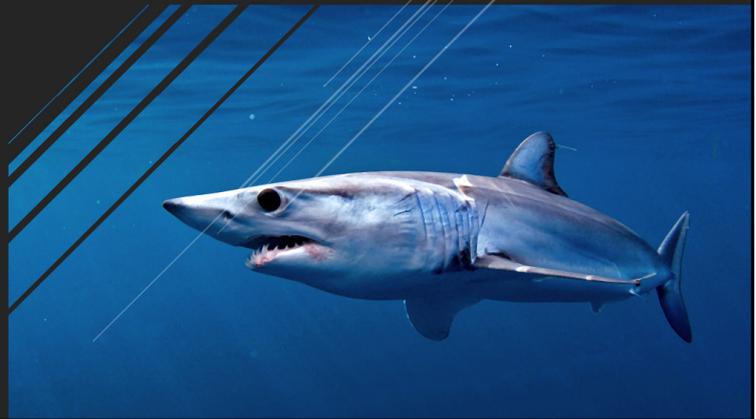


Application of biologging tools

Form and function of tags for fish



1

Application of biologging tools

Part 1: *Available tags*

Part 2: *Data retrieval*

Part 3: *Geolocation problems*

A collage of images related to biologging. It includes a map of North America with a color-coded overlay, a chart showing 'Chlorophyll a concentration (mg/L)' with a scale from 0.01 to 10, and a photo of a shark. The text 'tag', 'loggers', 'data recovery', and 'associated' is visible in the collage.

2

Available tags

Archival loggers

Pop-off archival tags

ARGOS-linked satellite tags

Fastloc™ GPS tags

Accelerometers



3

Available tags

Archival loggers

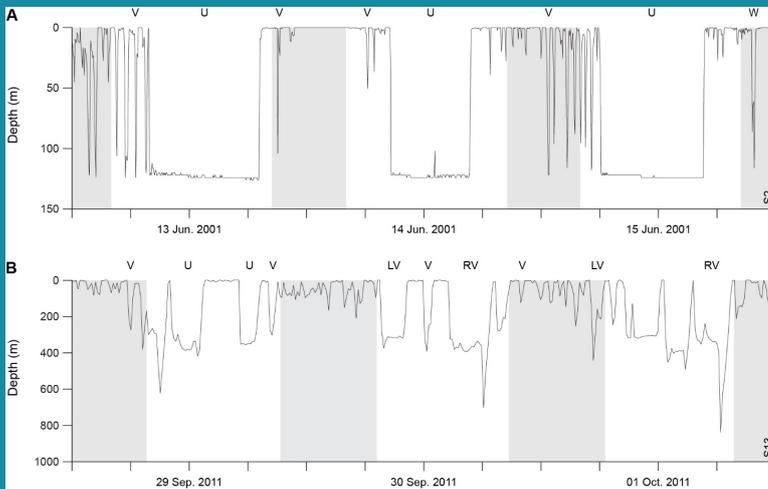
1. Typically record data at high resolution (e.g. 1s):
 - Depth;
 - External temperature;
 - Light-level (allows for track reconstruction);
2. Implantable in the fish.
3. Can be programmable which allows better storage management.
4. Need to be *recovered*.



4

Available tags

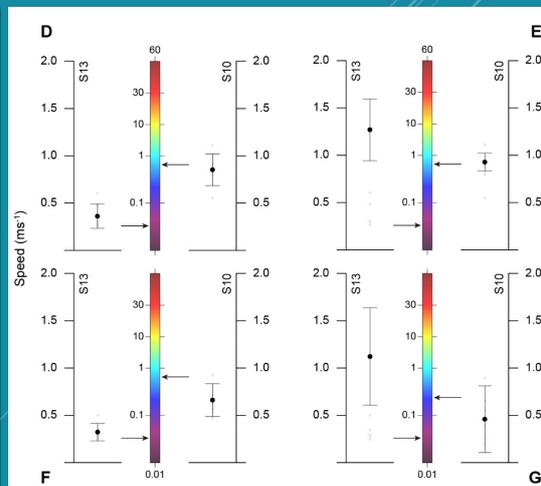
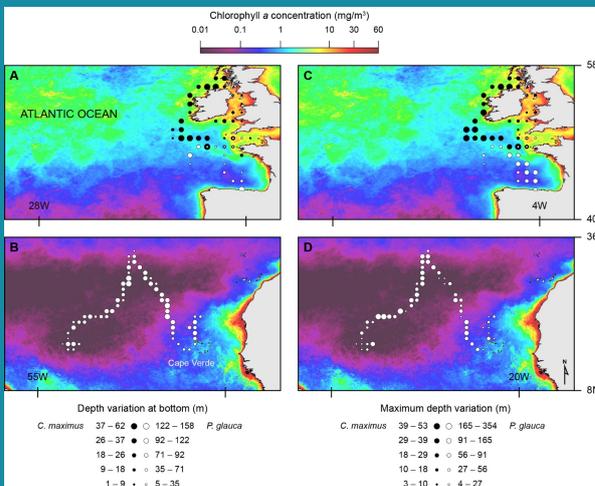
Archival loggers



5

Available tags

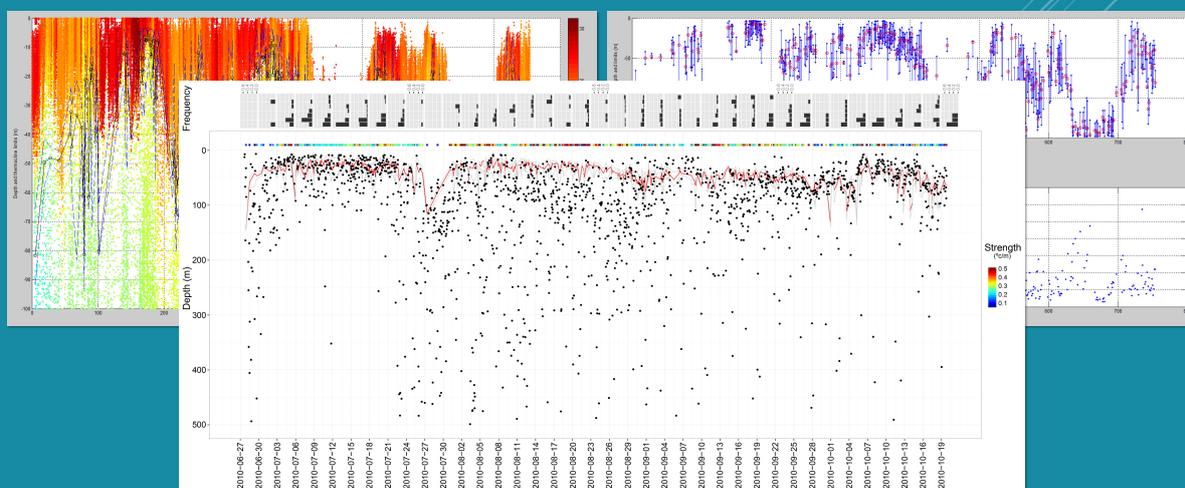
Archival loggers



6

Available tags

Archival loggers



7

Available tags

Pop-off archival tags

- Typically record data at high resolution (e.g. 1s):
 - Depth;
 - External temperature;
 - Light-level (allows for track reconstruction);
- Externally attached to the fish.
- Can be programmable which allows better storage/transmission management.
- At pre-programmed time (e.g. 120 days) the tag **releases** and transmits **summarised** data via the **ARGOS** system.



8

Available tags

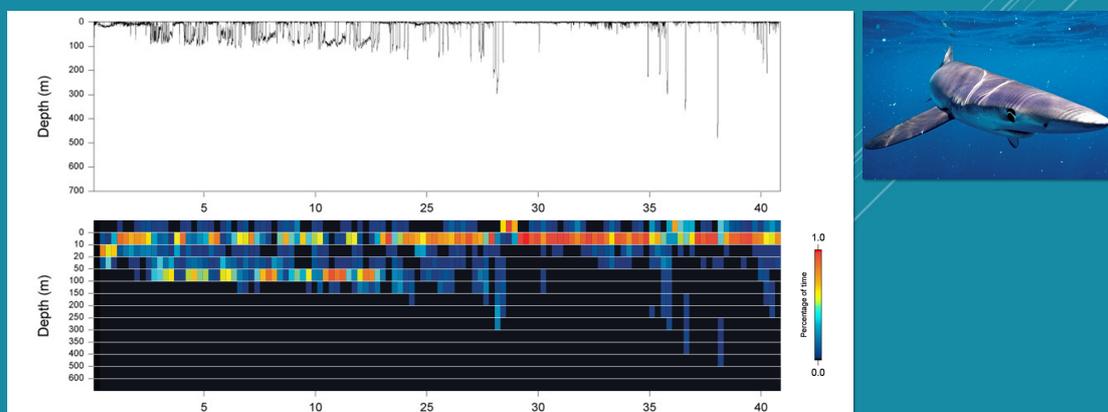
Pop-off archival tags



9

Available tags

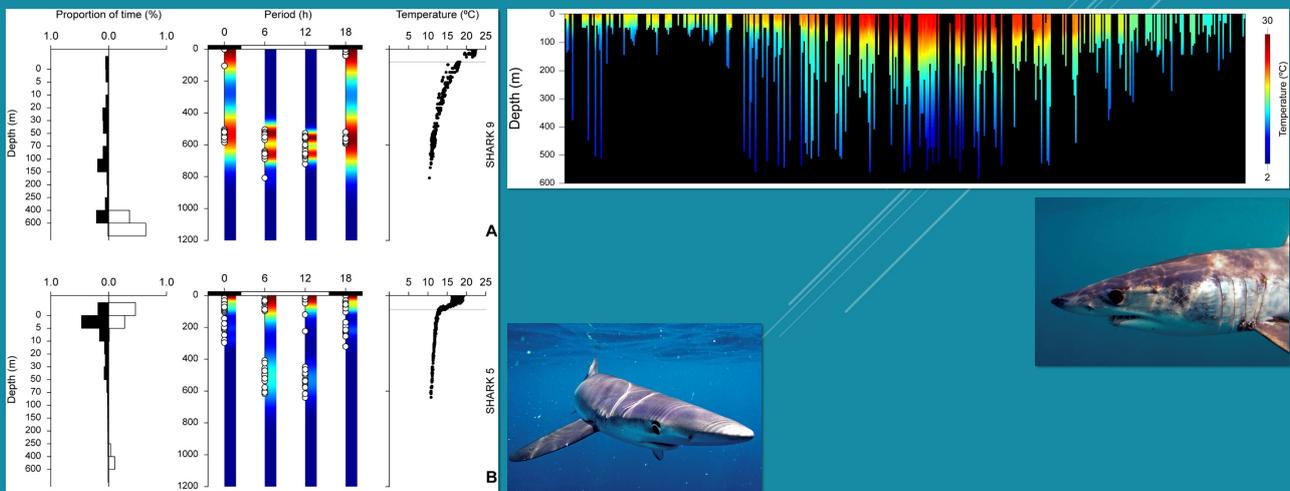
Pop-off archival tags



10

Available tags

Pop-off archival tags



11

Available tags

ARGOS-linked satellite tags

1. Externally attached to fish that surface frequently (e.g. sharks).
2. Can record temperature; some models can also record depth.
3. Can be programmable (e.g. number of daily transmissions; transmission days) which allows better battery/deployment duration.
4. Typically used to get *positional* data.



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Available tags

ARGOS-linked satellite tags

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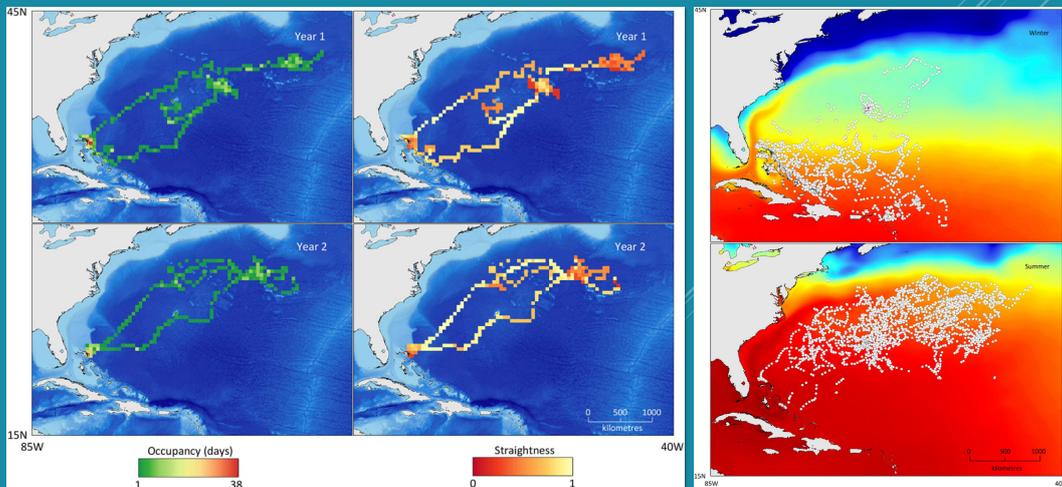
Available tags

ARGOS-linked satellite tags

14

Available tags

ARGOS-linked satellite tags



15

Available tags

Fastloc™ GPS tags

1. Externally attached to fish that surface frequently (e.g. sunfish; whale sharks).
2. Can be programmable (e.g. number of daily transmissions; transmission days) which allows better battery/deployment duration.
3. Used to get high-resolution *positional* data.
4. Some models also record depth and external temperature.
5. Archived GPS data is transmitted via the **ARGOS** system.



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Available tags

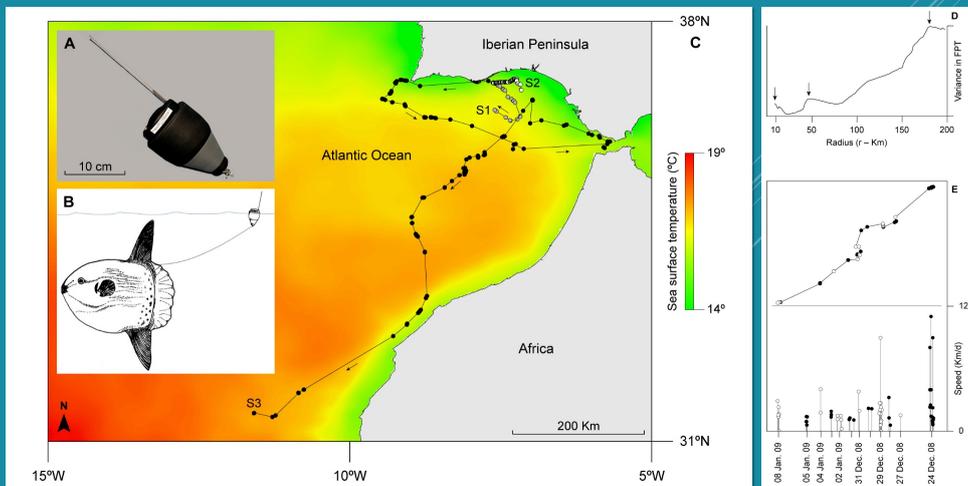
Fastloc™ GPS tags



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Available tags

Fastloc™ GPS tags

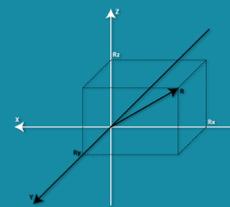


18

Available tags

Accelerometers

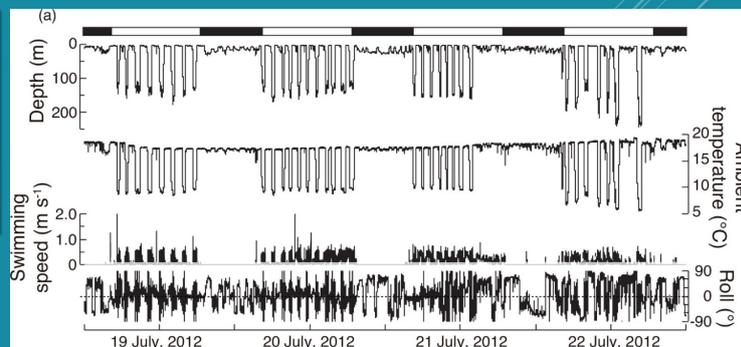
1. Acceleration data loggers (ADLs) record acceleration data at **high resolution** (e.g. > 30 Hz); can also record:
 - Depth;
 - Temperature.
2. Externally attached to the fish.
3. Can be programmable (e.g. lower Hz).
4. Coupled with GPS/gyroscopes/compass can be used to estimate the **fish track** (dead-reckoning). 
5. Typically used in fine-scale behavioural studies.
6. Need to be **recovered**.



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Available tags

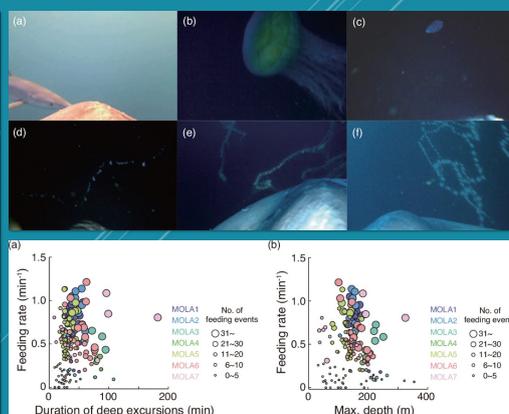
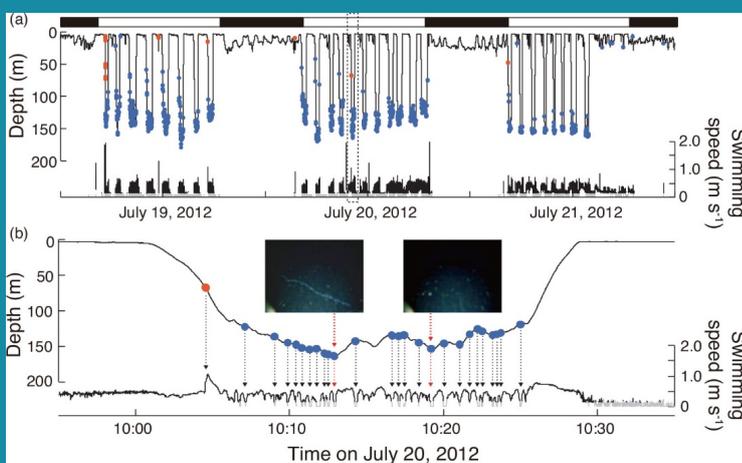
Accelerometers



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Available tags

Accelerometers



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Data retrieval

- Manual data recovery
- ARGOS satellite transmission
- GSM



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Data retrieval

Manual data recovery

1. Deploy loggers on **commercially important** species.
2. Use **floating** deployment packages with satellite/VHF transmission.



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Data retrieval

ARGOS satellite transmission

1. **Global** coverage.
2. Doppler location capability.
3. Miniaturization and low power consumption.
4. More recently the system allows for a two-way communication.
5. Low **data throughput**.

ARGOS



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Data retrieval

Global System for Mobile communication

1. Data can be relayed via GSM mobile phone module when animal/tag is within GSM coverage; limited application to fish due to low coverage (~10 km).
2. Very **high data bandwidth** and is over one hundred times more energy efficient than ARGOS.
3. Miniaturization and low power consumption.



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Geolocation problems

- Light-level errors
- ARGOS location errors
- Fastloc™ GPS
- Problems associated with tag geolocation

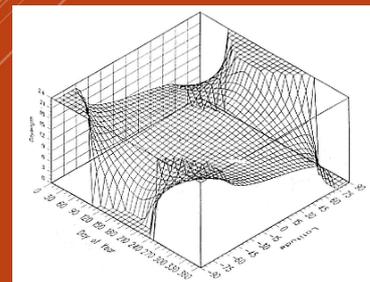
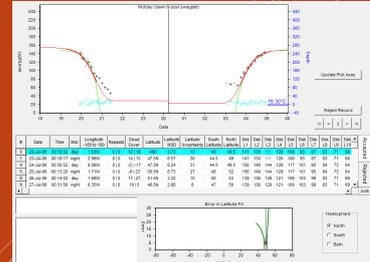


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Geolocation problems

Light-level errors

1. Measured ambient light level (solar irradiance) is used to establish geographical location using astronomical algorithms.
2. Tags incorporate an *accurate clock*.
3. Longitude is calculated by first establishing the time of *local noon or local midnight*; this is the time midway between sunrise and sunset.
4. Latitude is calculated by establishing the *day (or night) length*; this is the length of time between sunrise and sunset (or sunset and sunrise).
5. To be useful, the elevation (zenith) of the sun at sunrise and sunset is required; a *relationship* between the light level recorded and solar elevation is needed.

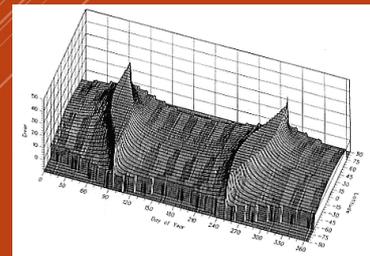
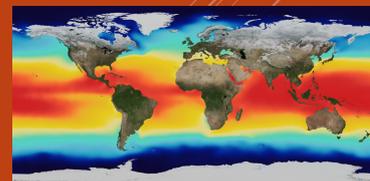


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Geolocation problems

Light-level errors

6. Light attenuation can have many causes (e.g. dives, clouds).
7. Because *sea surface temperature* (SST) has a latitudinal gradient, to increase accuracy in latitude estimation, SST data recorded by the tag is used.
8. *Two* position fixes can be obtained daily.
9. No locations at the equinoxes or the equator.
10. Typical *large spatial error* ~100 km (depends on the species).

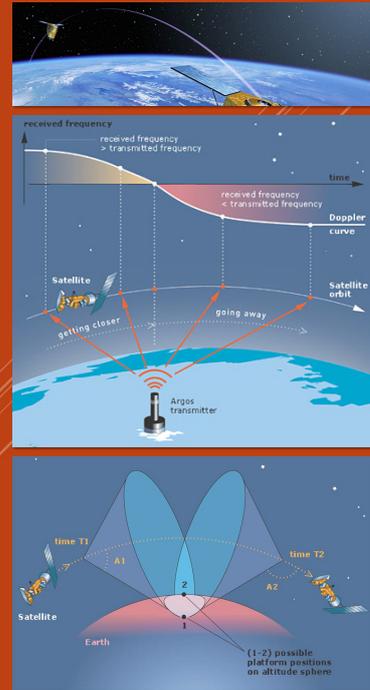


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Geolocation problems

ARGOS location errors

1. Moving satellite allows for locating *in-situ* platform using *Doppler* shift calculations.
2. When the satellite approaches a transmitter; frequency of the transmitted signal is *higher* than the actual transmitted frequency, and *lower* when it moves away.
3. Major feature of the Doppler location is the existence of *2 possible* positions of the platform that give exactly the same frequency measurements on board the satellite.



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Geolocation problems

ARGOS location errors

4. To assign a class of location accuracy *4 messages* from a tag must be received during a pass.
5. *Kalman* filters are now used to calculate positions; positions can be calculated based on *1 message* per satellite pass.
6. **Location class** errors:
 - LC3: < 150m
 - LC2: 150 – 350 m
 - LC1: 350 – 1000 m
 - LC0: > 1000 m
 - LCA: no estimate of location; estimated to be ~15 km
 - LCB: no estimate of location; *estimated* to be ~20 km
 - LCZ: invalid location



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Geolocation problems

Fastloc™ GPS

1. GPS system uses between 24 and 32 medium Earth orbit satellites that transmit precise microwave signals.
2. Any GPS receiver contains a computer that 'triangulates' its own position by getting bearings from at least **3** satellites.
3. Fastloc™ was developed by Wildtrack Telemetry Systems and is ideal for species that only surface *briefly*.
4. Fastloc-GPS tags take a quick (i.e. fraction of a second) *snapshot* of the radio signals produced by overhead GPS satellites; signals are processed onboard the tag and compressed into a snapshot containing just the satellite ID numbers, pseudo ranges and a timestamp.



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Geolocation problems

Fastloc™ GPS

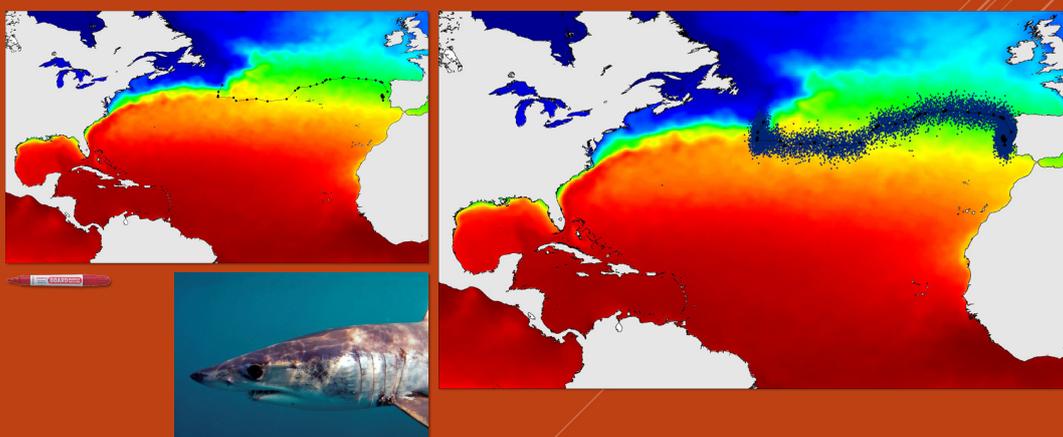
5. The processing and compression takes just 12 seconds and continues after the animal has dived.
6. Up to 10 GPS satellites can be processed to provide location *accuracies* from 20 – 75 m.



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Geolocation problems

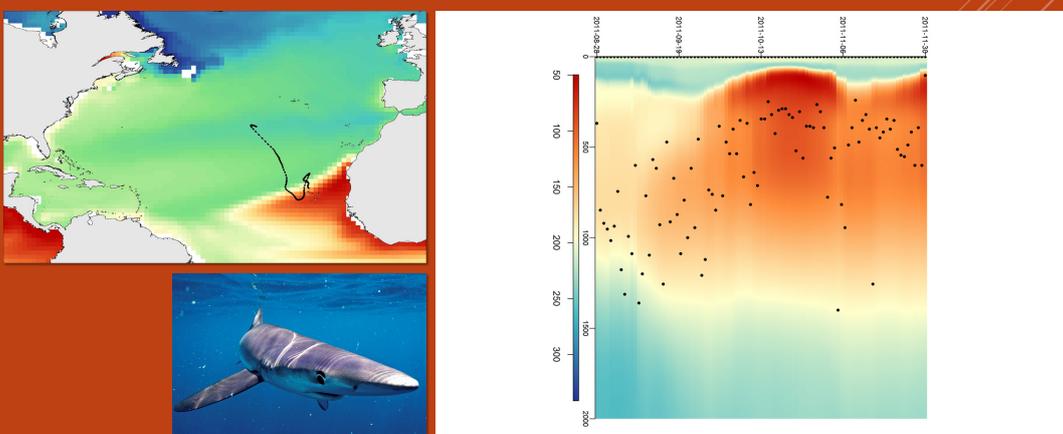
Problems associated with tag geolocation



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Geolocation problems

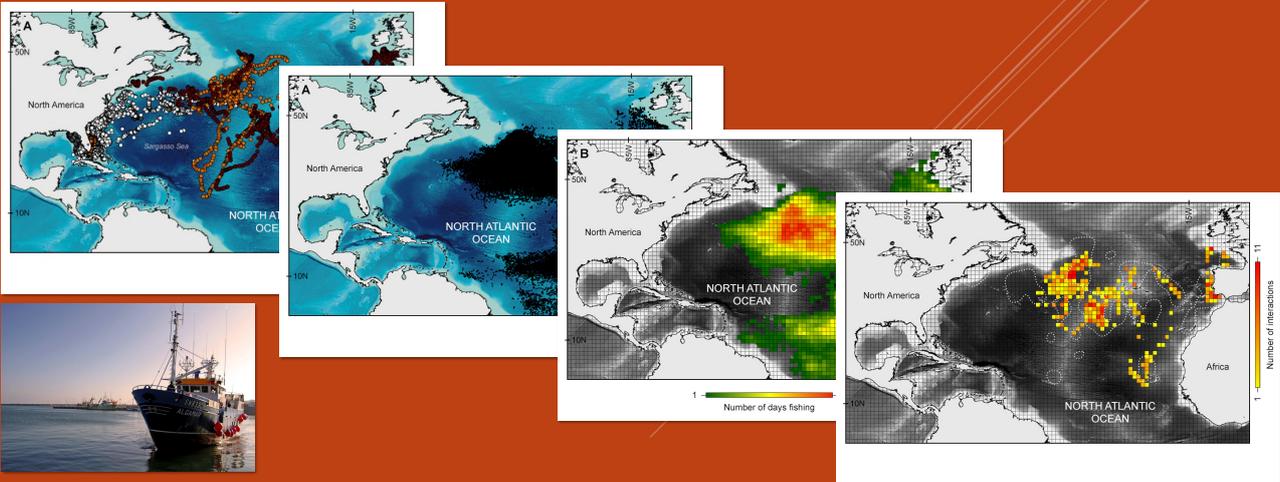
Problems associated with tag geolocation



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Geolocation problems

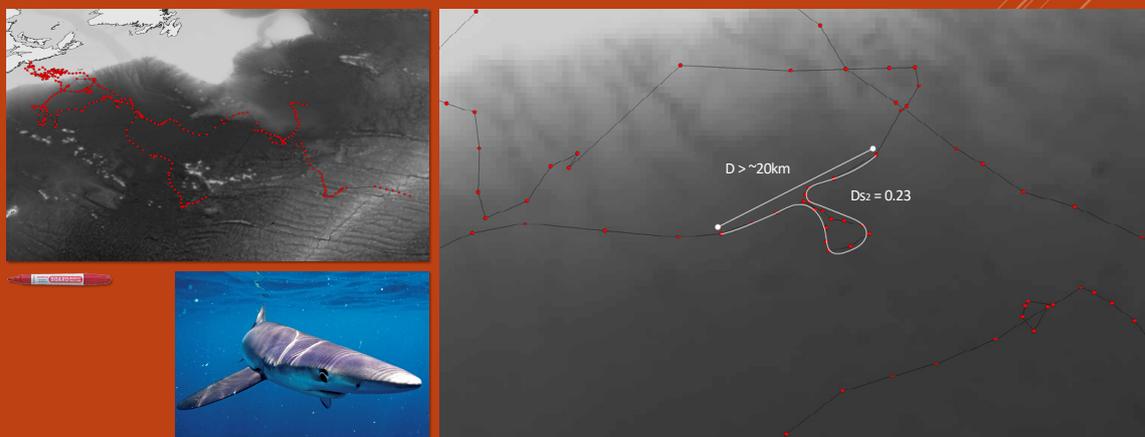
Problems associated with tag geolocation



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Geolocation problems

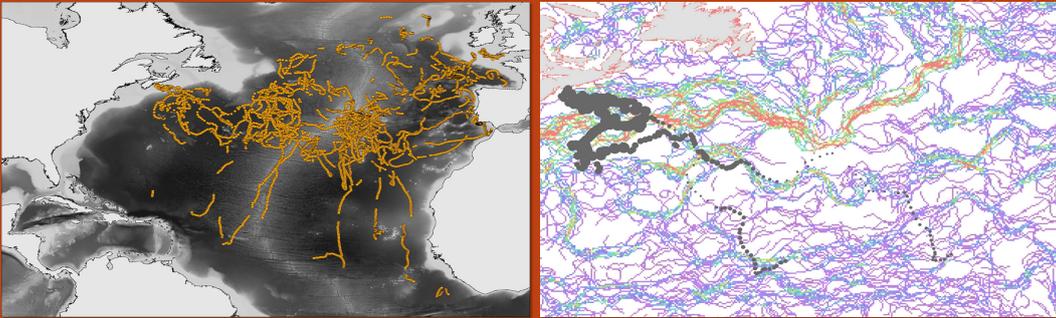
Problems associated with tag geolocation



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Geolocation problems

Problems associated with tag geolocation



1. Tracking error needs to be $\sim 10\text{-}15\%$ *movement rate* (e.g. daily).
2. Frontal metrics calculated using SST data at ~ 10 km.

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What tag to use?

Part 1: *What type of data you want.*

Part 2: *How you will get the data back.*

Part 3: *Errors associated with the data.*



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