MITIGATING ADVERSE ECOLOGICAL IMPACTS OF OPEN OCEAN FISHERIES

HORIZONTAL AND VERTICAL BEHAVIOR OF THE OCEANIC WHITETIP SHARK IN THE WESTERN ATLANTIC OCEAN

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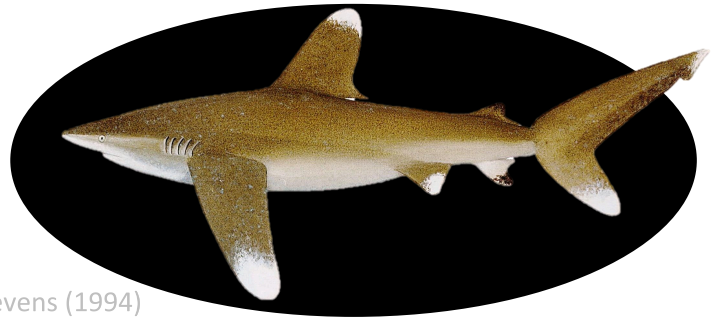
Fábio Hazin & Laurent Dagorn

OBJECTIVE



Last & Stevens (1994)

OCEANIC WHITETIP SHARK

Pop-up satellite archival tags

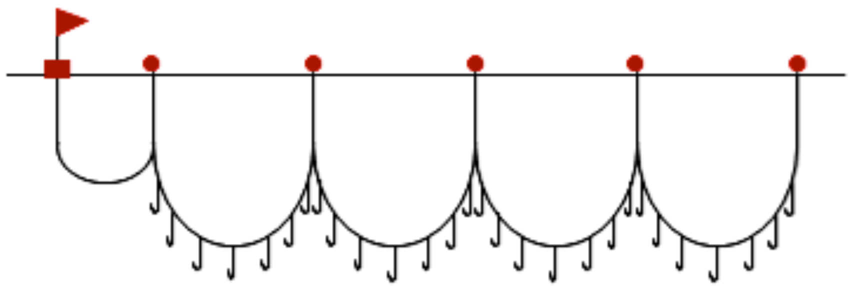
→

- Horizontal movements
- Depth distribution
- Temperature range

MITIGATION MEASURES

TAGGING

Observers on board commercial longliners



Mk10

miniPAT

ON DECK

FIN LOOP

TAGGING

2010

January

Mon	Tue	Wed	Thu	Fri	Sat	Sun
28	29	30	31	1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31
1	2	3	4	5	6	7

February

Mon	Tue	Wed	Thu	Fri	Sat	Sun
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
1	2	3	4	5	6	7
8	9	10	11	12	13	14

- **11 sharks tagged;**
- **3 tags never reported;**
- **deployment periods from 60 to 180 days.**

2011

January

Mon	Tue	Wed	Thu	Fri	Sat	Sun
27	28	29	30	31	1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
31	1	2	3	4	5	6

December

Mon	Tue	Wed	Thu	Fri	Sat	Sun
28	29	30	1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	1
2	3	4	5	6	7	8

2012

March

Mon	Tue	Wed	Thu	Fri	Sat	Sun
27	28	29	1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	1
2	3	4	5	6	7	8

GEOLOCATION

IKNOS WALK

OPEN ACCESS Freely available online

PLoS one

A Parsimonious Approach to Modeling Animal Movement Data

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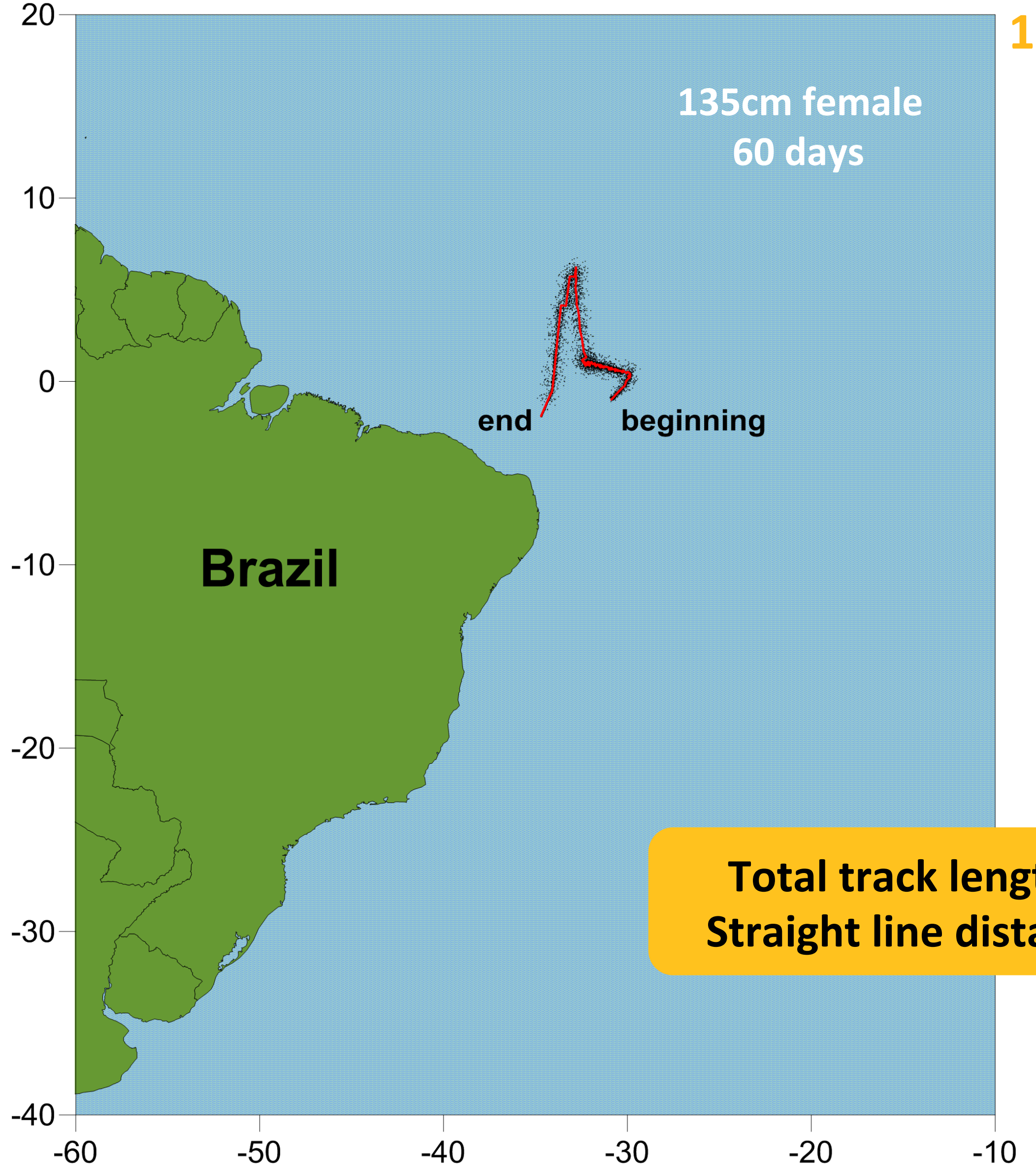
Abstract

Animal tracking is a growing field in ecology and previous work has shown that simple speed filtering of tracking data is not sufficient and that improvement of tracking location estimates are possible. To date, this has required methods that are complicated and often time-consuming (state-space models), resulting in limited application of this technique and the potential for analysis errors due to poor understanding of the fundamental framework behind the approach. We describe and test an alternative and intuitive approach consisting of bootstrapping random walks biased by forward particles. The model uses recorded data accuracy estimates, and can assimilate other sources of data such as sea-surface temperature, bathymetry and/or physical boundaries. We tested our model using ARGOS and geolocation tracks of elephant seals that also carried GPS tags in addition to PTTs, enabling true validation. Among pinnipeds, elephant seals are extreme divers that spend little time at the surface, which considerably impact the quality of both ARGOS and light-based geolocation tracks. Despite such low overall quality tracks, our model provided location estimates within 4.0, 5.5 and 12.0 km of true location 50% of the time, and within 9, 10.5 and 20.0 km 90% of the time, for above, equal or below average elephant seal ARGOS track qualities, respectively. With geolocation data, 50% of errors were less than 104.8 km (<0.94°), and 90% were less than 199.8 km (<1.80°). Larger errors were due to lack of sea-surface temperature gradients. In addition we show that our model is flexible enough to solve the obstacle avoidance problem by assimilating high resolution coastline data. This reduced the number of invalid on-land location by almost an order of magnitude. The method is intuitive, flexible and efficient, promising extensive utilization in future research.

HORIZONTAL MOVEMENTS



Total track length: 2852km
Straight line distance: 436km

Mk10

HORIZONTAL MOVEMENTS

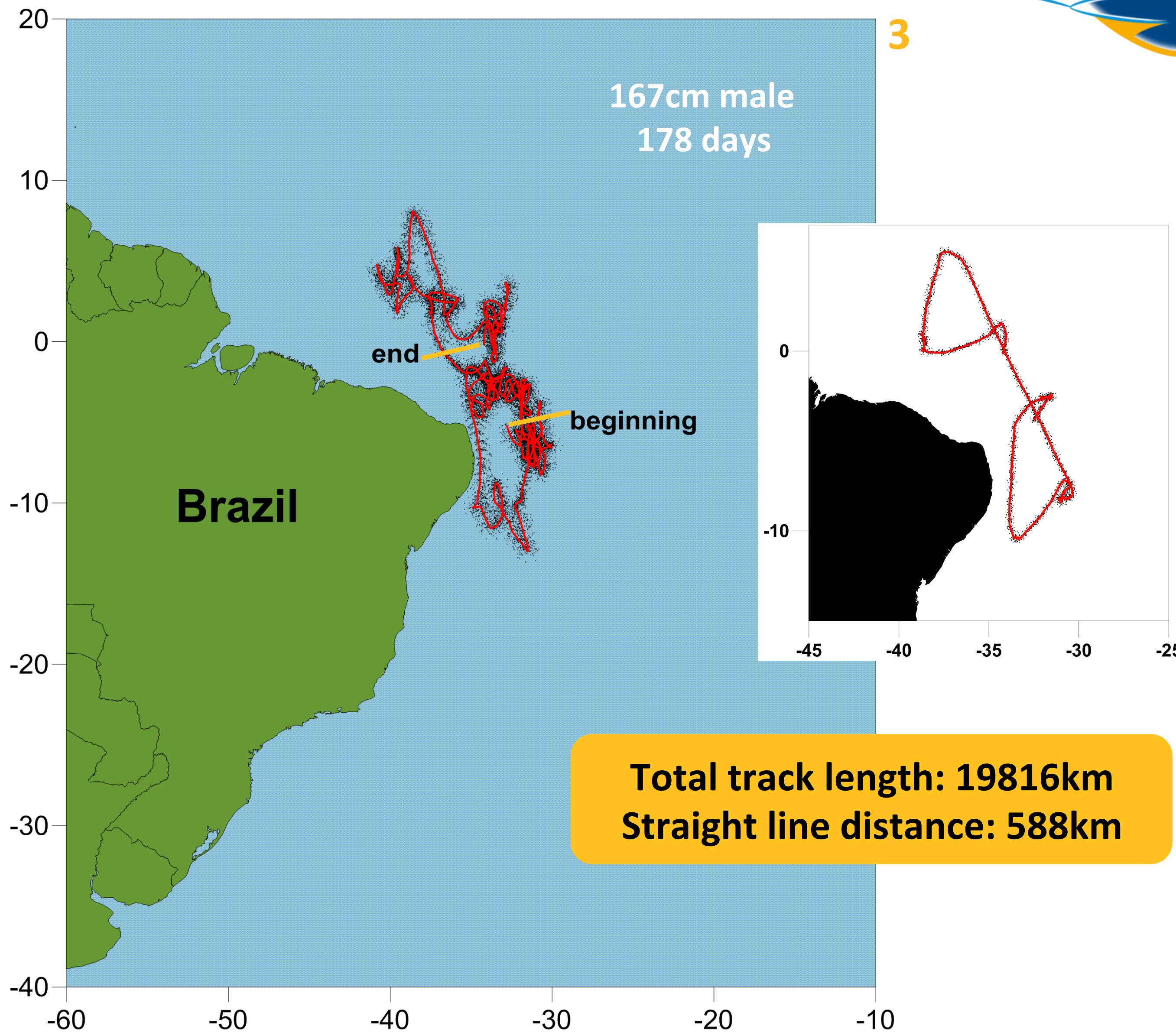
2

Total track length: 6490km
Straight line distance: 933km

Mk10

HORIZONTAL MOVEMENTS

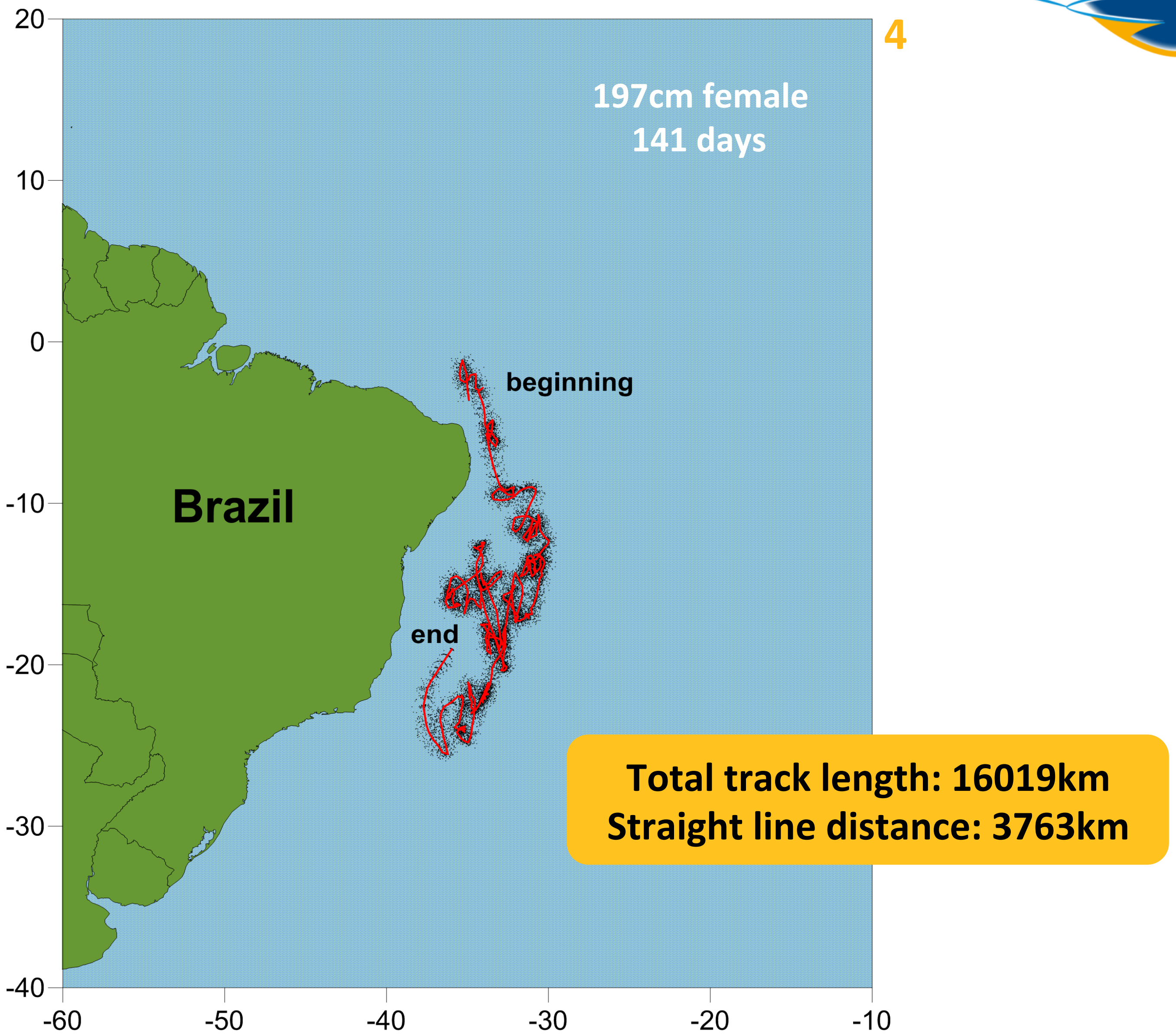
RECOVERED



Total track length: 19816km
Straight line distance: 588km

Mk10

HORIZONTAL MOVEMENTS



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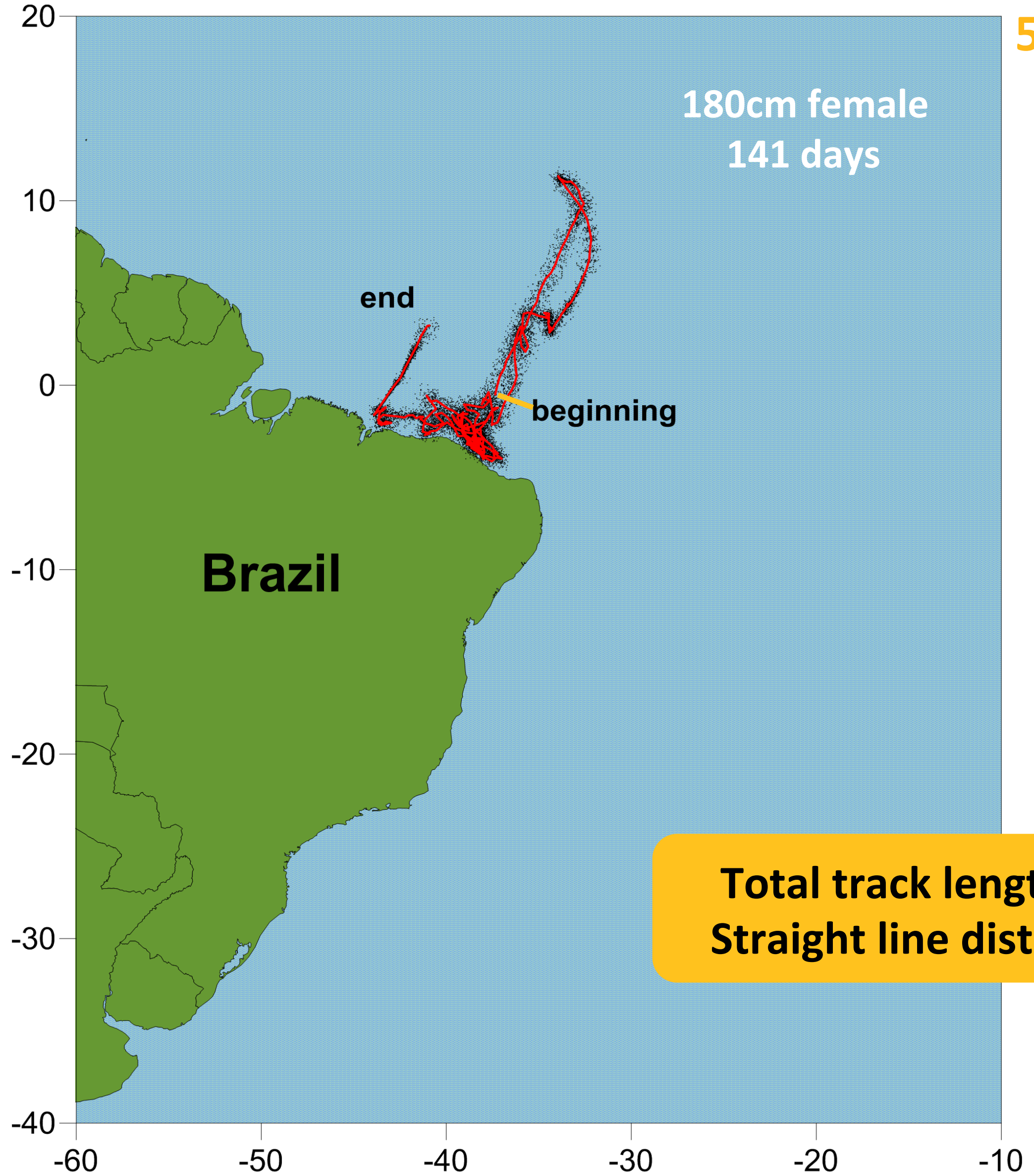
HORIZONTAL MOVEMENTS



5

Total track length: 11562km
Straight line distance: 580km

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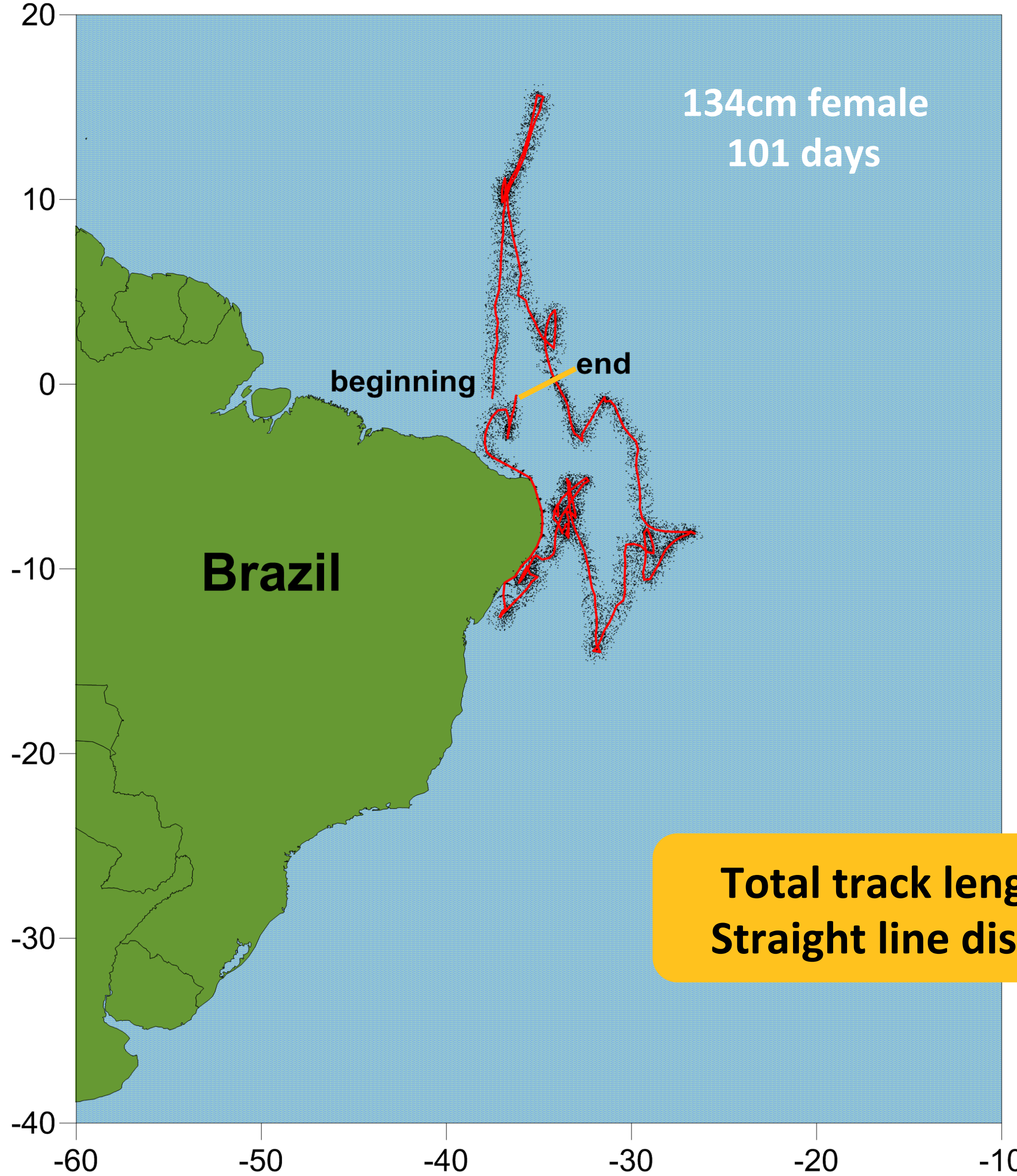
HORIZONTAL MOVEMENTS



Total track length: 14000km
Straight line distance: 145km

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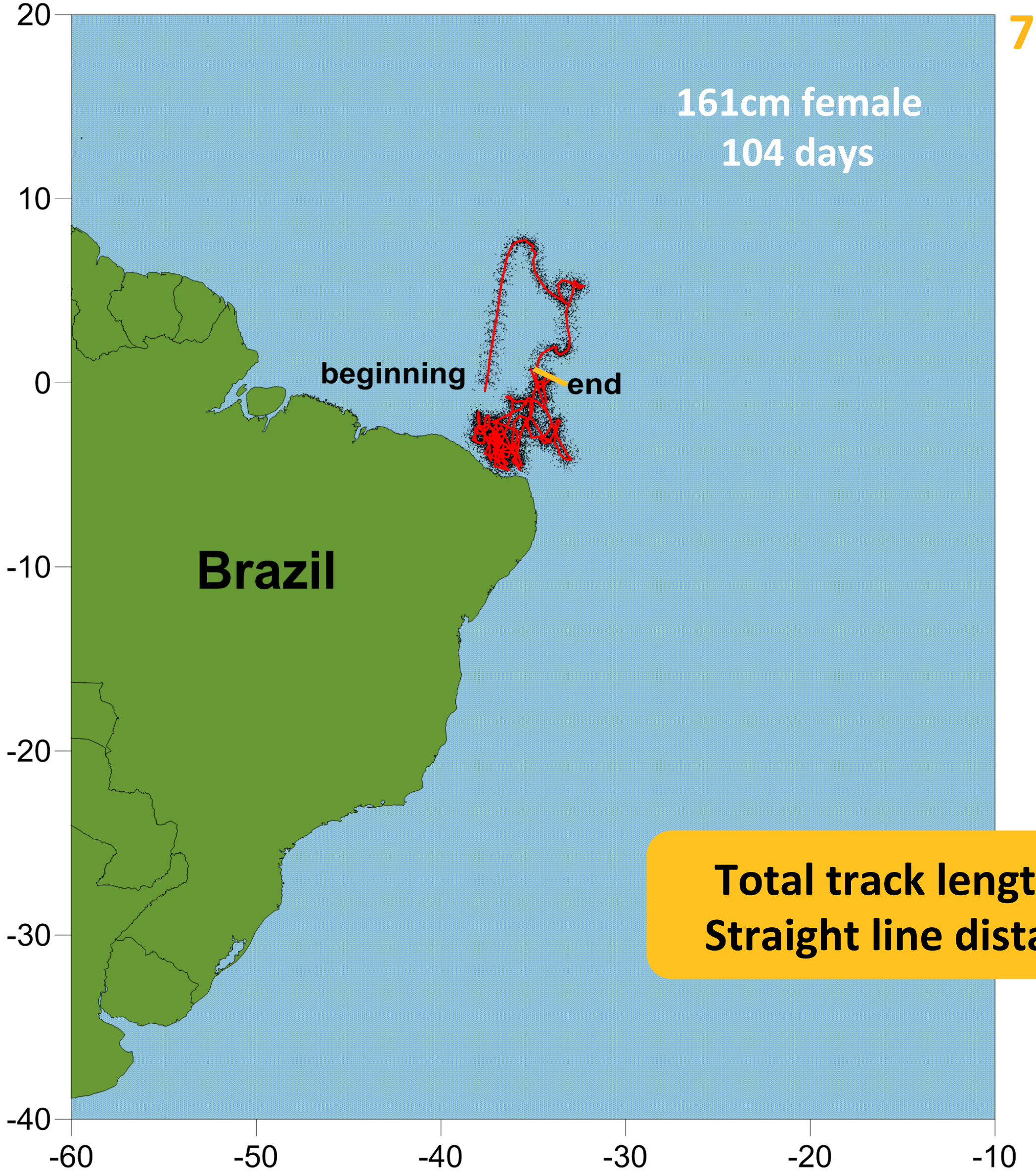
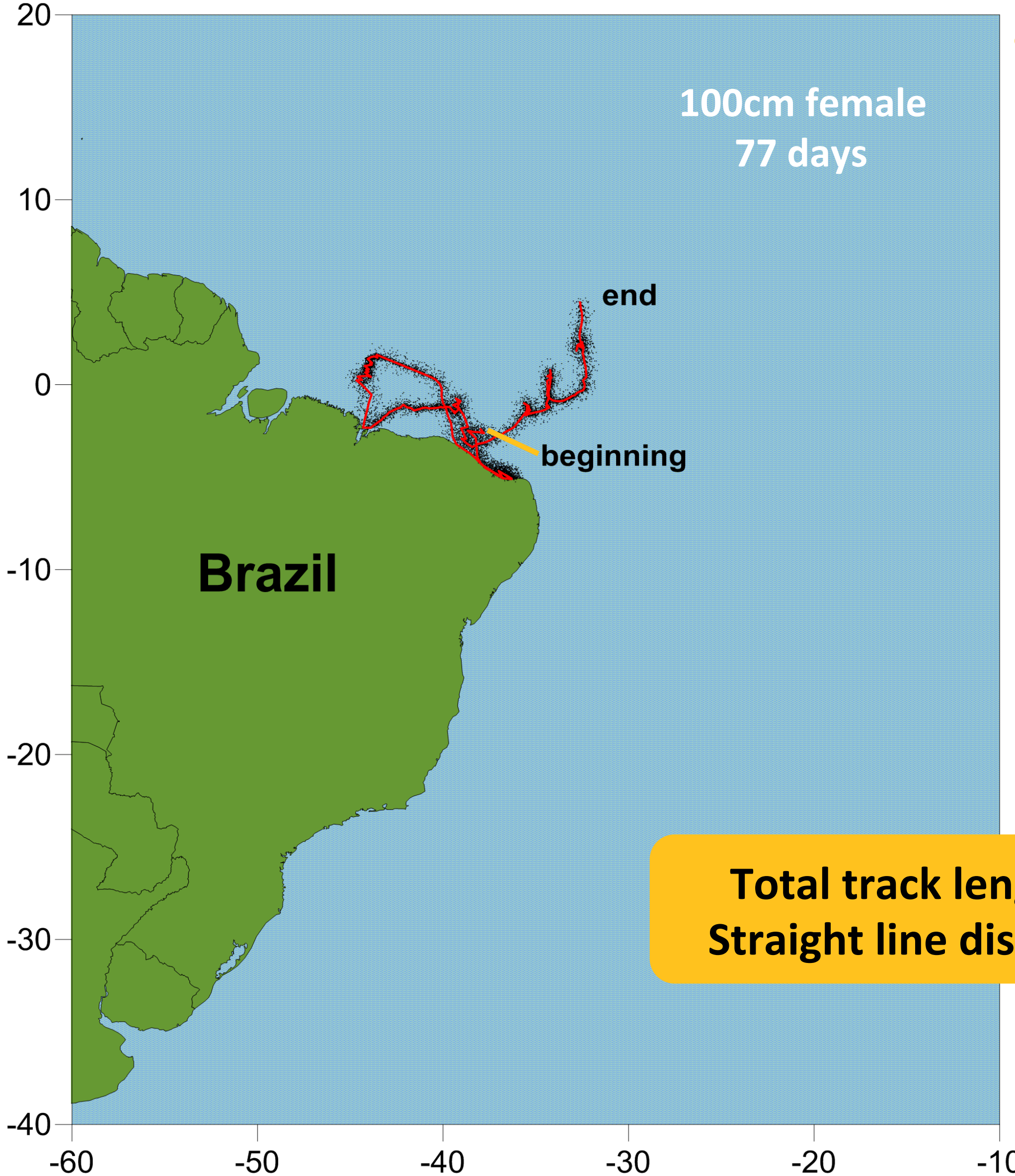
HORIZONTAL MOVEMENTS



Total track length: 12166km
Straight line distance: 307km

miniPAT

HORIZONTAL MOVEMENTS



Total track length: 6844km
Straight line distance: 968km

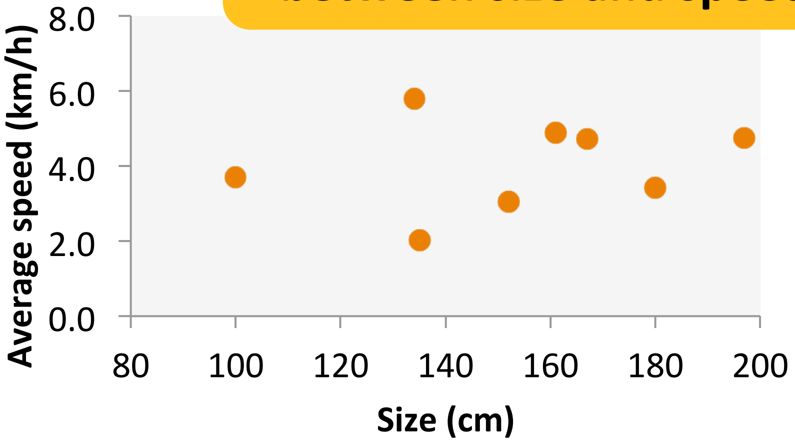
Mk10

HORIZONTAL MOVEMENTS

Average speeds from 2.0 to 5.8km/h

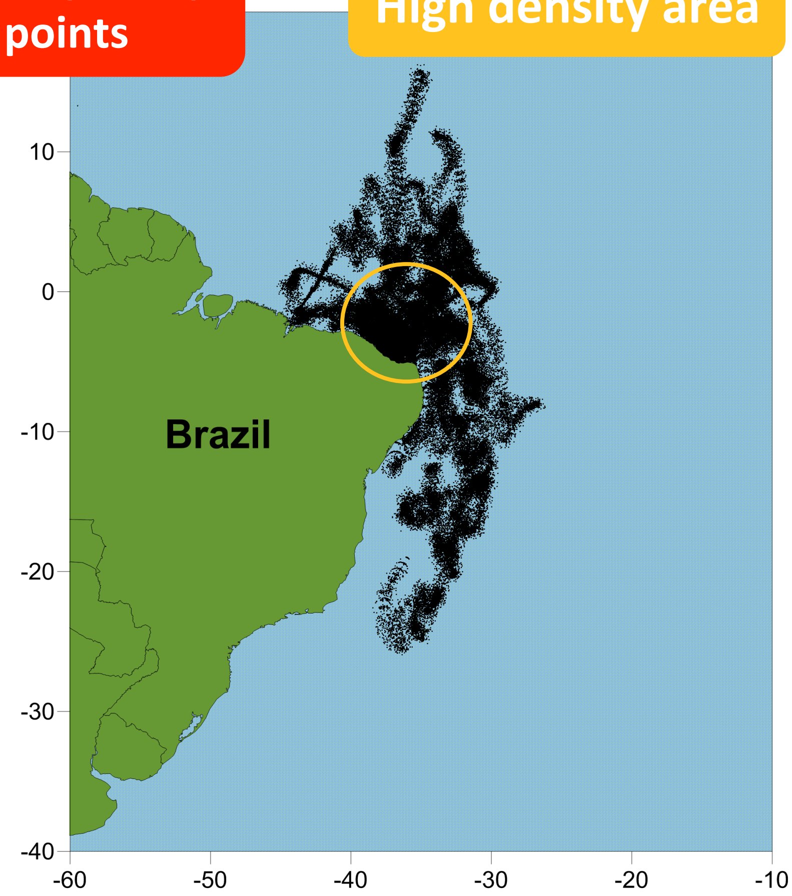
Maximum speeds from 5.7 to 9.6km/h

No apparent correlation between size and speed



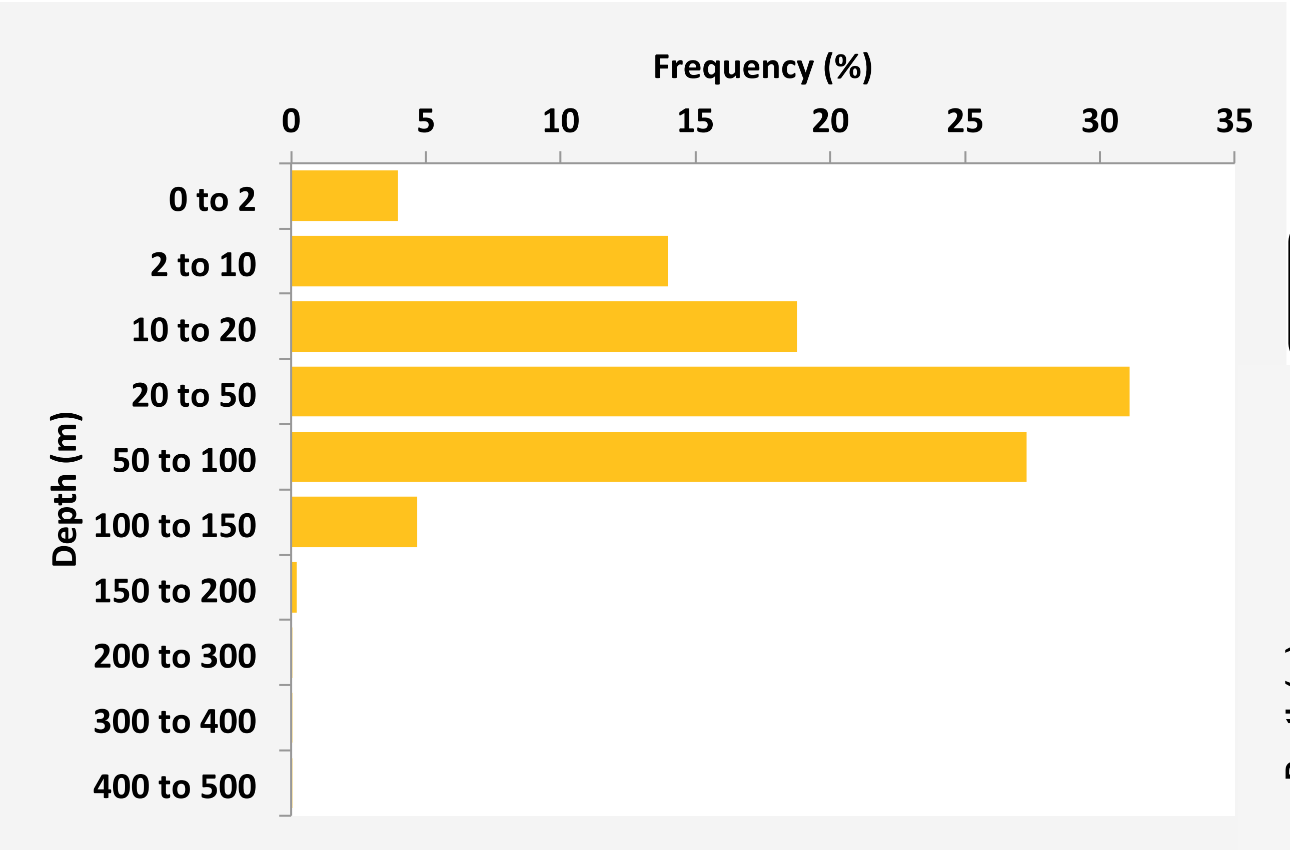
Proximity of beginning and end points

High density area

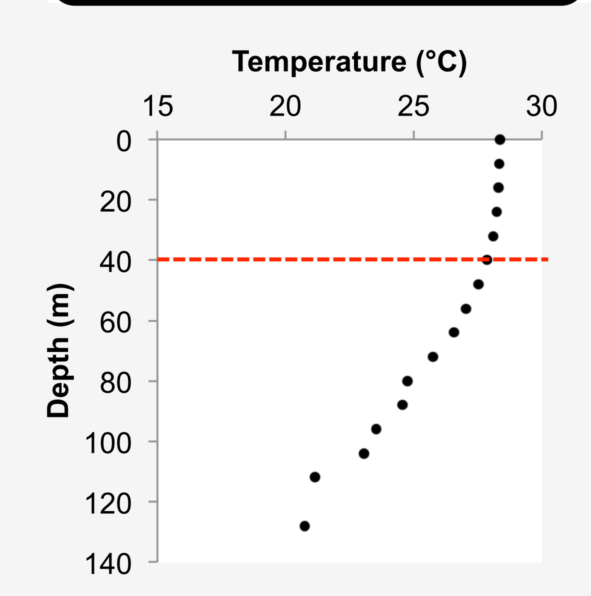


DEPTH DISTRIBUTION

Maximum depth: 405m



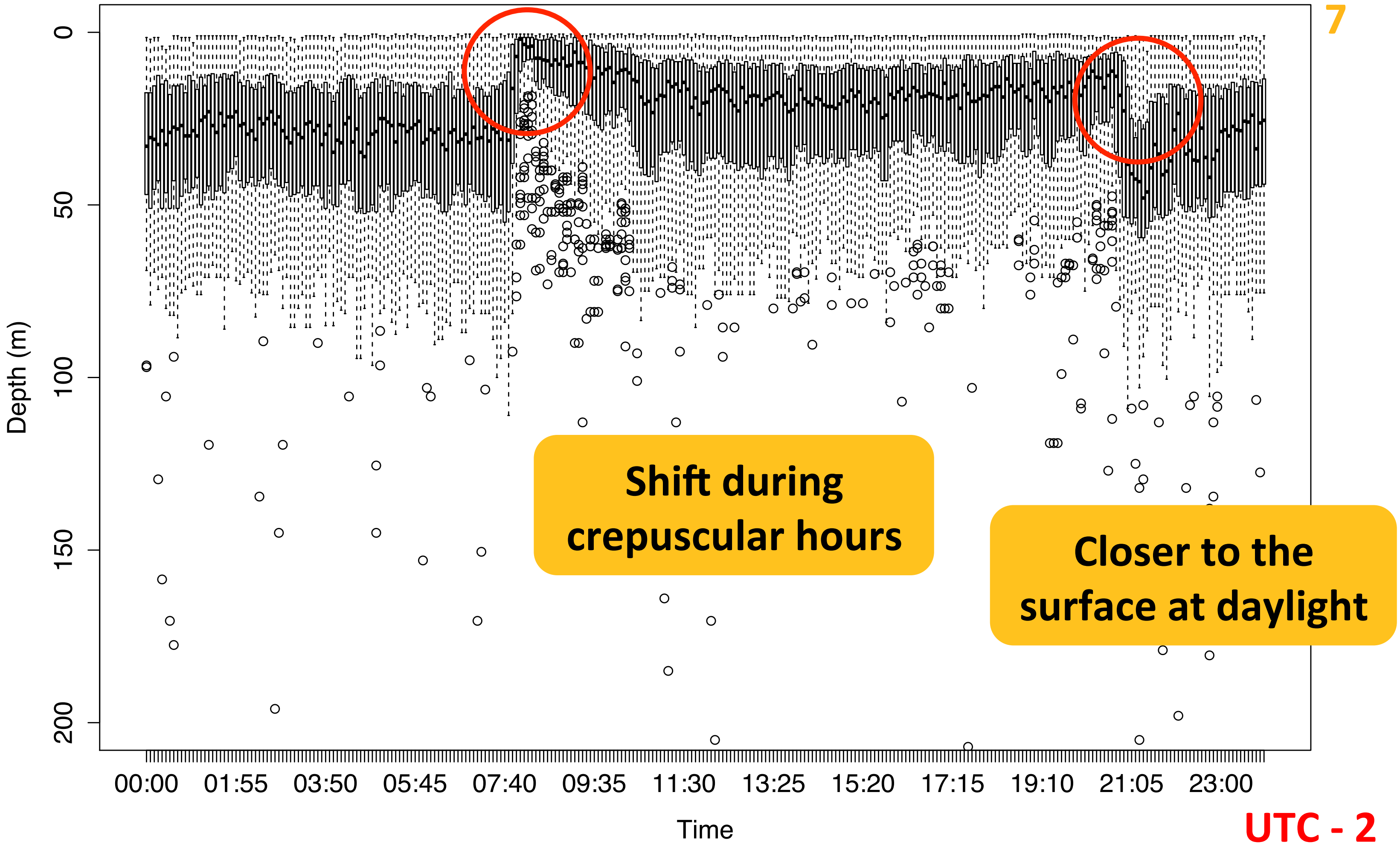
≈ 68% of the time above the thermocline



Marked preference for warm and shallow waters: 95% of the time above 100m

DEPTH DISTRIBUTION

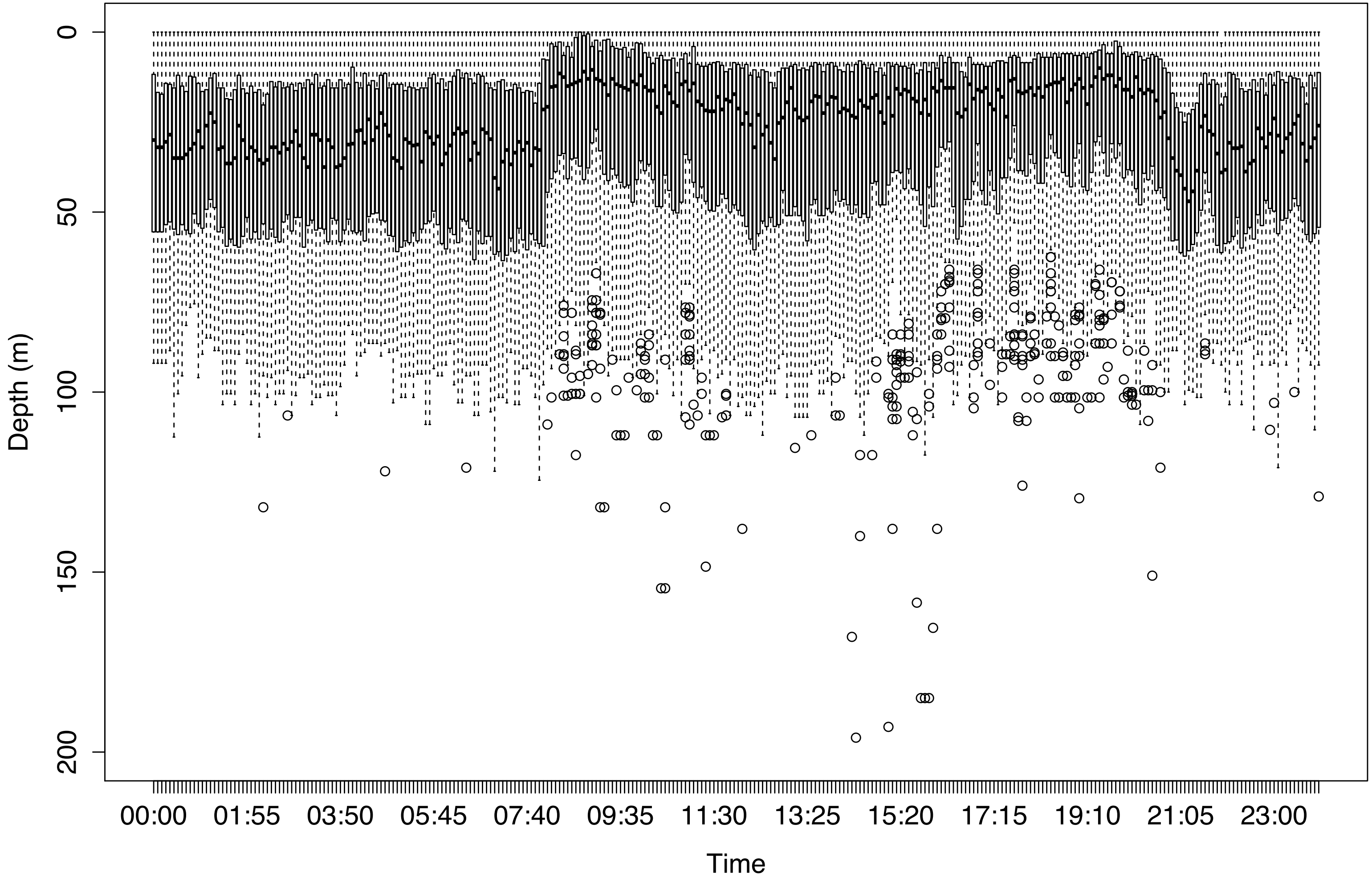
Diel movements



UTC - 2

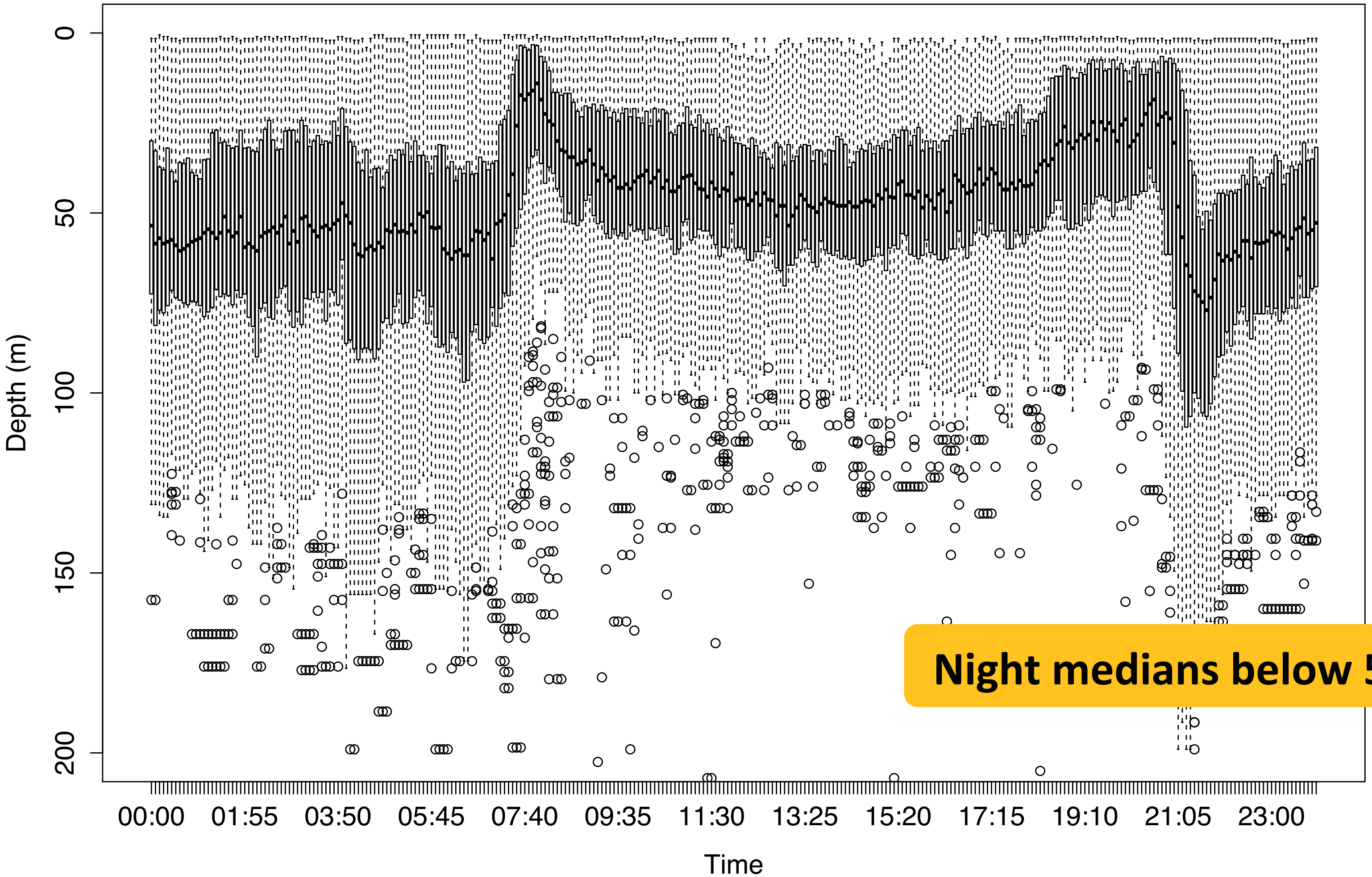
DEPTH DISTRIBUTION

⊙ Diel movements



DEPTH DISTRIBUTION

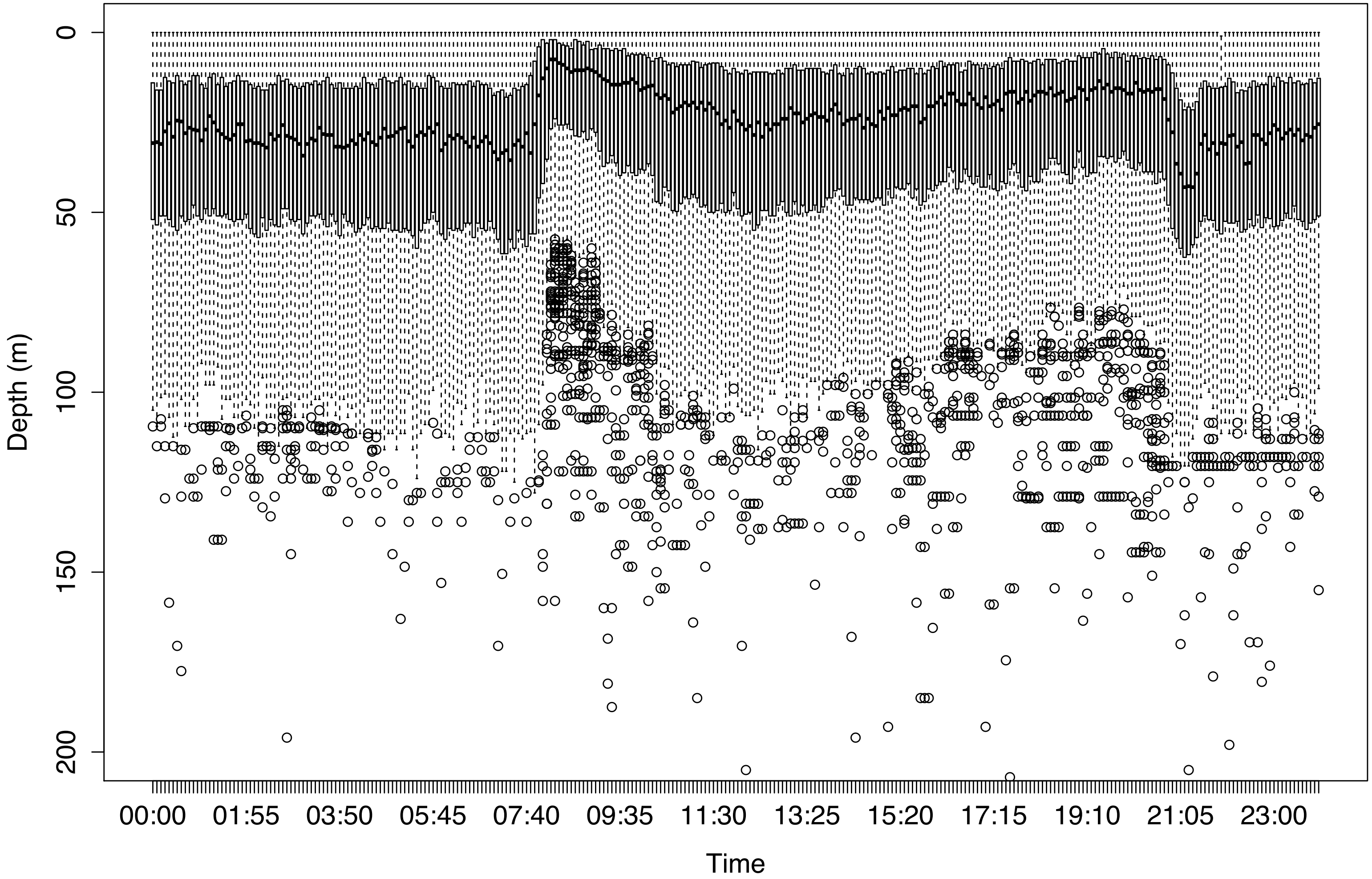
⦿ Diel movements



Night medians below 50m

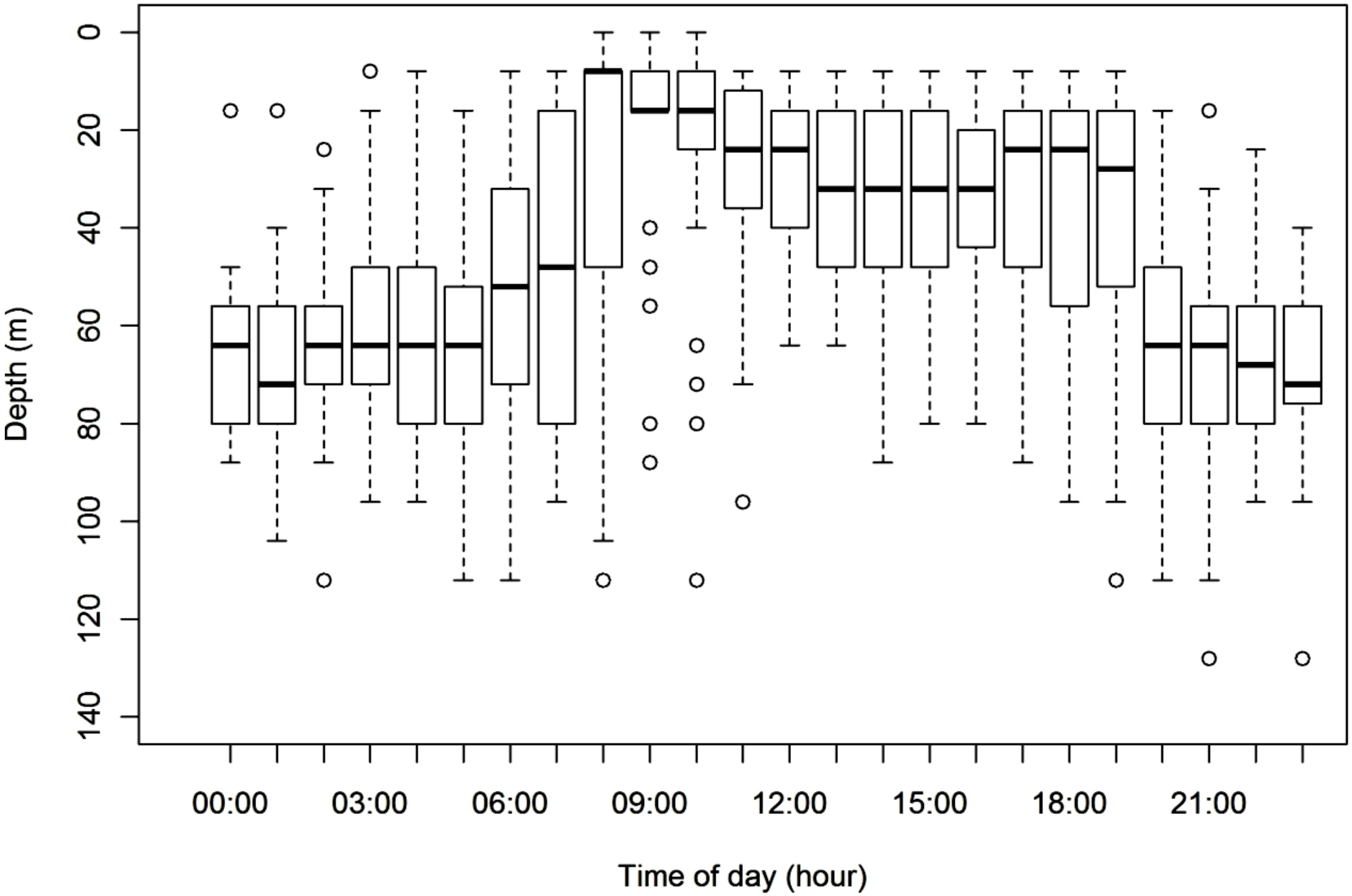
DEPTH DISTRIBUTION

Diel movements



DEPTH DISTRIBUTION

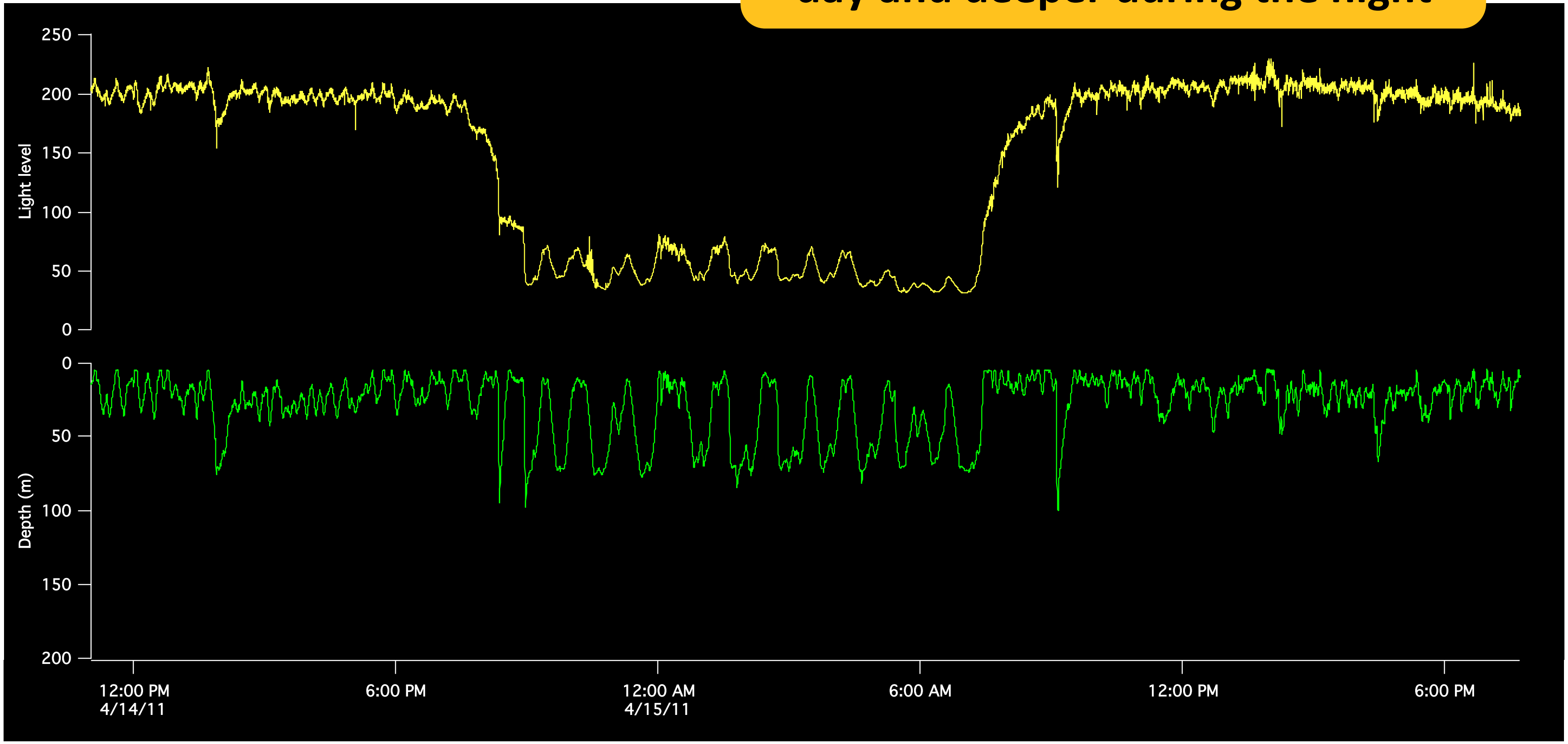
Similar pattern can be seen with the max depth data (Mk10 with no time series)



DEPTH DISTRIBUTION

Variability in diel behavior

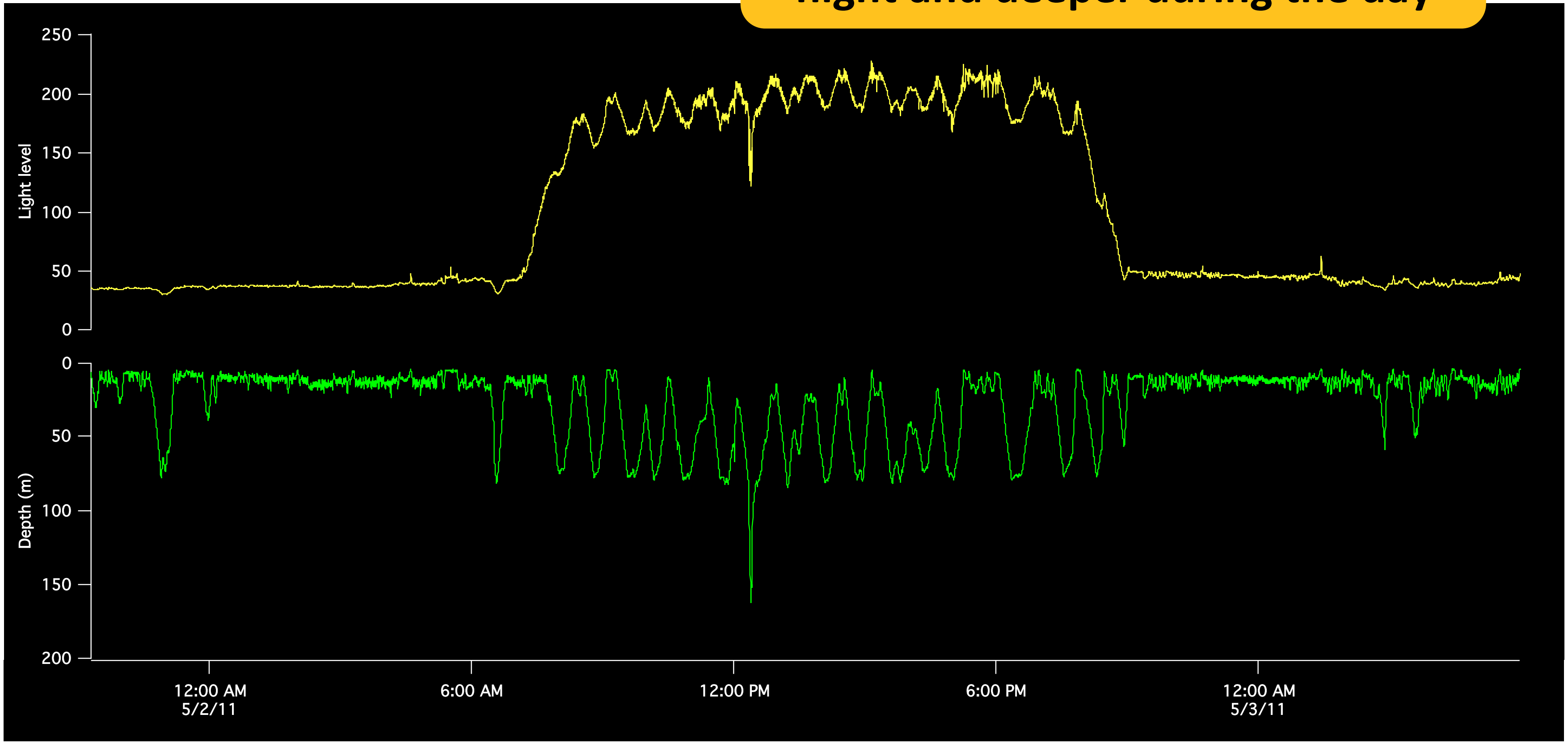
Closer to the surface during the day and deeper during the night



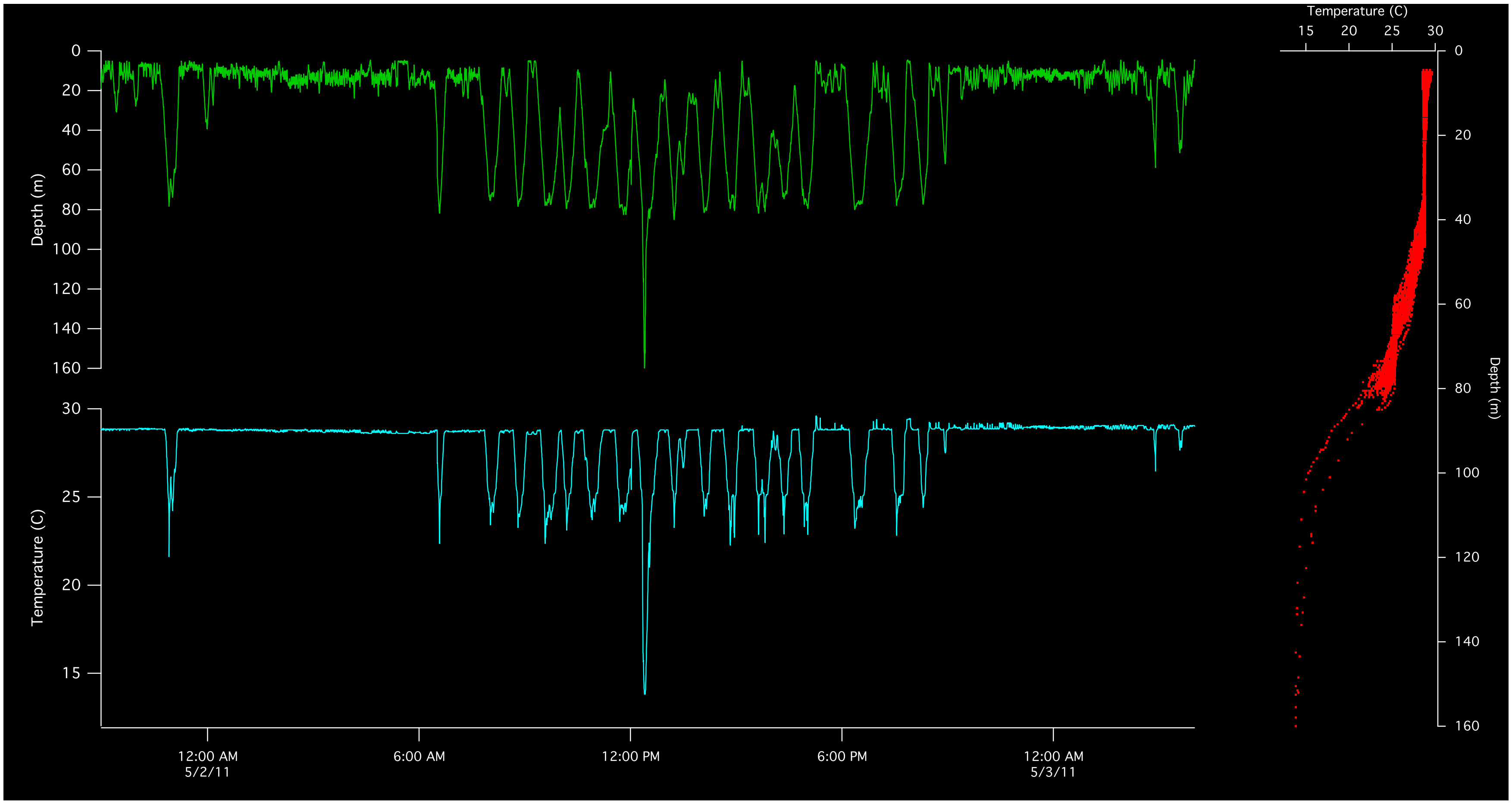
DEPTH DISTRIBUTION

Variability in diel behavior

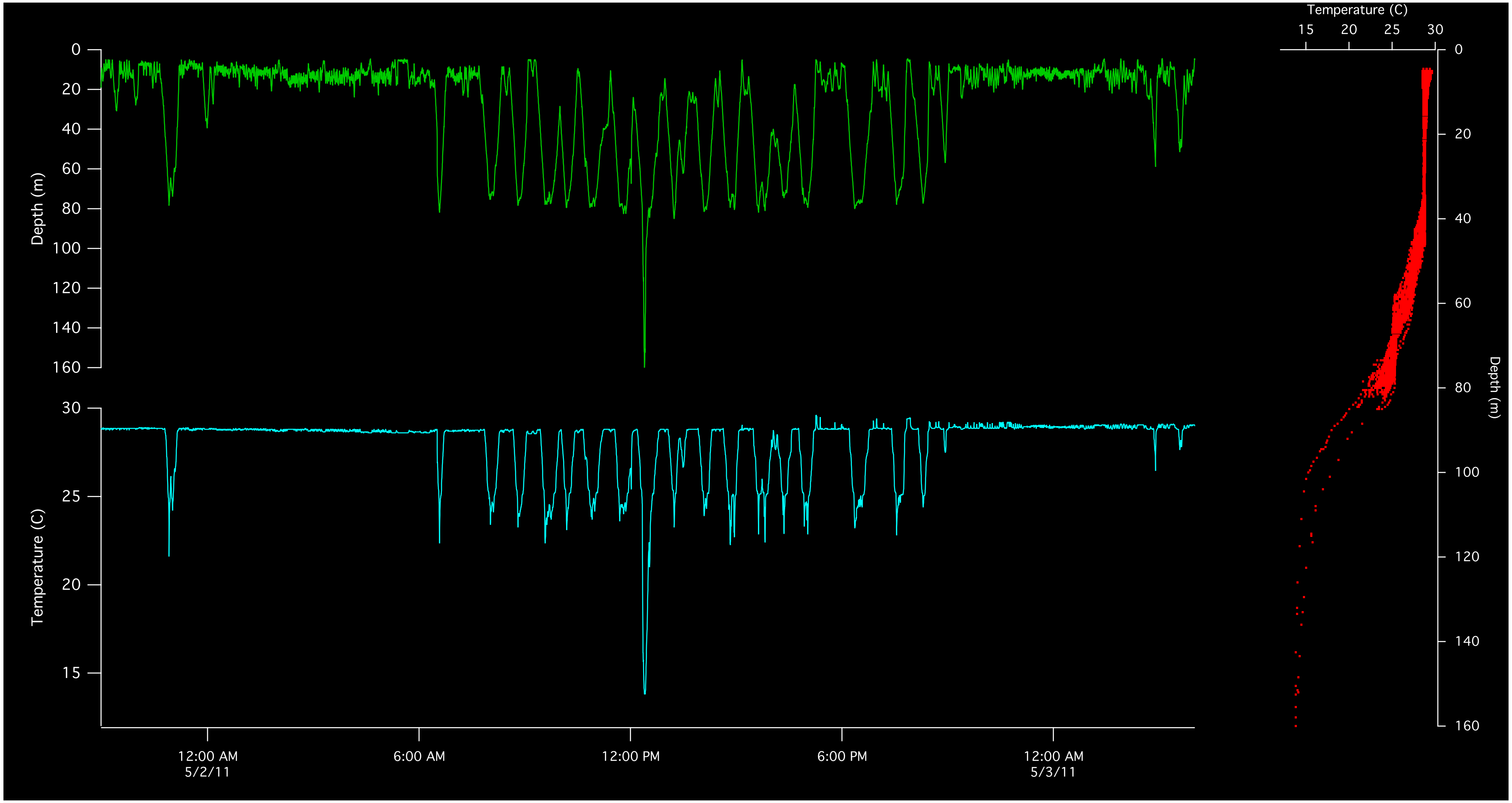
Closer to the surface during the night and deeper during the day



DEPTH DISTRIBUTION

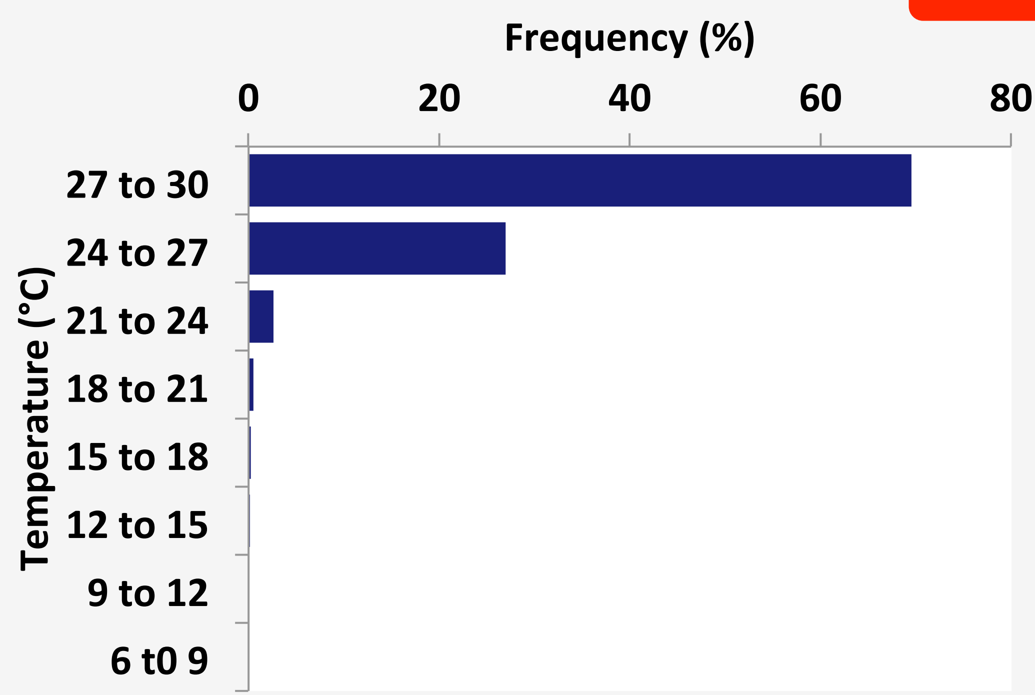


DEPTH DISTRIBUTION



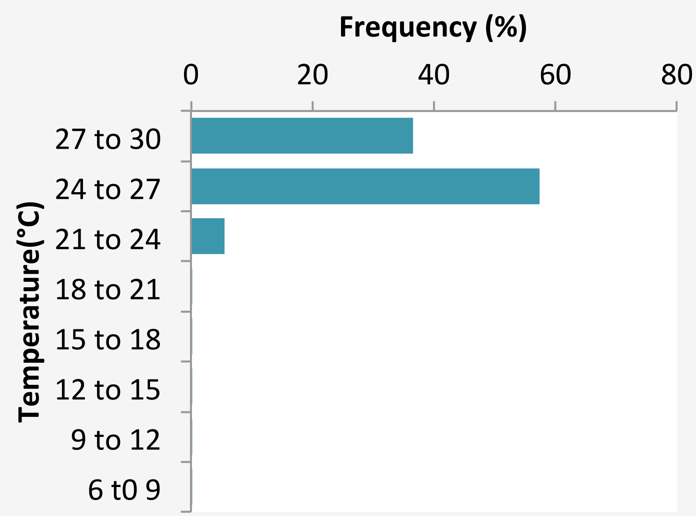
TEMPERATURE RANGE

Minimum temperature: 8.2°C



≈ 96% between 24 and 30°C

The only exception



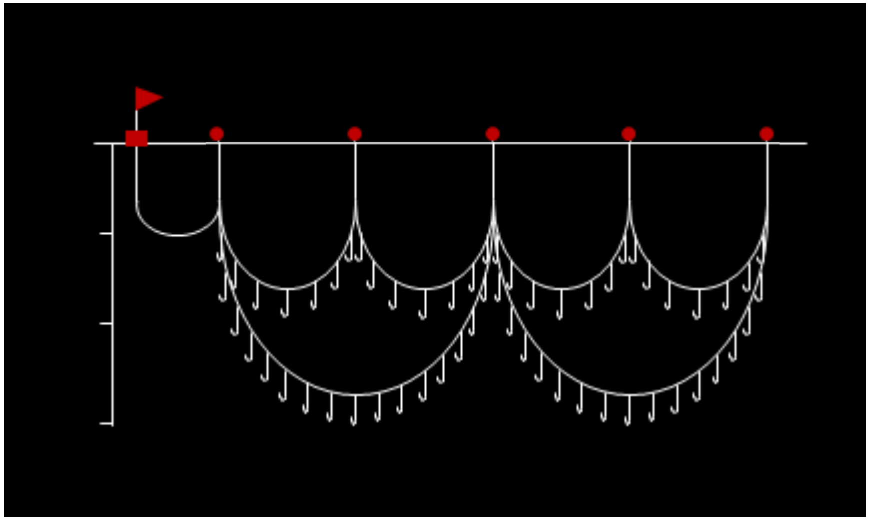
Marked preference for warm and shallow waters: 70% of the time in waters between 27 and 30°C

MITIGATION MEASURE?

- **Analysis of observers data from the Brazilian tuna longline fleet showed:**

CPUE ↑ **SPANISH TECHNOLOGY** **JAPANESE TECHNOLOGY** ↓

Deeper hooks to mitigate the bycatch of this species?



Obrigada!

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Special thanks to the observers!

Institut de recherche pour le développement