EXPLORATORY ANALYSIS OF ENVIRONMENTAL INFLUENCES ON TUNA MOVEMENT PATTERNS IN THE INDIAN OCEAN.

Indian Ocean Tuna Tagging Symposium

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OUTLINE OF TALK

- Data processing
- The environmental background
- Angular azimuth and distances
- Movements, SST variability and CHL regimes
- Prospects

Question : does interannual variability impact the spatial dynamics of tuna ?

1 – DATA PROCESSING

- Tag-recoveries dataset
 - Only RTTP and PS recoveries
 - Restricted to the first 6 months at liberty (30-180 days)
- Environmental data
 - SST : NCEP/GODAS model output (1°lon-0.33° lat)
 - CHL : MODIS 9-km level 3 data aggregated on the NCEP/GODAS grid



A 4 stages process

- 1) Shedding rate
 - simple constant rate model (Gaertner and Hallier 2008)
 - Probability of retention : $\pi_t = \alpha e^{(-\lambda t)}$
 - α and λ are only speciesdependent



2) Reporting rate

- Accurate estimates only available for PS (vary variable across gears)
- Single RR for all species (Hillary et al 2008)
- Discrete values by quarter
- Monthly estimates by fitting an exponential model

 $\beta_t = a(1-e^{-bt}),$

t being expressed in month



3) Correction of actual recoveries $R' = R + R(1-\pi) + R(1-\beta)$

With R' corrected number of recoveries π retention rate

β recovery rate

π varies with time and species, and that β varies only with time

- 4) Standardization using purse seine catch at size
- extrapolated purse seine catch at size (SKJ, YFT, BET) by 5°area-year-quarter and school type.
- the proportional distribution of the tagged fish (P_{ijk}) is estimated from the corrected recoveries (R'_{ijk}) weighted by the total PS catch (C_{ijk}) and the size of the area (A_{ij}) for the given size class :

$$P_{ijk} = \frac{R'_{ijk} / (C_{ijk} / A_{ij})}{\sum_{ijk} (R'_{ijk} / (C_{ijk} / A_{ij}))}$$

• assumes that the probability of a tag recapture is related linearly to the catch. A reliable hypothesis given the fast rate of mixing.



2 - THE ENVIRONMENTAL BACKGROUND

Sea Surface Temperature

Sea Surface Chlorophyll



THE EVIDENCE OF TWO REGIMES IN CHL AND SST VARIABILITY (10°N-10°S)



SST anomalies

CHL anomalies





3 – ANGULAR AZIMUTH AND DISTANCES

- The time-at-liberty considered in this analysis are between 30 and 180 days
- All the data represented here are based on standardized recoveries, where shedding rates of tags and the reporting rates have been considered for purse seiners.

YELLOWFIN JUVENILE MOVEMENT FROM RELEASE

Fish tagged in TANZANIA





recaptures by size category. S2_Y_juv_TZA_FD07, n = 56.27

BIGEYE JUVENILE MOVEMENT FROM RELEASE



SKIPJACK ADULTS MOVEMENT FROM

RELEASE

Fish tagged in TANZANIA



NORTH 30% 20% 10% 1100 - 1200 1000 – 1100 EAST 900 - 1000 WEST 800 - 900 700 - 800 600 - 700 500 - 600 400 - 500 **FREE SCHOOLS** 300 - 400 200 - 300 100 - 200 0 - 100 SOUTH

scaptures by size category. S3_S_juv_TZA_FD07, n = 80.79

Standardised tuna recaptures by size category. S3_S_Adt_TZA_FS07, n = 40.77

AZIMUTH ANGLE VS TAGGING SEASONS FISH TAGGED IN TANZANIA



AZIMUTH ANGLE VS TAGGING SEASONS FISH TAGGED IN SEYCHELLES



Angular motion of tuna in the Indian Ocean Tagged in Seychelles



AZIMUTH ANGLE VS SPECIES/SIZE CLASS FISH TAGGED IN TANZANIA



AZIMUTH ANGLE VS SPECIES/SIZE CLASS FISH TAGGED IN SEYCHELLES



SUMMARY ON AZIMUTH ANGLES

• Fish tagged in Tanzania

	FAD	FREE
Dominant directions :	Somalia Seychelles	Seychelles Mozambique
Species/size grouping :	All species together, towards Somalia	All species together, towards Seychelles

• Fish tagged in Seychelles

	FAD	FREE
Dominant directions :	SEY	Can concern all areas
Species/size grouping :	PreAds &Ads BET Juv. SKJ and BET	Ad BET & Juv SKJ PreAd BET&Ad SKJ

DISTANCE TRAVELLED DURING FIRST 6 MONTHS BY SCHOOL TYPE

• FADrecovered fish tend to travel longer distances compared to free schools

• A year effect is seen mostly for free schools, with shorter distances in cold year



SUMMARY ON DISTANCES TRAVELLED

- The major typology of movements is driven by the school type :
 - FAD recaptured fish move towards Somalia
 - Free schools move towards Seychelles and to Mozambique Channel
 - All species, at all life stages, travel the same direction when belonging to a given school type
- Larger distances by FAD-recovered fish
 - Could be due to the strong northward drift of the East-African current and Somali current carrying FADs

4- MOVEMENTS, SST VARIABILITY AND CHL REGIMES

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2006	Transfer ra	ates (%) W	ithin 180 da	ays of time	e-at-liberty.	
	Α	В	С	D	E	Н
MOZ	0	0	0	0	0	(
TZA	0.71	51.73	18.96	0.24	0.02	0.01
SYC	0	10.16	16.82	0.66	0.44	(
OMN	0	0.12	0	0.14	0	(
2007	Transfer ra	ates (%) w	ithin 180 da	ays of Time	-at-liberty.	
	A	В	С	D	E	Н
MOZ	0.02	0.08	0.05	0.02	0	(
TZA	0.5	57.57	34.19	5.24	0.39	0.02
SYC	0	0.2	1.56	0.15	0	(
OMN	0	0	0	0	0	(

Variable transfer rates across regimes

• More transfer to the East (zone C) and to the Moz. Channel (D) during warm regime (2007)



MOVEMENTS DURING TWO DISTINCT REGIMES







POTENTIAL EFFECT OF ELEVATED/DEPLETED CHL REGIMES ON THE DISTRIBUTION OF RECOVERIES



PATTERNS OF DISTANCE TRAVELLED IN TWO REGIMES

'Cold-productive'



(0,0) (0,0

Different patterns

- Cold productive :
 - Less opportunity to get into cold waters
 - Larger distances towards more productive waters

• Warm-depleted

 Increasing distances towards opposite environmental conditions

'Warm-depleted'





5 - PROSPECTS

- Need to further understand those relationships
- The space and time resolution of the environmental data may be too coarse compared to the tag-recovery dataset. Other finer scale env. datasets to be used
- Exploration of additional descriptors such as 'gradients' in time and space
- Working hypothesis :
 - In cold-productive regime, due to a highly spatially-structured environment, the fish would undertake more directed movements
 - In warm-depleted regime, because of a less spatiallystructured environment, the fish would patrol in different directions, with success or failure to reach the productive areas



DISTANCE TRAVELLED DURING FIRST 6 MONTHS BY SPECIES

 Except for skipjack in 2006 (with a group of lower values), distances distribute in a similar way across the 3 species

