

How French tropical tuna purse seiners split fishing effort between GPS-monitored and unmonitored FOBs and what it says about effort standardization



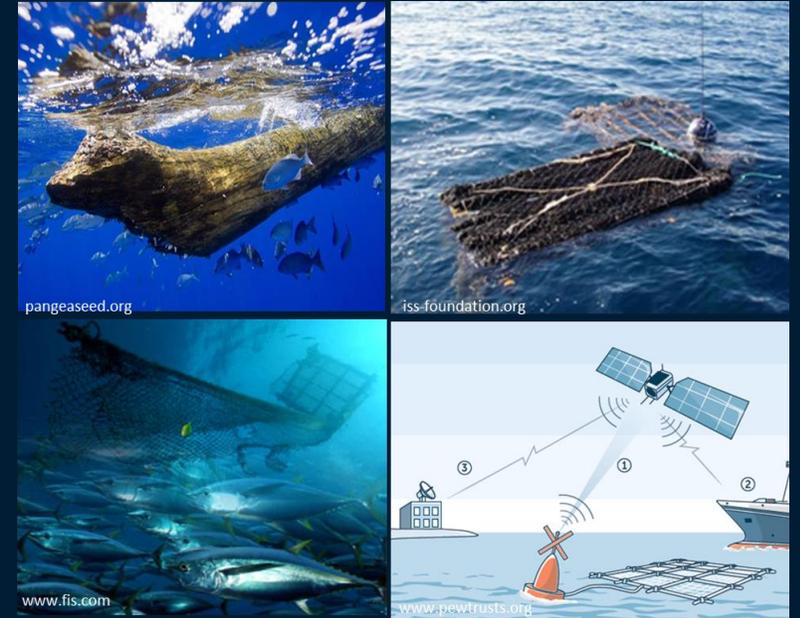
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Fishing Using Floating Objects

- Substantial increase in fishing on floating objects since early 1990s
- FOB fishing accounts for majority of global tropical tuna purse seine catch
- **Major driver:**
 - Ability to remotely track FOBs and associated tuna aggregations
 - GPS buoys
 - Vast signaling range
 - Ability to control reporting frequency
 - Echo-sounders
 - Can attach them to anything



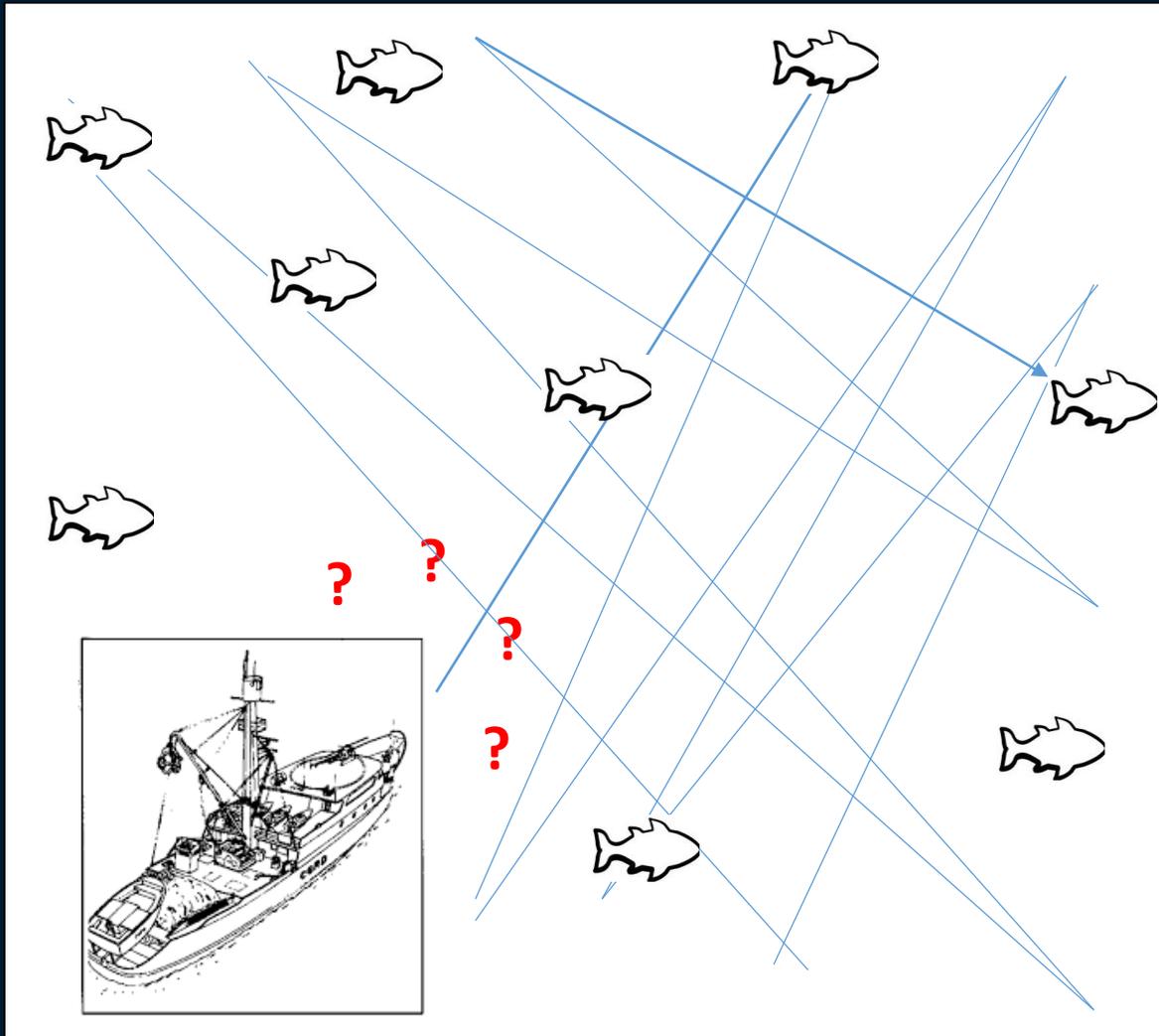
FOB:

- Natural floating object
- Anthropogenic debris
- Purpose-built fish aggregating devices

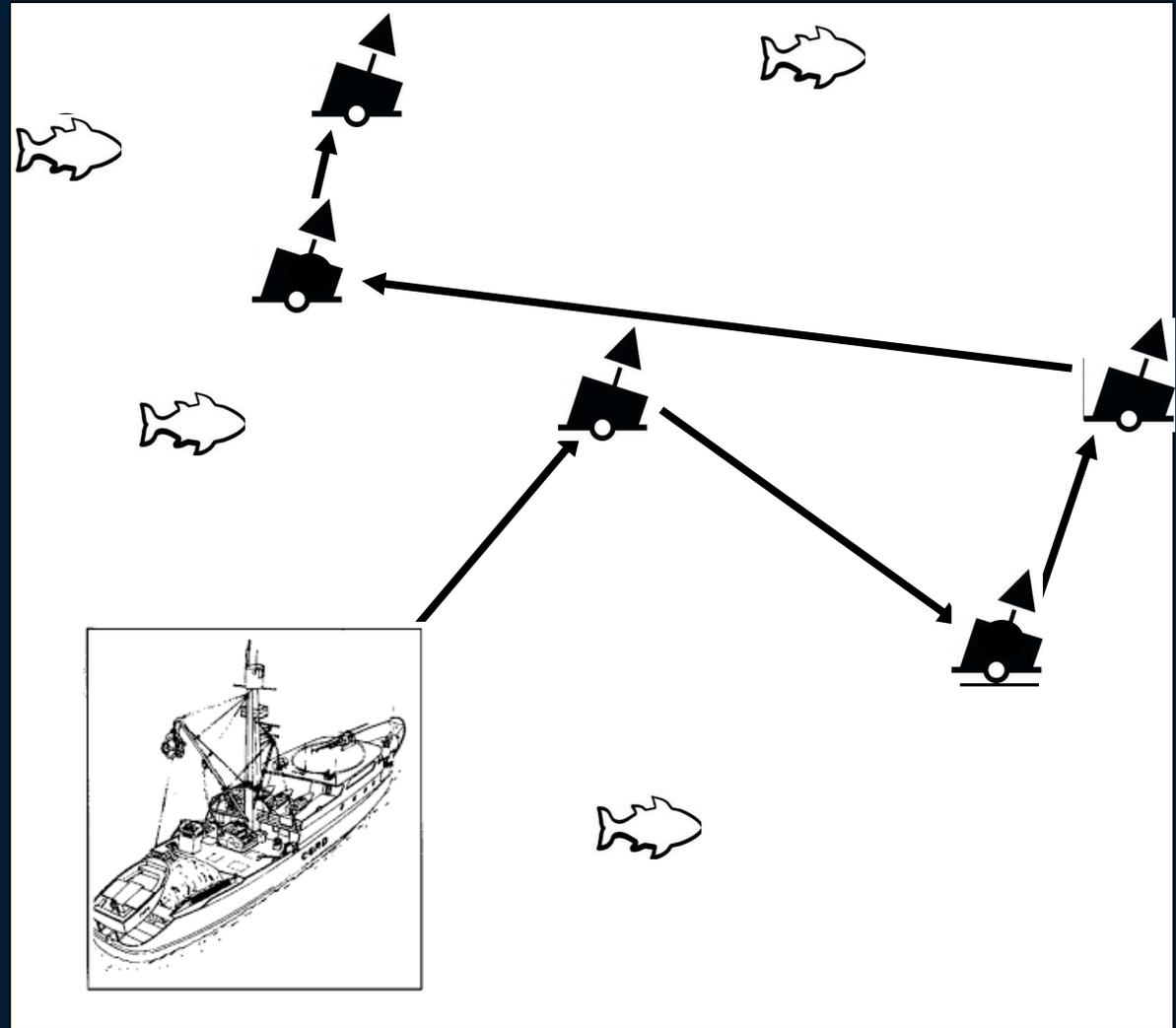
Advantage: Reduction in Search Time

 = Free-swimming school
 = school
 = dFAD with GPS buoy

Random Searching



Directed Fishing



However...

Catch per unit effort (CPUE) used to estimate abundance of fish stocks and determine sustainable fishing levels

- Advantages of GPS-tracked FOBs not reflected in current metrics of nominal effort
- Nominal effort measured in terms of searching time (e.g. time at sea, searching days)
 - Nominal effort only accurate for FSCs
- Confounds ability to calculate CPUE that will accurately reflect abundance (Fonteneau et al. 2000, Maunder and Punt 2004, Kaplan et al. 2014)

Need to incorporate FOB effects into metrics of effort

Reduction in Search Time



= Free-swimming school



= FOB with GPS buoy



= another vessel's FOB



= natural floating object

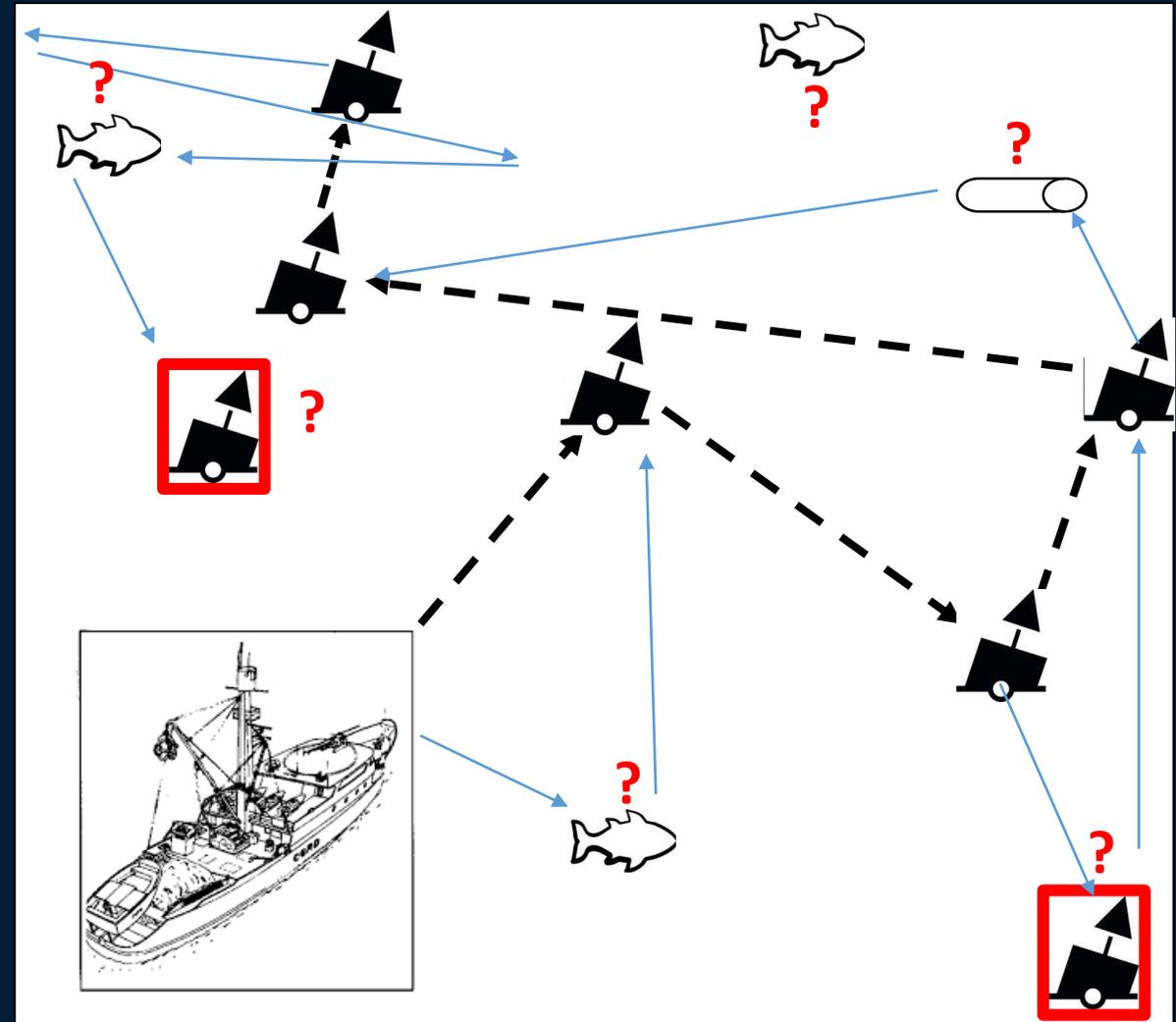
Not all FOB fishing sets associated with reductions in search time

Vessels also keep a lookout for:

1. Free-swimming schools
2. Random natural and artificial objects
3. Other vessels' buoy-tracked FOBs

NO POSITION INFORMATION AVAILABLE TO THE VESSEL FOR THESE!

Important to quantify how effort is divided between fishing on monitored vs. unmonitored objects





How often do French purse seine vessels fish on monitored vs. unmonitored FOBs?

French Purse Seine Fleet Datasets

Commercial Catch Data

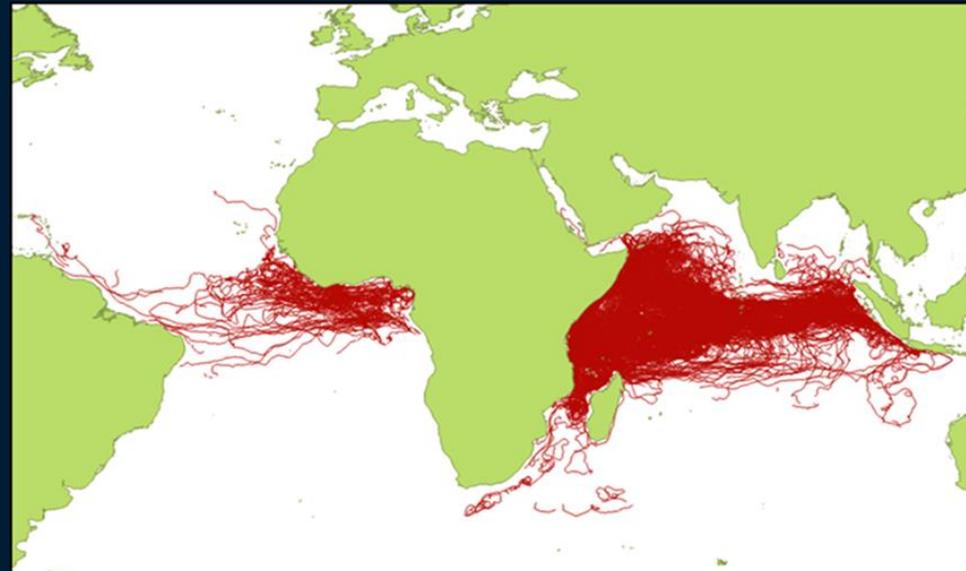
- 2007-2013
- Vessel captain logbooks
- Atlantic and Indian oceans
- 52,455 sets
 - **24,886 FOB sets**

Observer Data

- 2007-2013
- Independent observers
- Atlantic and Indian oceans
- 4,393 fishing sets
 - **1,991 FOB sets**

FOB Buoy Satellite Trajectories

- 2006-2014
- 13,772 buoys
- Mix of water and onboard GPS positions
- “Cleaned” in Maufroy et al. 2015
 - 39,696 water trajectory segments

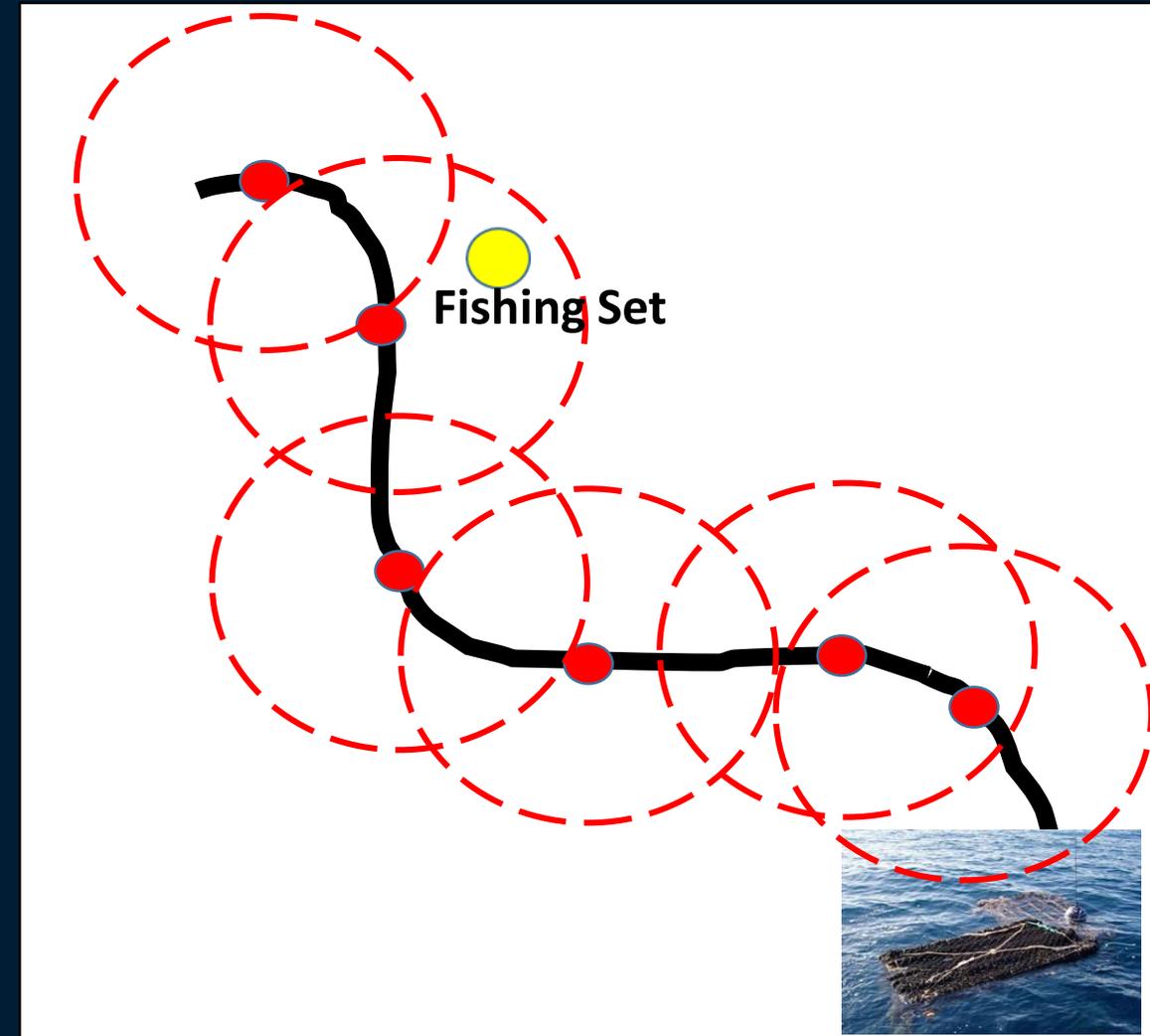


FOB= floating object equipped with GPS buoy

Step 1: Identify Buoy Trajectories that Resulted in a Fishing Set

- Match buoy satellite trajectories to FOB fishing sets
 - Missing link between trajectories and fishing sets
- Search filter:
 - Space-time radius: +/- 18 hours and 11 kms
 - Created initial set of matches

FOB Trajectory

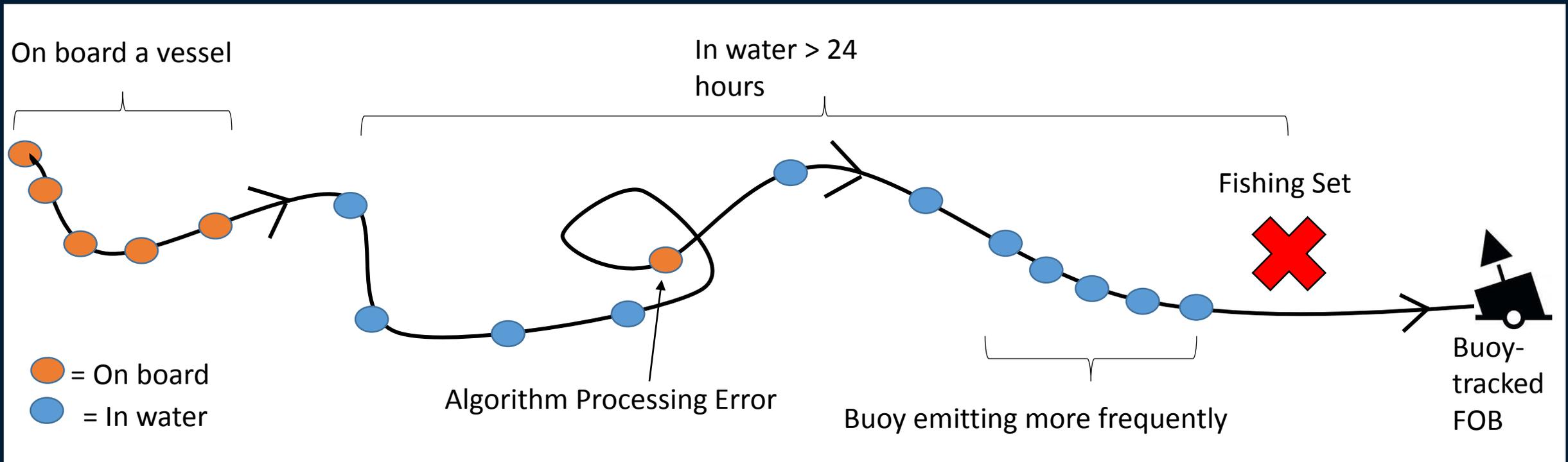


Step 2: Find Accurate Matches

Correct Match Characteristics:

- Consistently in the water
- Trajectory passes close to fishing set position in space and time
- Indicators of active tracking by vessel
 - increased buoy reporting rate

**Correct Match= Fob trajectory resulting in fishing set*



Step 3: Examine a Subset of Initial Matches

1. Broke initial matches down into categories based on proportion of trajectory that was in the water
 - Examined a subset of matches in each category
2. Incorporated uncertainty due to definition of correct match:
 - Created three definitions of a “correct” match: *Definite, Probable, All Possible*
3. Incorporated uncertainty due to subsample size:
 - Created confidence intervals of the fraction of good matches for each level
4. Developed estimates using both logbook and observer information

Results

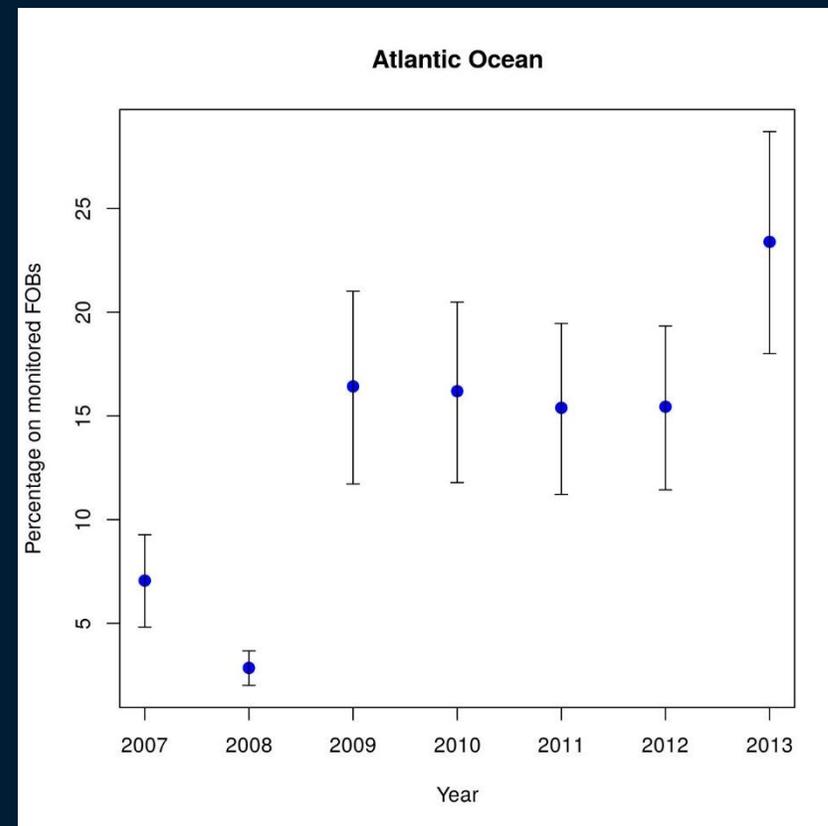
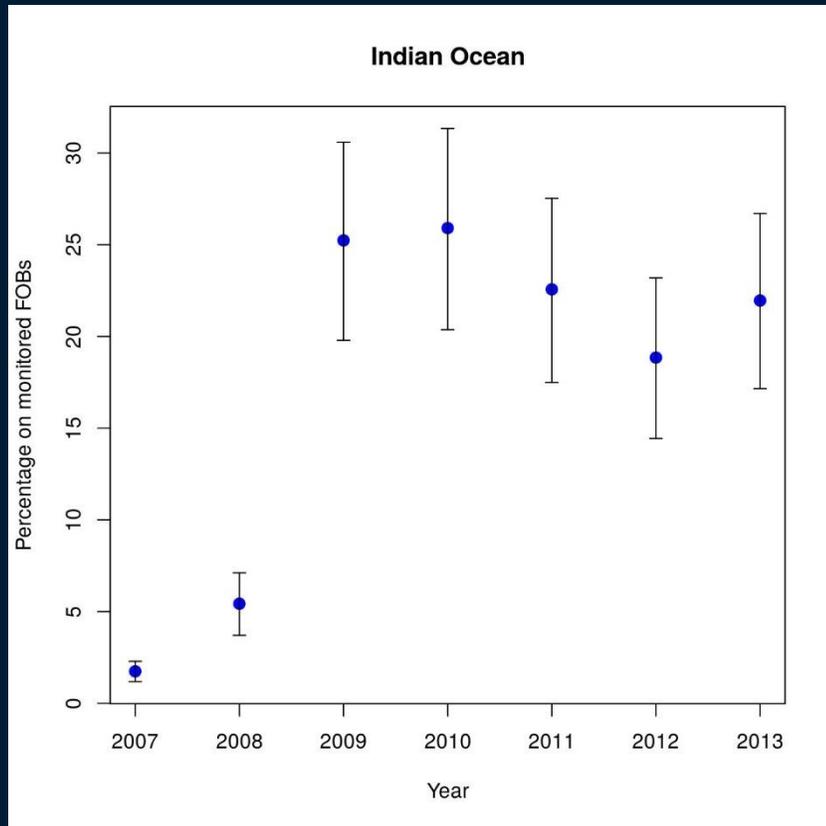
1. Only **2.8%-20.4%** of French FOB sets were made on monitored FOBs over 2007-2013 in the Indian Ocean

Commercial Data

Rating Categories	Indian Ocean	Atlantic Ocean	Both Oceans
<i>Definite</i>	5.2% [2.8%, 8.2%]	4.9% [2.4%, 8.25%]	5.1% [2.7%, 8.2%]
<i>Probable</i>	11.5% [8.1%, 15.3%]	11.1% [7.3%, 15.1%]	11.4% [7.9%, 15.2%]
<i>All Possible</i>	16.8% [12.9%, 20.4%]	16.1% [11.9%, 20.2%]	16.62% [12.7%, 20.6%]

Results

1. Only **2.8%-20.4%** of French FOB sets were made on monitored FOBs over 2007-2013 in the Indian Ocean
2. Percentage of fishing on monitored FOBs *may* be increasing over time



Discussion

Only 2.8%-20.2% of French FOB sets were made on monitored FOBs over 2007-2013 in the Indian Ocean

- Low percentage for such a significant fleet
- Majority of FOB sets are made on unmonitored FOBs (no tracking information available)
 - Consistent with estimates of dFADs in Atlantic → ~10k – 14k deployed annually in Indian Ocean (Fonteneau & Chassot 2014)
 - Fuel consumption per ton of tuna landed increased the more a purse seine vessel relied on FADs (Parker et al. 2015)

FOB sets probably not primarily used to reduce search time and associated costs

Why Might This be Happening?

1. Remotely tracked FOBs used as environmental indicators to find:
 - Productive areas (for FSCs)
 - Convergence zones (for other FOBs)
2. FOB-sharing
 - Limited evidence
3. Low percentage specific to the French Fleet
 - French vessels maintain fewer dFADs per boat (Maufroy et al. 2016)
 - Fewer than other countries with overlapping fishing territories
 - Fewer supply boats
 - Focus more on FSCs than FOB fishing than other countries
 - But this distinction has diminished over time

Consequences for effort standardization

- Current nominal effort indices ignore FOBs
 - Search time or number of FOB sets
- Need for CPUE standardization including “FOB effects” on fishing efficacy
- **Purse-seine FOB effort has both individual and collective components**
 - Individual:
 - Search time / FOB sets
 - dFADs / GPS-buoys deployed
 - GPS-buoy technology
 - Access to supply vessels
 - Collective:
 - Overall density of FOBs deployed in a zone
- ***Need to include both of these components when attempting to standardize purse-seine CPUE estimates!***

Acknowledgements

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