Methods for estimating fish tracks using AOTTP electronic tags.

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Light geolocation uncertainty increases due to:

Sun declination
- latitudinally > longitudinally
- when approaching to equinoxes.

Light at surface estimation
- Depth (during dusk and dawn)
- Water transparence ↓ ↓
High uncertainty in light-geolocations:

Technical limitations
- Depends on tag type and manufacturer;
  - Lotek > Wildlife Computers (Schaefer et al. 2006)

Major source is external to the tags.
- Environmental conditions: cloud cover, wind strength, sea state…
  - find analyzing moored tags (Welch et al. 1999; Musyl et al. 2001)

Alive animals:
- Two equal tags on a single individual → different results (Wilson et al. 2007).

Light estimation at surface:
- Deep diving → wrong light at surface curve → computed as a twilight → outlier
  - Is the case of BET (Lam et al. 2014)
- Upwelling areas → light attenuation ↑↑ → surface estimates limited in deep.
Uncertainty in light-geolocations

Example # 1

BET \rightarrow \text{deep distribution}

Upwelling \rightarrow \text{low transparence}

↓

High uncertainty

↓

Keep out outlier

(no recovery position)
Track estimation overcoming light-geolocations uncertainty relies on:

- The model and fitting parameters.
  - Sun declination error
  - Fish movement dynamic maximum speed diffusion coefficient + advection
- Fit data from the fish with external fields; Environmental variable’s with gradients
  - SST = sea surface temperature
  - PDT = Profiles of depth and temperature
### Most probable track estimation methods

<table>
<thead>
<tr>
<th>Tag type / manufacturer</th>
<th>Track estimation method</th>
<th>Number of tracks</th>
<th>Environmental fields</th>
<th>remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>miniPAT WC</td>
<td>Global Position Estimator 3 GPE3</td>
<td>83</td>
<td>SST</td>
<td>Black box usual recently</td>
</tr>
<tr>
<td>LAT-810 Lotek</td>
<td>(Braun et al., 2018) HMMoc</td>
<td>18</td>
<td>SST PDT</td>
<td>Open source, manipulable Review fitting process</td>
</tr>
</tbody>
</table>

Fish movement dynamic = maximum fish speed (user-defined)
Constrain = Bathymetry

The results are equivalent.
Both methods and are based in the same previous methods (Patterson et al. 2009; Pedersen et al. 2011; Michelot et al. 2016)
Fish track estimation

Geolocation errors will expand its uncertainty to the entire track, leading worse estimates with higher variance (Nielsen 2004).

*Overcome uncertainty estimating most probable track.*

SST fields small gradients $\rightarrow$ accuracy ↓ (Lam et al. 2010)
  - equatorial area
  - Western African upwelling.

Recovery position is not available (internal archival). $\rightarrow$ accuracy ↓
Overcoming uncertainty, track estimation.

Example # 2 YFT

SST

Equatorial area ↓
homogeneous fields ↓
Broad daily likelihood ↓
Uncertain track

PDT

constrained daily likelihood ↓
precise track
Fish track estimation

Overcoming uncertainty, track estimation.

Example #3 YFT

SST

2 cyclic migrations in a year
Complex behavior
Inconsistent result
Change default fitting params
Consistent result

PDT
Consistent &
More precise

ICCAT / AOTTP / CISEF CONSORCIUM
**Recommendations.**

Reviewing each step involved in track estimation process:

- Rejection of non-informative light-geolocations.
- Compare result’s uncertainty using PDT SST fields.
- Compare track with raw geolocations for consistency
- Try with different model fitting parameters to obtain robust results.

PDT (modeled) might not be realistic or too constraining $\rightarrow$ incongruent fitting probability $\uparrow$