Tag Shedding by Tropical Tunas in the Indian Ocean: First results and explanatory analyses

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Objective

Estimate of tag-shedding is required for an estimation of fishing and natural mortality rates from tagging data.

Tag shedding is of two types (Wetherall, 1982):

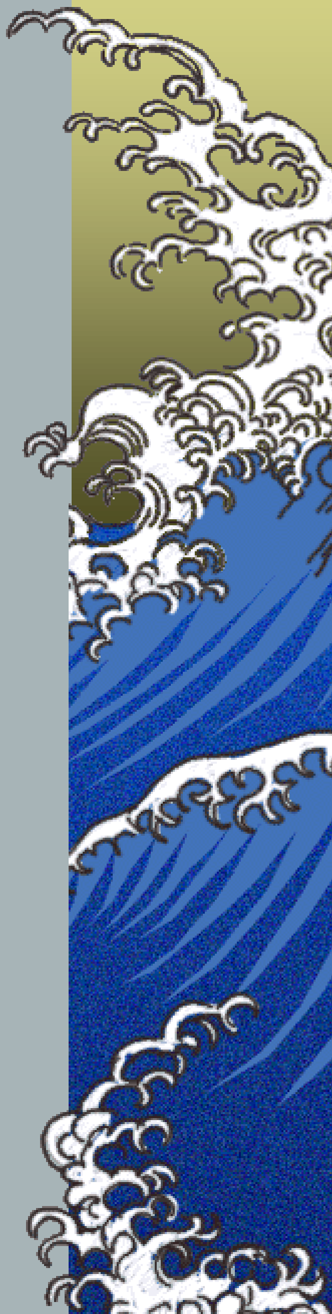
Type-1 shedding includes immediate tag shedding, immediate tagging-induced mortality and failure to report recovered tags

Type-2 shedding includes continuous tag shedding/mortality attributable to the tag, emigration away from the fishing ground, etc

Tagging data are commonly used to estimate mortality rates with the aid of tag attrition model , such:

$$\hat{r}_{ij} = (1-\rho_i)\, T_i \,\frac{F_j}{Z_{ij}} \left[1 - \exp\left(-Z_{ij}\right)\Delta_t\right] \exp\left(-\sum_{k=1}^{j-1} Z_{ik}\,\Delta_t\right)$$

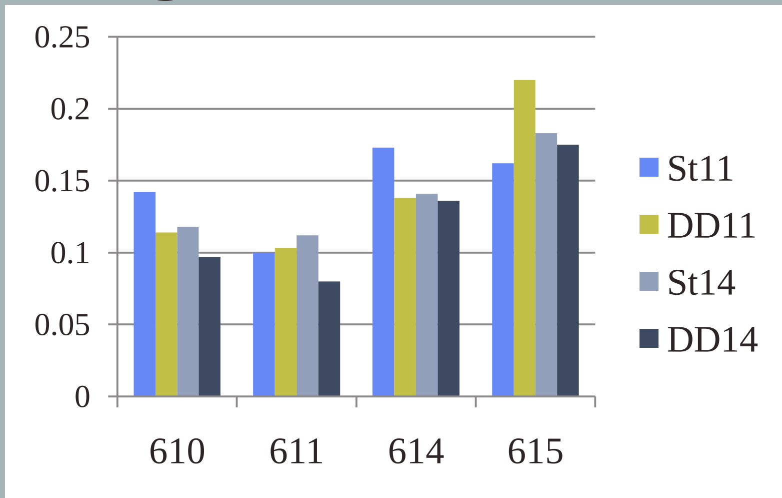
However, in general, type-1 (ρ) and type-2 (in $Z = F + M + \lambda_i$) shedding rates cannot be estimated directly from tag-return data (some exceptions in comparison between different tag types; Gaertner et al, 2004). As a consequence, different methods have been proposed for estimating shedding rates using data from double tagging experiments.



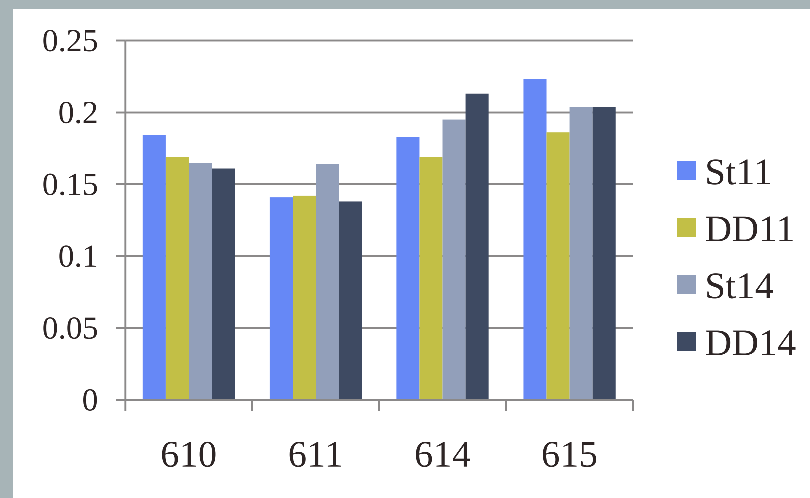
But, before modelling the shedding rate, we can explore first for the whole tagging data set (i.e., single tagging and double tagging experiments) what factor may affect the return rate,

- the size/characteristic of the tag (11 cm type CC vs 14 cm type EE and KK)
- the position where each double tag is inserted on the fish (Left vs Right side)
- the tagging cruise (tagging technician * strata)
- the double tagging itself (differences in mortality / in visibility: simple tagged vs originally double tagged fish)
- other factors (e.g., size of the fish, etc) not considered here in this preliminary analysis.

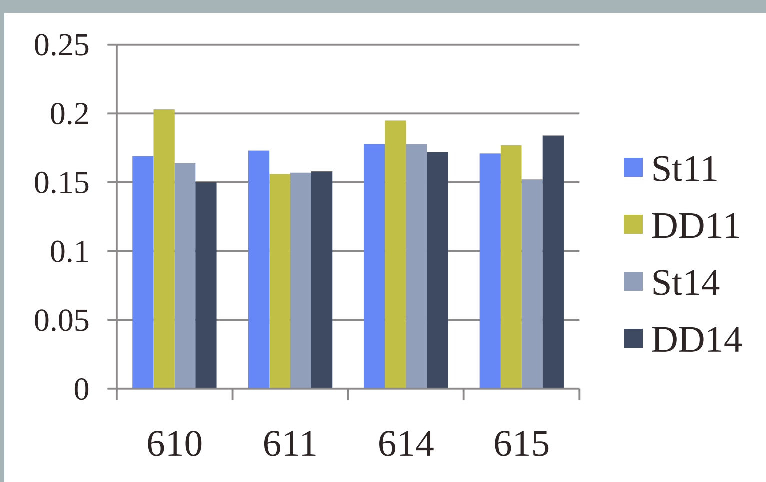
Tag size/characteristic (11 cm vs 14 cm)



BET



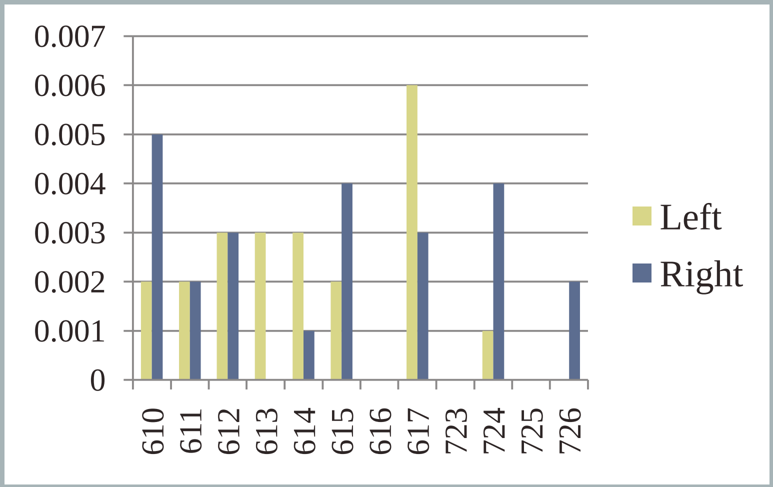
SKJ



YFT

Position of the tag insertion for the fish originally double tagged

(Left vs Right)



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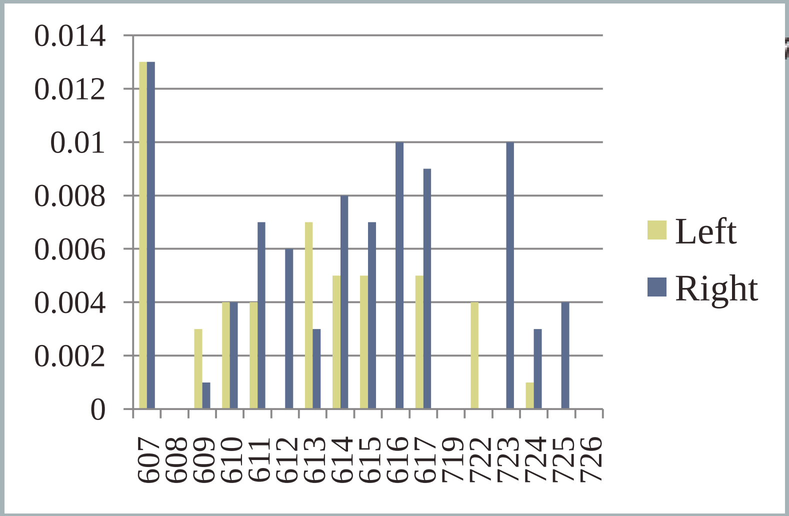
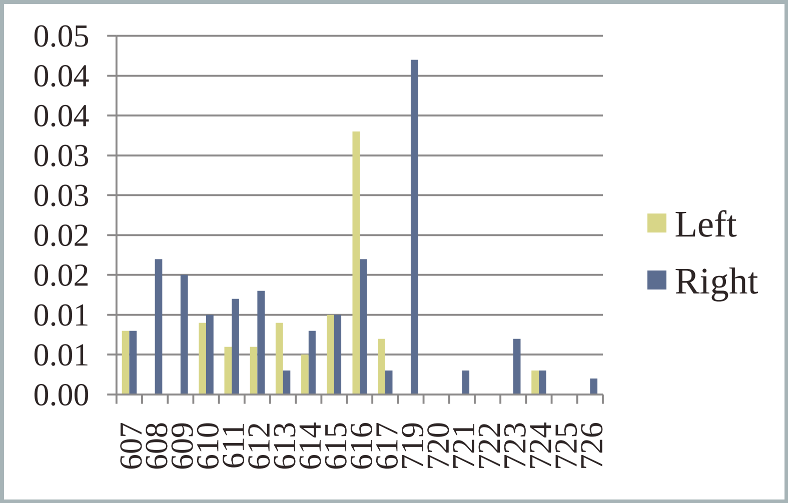
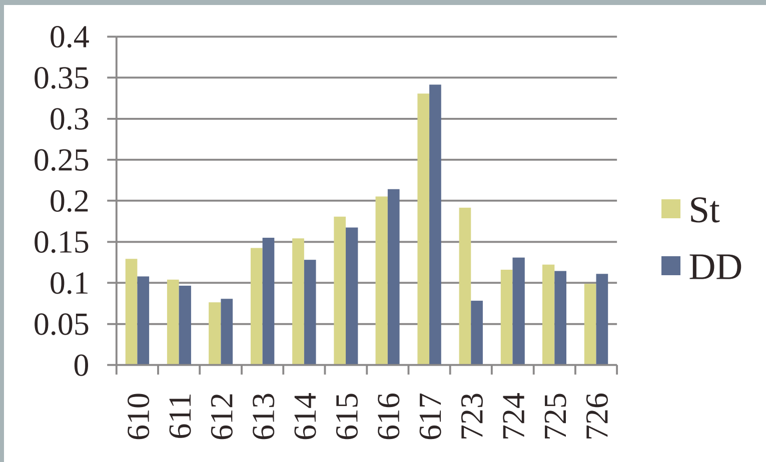
SKJ





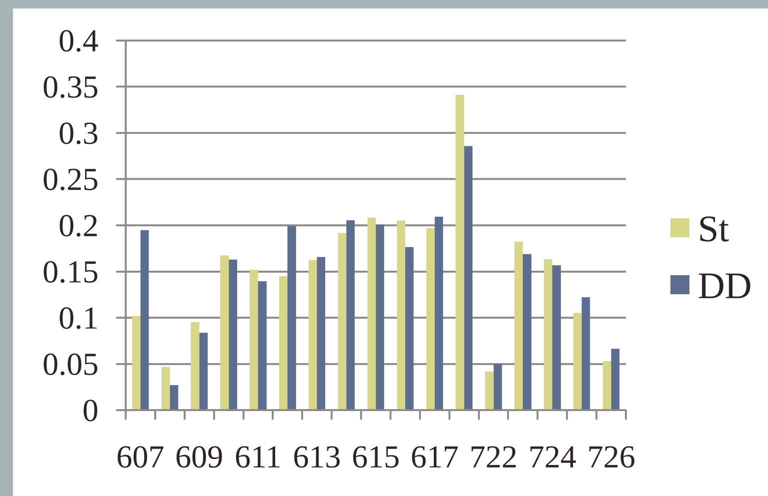
YFT

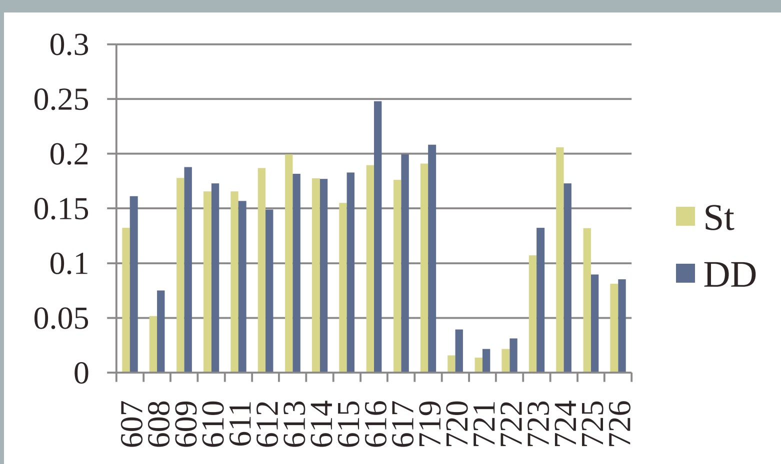
Comparison between single tagged fish and originally double tagged fish



BET

SKJ





YFT

Conclusion of the exploratory analysis :

Even if additional statistical analysis should be done, there is not strong evidence of difference in return rates between tag types or between the position of the inserted tag, but the tagging experiment (i.e., the cruise) could influence significantly the return rate.

Accordingly , we performed a simple analysis of the proportion of tags lost over time as:

P. Observed = $P_t = n^{ds}_t / (n^{ds}_t + 2\, n^{dd}_t)$,

Chapman et al, (1965), with n^{ds} and n^{dd} = numbers of recoveries of originally double tagged fish retaining one (ds) or two tags (dd), respectively, and t time at the middle of the k th time period since release.

Modelling the proportion of tags lost:

P. Fitted = 1 - Q_t , with different potential models for the probability Q_t of a tag being retained at time t after release e.g.:

$Q_t = a \exp^{(-L\, t)}$, see Hampton (1997), Adam and Kirkwood (2001), etc

$Q_t = a\, [\, \beta \,/\, (\beta + \lambda\, t)\,]^{\beta}$, see Kirkwood (1981), Hampton and Kirkwood (1989)

a = type-1 retention probability (i.e., 1 - immediate type_1 shedding rate),

L = continuous type-2 shedding rate,

λ and b = gamma parameters of L allowing a time-varying shedding rate

Under the assumption that all tags not immediately shed have independent and identical probabilities, the probabilities of 2, 1 and no tags being retained at time t after release are, respectively:

$P_t(2) = Q_t^2$; $P_t(1) = 2\,Q_t\,[\,1 - Q_t\,]$; $P_t(0) = [\,1 - Q_t\,]^2$

Since identifiable recaptures consist only of fish retaining either one tag or two tags, conditional on retention of at least one tag, the probability of capturing a fish retaining 2 tags at time t is :

$P_t(2) \,/\, (1 - P_t(0)\,)$,

and retaining only one tag at time t is:

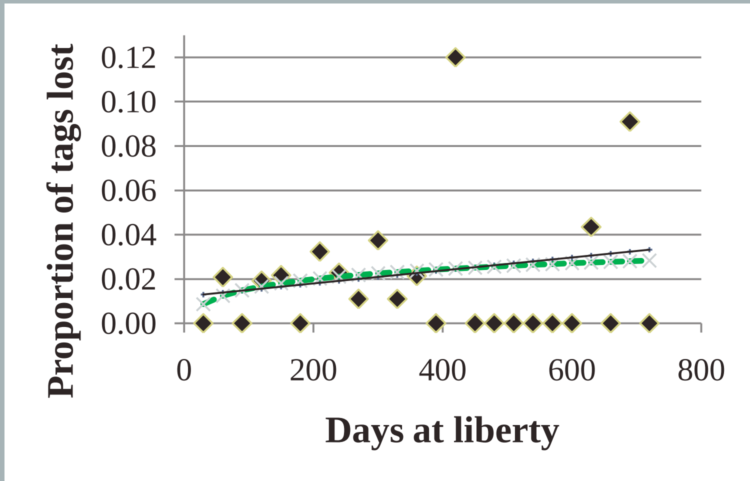
$P_t(1) \,/\, (\,1 - P_t(0)\,)$.

Estimates of the model parameters are obtained by minimizing the negative log-likelihood of the data conditional on recapture times:

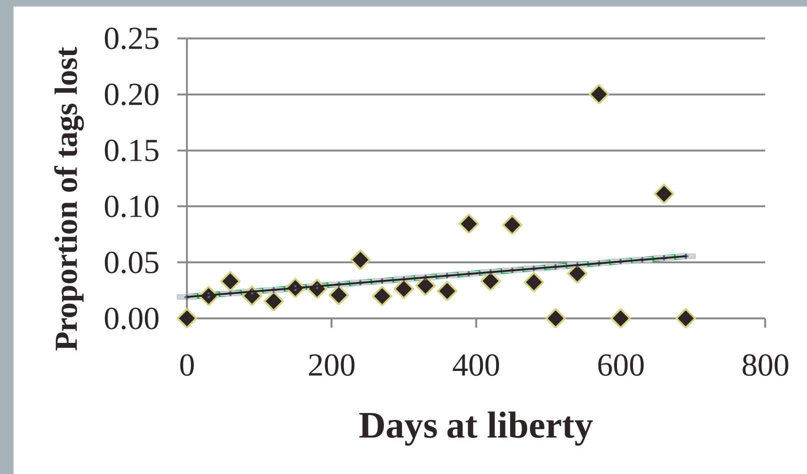
$$LL = - \Sigma \, Ln \, [P_t(2) / (1 - P_t(0))] - \Sigma \, Ln \, [P_t(1) / (1 - P_t(0))]$$

There are more sophisticated models taking into account differences in reporting rate between double and simple tags, differences in continuous tag loss depending on the position/side of the fish where each double tag is inserted, etc; see Barrowman and Myers (1996), Xiao (1996), Cadigan and Brattey, (2006), among others, or using tag-attrition model ; see Gaertner et al, (2004)

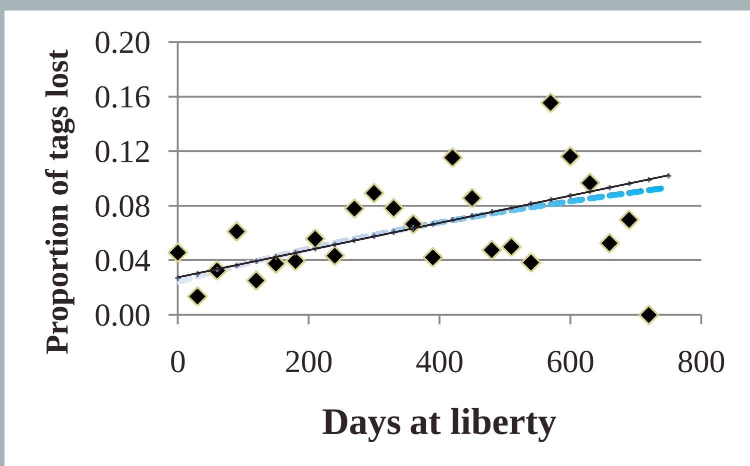
Some Results:



BET



SKJ



YFT

Solid line = constant type-2 shedding rate
Dotted line = time-varying type-2 shedding rate

Models were fitted with exact days at liberty but observed shedding rates are represented by time periods of 30 days

Constant shedding rate $Q(t) = \alpha \exp^{(-\lambda t)}$

Species	α	95% C.I.	λ (per year)	95% C.I.	
SKJ	**0.981**	**(0.972 - 0.990)**	**0.020**	**(0.003 – 0.037)**	present study
	0.97	(0.94 - 1.00)	0.22	(0.09- 0.35)	Adam-Kirkwood 2001
	0.965		0.086		Hampton 1997
YFT	**0.973**	**(0.962 - 0.983)**	**0.039**	**(0.019-0.057)**	present study
	0.934		0.018		Hampton 1997
BET	**0.988**	**(0.982 - 1.000)**	**0.011**	**(0.000- 0.031)**	present study
	0.953		<0.001		Hampton 1997

Time varying $Q(t) = \alpha [\beta / (\beta + \lambda t)]^{\beta}$

Species	α	λ (per year)	β
SKJ	**0.981**	**0.020**	**4070.824**
YFT	**0.976**	**0.053**	**0.100**
BET	**1.000**	**0.210**	**0.007**

Conclusions

Proportion of tags lost (constant shedding rate)

	Years after release		
Species	**0**	**1**	**2**
BET	**0,012**	**0,023**	**0,033**
SKJ	**0,019**	**0,038**	**0,057**
YFT	**0,027**	**0,064**	**0,099**

End of the preliminary analyses ….