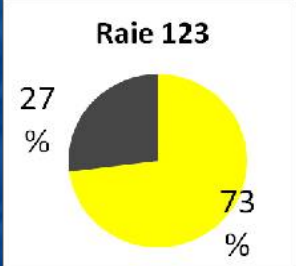
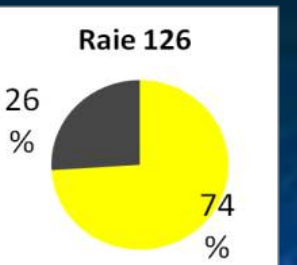
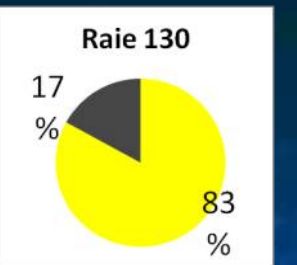
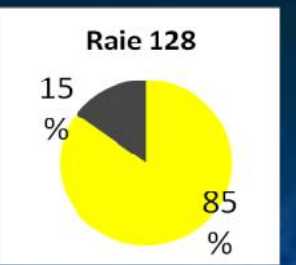
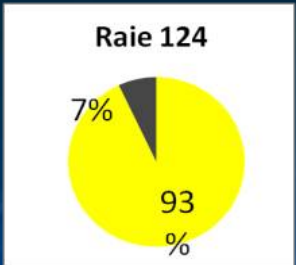
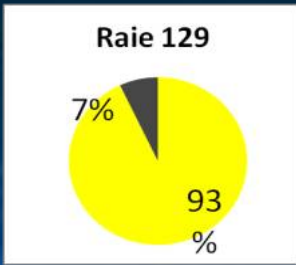
1 detection

=

10 minutes of presence of  
this individual



*Total of days with and without detection for each tagged ray*

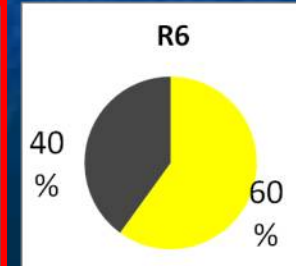
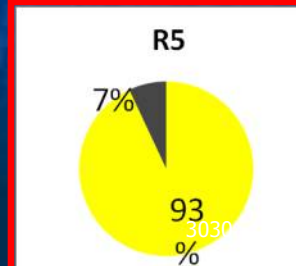
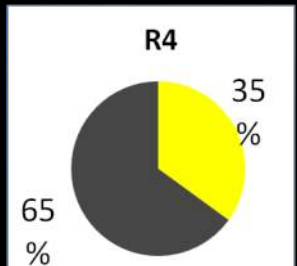
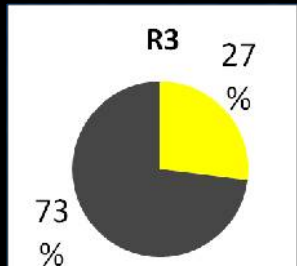
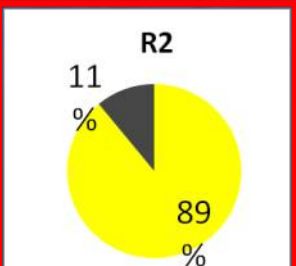
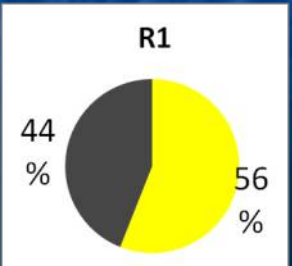


% of diurnal and nocturnal detection for each individual

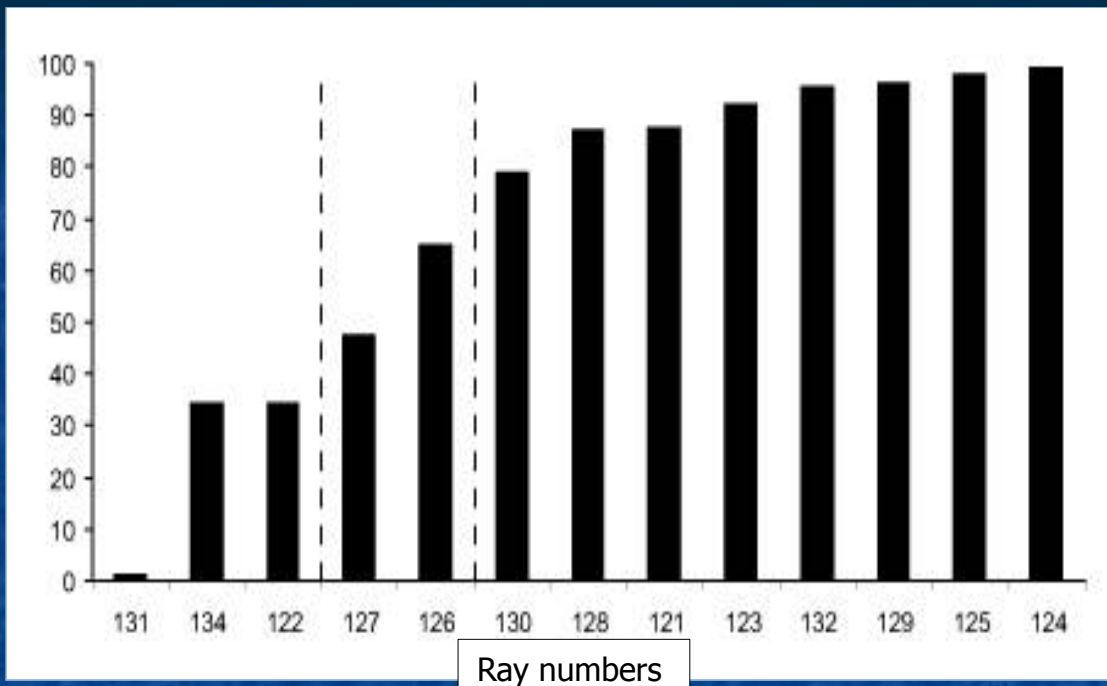
Average for all rays:  
71% day and 29 %  
night

Average all receivers: 60%  
day and 40 % night

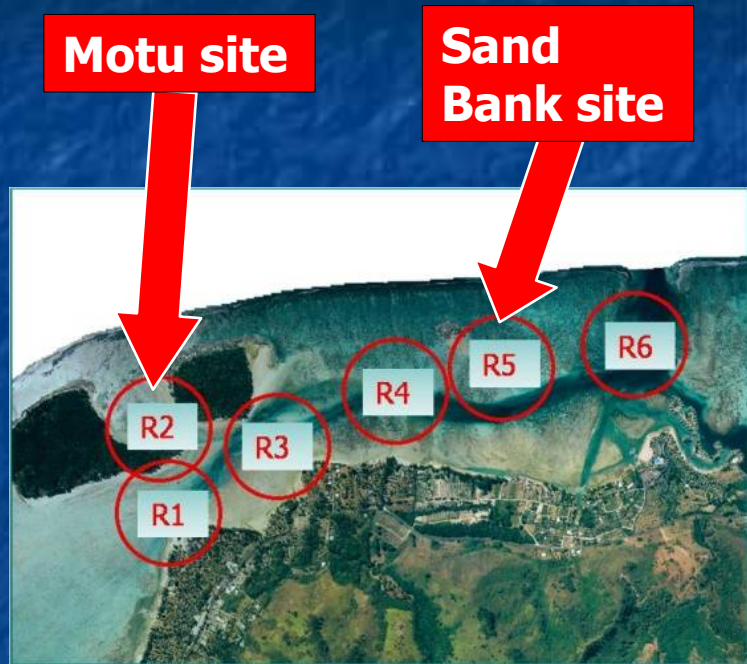
% of diurnal and nocturnal detection per receiver



## b/ passive acoustic tagging: feeding sites results



% of feeding site detections compared to total detections



1 ray (7%) feeding sites use > 2%

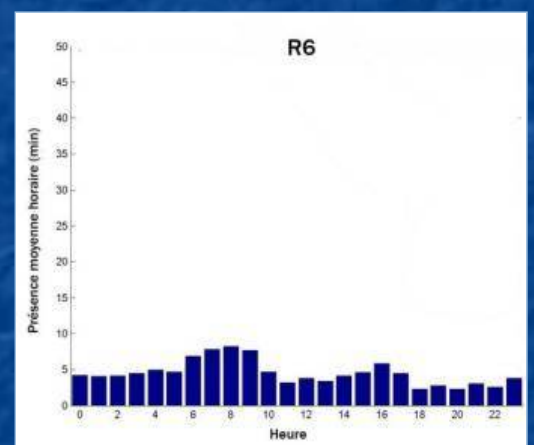
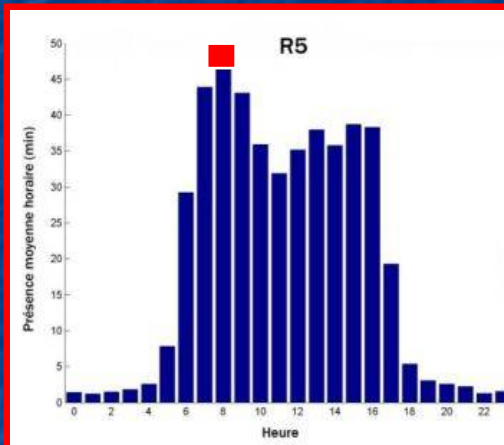
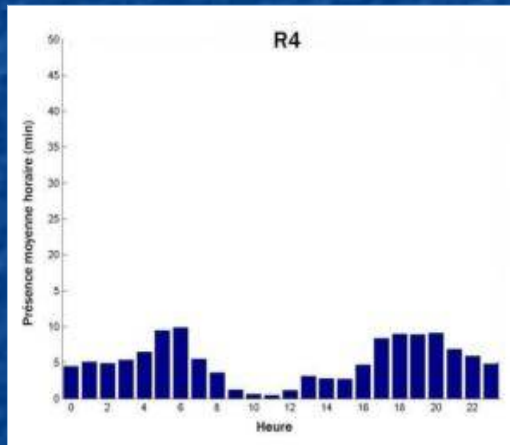
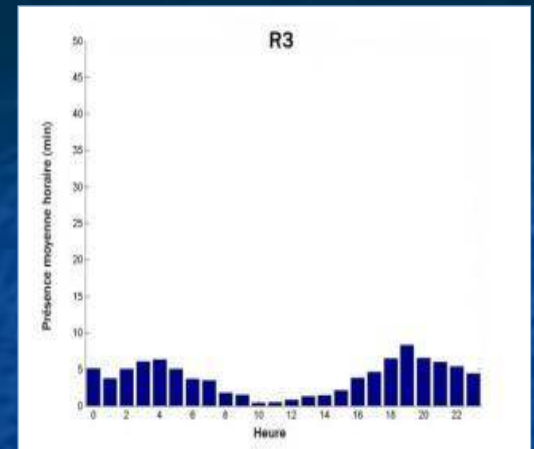
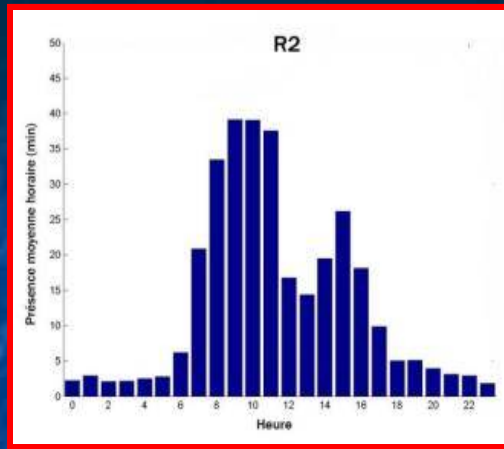
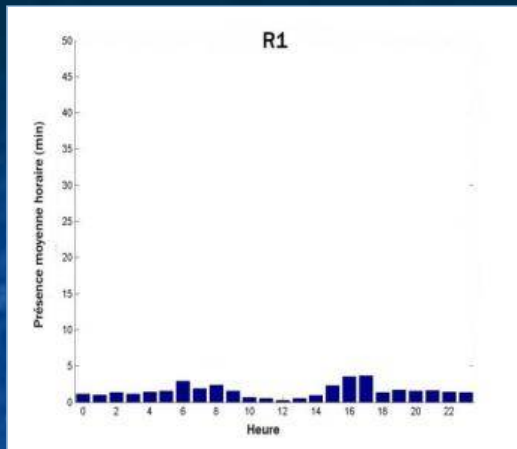
2 rays (15%) feeding sites use > 35%

8 rays (62%) feeding sites use > 80%

01 day (for 50%)

1 day (for 50%)

57,4% Motu and 42,6% BS



Average hourly detection for all rays (max: 47min on time interval 8h-9h for R5)

Feeding schedules:

- ✓ Motu: 90 % from 9 to 12 am and 10 % from 2 to 4 pm
- ✓ Sand Bank: 50 % from 9 to 12 am and 50 % from 2 to 4 pm

## Hourly variation of detection on each feeding site

### Definition of feeding site fidelity:

Mean hourly presence significantly higher during feeding times

#### Sand Bank

Mean hourly detection for 7 rays ( #122, #123, #126, #128, #129, #132 et #134) significantly higher during feeding hours (3,9 à 15,8 min)

Similar pattern for ray #121

#### Motu

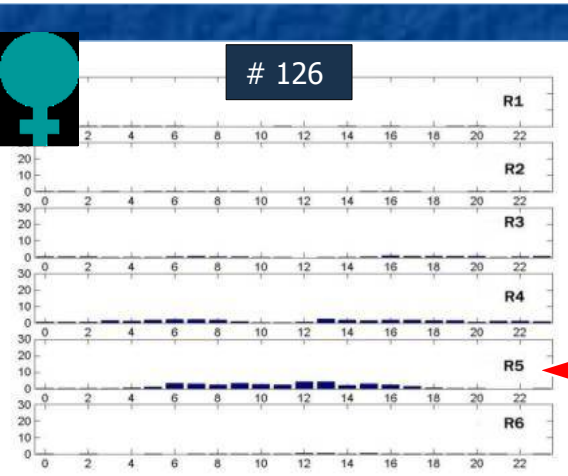
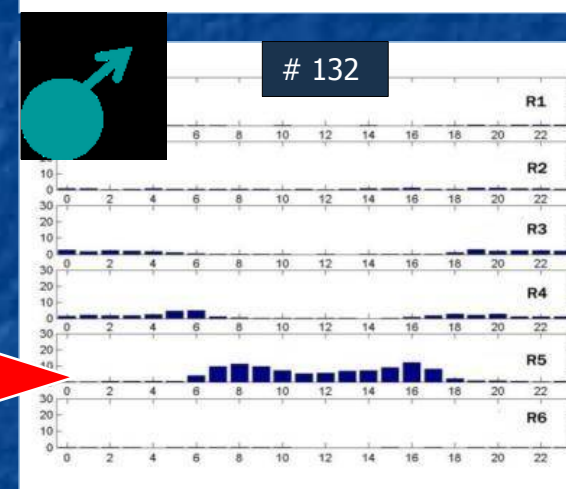
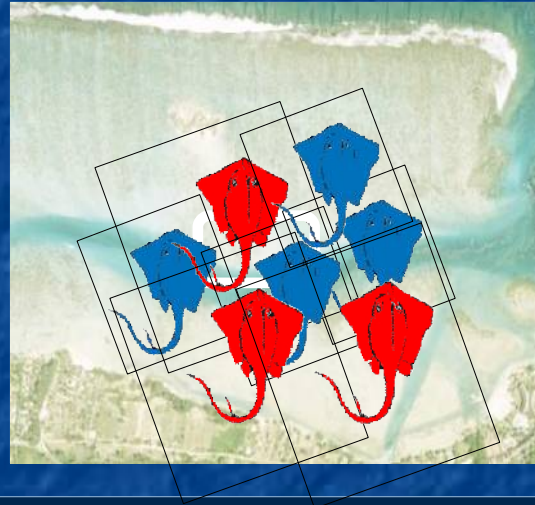
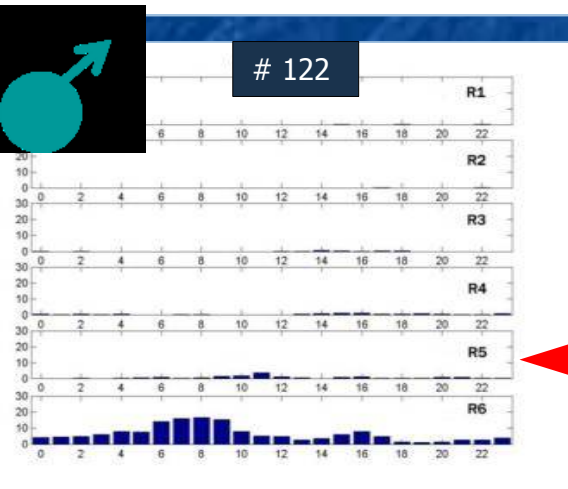
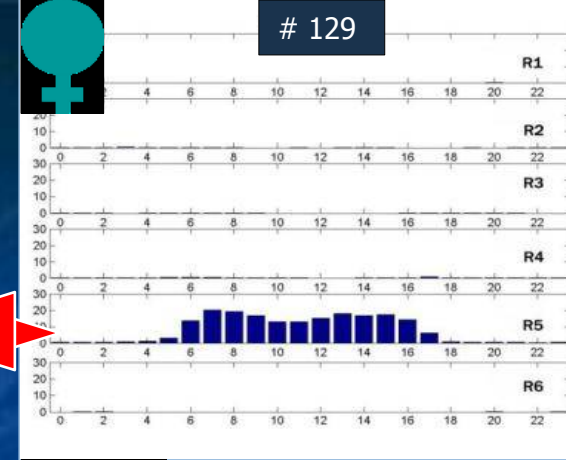
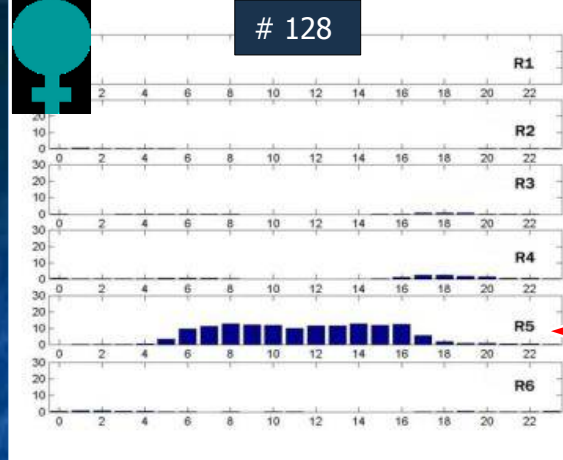
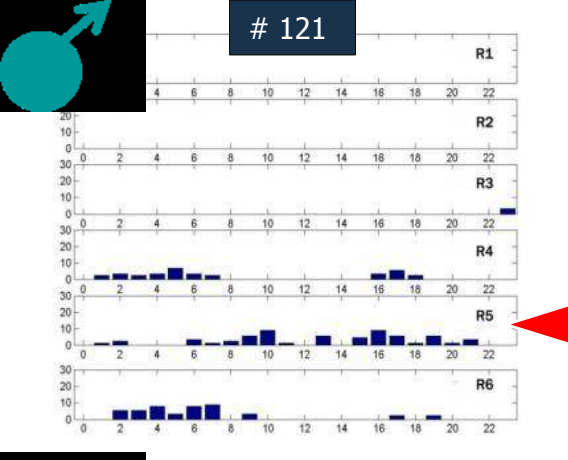
Mean hourly detection for 3 rays ( #124, #125, #130) significantly higher during feeding hours (14,7 à 20,9 min)

Similar pattern for ray #123

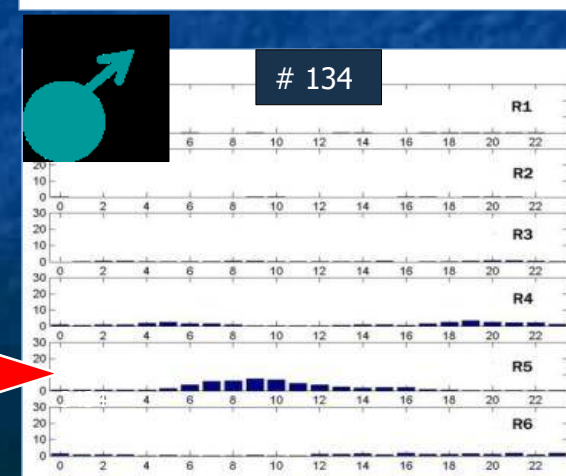
#### Tests

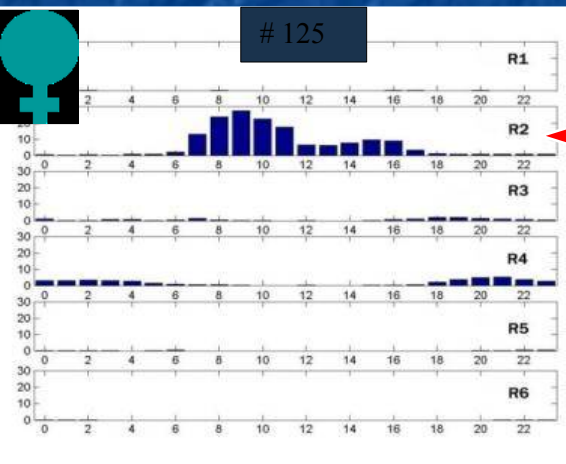
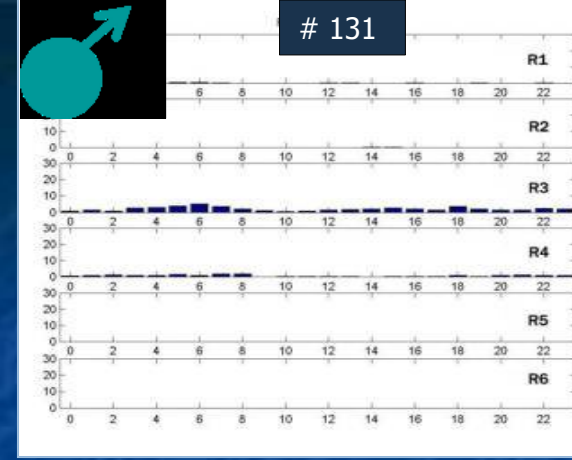
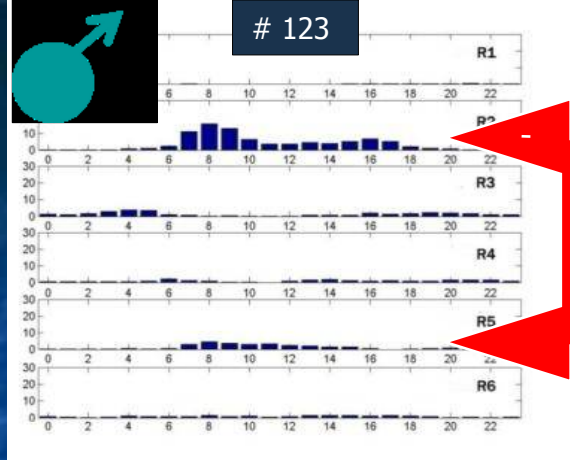
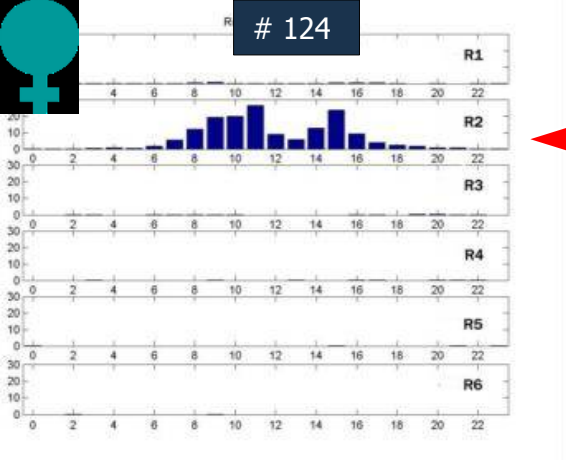
Mann-Whitney  $p \leq 0.05$   
Mann-Whitney  $p \geq 0.05$

Mann-Whitney  $p \leq 0.05$   
Mann-Whitney  $p \geq 0.05$

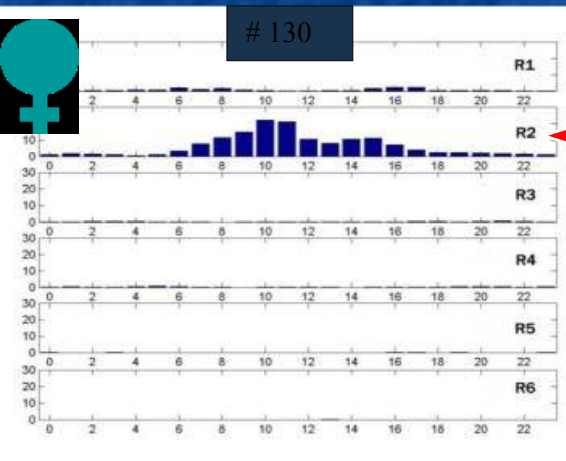
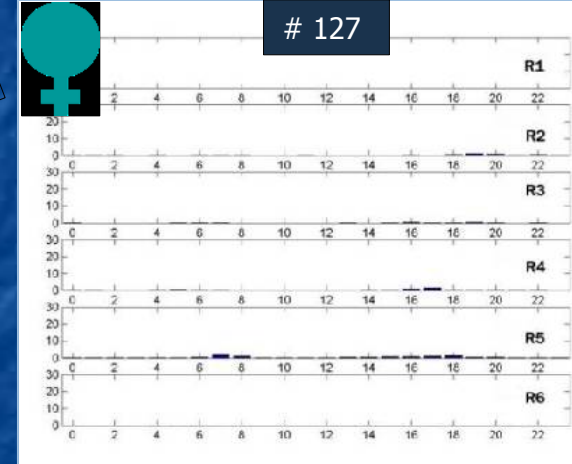


7 rays (4M et 3F)  
fidelised on Sand Bank





↑  
1 ray (M) fidelised on both feeding sites

↑  
2 rays ( M et F ) non fidelised to any feeding site




↑  
3 rays (F) fidelised on Motu feeding site

## Tourism:

- › Motu: number of tourists
- › Banc de Sable: presence or absence of cruiseships

## Other factors:

- › Rain
- › Swell and current
- › Sun
- › Moon
- › Wind
- › Water temperature



## b/ passive acoustic tagging: summary

- ✓ 7 rays fidelised on Sand Bank(4M + 3F): **54%**
- ✓ 3 rays fidelised on Motu (3F): **23%**
- ✓ 1 ray on 13 fidelised on both sites (M): **8%**
- ✓ 2 rays do not use feeding sites ( 1M + 1F): **15%**

Sand Bank site used  
since 11 years

Motu site used  
since 7 years

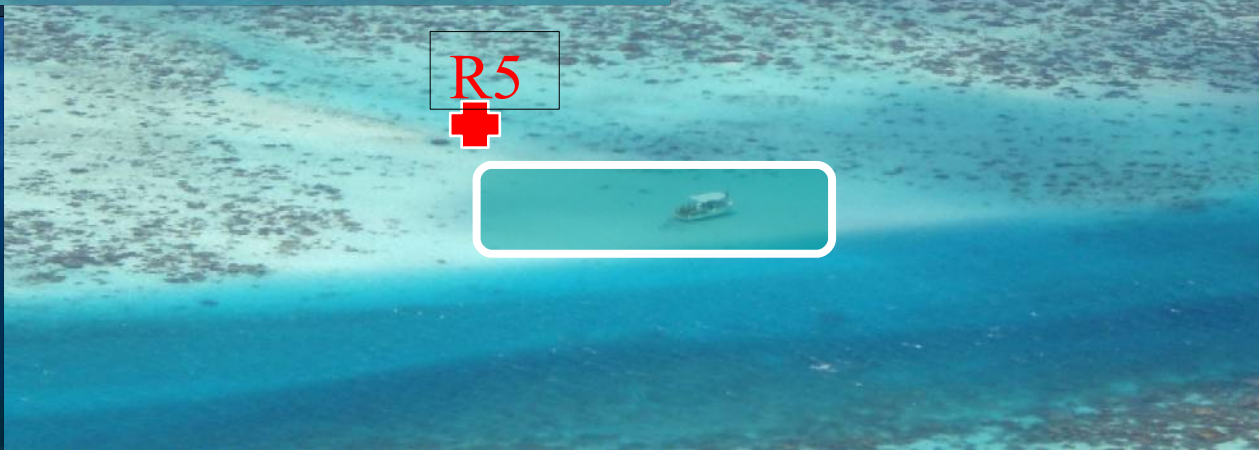
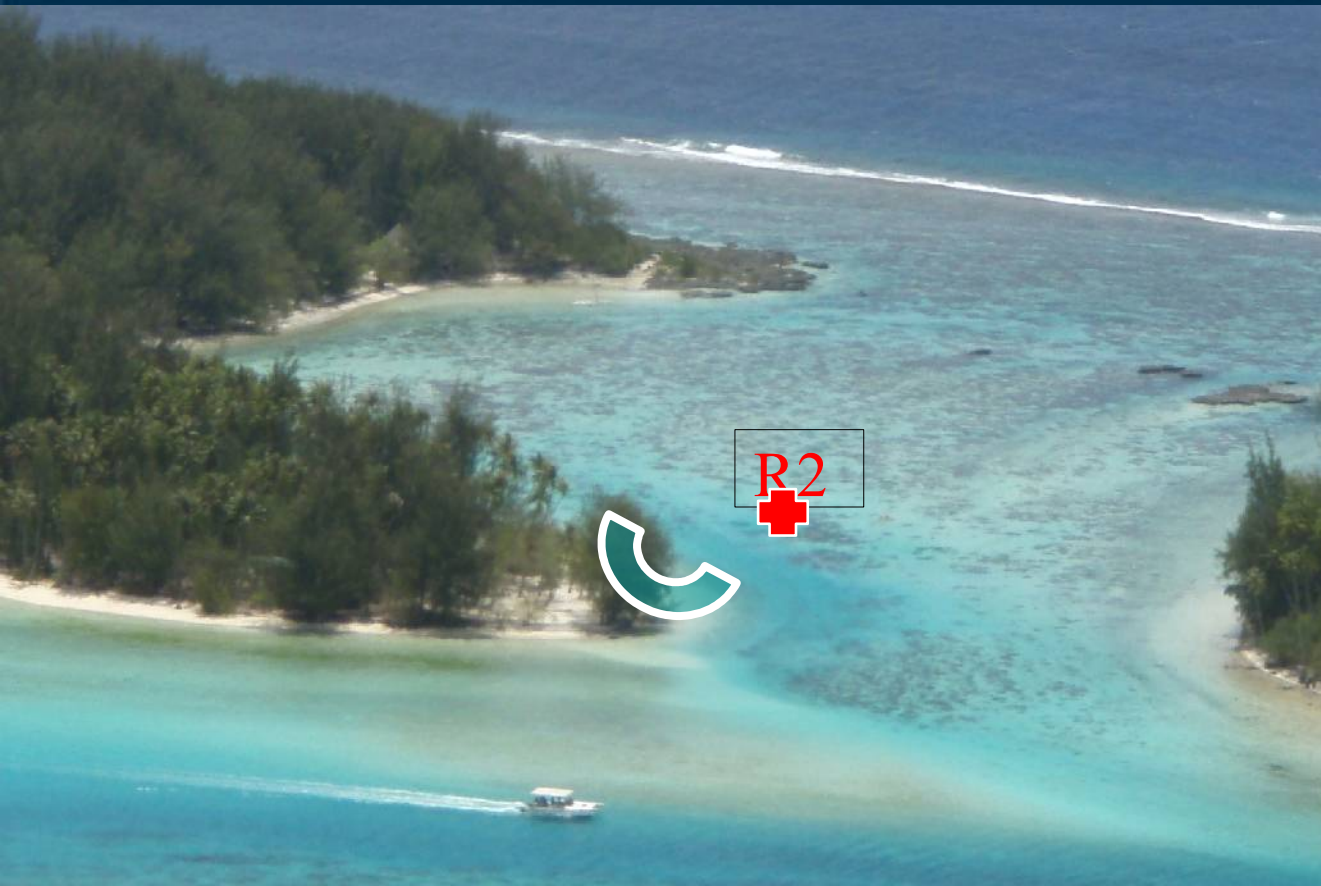
- ✓ Motu: 2 picks show high hourly presence of rays : 8 to 11 am and 3 pm : **1 hour of anticipation in the morning**
- ✓ Sand Bank: 2 picks of high hourly presence: 7 to 10 am and 3 to 4 pm: **2 hours of anticipation in the morning**

Tagged  
population= 22 %  
of total population

### Influence of environmental factors:

- ✓ Tourism: difficulty to obtain daily attendance and presence of unquantifiable residents
- ✓ Characteristics of area (swell, rain, sun, moon, tides, temperatures...)

b/ passive acoustic tagging: discussion



## c/ active acoustic tagging: material and method



Unidirectional hydrophone V10



Carolina Skiff J12



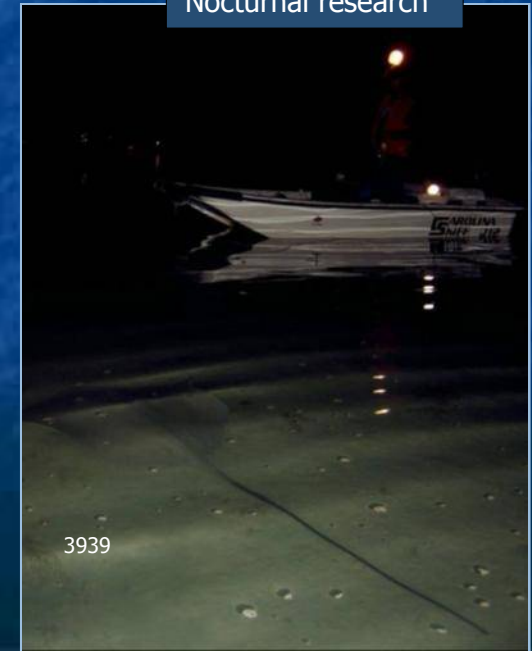
Receiver VR60, GPS



Nocturnal research

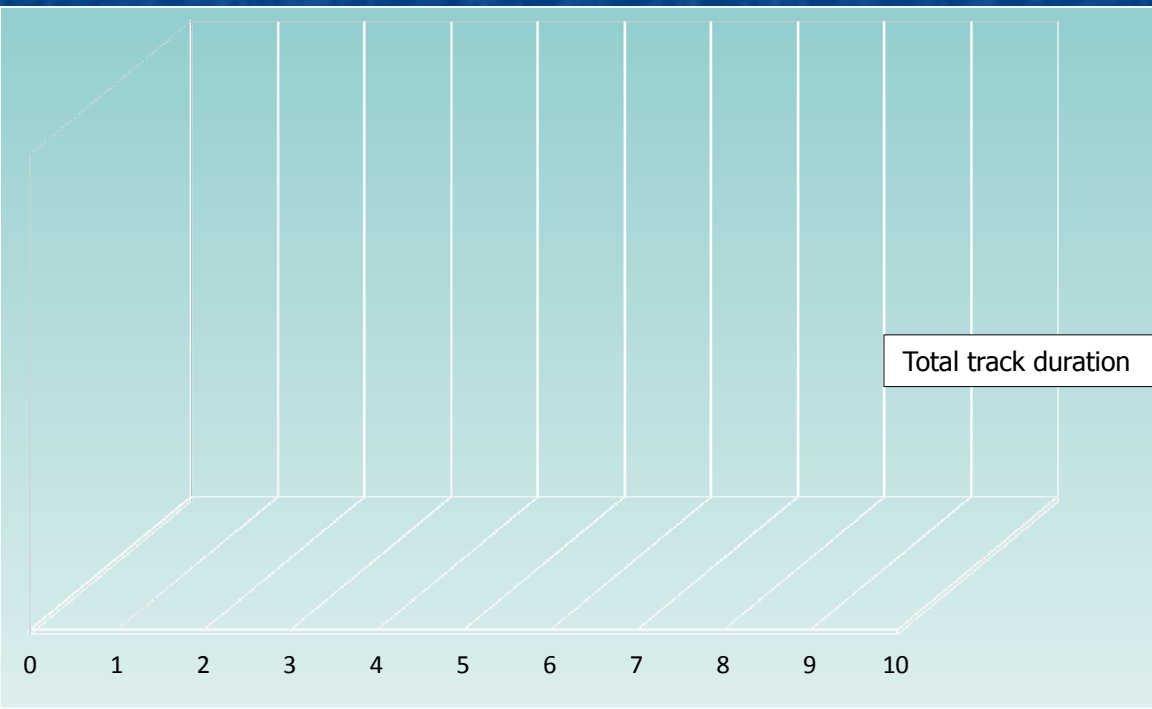
- 8 tagged rays
- 6 tracked
- 3 are fed, 3 are not fed

Tag tests: emission range  
**202 meters**

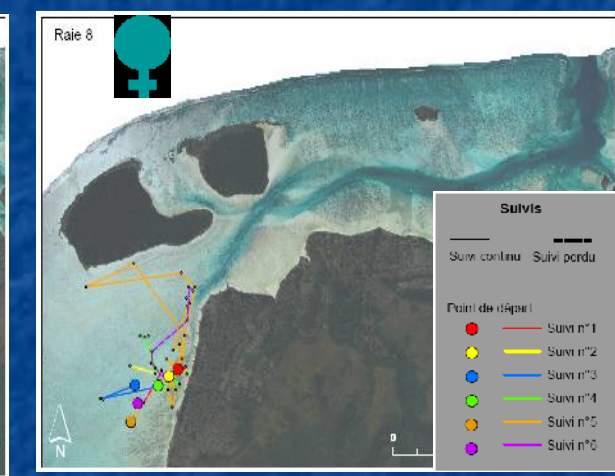
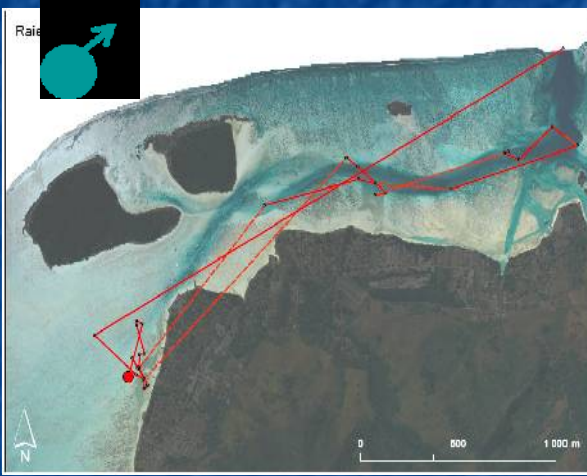
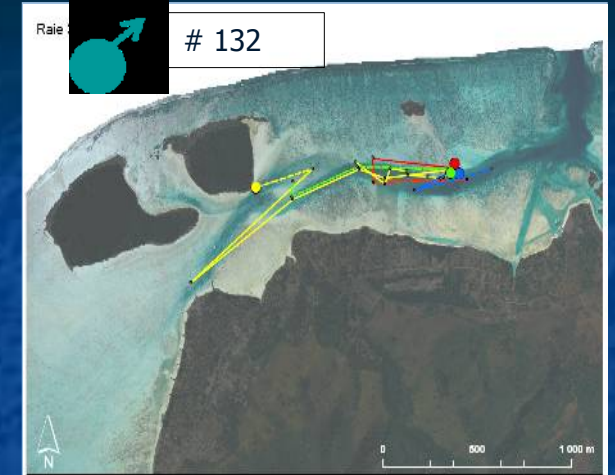
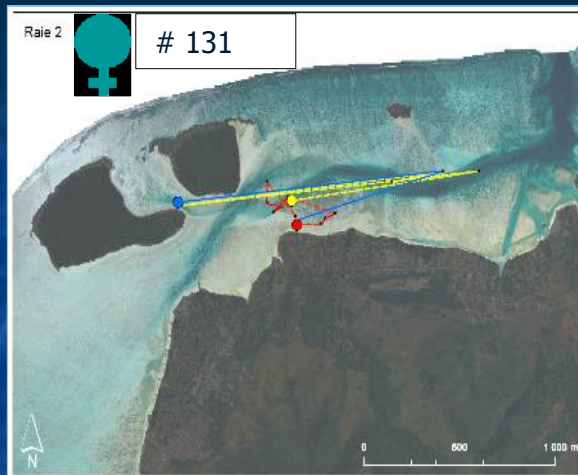
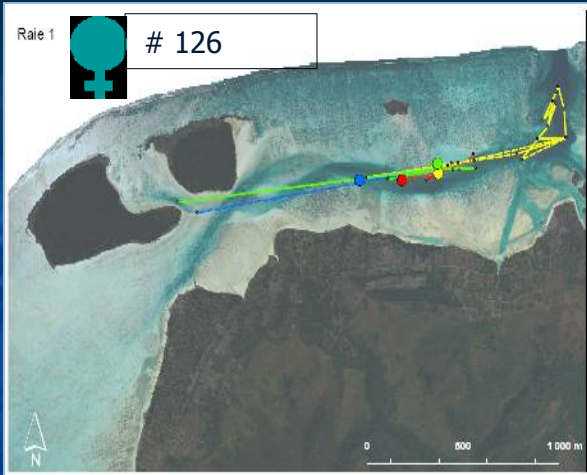


# c/ active acoustic tagging: results- tracking characteristics

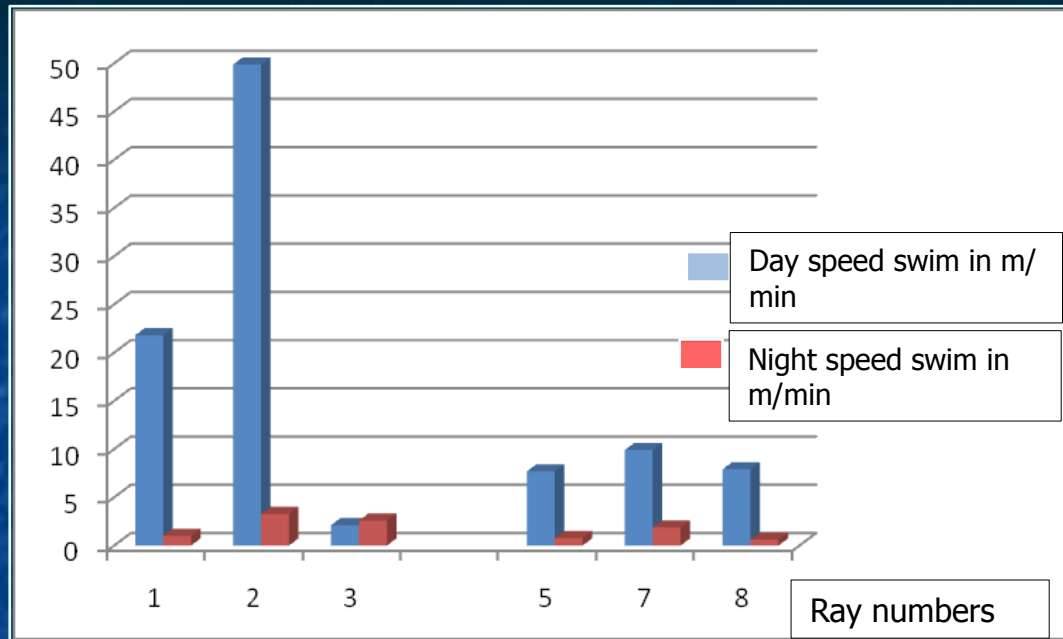
Ray number	Feeding	Sex	Size	Tracking numbers	GPS points	Track duration (h)	Track duation (min)	Loss period (min)	Actual tracks duration (min)
1	Yes	F	84	4	40	103h04	6 184	1074	5110
2	Yes	F	86	3	18	39h03	2 163	523	1640
3	Ys	M	91	4	30	52h50	3 170	658	2512
5	No	M	68	1	34	73h06	4 386	936	3450
7	No	F	114	3	18	28h24	1 704	1092	612
8	No	F	92	6	50	44h04	2 644	907	1737



# c/active acoustic tagging: tracks and swim speed



Tracks of individual movements (Arcgis 9.2)



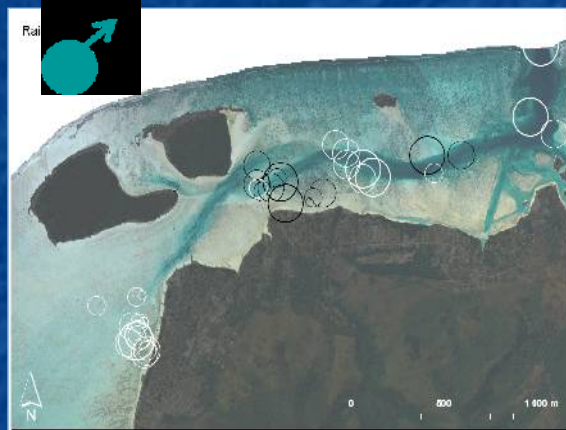
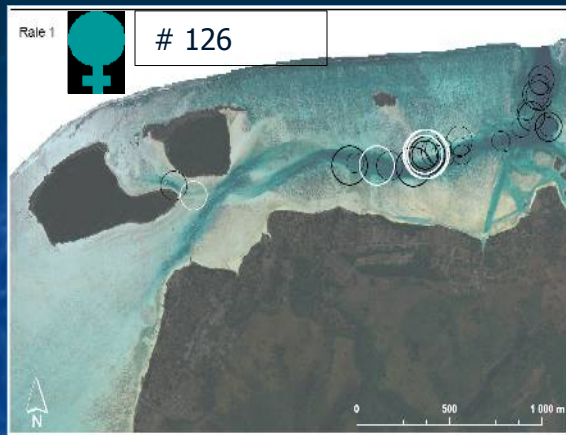
*Average speed swim (diurnal and nocturnal) for each individual*

Test Mann-Whitney		$\alpha=0,05$		
Vitesses moyennes		globale	de jour	de nuit
Variables testées	nourrissage	p=0,700	p=0,994	p=0,200
	sexe	p=0,667	p=0,133	p=0,800

$p > \alpha$  samples are not significantly different

Mann-Whitney test for feeding and sex parameters for speed swim

# c/ active acoustic tagging: results of stationing period



Day and night stationing period for each individual  
(Arcgis 9.2)

	Global stationning	Day stationning	Night stationning
Feeding	Fed rays: 1,886±2,710 Non-fed rays: 0,944±1,689	Fed rays: 4,838±4,025 Non-fed rays: 0,749±1,163	Fed rays: 1,018±1,254  Non-fed rays: 1,260±2,283

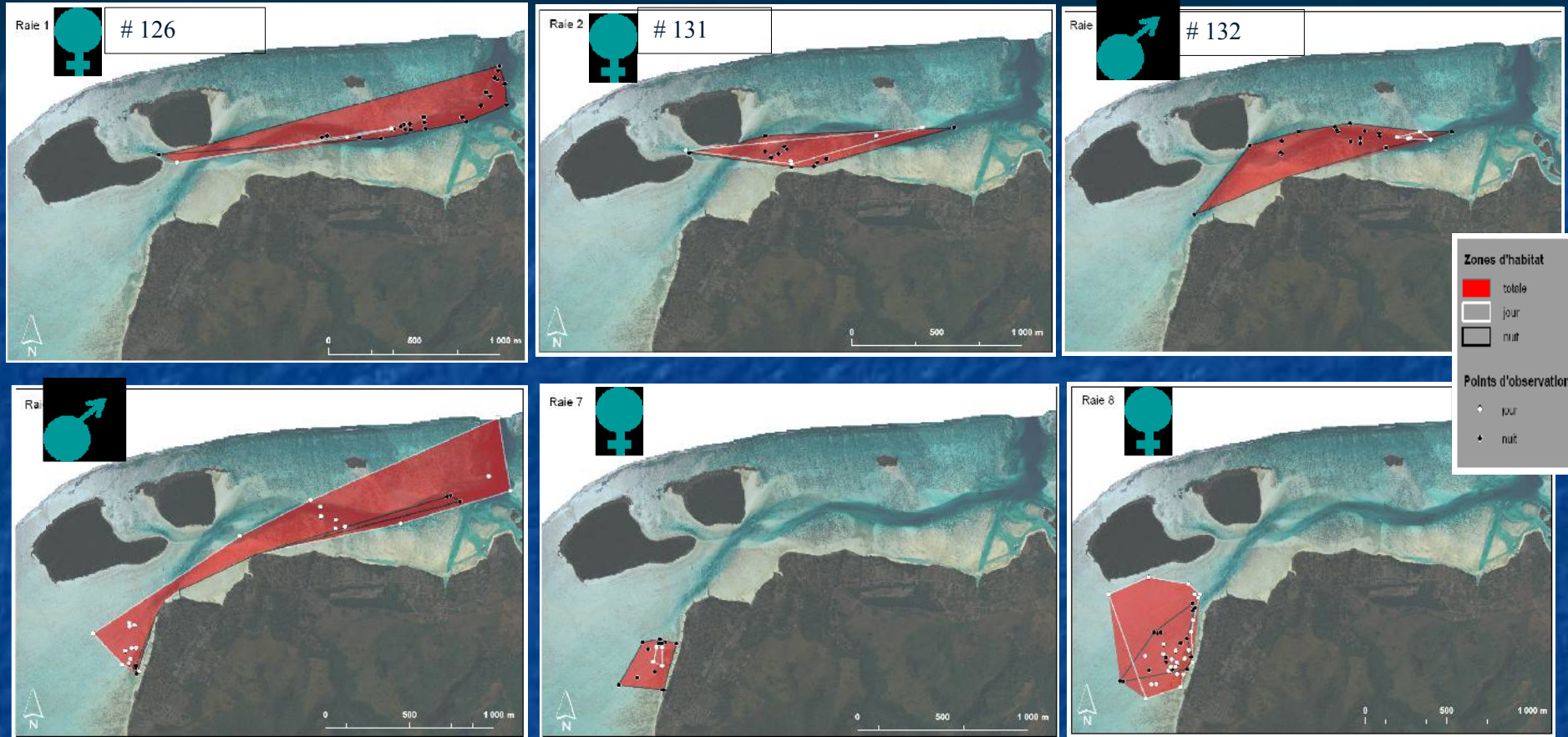
Mean stationning duration for fed and non-fed rays (in hours)

Test Mann-Whitney		$\alpha=0,05$		
Mean stationning time		global	day	night
tests	feeding	<b>p=0,003</b>	<b>p&lt;0,00001</b>	<b>p=0,987</b>
	sex	<b>p=0,113</b>		

$p > \alpha$  samples not significantly different  
 $p < \alpha$  significantly different samples

Mann-Whitney test for feeding and sex variable on stationning time

# c/ active acoustic tagging: results home range



Day and night home range per individual (Arcgis 9.2)

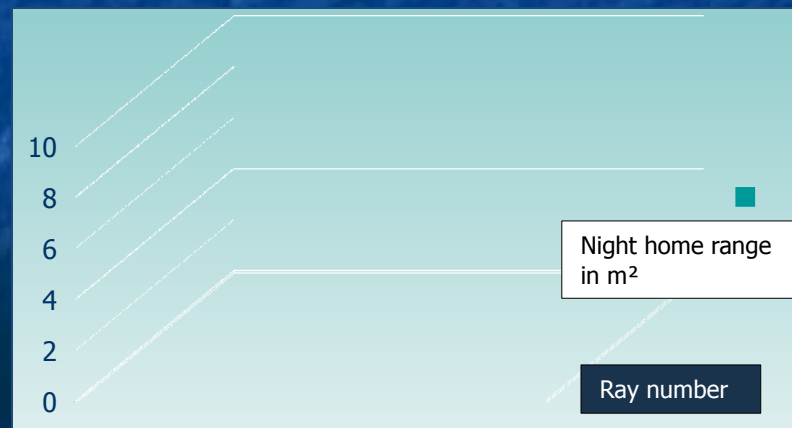
	Total home range	Day home range	Night home range
Feeding	Fed rays: 0,270±0,092 km <sup>2</sup> Non-fed rays : 0,345±0,295 km <sup>2</sup>	Fed rays : 0,037 ±0,054 km <sup>2</sup> Non-fed rays : 0,309 ±0,325 km <sup>2</sup>	Fed rays: 0,252 ±0,079 km <sup>2</sup> Non-fed rays : 0,065 ±0,034 km <sup>2</sup>
Sex	Females : 0,230 ±0,136 km <sup>2</sup> Males : 0,462 ±0,268 km <sup>2</sup>	Females : 0,096 ±0,126km <sup>2</sup> Males : 0,328 ±0,457 km <sup>2</sup>	Females : 0,165 ±0,116km <sup>2</sup> Males : 0,147 ±0,162 km <sup>2</sup>

Home range for fed and non-fed rays and males and females

Test Mann-Whitney		$\alpha=0,05$		
Home range		global	day	night
parameters	feeding sex	p=1	p=0,1	p=0,7
		p=0,533	p=0,800	p=0,800

$p > \alpha$  parameters are not significantly different

Mann-Whitney test for feeding and sex on Home range



Non-detection cases:

- ✓Coral area in study zone
- ✓Night tracking
- ✓High % of lost signals at night

Frequency, number and duration of tracking different

Behavior of fed and non-fed rays with the research boat

-  
Small sampling size (3 + 3)

✓Anterior active tracking studies on rays (5): influence of temperature, tides, moon cycles, light...

✓Stationing time: new parameter: interesting in case of wild animal feeding studies

✓No influence of sex

✓Observation of feeding behavior at night

✓**Only significantly difference between fed and non-fed rays: global and day stationing time**



3 different methods: complementarity, multi-scale approach

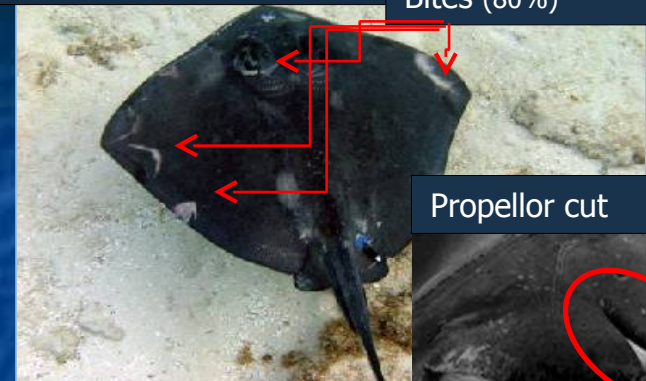
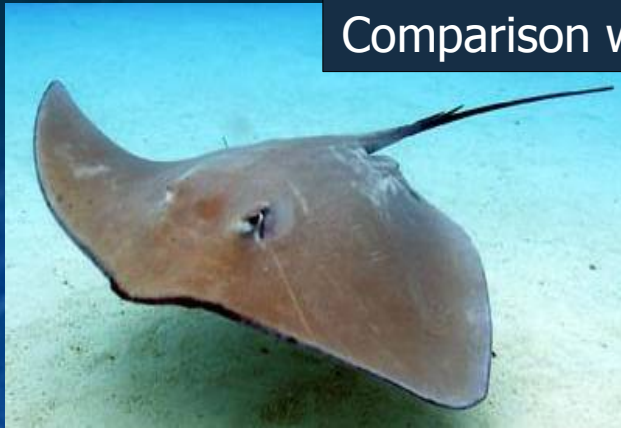
Behavior types: fidelity to feeding times

Influence of feeding on behavior and physiology of rays ?

- Lost of escaping reflex with human presence
- Inversed nycthemeral rythm
- Modification of skin mucus
- Absence of teeth erosion
- Use of different senses for prey detection
- Faster growth
- Unbalanced diet
- ingestion in vertical position
- Modification of reproduction seasonality
- Increase in specific density
- Parasitism load increase
- Increase of intra and interspecies aggression



## Comparison with Stingray City in Cayman Island



Bites (80%)

Propellor cut (12%)



Activity start date: 1986

Over 200 rays amongst which 172 are identified and 7 tracked

1.000.000 visitors per year (3000 pax/day)

18 % of fidelized rays are males; modification of reproduction season

Increase of specific aggression

Bites on guides

Fed rays home range 1/2 smaller than non-fed rays

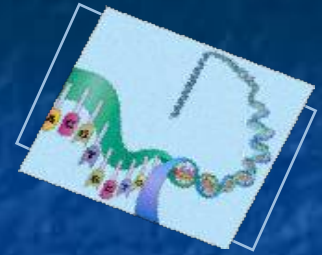




# Chapter 4 : Genetic structure of polynesian population

## a/ research definition

- Exploratory study
- Rays found in 4 of the 5 polynesian archipelagos (not in Australs)
- Understanding of dispersion strategy: on large scale
- Ovoviviparus species, no larvae dispersal phase
- Fragmented habitat, dispersed islands



## b/ material and method

2 sampling techniques



Study of Cytochrome Oxydase 1 (CO1) variation of Mt ADN:

- No meiotic recombination (transmissal by mother only)
- Slow variation compared to nuclear ADN
- Bar coding gene

Arlequin software

Introduction and research topics

1/ Species and study zone

2/ Sting ray feeding activity

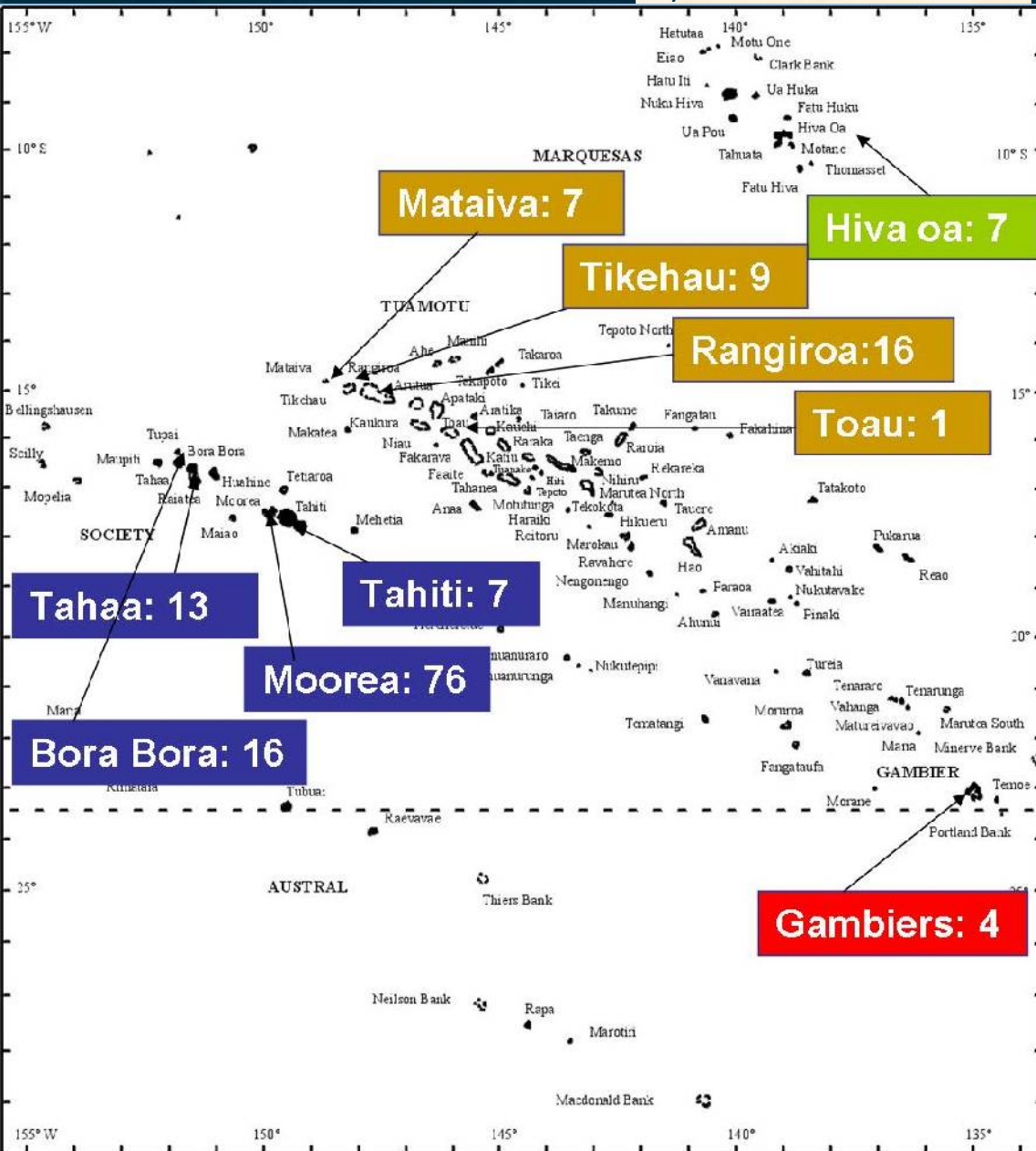
3/ Study on individual movements

4/ Genetic structure of polynesian population

Discussion

Conclusion and future research

## b/ material and method



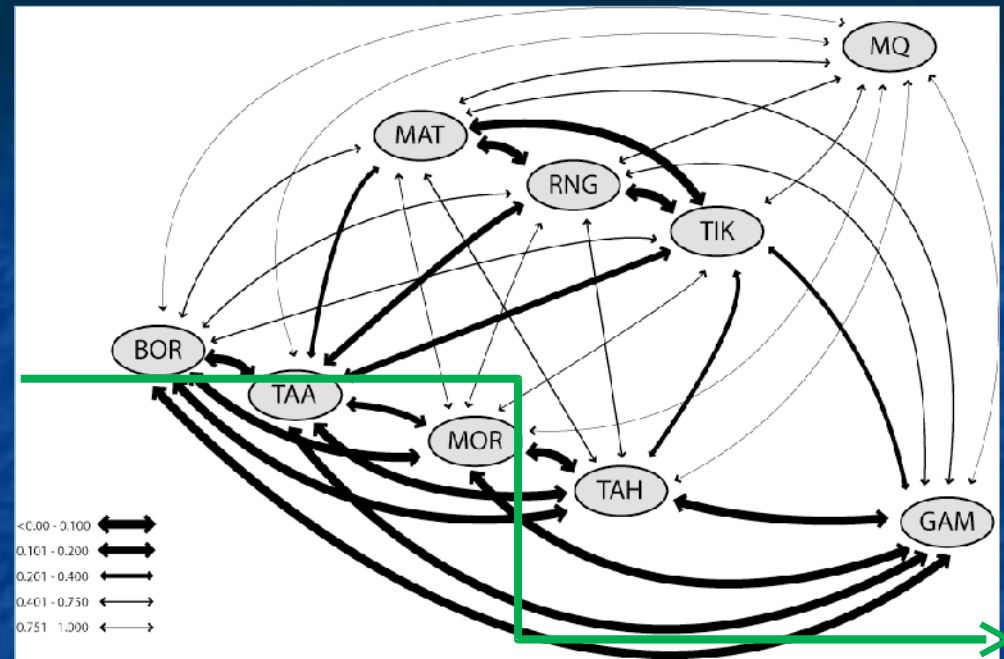
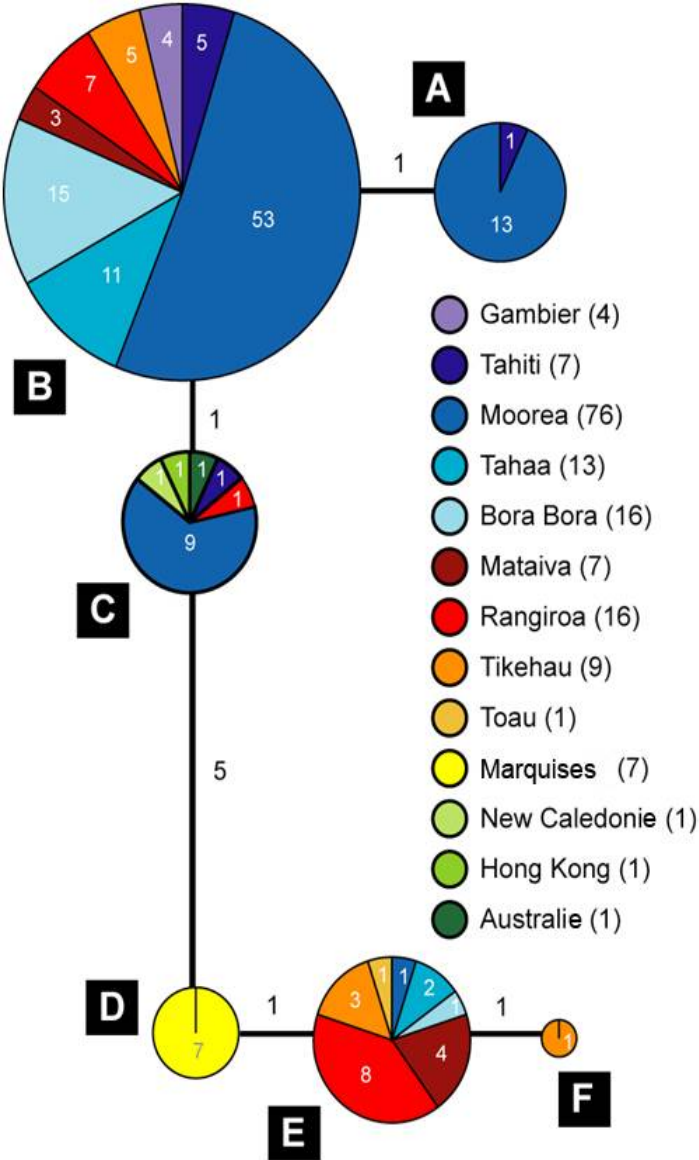
Sampling effort in polynesian territory

## ANALUSED SAMPLES

MOOREA	76
GAMBIER	4
TAHITI	7
TAHAA	13
BORA BORA	16
MATAIVA	7
RANGIROA	16
TIKEHAU	9
MARQUESIS	7
TOAU	1
<b>TOTAL IN FRENCH POLYNESIA</b>	<b>156</b>
NEW CALEDONIA	1
AUSTRALIA	1
HONG KONG	1
<b>TOTAL OUTSIDE POLYNESIA</b>	<b>3</b>

5252

# c/ results



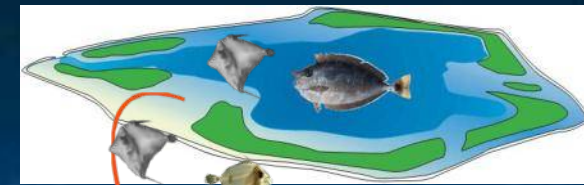
*ST* values between populations in PF (*ST* close to 1: diverging population, few exchanges of genes)

- > Amplified ADN: 629 pair bases
- > 6 haplotypes (A to F), maximum diversity of 9 pair bases
- > Gambier and Marquises: unique haplotype
- > Small divergence between individuals
- > Genetic affinity follows north-west / south-east trend
- > Society and Gambier close ; small *ST* more gene flows

Haplotype network(6) on 159 individuals sampled (max: 5 mutation of haplotypes)

3 samples Hong Kong, Australia and New Caledonie : haplotype C

## d/ discussion and future research



dispersal

**Biologic cycles of reef bony fish**



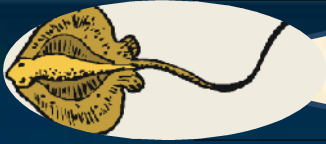
Is there nursery site for sting rays?



5454

- ✓ Preliminary study
- ✓ 3 samples (Hong Kong , Australia and New Caledonia): haplotype C : west colonization?
- ✓ Unicity of Marquesas population (high fish endemism : 12%)
- ✓ Small sample size except Moorea island
- ✓ Trend for gene flow: north-west / south east but limited exchanges
- ✓ Adults sedentary, small home range, no larvae dispersal stage
- ✓ Reproduction study : ovoviviparity, polyandry, nursery zones, philopatye, sexual maturity?
- ✓ Population size regulation ?





## Introduction research topics

1/ Species and  
study zone

2/ Sting ray  
feeding activity

3/ Study on  
individual  
movements

4/ Genetic  
structure of  
polynesian  
population

**General  
discussion**

Conclusion and  
future research

## **Exploratory study of genetic structure:** limited gene flow

- Need higher sampling numbers for Marquisas, Gambier and Tuamotu
- Study of one population on an Island level?
- Comparison of genetic structure between fed and non fed groups

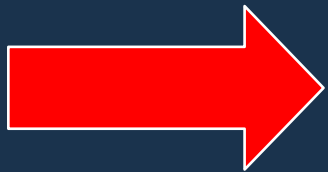




Importance to study **reproduction function**

- Polyandry ?
- Number of foetus?
- Gestation duration?
- New-born size?
- Survival rate?
- Nursery sites, mother philopatry?

September 14 th 2008: cookie cutter shark *Isistius brasiliensis* bite on a post pregnant female : do they give birth on outer slope?





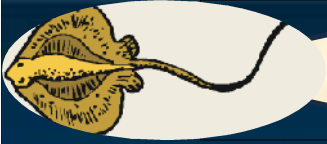
## Conclusion and future research

### Study at eco-sytem scale

Impact of feeding on fish and birds  
Particular case of black tip sharks



PGEM impact on protection through regulation



## Conclusion and future research

Animal species have various roles in ecosystem: what are the ones of *Himantura fai*?

People are modifying food resources in Nature to better interact with it? How much negative impacts are created, are they reversible?

Research on polynesian sting ray and their feeding...



The very first study on an emblematic species with high touristic value that is now opening many future research fields...

Introduction and research topics

1/Species and study zone

2/ Sting ray feeding activity

3/ Study on individual movements

4/Genetic structure og polynesian population

General discussion

Conclusion and future research



*māuruuru*