



FishInfo

FAO FISHERIES AND AQUACULTURE KNOWLEDGE BASE

IOTC SPECIES IDENTIFICATION AND SAMPLING WORKSHOP

ARTFISH methodology for catch and effort estimation

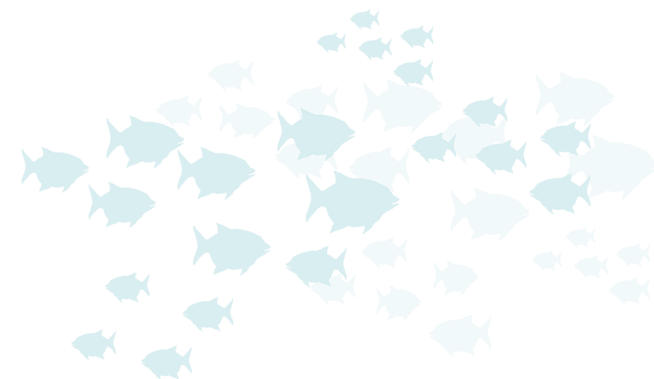
Kochi, India, September 29th to October 3rd ,2025

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Outline of the session



1. Objectives
2. ARTFISH methodology concept
3. CPUE Estimation
4. Effort Estimation
 1. Active vessels
 2. Active days
 3. Activity coefficient
5. Catch estimation
6. ARTFISH package

1. Objectives of the workshop



- Overview ARTFISH methodology
- Surveys to implement for sample-based approach
- Understand ARTFISH calculations
- Estimate catch and effort

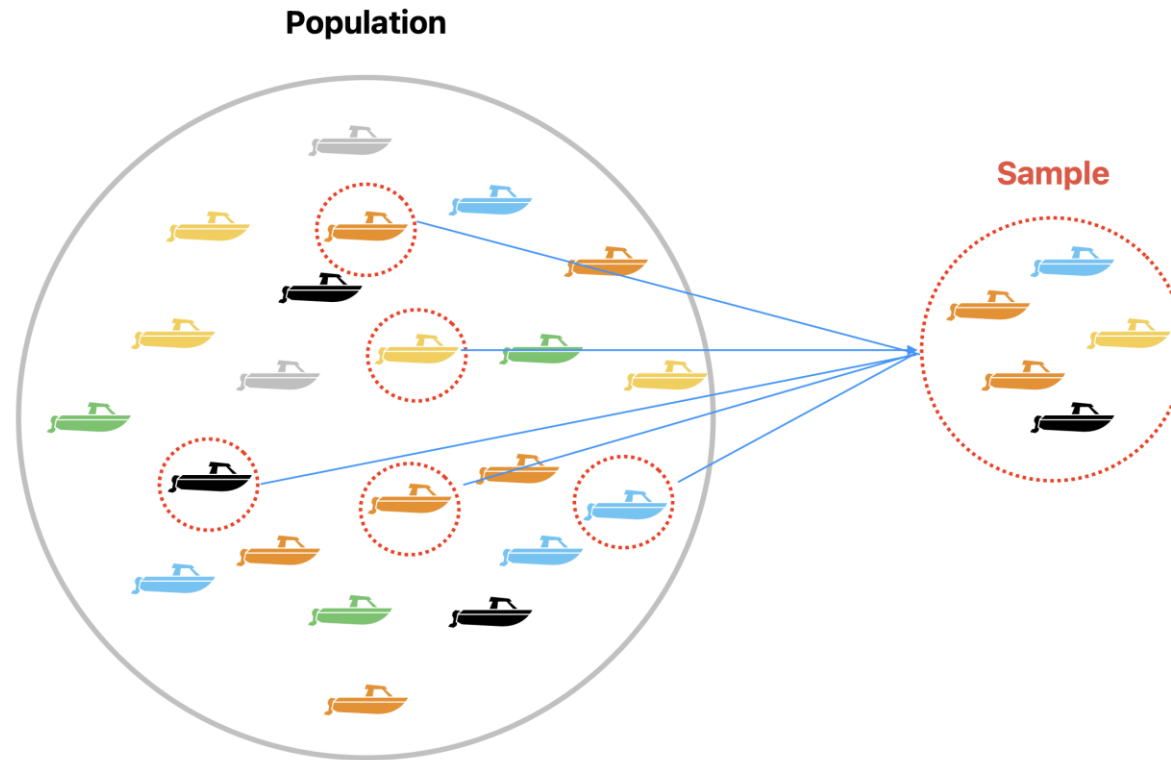
2. ARTFISH Methodology concept

ARTFISH in a nutshell...

- ARTFISH = Approaches, Rules and Techniques for Fisheries statistical monitoring
- Developed by Constantine Stamatopoulos in the mid-90s
- First implemented in Africa
- Limited local capacity in database design in the mid-90s directed ARTFISH towards a robust standardized tool for artisanal fisheries monitoring -> Good news: ARTFISH is not complicated

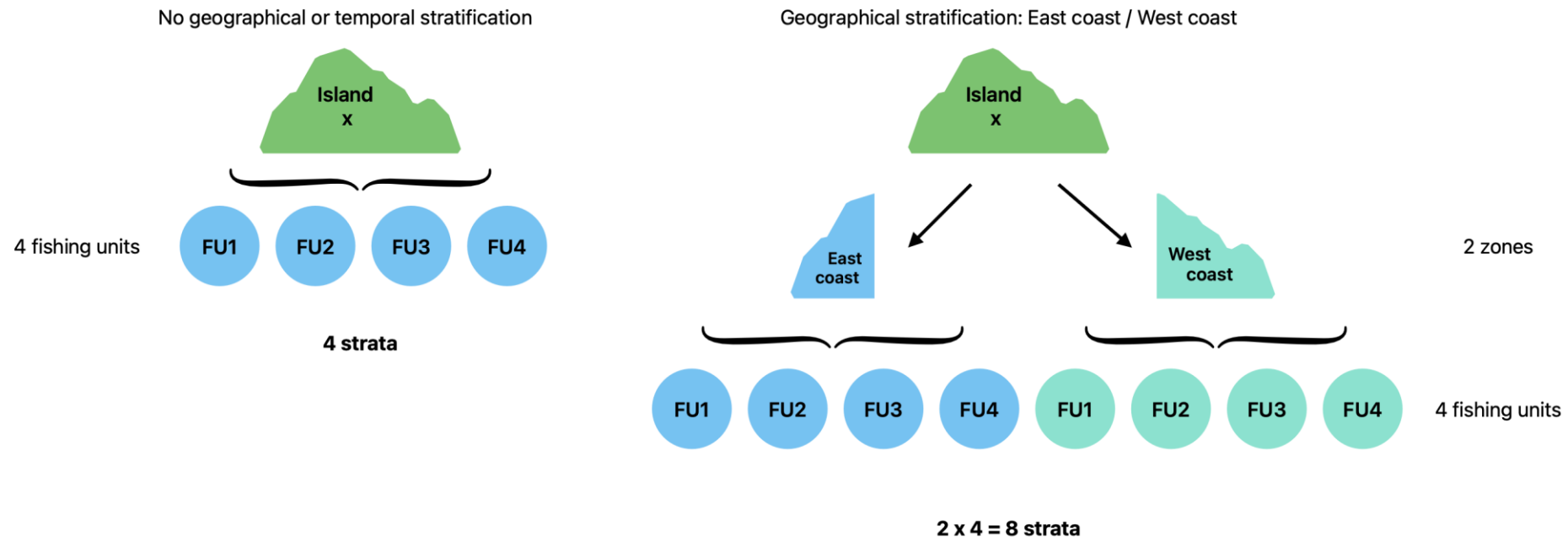
2. ARTFISH Methodology concept

- Sampled based approach



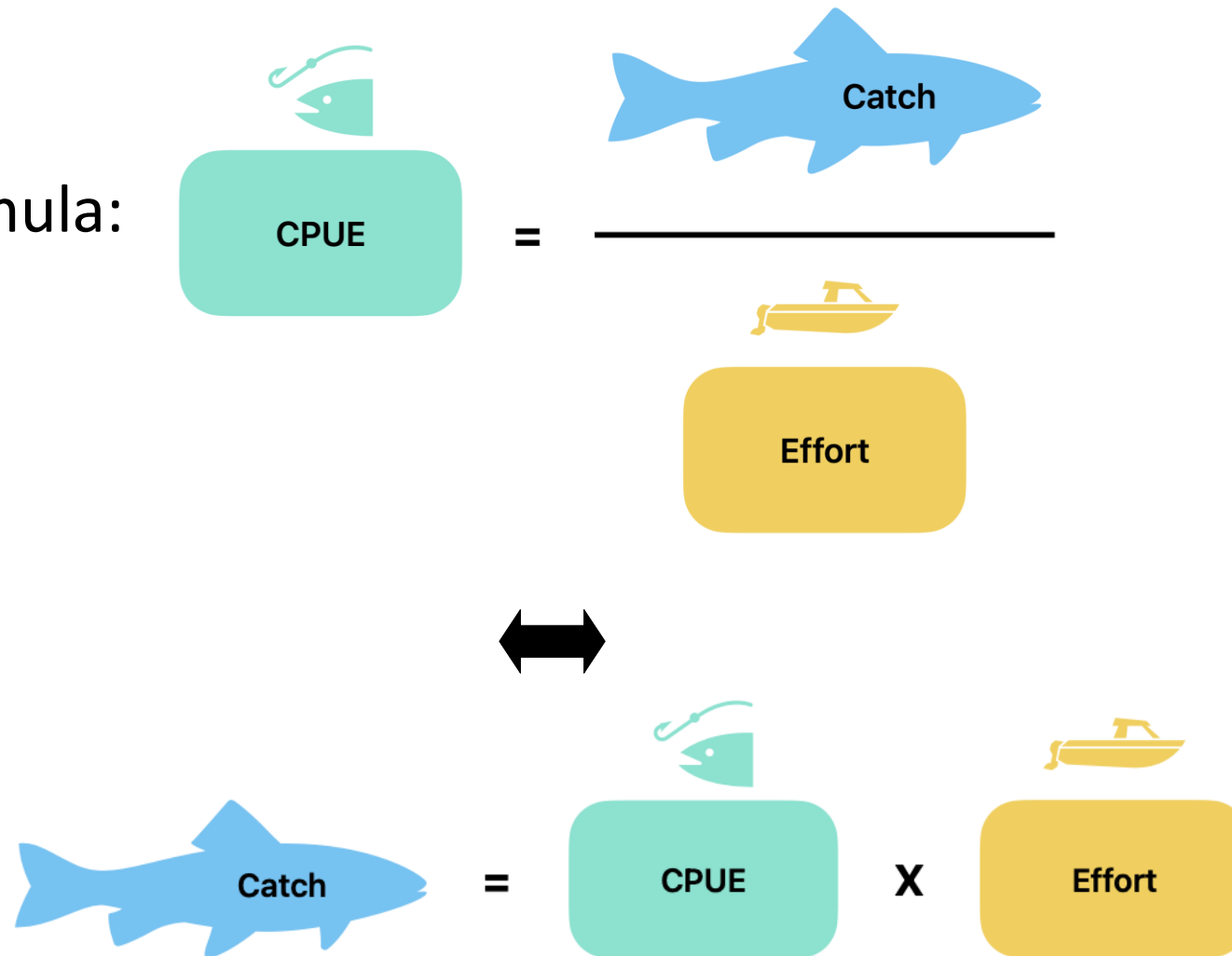
2. ARTFISH Methodology concept

- Stratified random sampling
 - Major strata: administrative divisions
 - Minor strata: geographical or temporal
 - Fishing units: vessel/gear combinations (in general)



2. ARTFISH Methodology concept

- CPUE formula:



What is effort ?



Effort

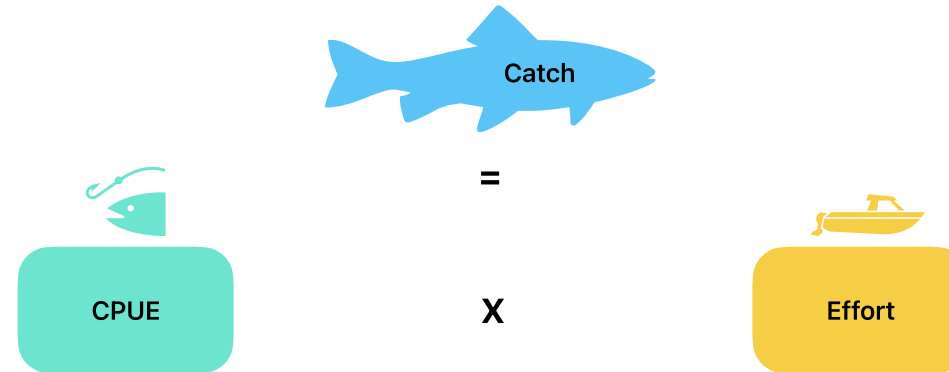
It is the total amount of fishing activity on the fishing grounds over a given period, often expressed for a specific gear type

e.g., Number of hours trawled per day, number of hooks set per day or number of hauls of a beach seine per day, or simply number of days at sea

How many energy put to catch a certain amount of catch?

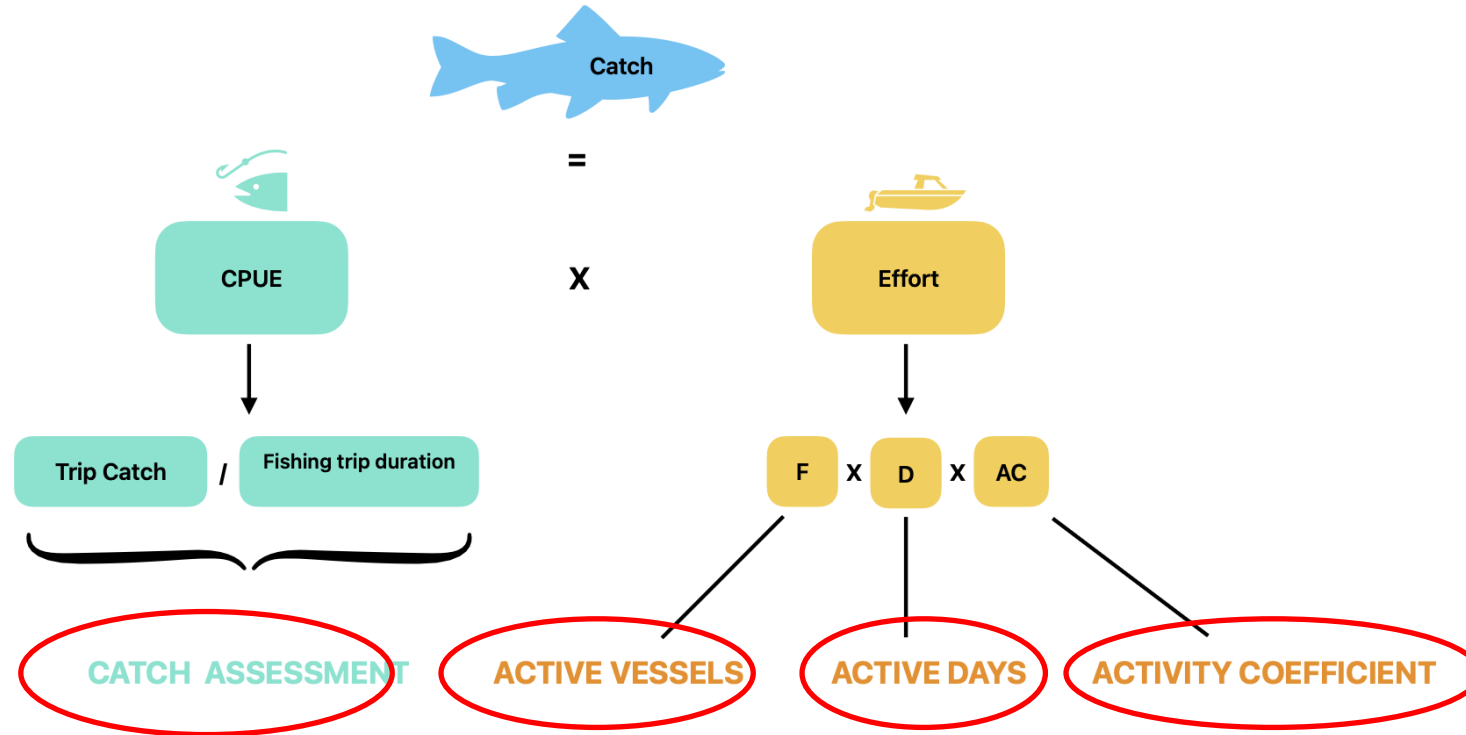
2. ARTFISH Methodology concept

- Generic formula:



- Minimum data required:
 - CPUE (catch and effort per trip)
 - **Overall fishing effort** which is often neglected in data collection

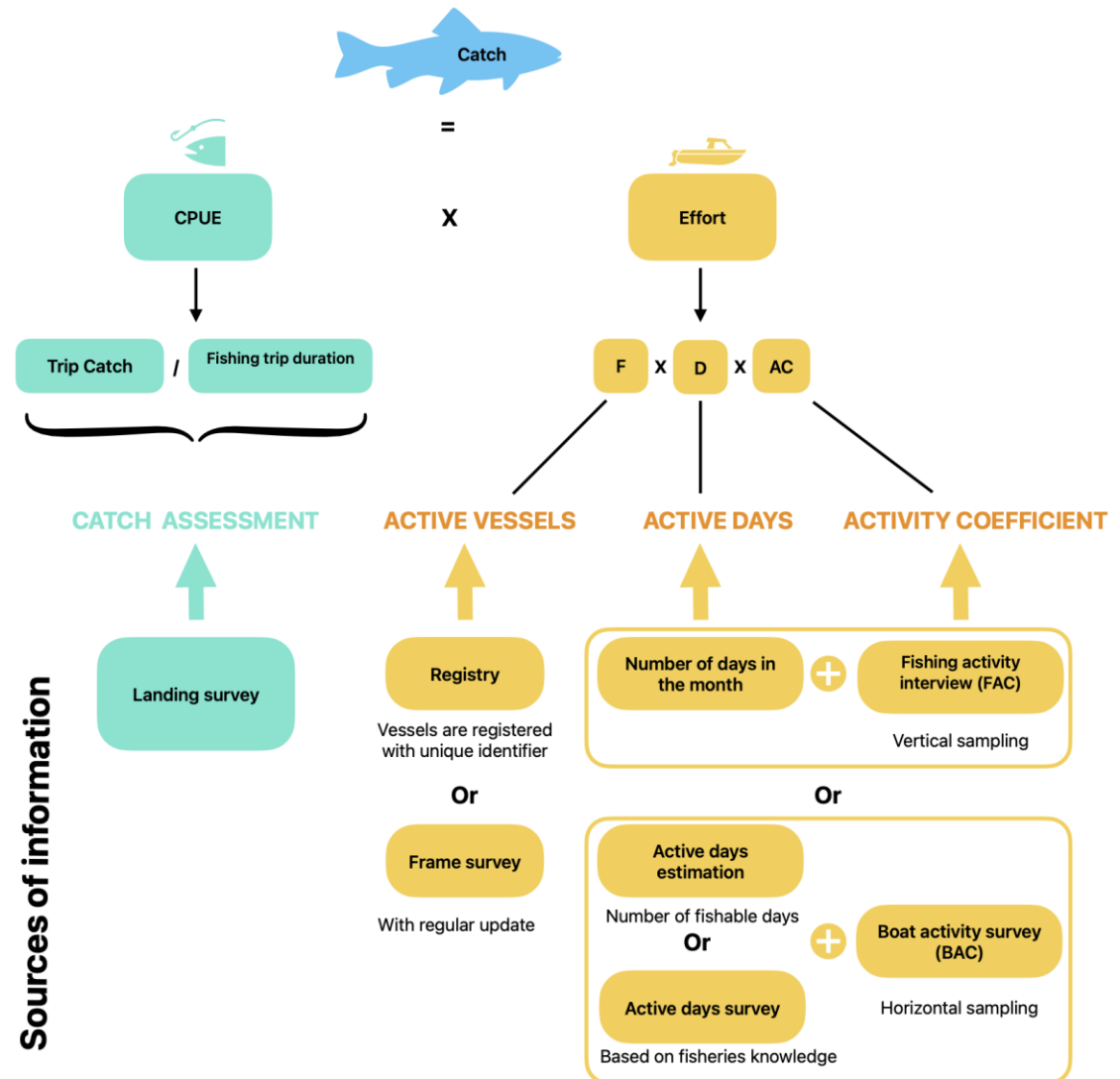
2. ARTFISH Methodology concept



- Data collection must provide these 4 parameters to apply the calculation

3. ARTFISH Methodology concept

- Sources of information
 - CPUE: landings
 - Registry
 - Frame survey
 - Active vessels:
 - Registry
 - Frame survey
 - Active days
 - Active days survey
 - Estimation
 - Activity coefficient
 - Boat activity survey
 - Fishing activity interviews



2. ARTFISH Methodology concept

CPUE

- Logbook (usually implemented for industrial fisheries but rare in artisanal fisheries) or self-reporting by fishers (EU catch declaration obligation) // Census
- Landings survey -> Require sampling

2. ARTFISH Methodology concept

Active vessels

2 options:

- **Registry**
 - Need to be complete (most of vessels are registered and up to date)
 - A rule can be set up to define what is considered as an active vessel
 - A rule to assign fishing unit
- **Frame survey**
 - Vessel census per landing site per fishing unit
 - Need to be update regularly:
 - Every 3/4/5 years or after major changes (hurricane...)
 - Or can be a continuous process

2. ARTFISH Methodology concept

Active days

- If fisher interviews: number of days in the month
- If boat counting: 3 options:
 - Active days survey
 - Objective = get the “potential fishing day”
 - Made for each stratum (by month, by fishing unit...)
 - Number of days in the month – (bad weather day + holidays)
 - Assumptions/Estimations
 - Based on knowledge about the fisheries
 - Discussion with fishers, data collectors
- By default, with no information, it will be the number of days in the month

2. ARTFISH Methodology concept

Activity coefficient

2 options:

- **Boat activity survey**

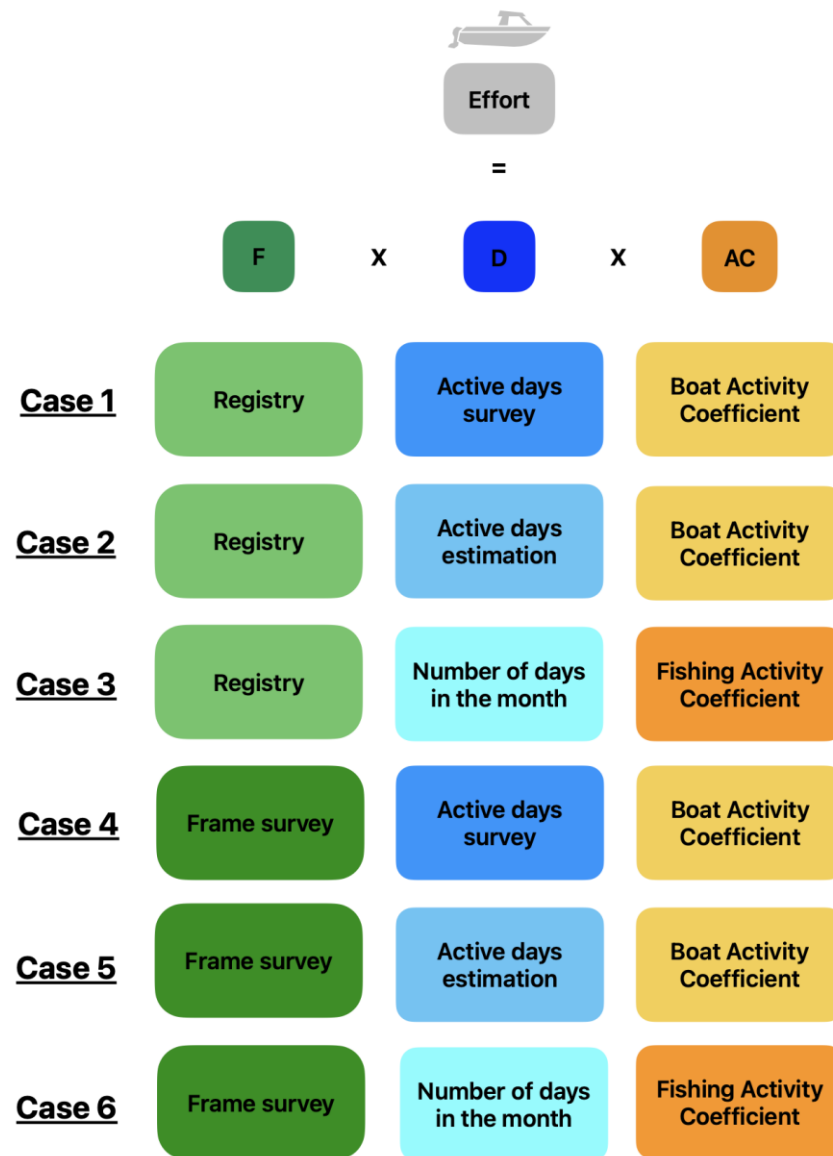
- Made for each stratum (by month, by fishing unit...)
- Count of vessel that went out on sampled days

- **Fisher interview**

- Made for each stratum (by month, by fishing unit...)
- Questionnaire to know how many days the fisher went fishing during the past x days
 - X the reference period time will differ depending on the type of fisheries
 - Example: 7 days for short trip (one day trip) or 30 days for long trips (3 weeks trip)

2. ARTFISH Methodology concept

- Depending on the source of data available
- Different cases to estimate fishing effort:



2. ARTFISH Methodology concept

Minimum data requirement

- **Active vessels:** composition of the fleet from registry or frame survey
 - Variables: date (year/month/day), vessel type/gear type (fishing unit), landing sites (or regions...), number of vessels engaged in the fishery (potentially fishing)
- **Active days:** active survey or estimation
 - Variables: year, month, fishing unit type, number of active days in the month (potentially fishing days)
- **Activity coefficient:** effort survey fishers' interview or boats counting
 - Fishers interviews variables: date (year/month/day), fishing unit type, number of days out, total days of reference period
 - Boats counting variables: date (year/month/day), fishing unit type, number of boats out, total number of boat at the reference site
- **CPUE:** catch per fishing trip per species with trip information gear/vessel type, duration
 - Variables: landing date (year/month/day), landing site, fishing unit type, catch weight, processing type
- [Data template/Data_template_artisanal_fisheries_statistics_2024-10-18.xlsx](#)

3. CPUE estimation

Landings survey

Different way to get data:

Landings survey

Logbook

Self-reporting

Landings survey are commonly implemented

Enumerators collected data at landing sites

Sampling landing sites/days/vessels

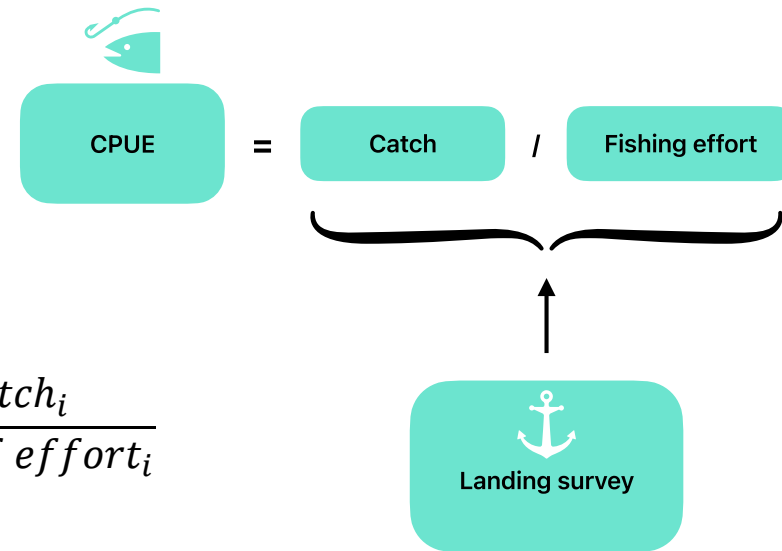


Warning

Random sample of landing sites/days/vessels

Consider fishing trip with no catch (zero is an information)

3. CPUE estimation Formula



$$CPUE = \frac{\sum_{i=1}^n Catch_i}{\sum_{i=1}^n Unit\ of\ effort_i}$$

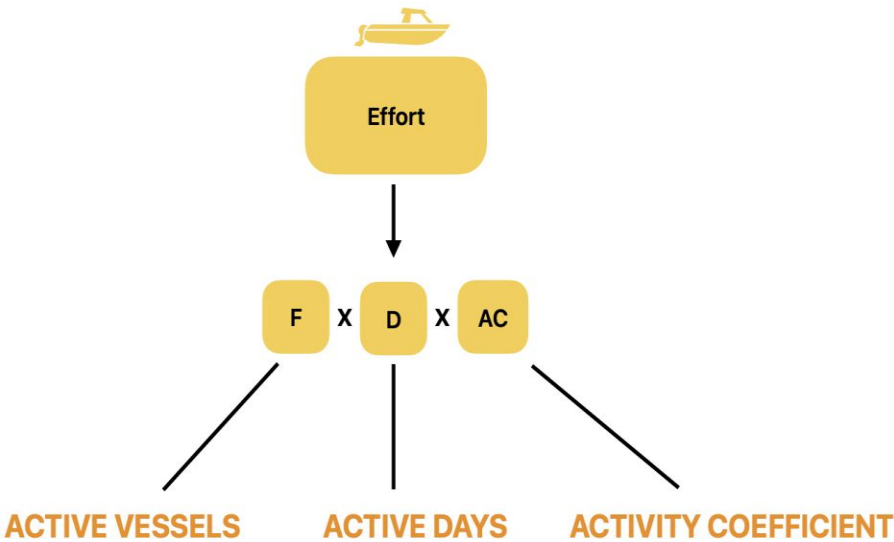
- $Catch_i$ is the total catch of the i^{th} sampled fishing trip
- $Unit\ of\ effort_i$ is the effort spent fishing of the i^{th} sampled fishing trip
- n is the number of fishing trips sampled for this specific determining context.

In general, for SSF, the unit of effort expresses the duration in day (or in hours): duration of the fishing trip or time spent fishing (depending on the level of detail of the data collected). Then the formula becomes:

$$CPUE = \frac{\sum_{i=1}^n Catch_i}{\sum_{i=1}^n Duration_i}$$

$$CPUE = \frac{Catch_1 + \dots + Catch_i + \dots + Catch_n}{Duration_1 + \dots + Duration_i + \dots + Duration_n}$$

4. Effort



Active days

Active Boats

Days	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
B1																															
B2																															
B3																															
B4																															
B5																															

Activity coefficient

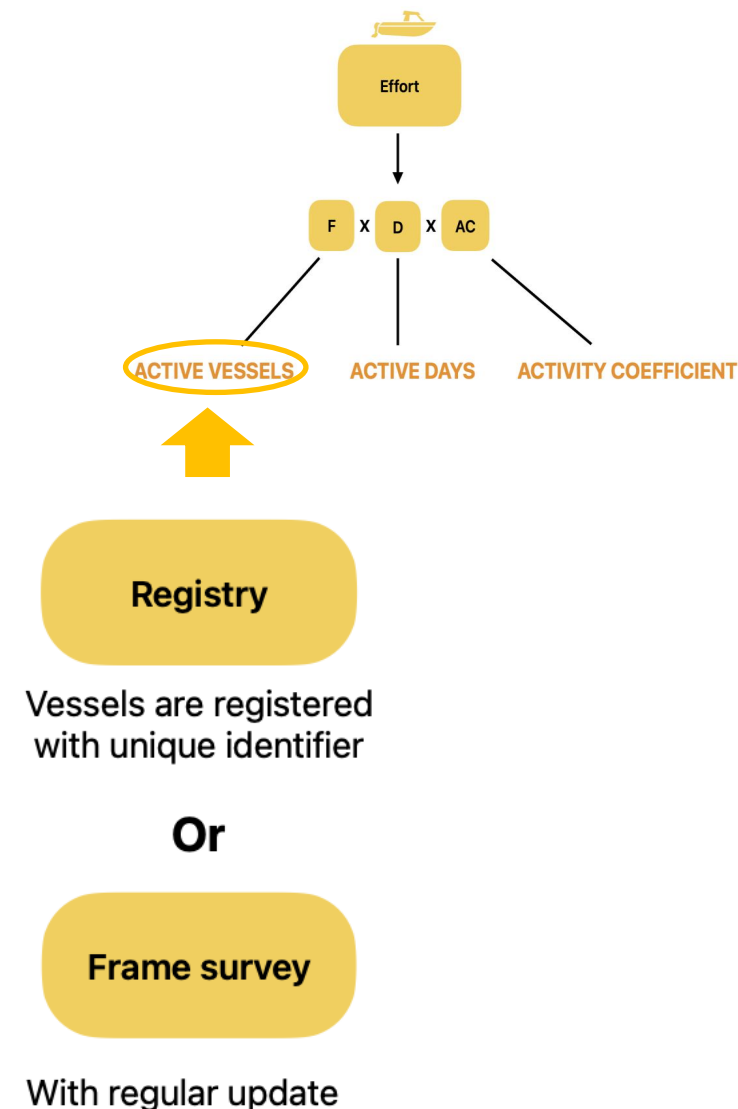
4. Effort

Active vessels: definition

- 2 potential sources of information:
 - Registry
 - Complete
 - Rules to define what is an active vessel
Ex: based on licenses, or operational status
 - Definition of fishing unit

or

- Frame survey (complete enumeration)
 - Simple count can be done regularly



4. Effort

Active vessels: Formula

- For the stratum i and the fishing unit j , F is the sum of the number of boats of this fishing unit of the sites include in the stratum:

$$F_{i,j} = \sum_{k=1}^q \text{fleet_engagement_number}_{i,j,k}$$

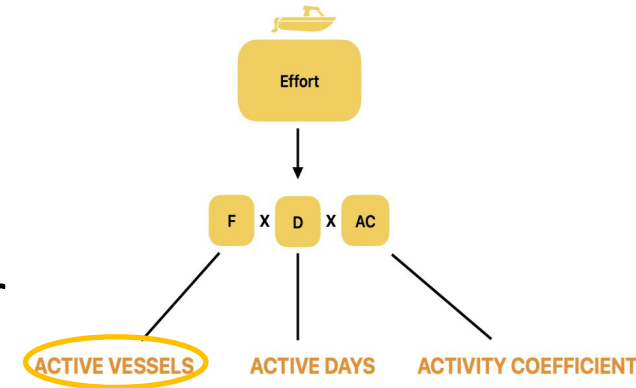
Where:

i is the stratum

j is the fishing unit

k is the k^{th} site

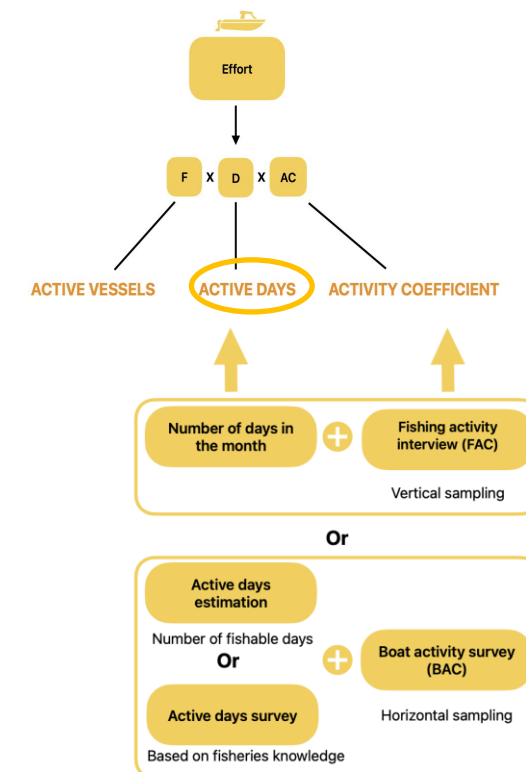
q is the number of sites in the stratum i



4. Effort

Active days: definition

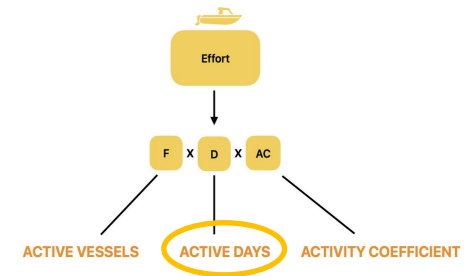
- Number of days with a potential fishing activity
 - -> remove public holidays, bad weather
- Two options
 - If Vertical sampling: Fisher interview,
 - Active days = number of days in the month
 - If Horizontal sampling: Boat counting, 2 potential sources of information:
 - Estimation (or by default number of days in the month)
 - or
 - Active day survey



Days	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
B1																															
B2																															
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B4																															
B5																															

4. Effort

Active days: Formula



The coefficient A can be calculated by deducing the number of non-potentially fishing days from the total number of days in the month:

$$D_{i,j} = \text{Number day in the month} - \text{Number of nonfishing days}$$

When there are several sites in the stratum, D is the weighted mean of the values, weighted by the number of boats of the fishing unit at the different sites.

$$D_{i,j} = \frac{\sum_{m=1}^t (D_{i,j,m} \times x_{i,j,m})}{\sum_{m=1}^t x_{i,j,m}}$$

Where:

m is the number of the mth sampled site. m goes from 1 to t

t is the total number of sampled sites

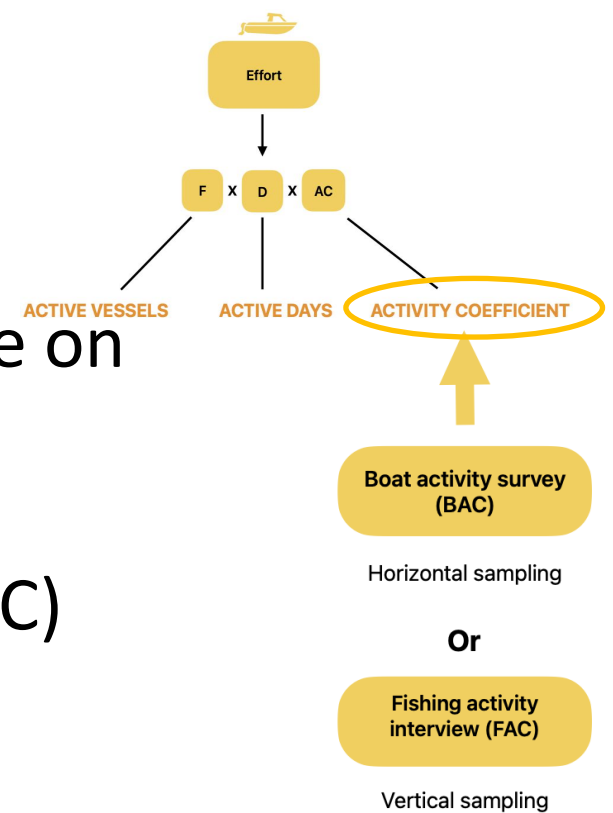
$x_{i,j,m}$ is the number of active boats at the site m in the stratum I for the fishing unit j

$D_{i,j,m}$ is the number of active days at the site m in the stratum I for the fishing unit j

4. Effort

Activity coefficient: Definition

- AC express the probability that any boat will be active on any (active) day during the month
 - 2 potential sources of information:
 - Fisher interviews -> Fishing activity coefficient (FAC)
- or
- Boat counting -> Boat activity coefficient (BAC)

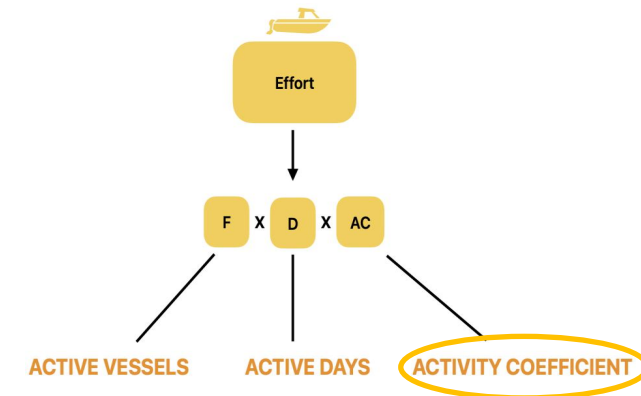


Days	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
B1																															
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B5																															

4. Effort

Activity coefficient: Formula

Horizontal sampling: boat counting



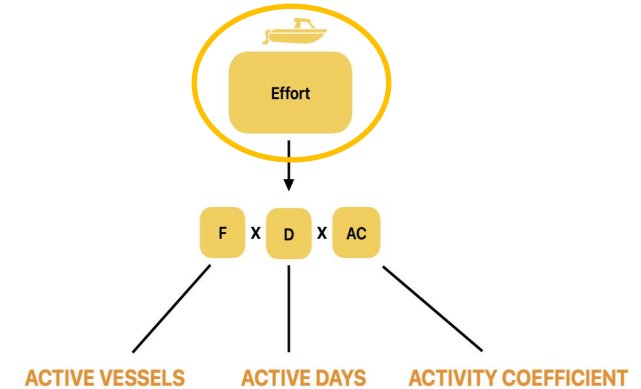
$$BAC = \frac{\sum \text{fleet_engagement_number}}{\sum \text{fleet_engagement_number_max}}$$

Vertical sampling: fisher interview

$$FAC = \frac{\sum \text{effort_fishing_duration}}{\sum \text{effort_fishing_reference_period}}$$

4. Effort

Total effort estimation: formula



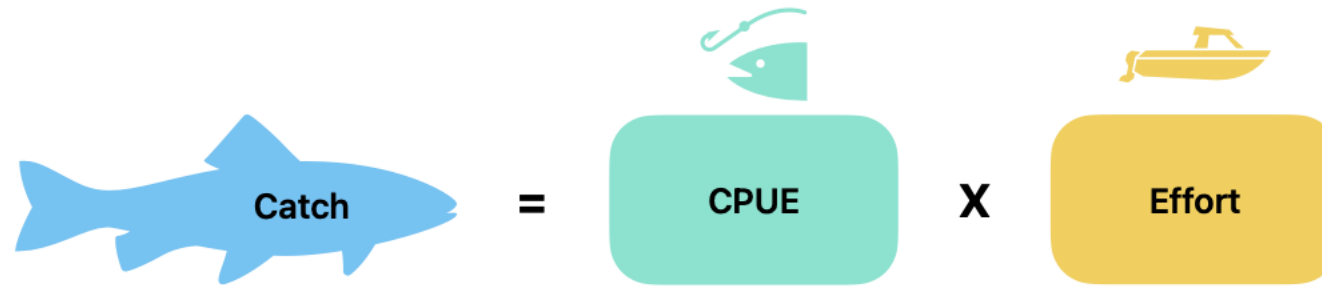
Total fishing effort = F x D x BAC

or

Total fishing effort = F x D x FAC

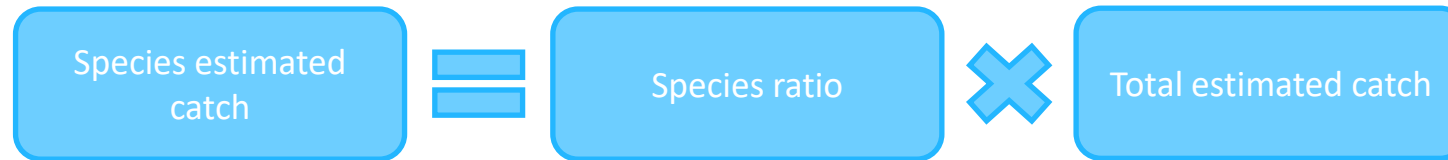
5. Catch estimation

Catch estimation: formula



5. Catch estimation

Catch per species: formula



Where:

- Species ratio: is a fraction of the total catch corresponding to a species and is formulated from the proportion of a species found in the samples.
- Total estimated catch: is the estimated total catch discussed earlier

$$\textit{Speciesratio} = \frac{\textit{Totalcatchofthespecies}}{\textit{Totalamontofcatch}}$$

5. Catch estimation

Species value and total value: formula

$$\text{Species estimated value} = \text{Price} \times \text{Species estimated catch}$$

Where:

- Price: is the sample first-sale price of the landed species
- Species estimated catch: is the estimated species catch discussed earlier

5. Catch estimation

Species value and total value: exercise

$$\text{Species estimated value} = \text{Price} \times \text{Species estimated catch}$$

- Sum the trade_value per species
- Calculate the “average” species price
- Calculate the total estimated value per species

6. ARTFISH R package


$$\text{CPUE} = \frac{\text{Catch}}{\text{Fishing effort}}$$

- Good news : ArtfishR package has been developed
- Functions are using the templates: active_vessels, effort, active_days, landings
- So, once data are formatted you can run the functions

- Let's install the package

ArtfishR package

6. ARTFISH R package

R package: installation

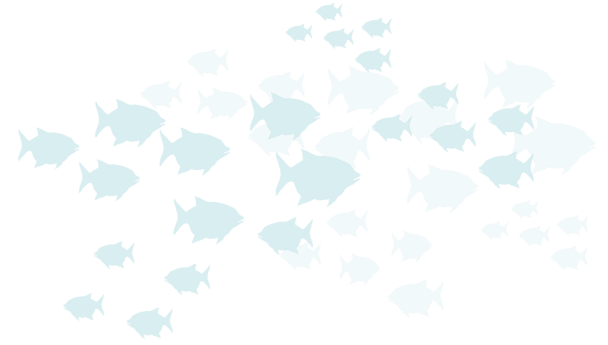
1. Install remotes package: `install.packages("remotes")`
2. Install vrule package: `remotes::install_github("fdiwig/vrule")`
3. Install artfishr: `remotes::install_github("fdiwig/artfishr")`
4. Load the package: `library(artfishr)`

4. Database

Remarks on data good practices

- Standardisation: code list definition, CWP
- Good practices in data storage
- Discussion any difficulties to fill it

Reference and further reading



- SOFIA 2020 <http://www.fao.org/publications/sofia/2020/en/>
- CWP <http://www.fao.org/cwp-on-fishery-statistics/en/>
- International training course in fisheries statistics and in data collection <http://www.fao.org/3/a-i3639e.pdf>
- Guidelines for the routine collection of capture fishery data <http://www.fao.org/3/a-x2465e.pdf>
- Sample-based fishery surveys <http://www.fao.org/3/a-y2790e.pdf>
- Handbook for fisheries socio-economic sample survey <http://www.fao.org/3/a-i6970e.pdf>
- FAO SDGs <http://www.fao.org/sustainable-development-goals/en/>
- FAO'S methodology for damage and loss assessment in agriculture (incl. fisheries and aquaculture) <http://www.fao.org/3/ca6990en/CA6990EN.pdf>
- Impacts of climate change on fisheries and aquaculture (incl. methods and tools for adaptation) <http://www.fao.org/3/i9705en/i9705en.pdf>



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Thank you ▪ Merci
Благодарю ▪ ¡Muchas gracias!
شكرا ▪ 謝謝



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8. Control of estimation quality

Different way to control the quality of the estimations and samples

1. Dispersion parameters: SD, IC, CV
2. Sampling uniformity index (SUI)
3. Accuracy for CPUE and for AC
 - Spatial and temporal accuracy
 - 2 approaches: probabilistic and algebraic
 - Overall accuracy

8. Control of estimation quality

Dispersion parameters

1. Dispersion parameters: SD, IC, CV

- For CPUE
- For AC

8. Control of estimation quality

Sampling uniformity index (SUI)

SUI for FAC

$$\text{Average interviews per day} = \frac{\text{Total number of fishers effort interviews}}{\text{Number of calendar days sampled}}$$

For each sampled day, $\text{Ratio1} = \frac{\text{Number of interviews}}{\text{Average interviews per day}}$ and if $\text{Ratio1} > 1$, $\text{Ratio1} < -1$.

$$\text{SUI FAC} = \text{Arithmetical mean}(\text{Ratio1})$$

SUI for CPUI

$$\text{Average sampled landings per day} = \frac{\text{Total number of landings sampled}}{\text{Number of calendar days sampled}}$$

For each sampled day, $\text{Ratio2} = \frac{\text{Number of landings sampled}}{\text{Average sampled landings per day}}$ and if $\text{Ratio2} > 1$, $\text{Ratio2} < -1$.

=> Interpretation: SUI is considered good if $\text{SUI} > 0.6$ => Sample is well distributed

8. Control of estimation quality

Accuracy

- 2 approaches
 - Probabilistic approach
 - Algebraic approach
- Both can be calculated
- The higher result will be kept
- Accuracy is considered good if **Accuracy >0.9 => Estimate is close to the “real population”**

8. Control of estimation quality

Accuracy: Probabilistic approach

Formula:

$$A = 1 - 1.96 \frac{\sigma_R}{\sqrt{n}} \sqrt{1 - \frac{n}{N}}$$

with

$$\sigma_R = \sqrt{\frac{2N - 1}{6(N - 1)} - \frac{1}{4}}$$

This formula arises from estimating the accuracy of a measurement or proportion under probability sampling with correction for a finite population.

8. Control of estimation quality

Accuracy: Probabilistic approach

The parameters of the equation are computed as follow:

$$x = \frac{\ln(n)}{\ln(N)}$$

$$W = 0.75(1 - \frac{1}{N})$$

$$a = \frac{2WN^2}{(N-1)^2} - \frac{N+1}{N-1}$$

$$g = a + \frac{1-a}{N}$$

$$S = (1-a)(\frac{1}{\ln N} - \frac{1}{N \ln N} - \frac{1}{N})$$

$$k = \frac{-2}{\ln N} \ln \left(\frac{S}{1-S-g} \right)$$

$$a_2 = \frac{(1-S-g)^2}{2S+g-1}$$

$$a_1 = g - a_2$$

On algebraic approach for large populations, the accuracy A is defined by the equation (Stamatopoulos, 2014):

$$A = a_1 + a_2 N^{-kx}$$

8. Control of estimation quality

Estimate the sample size

2 options interesting to compare:

- With tables: in case no previous data are available
- Calculations:
 - Probabilistic approach

$$n = \left[\frac{1}{N} + \left(\frac{1-A}{1.96\sigma_R} \right)^2 \right]^{-1}$$

- Algebraic approach

$$n = \left(\frac{A - a_1}{a_2} \right)^{-\frac{1}{k}}$$

- n retained = smaller result from the 2 approaches