

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



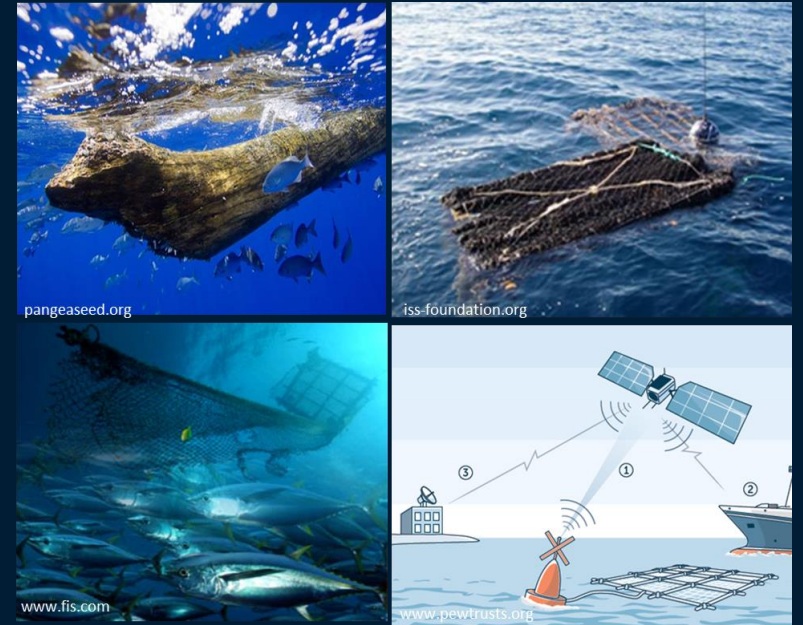
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# Fishing Using Floating Objects


- 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



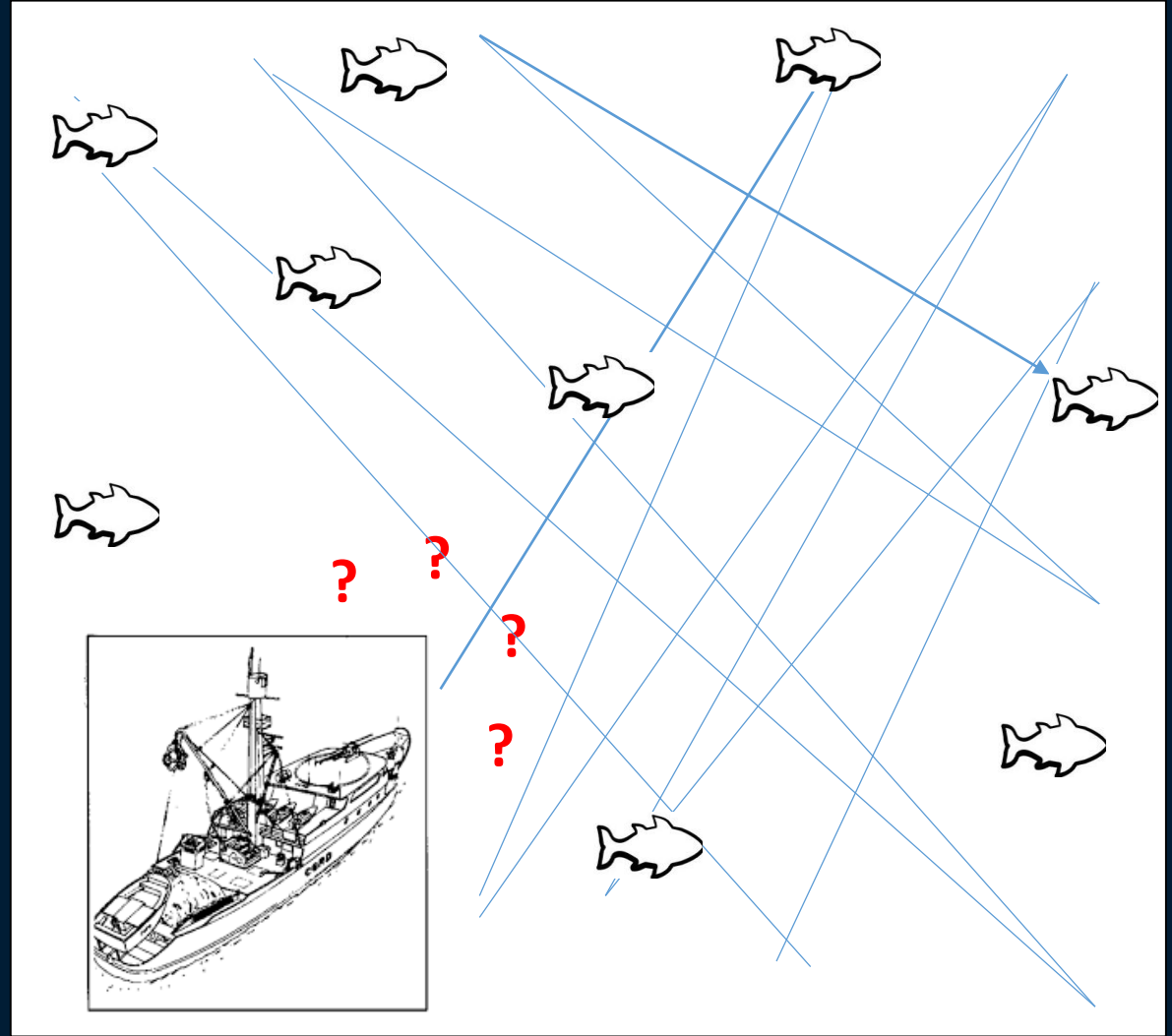
## FOB:

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

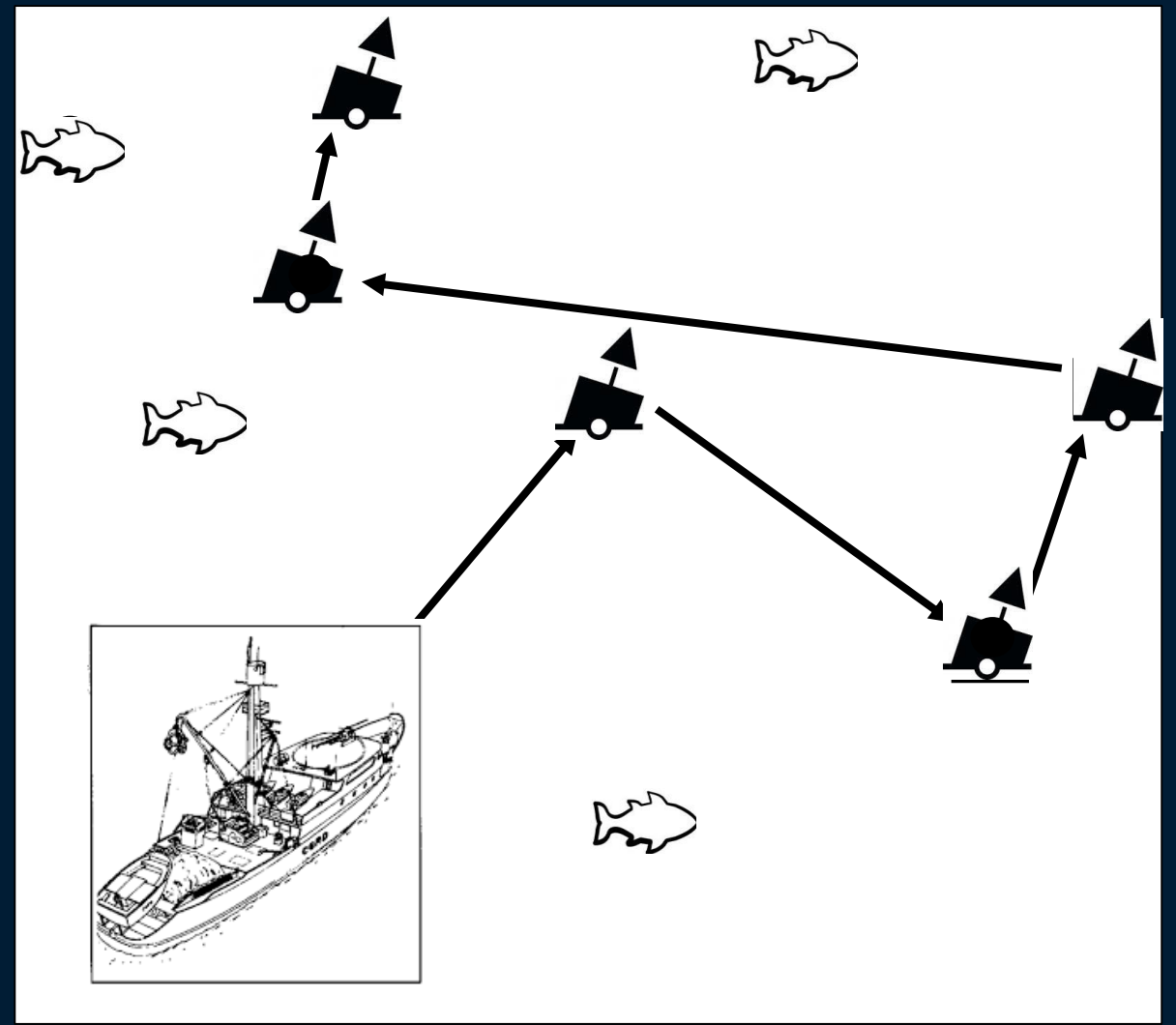
# Advantage: Reduction in Search Time

 = 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

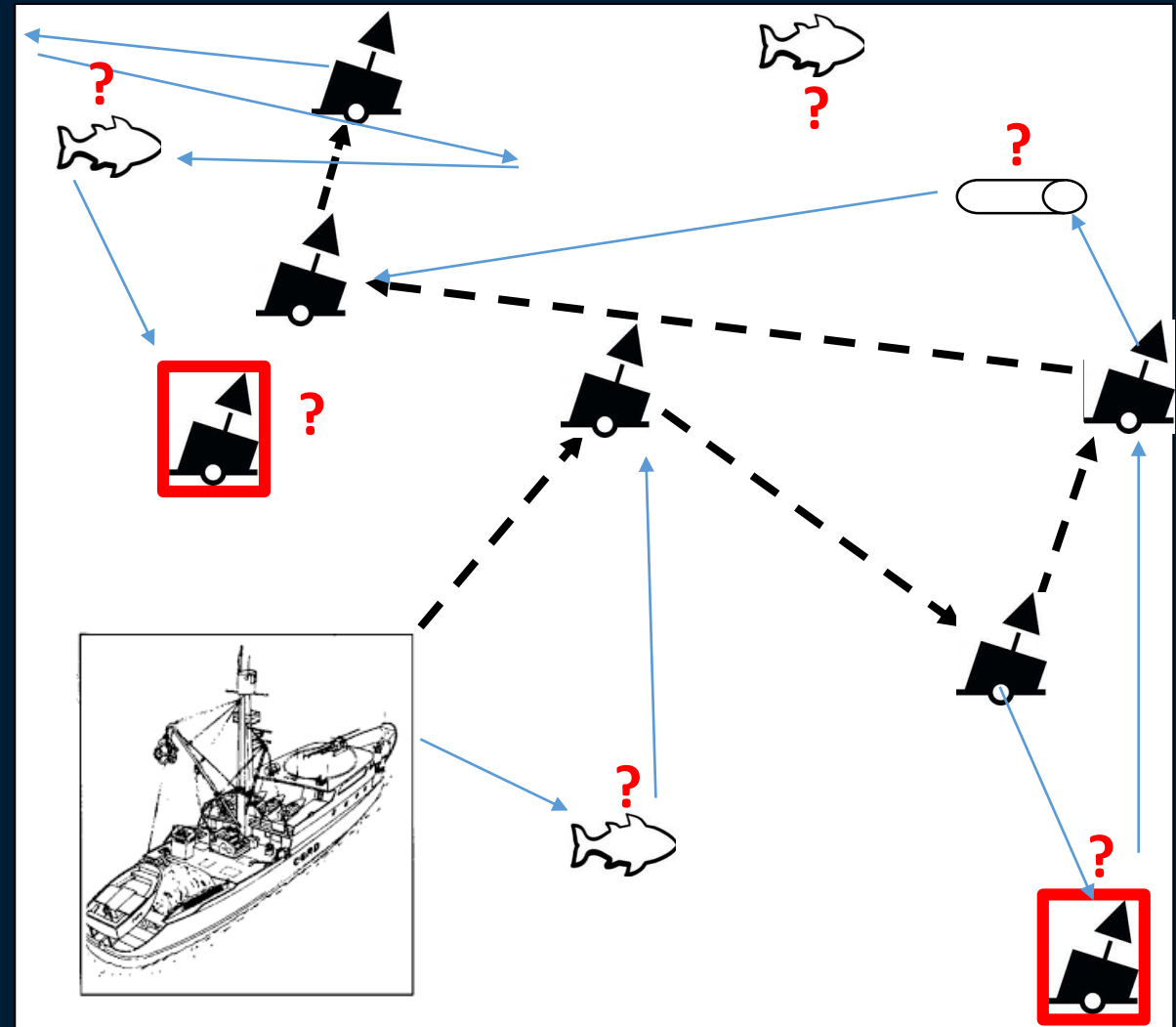
**Not all FOB fishing sets associated with reductions in search time**

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

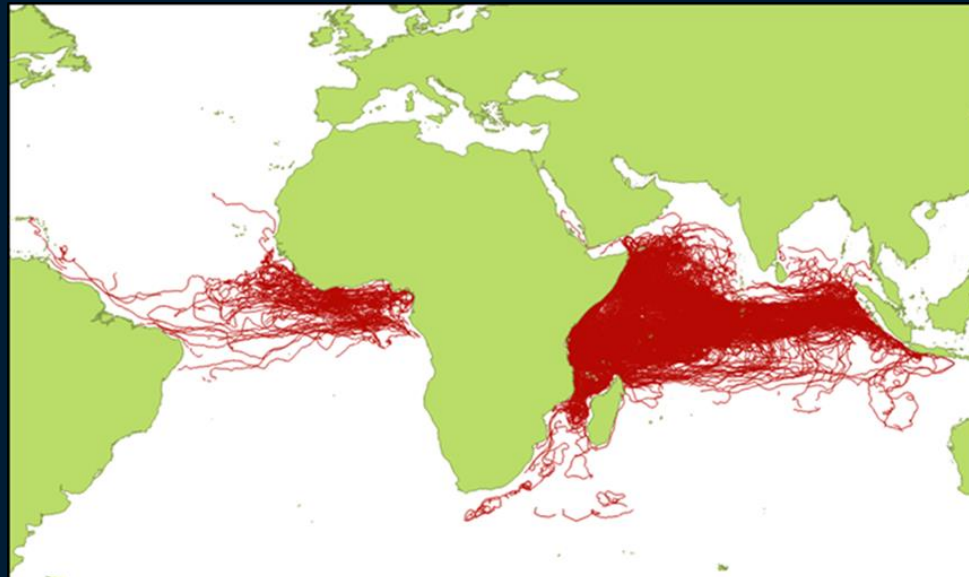
- 2007-2013
- Vessel captain logbooks
- Atlantic and Indian oceans
- 52,455 sets
  - **24,886 FOB sets**

## 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

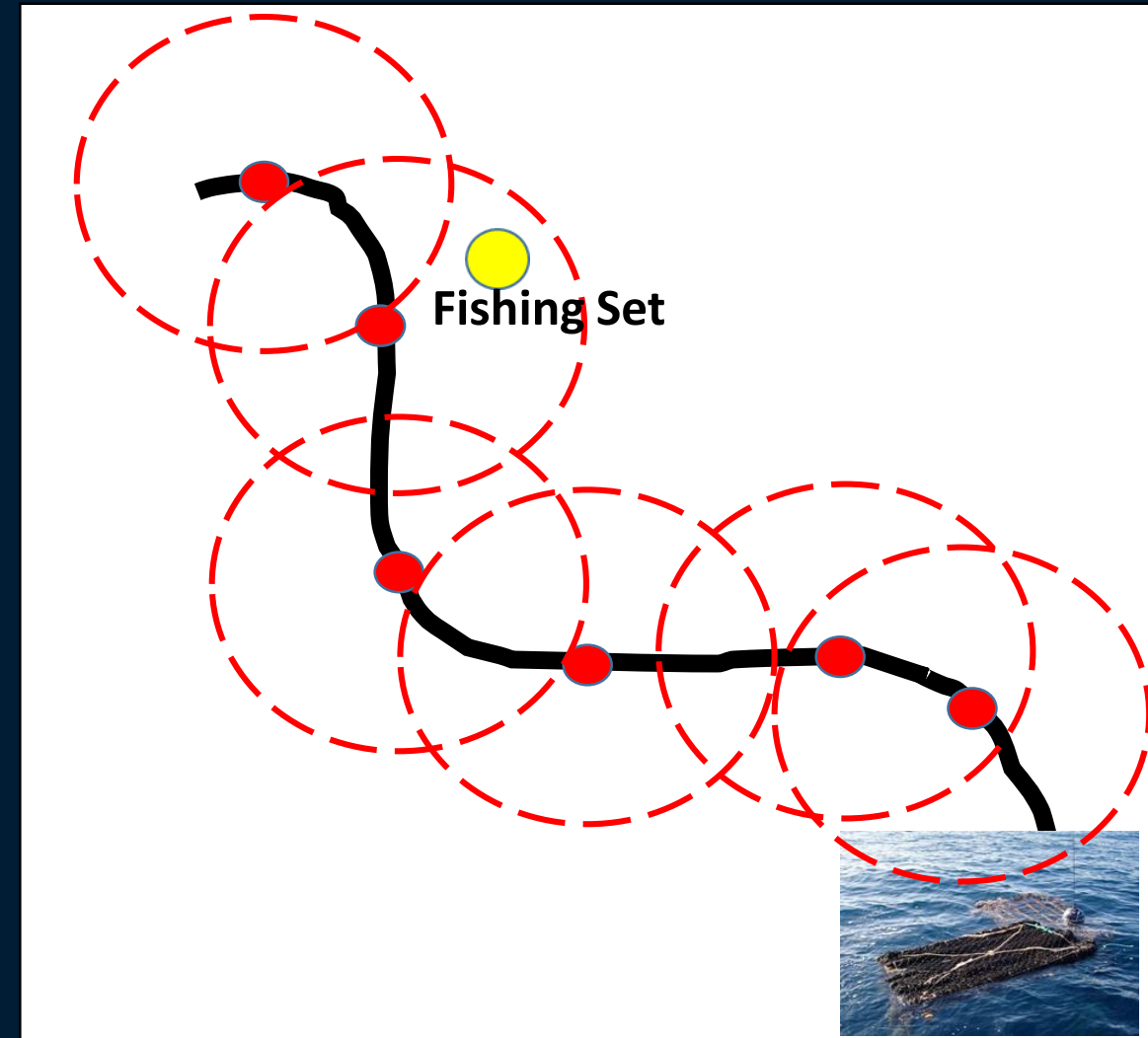


*FOB= floating object equipped with GPS buoy*

# 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



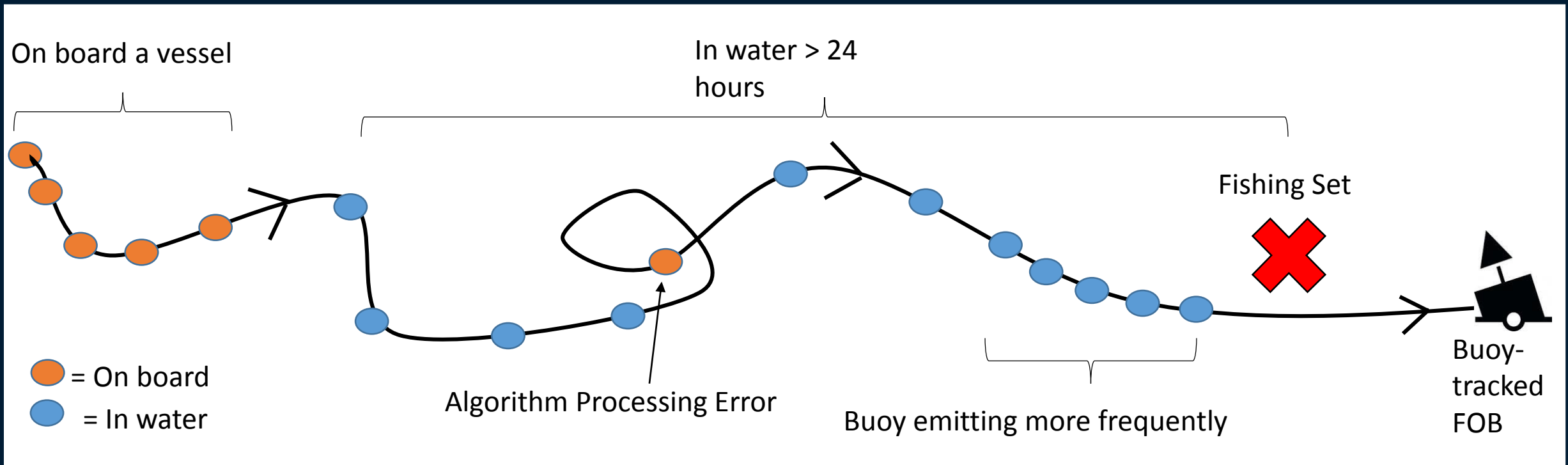


# Step 2: Find Accurate Matches

## 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

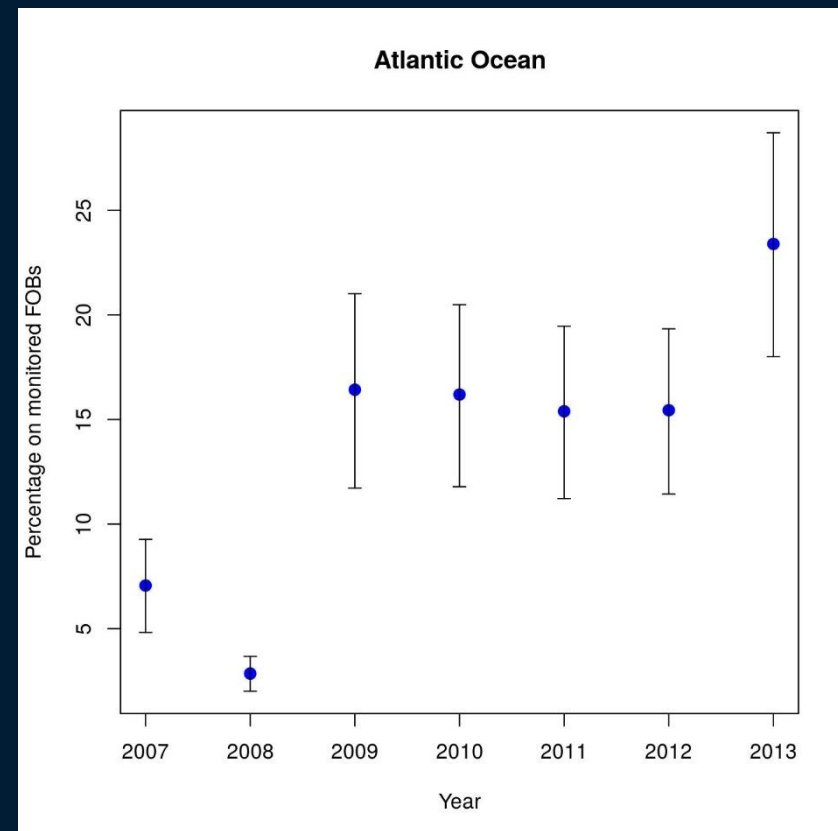
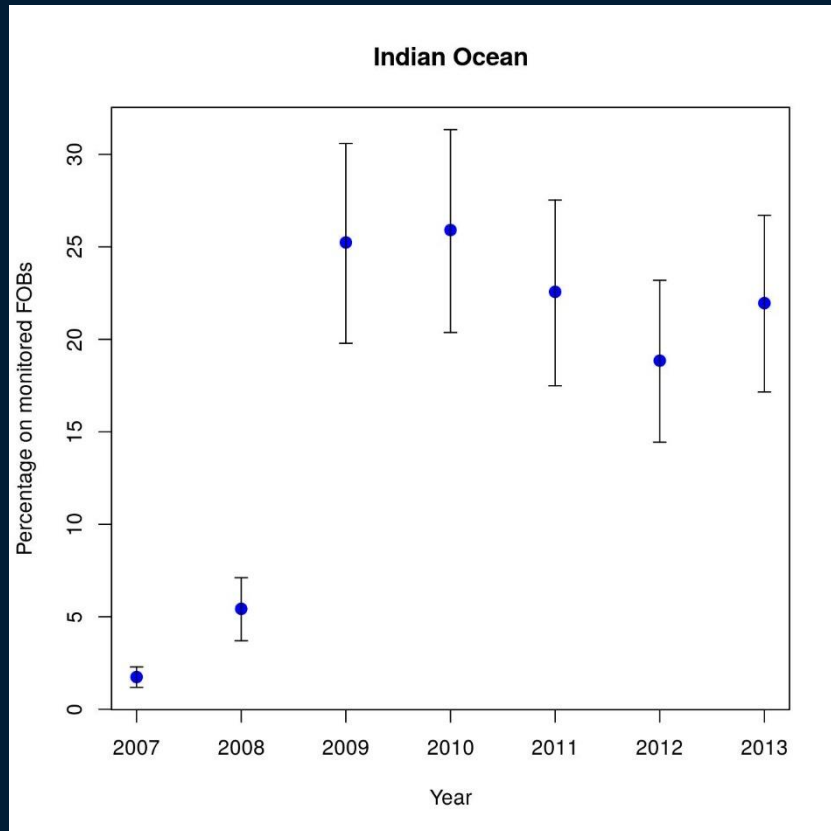
1. Only **2.8%-20.4%** of French FOB sets were made on monitored FOBs over 2007-2013 in the Indian Ocean

## 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

## *Special thanks to:*

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