Training Course
for District Fisheries Officers
Fisheries data collection and analysis, Tanzania

Trainers and District Officers manual
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Preparation of this manual

This training manual on improvement of fisheries data collection was developed through the FAO FishCode CTC project, FAO FishCode STF project and the United Nations University’s Fisheries Training Programme. The basic structure of the training course was developed during two workshops held in 2007 and 2008 with participants from Tanzania, Tanzania, Uganda, FAO and UNU/FTP.

The manual was prepared by Mrs. Fatma Sobo (DoF Tanzania), Mr. Peter M. Nzungi (DoF, Kenya), Mr. Musa O. Ogolla (RIAT, Kenya) Mr. Konrad Thorisson (UNU/FTP, Iceland), Mr. Jon Solmundsson (UNU/FTP, Iceland), Mr. Peter Manning (FAO, Italy) and Mr. Gertjan de Graaf (FAO, Italy).

Support for the development of the manual has been provided by the Government of Iceland through the FAO FishCode CTC project and the United Nations University Fisheries Training Programme.
FOREWORD

Reliable data on the fisheries sector is essential for the formulation of fisheries policies and for fisheries management. Since the 1960s fisheries data has been collected through different institutes and systems.

Improvement of data collection is one of the objectives of the Fisheries Development Department of Tanzania. Improvement starts with building the capacity of the human resources involved.

In 2007 the Department in collaboration with the FAO’s Custom Training Courses Project, FAO FishCode STF Project and the United Nations University Fisheries Training Programme (UNU-FTP), with the financial support of the Government of Iceland, started the development of a training course on fisheries data collection and analysis.

In September 2009, the training course will be delivered for the first time in Bagamoyo, Tanzania.

I would like to congratulate the staff of the Ministry of Fisheries Development, Ramogi Institute of Advance Technology (RIAT), UNU-FTP and FAO on the successful collaborative preparation of this course manual and thank them for the time, thought and effort devoted to the task.

It is hoped that the course will be extensively used in the months and years ahead and contribute to improved sustainability of the fisheries sector.

Peter Manning
FAO Custom Training Courses Project
FAO Fisheries and Aquaculture Department
Rome
Italy
Training Course for District Fisheries Officers
Fisheries data collection and analysis, Tanzania

Trainers manual
BACKGROUND

Fisheries in Tanzania

Tanzania is well endowed with water resources, sharing three of the largest inland lakes in Africa, namely Lake Victoria, Lake Tanganyika and Lake Nyasa, a diverse river system, numerous wetlands and the Indian Ocean. The country is reasonably rich in marine and inland fishery resources and therefore has a significant fisheries sector. The main water bodies for freshwater fishing are Lake Victoria, Lake Tanganyika, Lake Nyassa, and Lake Rukwa. The fishing industry in Tanzania is categorised into artisanal and industrial fisheries where the difference is due to the use of traditional and modern/mechanised fishing vessels and gears, respectively. The country has a total of 170,038 artisanal fishers (133,791 freshwater and 36,247 marine) and 52,180 fishing vessels (44,838 freshwater and 7,342 marine vessels). The Tanzanian marine fishery is mainly artisanal (97% of the catch) with a small industrial fleet which targets commercially important species like prawns and tunas. The country’s total catch for 2008 is estimated to be approximately 332,200 metric tons.

The fishery industry accounts for 10% by value of national exports while the contribution of fisheries to GDP is estimated to be 1.6%. The fisheries in Tanzania are managed in accordance with the Fisheries policy, which aims to promote conservation, development and sustainable management of the fishery resources for the benefit of present and future generations. The policy encourages fishing investment, which has resulted in an increase in effort and oscillating downward trends in catches. Post harvest loses in Tanzania can be observed in various products but, unfortunately, precise information is lacking due to there being too few enumerators working within the country.

Fisheries data collection system in Tanzania

Fisheries statistics have been collected since the 1960’s and various systems have been used. Fisheries monitoring started with the Tanzanian Fisheries Information System (TANFIS) between 1989-1996. In subsequent years difficulties were experienced following decentralisation, when regional/district fisheries officers ceased to be answerable to a central Fisheries Division. A catch assessment system was produced under the Southern African Development Community-Regional Fisheries Information Systems (SADC-RFIS) program 2002-2005. This provided a database but was incomplete. The database has since been updated by UNU-FTP and finalised by the Ministry of Natural Resources and Tourism expert. There has also been support from the Indian Ocean Tuna Commission (IOTC). Frame surveys describing the fishing, landing, processing and marketing patterns were undertaken in 1995, 1998, 2001, 2005 and most recently in 2007. Currently catch assessment of the marine landings is based on 22 of 259 coastal landing sites identified in the 2005 frame survey. Data is inputted from 5 districts that are in 5 different administrative regions. A new catch assessment survey (CAS) was introduced from January 2007, following the same procedure of estimation as that of TANFIS, which is based on FAO recommendations.

Why training on fisheries data collection in Tanzania is needed

The main problems/challenges in the fisheries monitoring system are:

- Lack of human and financial resources
- Lack in capacity/knowledge in fisheries monitoring at local level
- Lack of appropriate, cost effective data collection systems
- Lack of reliable, adequate and accurate information
• Gaps in data collection, processing and analysis

Capacity building in fisheries monitoring is a priority and should take place at three levels:

i) Senior staff (University level)
ii) District fisheries officers (Medium level)
iii) Data collectors (Basic level).

An overall strategy is to involve the fishing communities in data collection through Beach Management Units (BMU). This will be achieved in three steps;

i) Training of District Fisheries Officers (DFOs) in Fisheries data collection
ii) Sensitization of BMUs on the importance of data collection for their own use
iii) Subsequent training of the BMUs in data collection by the DFOs

This training manual provides the material aimed at improving the capacity of DFOs in fisheries data collection and basic data processing

The training manual

The training of DFOs (the trainees) will be done through senior staff of the Department of Fisheries (DoF) (trainers) and will cover the following topics:

*Introduction to the training course*

*Module 1: Why collect data*
*Module 2: What to collect;*
*Module 3: How to collect data*
*Module 4: National data collection systems*
*Module 5: Roles in data collection*
*Module 6: Reporting*
*Module 7: Training of enumerators*

The training will be participatory to ensure that DFOs draw on their own experience, to which they can relate the training. This is reflected in the set up of the manual. For each module there are three sections in the manual:

1) The section for the trainers explaining the training objective and techniques for the module. (trainers manual)
2) The section distributed before hand to DFOs with some in information on the module (DFOs manual Part 1).
3) The section to be distributed after the training module is finished, providing background, theory and other information (DFOs manual Part 2).
OPENING OF COURSE

Opening - Trainers material

Objective: The trainees (District Fisheries Officers) develop a clear, common understanding of course objectives; agree on training rules and training schedule

Estimated duration: 1.5 hours

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<td>Formal opening</td>
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<td>Ask the DFOs to introduce themselves and say what they expect from the training course</td>
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<tr>
<td>Explain objective of the training course (PP)</td>
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<tr>
<td>Introduction to the modules and how the training will be conducted i.e: using PowerPoint material, card storming techniques or printed handouts</td>
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<tr>
<td>Plenary questions on above</td>
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<td>DFOs are asked to propose rules. Trainer can then suggest others leading to agreement by the DFOs. (Flipchart and we ask the participants to define the rules)</td>
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**INTRODUCTION**

**Introduction – History**

- Data were collected since 1960
- 1986 – 1996 Tanzania Fisheries Information System (TANFIS)
- 1997 – 2001 Dormant period
- 2002 – 2003 South African Development Countries-Regional Fisheries Information System (SADC-RFIS) Project
- 2004 – 2006 Updated Catch Assessment Survey (CAS) - United Nations University Fisheries Training Program (UNU-FTP), and Indian Ocean Tuna Commission (IOTC) provide equipment
- 2007 – 2009 – FAO Custom Training Courses Project /UNU-FTP develop this training course
Introduction – Bottlenecks in data collection

- Lack of human and financial resources
- Lack in capacity/knowledge in fisheries monitoring at local level
- Lack of appropriate, cost-effective data collection systems
- Lack of reliable, adequate and accurate information
- Gaps in data collection, processing and analysis

Introduction – Capacity building

- Capacity building is needed at all three levels
  - Senior staff
  - DFO’s
  - Data Collectors

  This course can only deal with the last two levels
Introduction - Objectives

Objectives of this course:

- To provide a refresher course on fisheries data collection and analysis for DFOs
- To involve the fishing communities in data collection through Beach Management Units (BMU) by:
  - Training District Fisheries Officers to become trainers (this course)
  - Training of BMU/Enumerators by the DFO’s

The Modules of the training Course

1: Why collect data
2: What to collect;
3: How to collect data
4: National data collection systems
5: Roles in data collection
6: Reporting
7: Training of enumerators
Course Setup

- Training course will be participatory
- Your experience is needed
- Training methods
  - Presentations
  - Handouts/Manual
  - Group sessions/Card storming
  - Plenary meetings
  - Exercises
MODULE 1: WHY COLLECT DATA

Module 1 - Trainers material-Why collect data

Objective: DFOs understand the need for data collection and the use of data in fisheries management and policy development

Estimated duration: 1.5 hours

Training Technique: Why collect data

Start directly with card storming, explain card storming technique

Card storming: Break into small groups and use card storming technique to obtain the ideas from the participants about why data are needed.

As part of the activity DFOs should discuss what is meant by the articles of the Code of Conduct in Boxes 5 and 6.

Plenary: Groups report back. The trainer groups the cards of the DFOs in the three main topics:
   i) National Policies
   ii) Fisheries Management
   iii) Regional/International requirements

Discuss the three topics

National policies
  ➢ Ask the DFOs if they can name some National policies for which data of the fisheries sector is important

Fisheries management
  ➢ Ask DFOs why we need fisheries management
    Search for topics as:
    • Stock size are limited
    • Fishing effort has impact on stock size
    • There is optimal level exploitation
    • Fishing beyond the sustainable level can result in reduced fish catches
    • Emphasize long-term sustainability

Regional/international requirements
  ➢ Ask DFOs to give example
    Most obvious - Lake Victoria fisheries, Marine water, Tuna fisheries

Fill in gaps - Summing up, using prepared PP
Module 1: Why collect data

- Why are you collecting data?
- We will get you card storming and then we can discuss
- What is card storming?

Card storming

- Three rules to follow:
  1. Give your idea in one short sentence
  2. One idea per card
  3. Write clearly and large
Card storming

Rule 1: Provide your idea in one short sentence

- Budget
  - With the allocated budget we can do our work
  - We have to use a large part of our budget for other purposes

Card storming

Rule 2: Only one idea per card

- The budget is not enough. The staff is not qualified and information is not available
  - There are too many fishers in the area
Card storming

Rule 3: Write clearly and large

- To many fishers in the area

Regrouping of cards/ideas

Provide your ideas

Regrouping & Naming
Card storming: Why collect data

Why collect data
1. Split in two groups
2. Use card storming
3. Report back in plenary

Module 1: Summary-Why collect data

Data are needed to make rational decisions for:
- Development of national policies
- Evaluation of the fisheries performance in relation to management objectives
- Fulfilling regional requirements
Module 1: Summary - why collect data

* National policies
  - Formulation of policies concerning
    - Contribution to economy
    - Maintaining food security
    - Sustaining ecosystem
  - Evaluation of policies
  - Policies update

* Fisheries management
  - Evaluation of fisheries activities
  - Fishing effort has impact on fish stock size
  - There is an optimal level of exploitation
  - Fishing beyond the sustainable level can result in reduced fish catches
  - Long-term sustainability - maintain fish stock for future generation
Module 1: Summary - why collect data

Regional/international requirements
- Regional coordination
- Data sharing for management purpose etc
- E.g. Lake Victoria Fisheries Organization (LVFO), Indian Ocean Tuna Commission (IOTC) etc. Shared stocks cannot be managed by one nation alone
MODULE 2: WHAT TO COLLECT

Module 2A: Trainers material - Introduction, types of data needed for fisheries management

Objective: The DFOs understand what they have to collect, and how the collected data can be used in fisheries management.

Estimated duration: 1.5 hours

Training Technique: What to collect for fisheries management

Introduction using PP

Card storming: Break into small groups and ask the DFOs to list the data needed for Fisheries management. Group the cards following

- Effort (Collected or calculated)
- CPUE (Collected or calculated)
- Species
- Total catch (note calculated, not collected)
- Stock assessment, length frequencies, acoustic surveys
- other data

Plenary: In discussion with DFOs, group data for routine data collection and that for ad hoc research projects.

- Effort (Collected or calculated), routine
- CPUE (Collected or calculated), routine
- Species, major species, routine
- Total catch (note calculated, not collected), routine

- Stock assessment, length frequencies, acoustic surveys, ad hoc
- other data, ad hoc

Summary: Training emphasise on routine data collection: Fishing effort, Total catch, CPUE
Module 2A: What to collect

- We collect data for:
  - Fisheries management
  - National policies
  - Regional requirements
- In this module, we will only discuss data to support fisheries management

Card storming

- Split into two groups and come up with the data needed to support fisheries management
- Report back in plenary
Module 2A: Summary—What to collect for fisheries management

- **Routine basis data**
  - Effort
  - CPUE
  - Species
  - Total catch

- **Non routine (Ad hoc) data**
  - Stock assessment, length frequencies, acoustic surveys
  - Other data
Module 2B: Trainers material - What is needed to estimate fishing effort

Objective: The DF0Os understand what is effort and what data is needed to estimate fishing effort

Estimated duration: 1.5 hours

**Training Technique: What is needed to estimate fishing effort**

Plenary session: Take the cards for effort from the previous card storming of Module 2A.

Ask DFOs:
- What is fishing effort?
- What is needed to estimate fishing effort?
- How is fishing effort used for informing fisheries management decisions?

Trainer: Through plenary group discussion followed by traditional lecture

- Structural fleet data or capacity: frame survey, vessel register, register of fishing licenses etc
- Data used to calculate effective fishing effort measured as number of trips, number of vessels active per day, boat activity coefficient (BAC) or gear activity coefficient (GAC).
- Try to explain that at small landing site no of active boats is easy to see, So fishing effort= No of active vessels*no of fishing days
- In large water body/or large landing site, where you can not follow all boats you need to use Boat Activity Coefficient. then fishing effort=Fishing capacity*BAC*no of fishing days, whereby
- BAC= No active boats sampled/Fishing capacity

If formula fishing effort = fishing capacity*activity level
or Fishing effort = Fishing capacity*BAC* no of fishing days, is understood then distribute exercises,

Go through exercises, discussion
Module 2B: What is needed to estimate fishing effort

- What is needed to estimate fishing effort?
- How is fishing effort calculated?
- How is fishing effort used in fisheries management?

Small groups with Flip charts
- Discuss in small groups, use info which came up in Module 2A
- Use flip charts
- Report in plenary
Module 2B: Summary - What is needed to estimate fishing effort

- Fishing capacity is number of crafts/gears as recorded in frame survey
- Fishing effort is related to number of active crafts as only active crafts catch fish
- Fishing effort = $F_{\text{cap}} \times$ Activity level
MODULE 2B: Summary - What is needed to estimate fishing effort

ONLY ACTIVE BOATS CATCH FISH

- Fishing effort related to the proportion of the Fishing capacity which is active.
- This proportion is called Boat Activity Coefficient (BAC)
- $BAC = \frac{\text{No active crafts}}{\text{Total number of crafts from frame survey}}$
- $BAC = \frac{\text{No active crafts}}{F_{\text{cap}}}$
- $BAC$ from example?

Module 2B: Summary - What is needed to estimate fishing effort

- Activity level is related to no of active crafts (BAC)
- And on how many days the active crafts go fishing in a month or the No of Fishing days (A)
Module 2B: Summary—What is needed to estimate fishing effort

- Fishing effort = $F_{cap} \times \text{activity level}$
- Fishing effort = $F_{cap} \times \text{BAC} \times A$

Where:
- \text{BAC} = \text{Boat Activity Coefficient}
- \text{BAC} = \frac{\text{No. of active fishing crafts}}{\text{total number of crafts from frame survey}}
- \text{BAC} = \frac{\text{No. of active fishing crafts}}{F_{cap}}
- A = \text{Number of fishing days}
Module 2B: Summary - What is needed to estimate fishing effort

- Only active boats catch fish
- Lake is too large to follow all boats
- We follow one landing site only
- Boat activity of the sampled landing site is representative for the whole lake

Module 2B: Summary - What is needed to estimate fishing effort

- **Large landing sites**
  - Fishing effort = $F_{\text{cap}} \times (\text{No. of active crafts}/F_{\text{cap}}) \times \text{no. of fishing days}$

- **Small landing sites**
  - Fishing effort = No. of active boats $\times$ no. of fishing days (this only applies if it is possible to monitor all the boats)
Module 2B: How is fishing effort used in Fisheries management

- Could you tell how fishing effort is used in fisheries management
- In case of over-fishing, effort can be reduced

Module 2B: Summary-What is needed to estimate fishing effort

- Exercises
Module 2C: Trainers material - Catch per Unit of Effort (CPUE)

Objective: The DFOs understand what data is needed to estimate CPUE.

Estimated duration: 1.5 hours

Training Technique: What is needed to estimate CPUE?

Introduction Take the information from Module 2 A

In small groups,
- Ask participants if they know what is CPUE
- Ask participants for examples of CPUE
- Ask the participants what are the best measures of CPUE

Groups report back to plenary. Discussions
- Ask the participant why we need CPUE (Total catch estimation & fisheries management)
- Boat based CPUE versus Gear based CPUE

CPUE and Fisheries management will be covered in Module 2E

Summary using PP: How CPUE can be used as an index on stock size

Module 2C: Catch per Unit of Effort (CPUE)

- Give examples of CPUE
- Definition of CPUE
- How CPUE is used
- Boat based CPUE vs Gear based CPUE
Module 2C: Catch per Unit of Effort (CPUE)

Small groups with flip charts

Module 2C: Summary - Catch per Unit of Effort (CPUE)

- CPUE = Average catch of a fishing unit by unit of time
  
  Eg.
  
  ✓ Catch by canoes per day
  ✓ Catch by fisher per trip
  ✓ Catch by gillnet per day
  ✓ Catch by trap per day
Module 2C: Summary - Catch per Unit of Effort (CPUE)

- Measure of CPUE
  
  \[ \text{CPUE} = \text{Amount of Catch per one Fishing Unit by Unit of time} \]

- Boat based CPUE vs Gear based CPUE

  - In artisanal fisheries Boat based CPUE is the most cost effective way to estimate total catch
  - For scientific reasons gear based CPUE is more appropriate to use but very difficult to obtain in artisanal fisheries
Module 2C: Summary - Catch per Unit of Effort (CPUE) and Fisheries management

❖ CPUE use
  ▪ Calculate Total catch
  ▪ The CPUE may be seen as an indicator of the abundance of exploitable stock of fish (without knowing the exact stock size).
  ▪ If the CPUE goes down we assume the stock is decreasing

Module 2C: Exercises - Catch per Unit of Effort (CPUE)

❖ Exercises
Module 2 D: Trainers material - Total catch

**Objective:** DFOs should be able to calculate total daily, monthly and annual catch from boat-based and gear-based CPUE

Estimated duration: 1.5 hours

**Training Technique: Total catch**

Introduction, using PP: How to calculate total catch

Traditional lecture on Total catch

- Check if DFOs understand the boat and gear activity coefficients (BAC and GAC) concepts.

- Check that DFOs do not confuse boat based CPUE and gear-based CPUE

DFOs work in pairs on exercises for calculation of total catch by species. Include examples with errors for DFOs to identify.

Go through exercises, discussion

Summary on total catch, using PP

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**Module 2D: Total catch**

- Total catch can be calculated by multiplying the catch per unit of effort with total fishing effort
  
  Total catch = CPUE * Fishing effort
  
  As: Fishing effort = BAC * F_{cap} * A
  
  Total catch = CPUE * BAC * F_{cap} * A

- BAC = Boat Activity Coefficient
- BAC = No. of active fishing boats/fishing capacity
- F_{cap} = Fishing capacity
- A = Number of fishing days per month
Module 2D: Total catch

**Boat as a sampling unit**
Total Catch = Fishing capacity*activity level*CPUE
Total catch = $F_{cap-boat} \times A \times BAC \times CPUE_{boat}$

**Gear as a sampling unit**
Total Catch = Fishing capacity*activity level*CPUE
Total catch = $F_{cap-gear} \times A \times GAC \times CPUE_{gear}$

Module 2D: Total catch

**Exercises**
Module 2 E: Trainers material - Total catch by species

**Objective:** DFOs should be able to calculate total catch by species

Estimated duration: 0.5 hours

Training through exercise

---

**Module 2E: Total catch by species**

- Total catch by species is calculated by the proportion of the species in the catch obtained from a sampling programme.
- Total catch\text{\_species} = \text{Total catch} \times \text{proportion species}
Module 2E: Total catch by species

Exercises
Module 2F: Trainers material – CPUE and Fisheries management

**Objective:** The DFOs understand the value of CPUE for fisheries management and understand the concept of a Scheafer curve

This is an advanced module, only to be used if DFOs have gone easily through the previous modules

Estimated duration: 2 hours

---

**Training Technique: CPUE and Fisheries management**

Trainer gives classical lecture about this topic

Summary up using PP: How CPUE can be used as an index on stock size

---

**Catch per Unit of effort** is often the single most useful index for long term monitoring of a fishery

CPUE is often used as an index of stock abundance, as there is a relation assumed between CPUE and stock abundance

E.g. if there are twice as many fish in a lake, twice as many will be caught by the same fishing effort.
Module 2F
CPUE and fisheries management

This assumption has been used in the development of surplus production fish stock assessment models.

The objective of surplus production models is to find optimum level of fishing effort, which produces maximum sustainable yield (MSY).

Module 2F
CPUE and fisheries management

Surplus production models are relatively simple to apply as they pool the overall effect of recruitment, growth and mortality into a single parameter called production.

The whole fish stock is considered as a homogenous biomass, age-, size-, sex- and other differences are ignored.

Tanzania Trainers manual
Module 2F
CPUE and fisheries management

In Module 1 we introduced the biomass model:

\[ \text{Biomass}_{\text{year2}} = \text{Biomass}_{\text{year1}} + \text{Recruitment} + \text{Growth} - \text{Natural mortality} - \text{Catch} \]

Surplus models combine all three parameters in grey into one “surplus production”:

\[ \text{Biomass}_{2} = \text{Biomass}_{1} + \text{surplus production} - \text{Catch} \]

Module 2F
CPUE and fisheries management

Biomass\textsubscript{2} = Biomass\textsubscript{1} + surplus production -Catch

The basic idea is that if we maintain the catch equal to the surplus production (i.e. they cancel out), then the biomass remains the same between years (Biomass\textsubscript{2} = Biomass\textsubscript{1}), and we have a sustainable yield
Module 2F
CPUE and fisheries management

- Maximum Sustainable Yield (MSY) in a surplus production model is estimated through a Schaefer curve
- In a Schaefer curve we plot CPUE against effort and with the estimated parameters of the regression line we can calculate MSY and $F_{msy}$

The Schaefer model
- Assume a lake with fish stock of unfished biomass $B_0$
- Then we start fishing
- As fishing effort is increased yield increases and the biomass decreases up to a point, where the Biomass is halved ($B_0/2$)

- At $B_0/2$ the highest growth rate of the stock (and MSY) are reached
- Increasing effort beyond 5.5 reduces both biomass and catch again and is not sustainable
MODULE 3: HOW TO COLLECT DATA

Module 3: Trainers material - How to collect data

Objective: By the end of Module 3: DFOs understand basic statistical concepts and that samples need to be collected according to statistical protocols so as to obtain reliable data and to reduce the risk of bias.

Estimated duration: 10 minutes

In an introduction the trainer explains the objectives of the two modules

3A: Basic Statistical methods and concepts
   Objective: The DFOs understand the basic statistics of data collection

3B: Sampling techniques and dealing with potential problems
   Objective: The DFOs realize what can go wrong at various stages of the data collection process
Module 3 A: Trainers material - Basic Statistical methods and concepts

**Objective:** The DFOs understand the basic statistics of data collection  
Estimated duration: 2.5 hours

**Training Technique: Basic statistical methods and concepts**

Provide the example of “Lake Pisces”, 100 hectares, 20 boats, 1 landing site. Unlimited funds. Ask what would be best way to monitor this lake.- to get the most accurate result.

Short discussion with partner, followed by discussion in plenary

DFOs in small groups: Hand out fact sheet of Lake Victoria and ask if the same method can be used. If not, why not? Ask to list reasons why not.

=> **Conclusion: Sampling is needed**

After this short introduction card storming on major issues followed by plenary discussion.

Major issues through traditional lecture
- Stratification
- Sample size, minimum sample size 30 crafts, per type, per month

Summary on Major strata and Minor strata and sampling table

---

**Module 3A: Basic Statistical Methods and Concepts**

- **Lake Pisces**
  - Area 100 hectares, 20 boats, 1 landing sites, well trained staff and unlimited funds
  - How do you monitor this small lake to get most accurate results?

Plenary discussion
Module 3A: Basic Statistical methods and concepts

Lake Victoria?
- Area 35,000 km², 30,208 boats, 634 landing sites, limited staff and limited funds
- How would you monitor this big lake to get most accurate result?

Module 3A: Basic Statistical methods and concepts.

Conclusion
- Lake Pisces: Small area, limited no of boats, you can cover completely:
  Full Enumeration or Census
- Lake Victoria: Large area, large numbers of landing sites, large number of boats:
  Sampling is essential.
Module 3A: Basic Statistical methods and concepts

- What are the major issues in sampling

*Card storming and Discussion*

---

Module 3A: Basic Statistical methods and concepts

- Major issues in sampling
  - What is sampling
  - Design/select sample sites/stratification
  - Sample size
  - Sampling frequency
  - Sample methods
  - Others/Resources
What is sampling?

Sampling is a ‘short-cut' method for investigating a whole group.

What is sampling?

Let’s say it costs 1$ to investigate one square of the puzzle.

Cost of sample = 4$

Good estimate

Total cost = 16$
What is sampling?

Can we reduce the cost and still get an acceptable estimate?

Total cost = 16$

Sampling in Time and Space

★ At some sites, boats are sampled (Space)
★ Sampling is done at certain days only (Time)
It matters greatly how the sampling is done

Random sampling (i.e., not choosing) is the best scientific way to sample. If not possible or practical use stratification.

8 LANDING SITES, WHERE AND WHAT DO WE SAMPLE?

make six with dice
Module 3A: Basic Statistical methods and concepts

We select at Random?

- Random picking of two landing sites -> high probability of only picking red sites
- It can work for the boats but absolutely not for landing sites
- So we use systematic site selection through stratification

Module 3A Summary: Basic Statistical methods and concepts

Stratification

- **Major strata** – are done for Administrative classification, e.g. Region, District
- **Major substrata** – Ecological purpose - water bodies, rivers, dams, lakes etc
- **Minor strata** – to improve sampling for higher accuracy and to reduced costs! e.g boat types, gear types
Module 3A: Basic Statistical methods and concepts

Example

**Major stratum**: Kilimanjaro District

**Major substratum**: Lake Mayan Mara

**Minor strata**: Boats with traps
                 Boats with gillnets

Structure of sampling

1. Similar boats and similar gear are already grouped and counted separately in Frame survey
1. Similar boats and similar gear are already grouped and counted separately in Frame survey.

2. Samples are taken from all gear and boat groups, so that all fish species and all fish sizes have a chance to be included.
Structure of sampling

1. Similar boats and similar gear are already grouped and counted separately in Frame survey

2. Samples are taken from all gear and boat groups, so that all fish species and all fish sizes have a chance to be included

Minor Strata

Sample Size and frequency?
What is your opinion on sampling sizes
Sample size?

<table>
<thead>
<tr>
<th>Total number of landings</th>
<th>Number of landings to be measured</th>
</tr>
</thead>
<tbody>
<tr>
<td>300</td>
<td>90      91     92     93     94     95     96     97     98     99</td>
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<tr>
<td>400</td>
<td>39      38     37     36     35     34     33     32     31     30</td>
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<td>5000</td>
<td>39      38     37     36     35     34     33     32     31     30</td>
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</table>

Conclusions for sample size

Minimum requirement

Per landing site

- 30 type of boats or gears sampled per month!, 90% accuracy,
- 125 type of boats or gears sampled per month, 95% accuracy, if enough funds are available
**Sampling Frequency**

- Refers to how often sampling is done.
- Since your sample size should be a minimum of 30, then you have to take either 1 sample per day for 30 days or 30 samples once in a month or 5 landings in 6 days.
- The rule is you should end up with at least 30 landings in a month.

**Why this stratification?**

Combined sampling of traps and gill nets
Large variation
Why this stratification?

- Even if you take a lot of samples from Traps and Gillnets combined you still wouldn’t get accurate estimates
- By separating Traps and Gillnets you get a more accurate estimate for less costs (smaller samples needed)

Module 3A: Basic Statistical methods and concepts

- Make Recap with Frame survey $F_{cap}$ and sampling
Module 3B: Trainers material – How to sample and dealing with potential problems

Objective: The DFOs realize what can go wrong at various stages of the data collection process
Estimated duration: 2.5 hours

Training Technique: Monitoring techniques and dealing with potential problems

Introduction using PP
Card Storming: Break into small groups. List problems leading to inaccurate data
Plenary: Discuss problems and make a complete list
Card Storming: The same groups.
Ask what problems can be solved and how.
Plenary: Discuss solutions to problems and make a list.
Summing up and filling in gaps, using PP.

Two card storming sessions

- List problems leading to inaccurate data
  Plenary discussion

- What problems can be solved and how
  Plenary discussion
Module 3B: Summary - How to sample and dealing with potential problems

- Problems leading to inaccurate data
  - Including/excluding certain vessels
  - Including day landings and excluding night landings
  - Conflict of interests (e.g. illegal gear)
  - Multigear problems
  - Cooked data
  - Recording errors

Module 3B: Summary - How to sample and dealing with potential problems

- Monitoring techniques
- Cleaning data
- Ethics, confidentiality, attitude, reluctant respondents
- Design problems
- Implementation problems
Module 3B: Summary - How to sample and dealing with potential problems

- **Monitoring techniques**
  - A on-going process of checking the data collection process.

- **Cleaning data**
  - Identifying discrepancies in the collected data, verifying and ground truthing the data

- **Ethics, confidentiality, attitude, reluctant respondents**
  - To gain the acceptance of the fishing communities from which the data will be collected

---

Module 3B: Summary - How to sample and dealing with potential problems

- **Design problems**
  - Biased sample
  - Poor sampling plan
  - Inappropriate sample size

- **Implementation problems**
  - Unclear instructions for enumerators
  - Conflict of interest
  - Lack of motivation
MODULE 4: DIFFERENT COMPONENTS OF THE NATIONAL DATA COLLECTION SYSTEMS

Module 4A: Trainers material – Different components of the fisheries data collection system in Tanzania.

Objective: To ensure that DFOs have a clear understanding of how the national data collection system is structured
Estimated duration: 2.5 hour

Training Technique: National data collection systems

Introduction two slides to provide the data collection system (PP)

Plenary,
  A. What is frame survey, & problems & forms
  B. What is CAS & problems and forms
  C. Others, ........

Discussion of the national data collection system – merits and problems discussed based on what DFOs have learned in previous module

Present forms as PP and discuss filling

Recapping on the national data collection system (PP)

Module 4: National Data Collection System

🌟 Routine data collected in Tanzania
  – Frame survey
  – Catch Assessment survey (CAS)
  – Others
    • Export data
    • Import data
    • Other important information in fisheries
Module 4: National Data Collection System

**Plenary discussion**
- What is frame survey? (problems, forms)
- What is CAS? (problems, forms)
- National data collection system
- Filling of forms

Module 4: National Data Collection System

**Frame survey - biannual**
- Inventory
- Total enumeration
- Problems /bottlenecks
- Forms
### FISHERY INVENTORY FORM

**INVENTORY OF FISH PRODUCING FACTORS - LANDING SITE APPROACH**

<table>
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**TOTAL**

---

**MINISTRY OF NATURAL RESOURCES AND TOURISM**

**FISHERIES DIVISION**

**SHEET 1: SUMMARY DETAILS OF NUMBER OF CRAFT ON BEACH AND FACILITIES**

1. **NAME OF RECORDER** ........................................ TEL NO. ........................................

2. **STATUS/RANK OF RESPONDENT** ........................................

3. **DATE** ........................................

4. **REGION** ........................................

5. **DISTRICT** ........................................

6. **VILLAGE** ........................................

7. **NAME OF LANDING SITE** ........................................

**CRAFT SUMMARY**

8. **TOTAL NUMBER OF CRAFT ON BEACH** ........................................

9. **TOTAL NUMBER OF DERELICT CRAFT** ........................................

10. **TOTAL NUMBER OF TRANSPORT CRAFT (NO FISHING)** ........................................

11. **TOTAL NUMBER OF FISHING CRAFT WITH OUTBOARD ENGINE** ........................................

12. **TOTAL NUMBER OF FISHING CRAFT WITH INBOARD ENGINE** ........................................

13. **TOTAL NUMBER OF FISHING CRAFT USING PADDLES ONLY** ........................................

14. **TOTAL NUMBER OF FISHING CRAFT USING SAILS** ........................................

**FACILITIES SUMMARY**

15. **BANDA** ........................................

15a. **PERMANENT** ........................................

16. **COLD ROOM** ........................................

16. **FREEZER** ........................................

18. **FISH KILN** ........................................

19. **FISHING FACILITIES** ........................................

20. **ALL WEATHER ROAD** ........................................

20a. **IF NO HOW FAR TO NEAREST** ........................................

---

Tanzania Trainers manual
### Module 4: National Data Collection System
#### Catch Assessment Survey

**Catch Assessment Survey (CAS) – on-going**
- Routine survey for effort and catch data
- Sampling
- Estimation
- Total catch by major species
- Problems / bottlenecks
- Forms
**DAILY RECORD OF FISH LANDED**

<table>
<thead>
<tr>
<th>Date</th>
<th>Type of Fish</th>
<th>Station</th>
<th>Weight (Kg)</th>
<th>Value (Ksh)</th>
<th>Species</th>
<th>Length (cm)</th>
<th>Weight (Kg)</th>
<th>Value (Ksh)</th>
<th>Total</th>
</tr>
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</tr>
</tbody>
</table>

**Note:**
(a) Weight of fish in Kilograms
(b) Value in Kshs.
(c) No of fish

**Recorded by:** 
Name: ____________________________  Date: ____________________________  Signature: ____________________________

**FU - Fish Unit**
**FC - Fish Center**
**MFU - Multiple Fish Unit**

---

**Module 4: National Data Collection System - Other data**

**Other data collected**
- Export data
- Import data
- Other important information in fisheries
**Module 4B: Trainers Material - Species identification**

**Objective:** The DFOs identify species which are difficult to identify

Estimated duration: 1 hours

**Training Technique: Species identification**

Introduction: Species identification, standardisation,
- Ask DFOs to list major species
- Ask DFOs which species are confusing or difficult to identify

Summary: Give examples of the main commercial species in the relevant water-bodies and their importance in the fishery.

**Module 4B: Species identification**

- Problems in fish identification
- Two groups (exercise)
- Freshwater
- Marine
- List major species – local names
- Point out the confusion or difficulties in species identification
MODULE 5: ROLES IN DATA COLLECTION

Module 5: Trainers material - Roles of DFOs and enumerators in data collection

Objective: The DFOs get a clear picture on their roles and responsibilities in the data collection system.
Estimated duration: 1.5 hours

Training Technique: Roles of DFOs and enumerators in data collection
Introduction
Card Storming: Break into groups. How do you see your role as DFOs? What specific functions do you have?
Plenary Flipchart, Create a complete list of functions, with emphasis on data collection
Plenary: Discuss list and roles in general
Summary of roles (PP)

DFOs roles in data collection
- At the local level
- At the district level
- At the national level
- In relation to enumerators/Feed back to communities
Module 5: Roles In Data Collection

Card storming

Module 5: Summary - Roles In Data Collection

- The functions of a DFO at local levels
  - Link between district office and grass roots
  - Implement data communication policies – Make sure that, data are collected continuously and safely stored
  - Ensuring raw data collected reaches the district office in time
  - Feedback to communities
  - Train Enumerators
Module 5: Summary - Roles In Data Collection

The functions of a DFO at district levels
- Link between Fisheries Headquarters and district officials.
- Implement data communication policies – Make sure that, data are continuously submitted to relevant authorities in time.
- Responsible for custody of field returns.
- Feedback to communities.

Module 5: Summary - Roles In Data Collection

The functions of a DFO at national levels
- Sending fisheries data to Fisheries Headquarters.
- Sending fisheries data to other relevant organizations.
- Feedback to communities.
Module 5: Summary - Roles In Data Collection

Roles of DFOs in relation to enumerators

- Supply data collection tools/inputs
- Ensure quality data is collected
- Supervise data collection processes
- Train enumerators
MODULE 6: REPORTING

Module 6A: Trainers material - Reporting in Tanzania

Objective: The DFOs know their responsibilities in data reporting and understand data flow from landing site to HQ.

Estimated duration: 1 hour

Training Technique: National reporting

Introduction to National reporting and data flow

Plenary: Each group describes their understanding of how the system works. List problems, compare and discuss.

Summary (PP)

MODULE 6A: Reporting

✦ National reporting and data flow
  – Landing site to district
  – District to national level
Data flow

MODULE 6A: Reporting

Meeting deadlines
- The raw data (Form 21B) should reach to District Fisheries Officer not later than 5th day of each month
Module 6B: Trainers material - Storage and use of data

Objective: The DFOs know how to store and use data at District level

Estimated duration: 1 hour

Training Technique: Storage and use of data

Introduction to Storage and use of data

Group discussions: Split into groups say two or three. Each group will discuss on storage and use of data

Plenary: Each group describes their finding and understanding on storage and use of data

List problems encountered during the process, compare the presentation from different groups and discuss.

Summing up

MODULE 6B: Storage and use of data

- At the district all fisheries data are stored in electronic and/or hard copy form at Fisheries Division, Statistics section
- Split into groups. Discuss storage and use of data
- Plenary: Each group describes their finding
- Compare the presentation from different groups and discuss.
- Flip charts
MODULE 6B: Summary storage and use of data

- Data enumerators collect information about fish catch from all vessels/boats landed in their respective landing sites.
- At the site, form no 21A is used, thereafter the data is transferred to form 21B.

- The recorded forms have to be sent to the respective DFO.
- If computer is available, the DFO enters the data into CAS database.
- On a monthly basis the DFO will send an electronic or hard copy of the collected data to the Fisheries Division Headquarters to be joined to the main CAS Database.
MODULE 6B: Summary storage and use of data

* The information of fish production will be disseminated to DFOs, cross sectors, institutions and other stakeholders.
**MODULE 7: TRAINING OF ENUMERATORS**

**Module 7: Trainers material – Training of enumerators**

**Objective:** To prepare the DFOs for training enumerators at the landing sites and obtain ideas of DFOs for training of enumerators/BMUs

Estimated duration: 3 hours

<table>
<thead>
<tr>
<th><strong>Training Technique: Training of Enumerators</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>In plenary session</td>
</tr>
<tr>
<td>• What is the importance of training enumerators</td>
</tr>
<tr>
<td>• Which topics are important for training of enumerators/BMUs</td>
</tr>
<tr>
<td>• Implementation of training by DFOs.</td>
</tr>
</tbody>
</table>

---

**Module 7: Training of enumerators**

- Importance of training enumerators
- Why are BMUs involved in data collection?
- How should enumerators be trained?
Module 7: Training of enumerators

Card storming

Module: Training of enumerators

- Implementation of training
  - DFOs organise the training
  - Train in groups
  - Train only the basics not the difficult matters
Module 7: Training of enumerators

- List of topics to be covered
  - Fisheries management
  - Co-management
  - Why data collection
  - Species/boat/gear identification
  - What data to collect
  - How to collect
  - Problems associated with data collection
Training Course
for District Fisheries Officers
Fisheries data collection and analysis,
Tanzania

District Fisheries Officers manual
Part 1 & Part 2
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Preparation of this manual

This training manual on improvement of fisheries data collection was developed through the FAO FishCode CTC project and the FAO FishCode STF project. The basic structure of the training course was developed during two workshops held in 2007 and 2008 with participants from Kenya, Tanzania and Uganda.

The manual was prepared by Mrs. Fatma Sobo (DoF Tanzania), Mr. Peter M. Nzungi (DoF Kenya), Mr. Musa O. Ogolla (RIAT Kenya) Mr. Konrad Thorisson (UNU/FTP, Iceland), Mr. Jon Solmundsson (UNU/FTP, Iceland), Mr. Peter Manning (FAO, Italy) and Mr. Gertjan de Graaf (FAO, Italy).

Support for the development of the manual has been provided through the government of Iceland-funded FAO FishCode CTC project.
FOREWORD

Reliable data on the fisheries sector is essential for the formulation of fisheries policies and for fisheries management. Since the 1960s fisheries data has been collected through different institutes and systems.

Improvement of data collection is one of the objectives of the Ministry of Fisheries Development of Tanzania. Improvement starts with building the capacity of the human resources involved.

In 2007 the Ministry in collaboration with the FAO’s Custom Training Courses Project, FAO FishCode STF Project and the United Nations University Fisheries Training Programme (UNU-FTP), with the financial support of the Government of Iceland, started the development of a training course on fisheries data collection and analysis.

In September 2009, the training course will be delivered for the first time in Machakos, Tanzania.

I would like to congratulate the staff of the Ministry of Fisheries Development, Ramogi Institute of Advance Technology (RIAT), UNU-FTP and FAO on the successful collaborative preparation of this course manual and thank them for the time, thought and effort devoted to the task.

It is hoped that the course will be extensively used in the months and years ahead and contribute to improved sustainability of the fisheries sector.

Peter Manning
FAO Custom Training Courses Project
FAO Fisheries and Aquaculture Department
Rome
Italy
Training Course
for District Fisheries Officers
Fisheries data collection and analysis,
Tanzania

PART 1 - PRELIMINARY INFORMATION FOR THE MODULES

**ACANTHURIDAE**

*Acanthurus dussumieri* Valenciennes, 1835

- 9 spines and 25–27 soft rays
- Peduncle spine
- 3 spines and 24–26 soft rays

**Remarks:** Minute scales; caudal fin lunate in adults; yellow-orange band between eyes, body pale brown; dorsal and anal fins yellow, caudal fin blue.
BACKGROUND

Fisheries in Kenya

Kenya is endowed with both marine and inland water resources. The inland water resources include Lakes and Rivers of varying sizes. Some of the major Lakes include; Lake Turkana (6,405 Km2), Lake Victoria-Kenyan side (6% of the whole lake =3,755 km2), Lakes Naivasha (210 Km2), Baringo (129 Km2), and Jipe (39 Km2). Major rivers include the Tana (700 Km), the Athi/Galana/Sabaki (530 Km), the Ewaso-Ngiro-North (520 Km), the Kerio (350 Km), the Yala, the Nyando, the Nzoia, and the Sio among others.

In addition to these inland water resources, Kenya also enjoys a vast coastline of 640 km on the Western Indian Ocean, and has under its jurisdiction the 200 nautical miles Exclusive Economic Zone (EEZ).

The Kenyan fishery is mainly artisanal with very few commercial/industrial vessels, which target mainly shrimp, and several tens of purse seiners and long liners belonging to Distant Water Fishing Nations (DWFN) which operate under Kenyan licenses in the EEZ targeting tuna and tuna-like species. The artisanal fishery accounts for almost all the inland and marine water catches and consequently it is currently the most important fishery in the country, even though our EEZ, which is predominately for commercial fishing, is under-exploited with an estimated potential of between 150,000 to 300,000 metric tons (Commonwealth secretariat report 2003 by Dr. Habib)

Inland capture fisheries contributed 91.4% (124,643 mt ) in 2007 followed by Marine artisanal fishery 5.5% (7,467 mt ) and Aquaculture (fish farming) with a contribution of 3.1% (4,245 mt). This catch was produced by 62,033 fishers (51,879 from inland and 10,154 from the marine waters) using 18,606 fishing crafts (16,238 from inland and 2,368 from marine)

The fisheries sub-sector provides employment and income to over 800,000 Kenyans engaged in fish production and related enterprises. In terms of contribution to the Gross Domestic Product (GDP), Kenya's fishing industry is small but growing. The fishing industry contributed 0.5% of the monetary GDP in the year 2007 up from an annual average of 0.2% between 1971 and 1981

Fisheries data collection system in Kenya

Kenya’s national data collection system comprises three main components namely frame surveys, catch assessment surveys and the routine data collection.

Frame surveys

These are carried out bi-annually for Lake Victoria and the artisanal fisheries of the marine waters. The surveys were started in 2000 for Lake Victoria and 2004 for the artisanal marine waters.

Catch assessment survey (CAS)

Catch Assessment Surveys have been carried out only in Lake Victoria since 2005 on quarterly basis

Routine data collection

This is a daily data collection carried out by fisheries staff and members of the Beach Management Units (BMUs). Mainly it deals with collection of data on catch weight and ex-vessel value of the fish by species per fishing boat. This routine daily data collection applies to all water bodies in the country. The data collection forms used in Lake Victoria and the artisanal marine waters are given below.
**Why training on fisheries data collection in Tanzania is needed**

The main problems/challenges in the fisheries monitoring system are:

- Lack of human and financial resources
- Lack in capacity/knowledge in fisheries monitoring at local level
- Lack of appropriate, cost effective data collection systems
- Lack of reliable, adequate and accurate information
- Gaps in data collection, processing and analysis

Capacity building in fisheries monitoring is a priority and should take place at three levels:

1. **Senior staff (University level)**
2. **District fisheries officers (Medium level)**
3. **Data collectors (Basic level)**

An overall strategy is to involve the fishing communities in data collection through Beach Management Units (BMU). This will be achieved in three steps:

1. Training of District Fisheries Officers (DFOs) in Fisheries data collection
2. Sensitization of BMUs on the importance of data collection for their own use
3. Subsequent training of the BMUs in data collection by the DFOs

This training manual provides the material aimed at improving the capacity of DFOs in fisheries data collection and basic data processing.

**The training manual**

The training of DFOs (the trainees) will be done through senior staff of the Department of Fisheries (DoF) (trainers) and will cover the following topics:

*Introduction to the training course*

**Module 1:** Why collect data

**Module 2:** What to collect;

**Module 3:** How to collect data

**Module 4:** National data collection systems

**Module 5:** Roles in data collection

**Module 6:** Reporting

**Module 7:** Training of enumerators

The training will be participatory to ensure that DFOs draw on their own experience, to which they can relate the training. This is reflected in the set up of the manual. For each module there are two sections in this manual:

1. A section provided to the DFOs before the training starts, explaining the objective and providing necessary info for each module
2. The second section to be distributed after the training module is finished and provides more background, theory, solutions of exercises and other information.
INTRODUCTION
Introduction – History

- Data were collected since 1960
- 1986 – 1996 Tanzania Fisheries Information System (TANFIS)
- 1997 – 2001 Dormant period
- 2002 – 2003 South African Development Countries-Regional Fisheries Information System (SADC-RFIS) Project
- 2004 – 2006 Updated Catch Assessment Survey (CAS) - United Nations University Fisheries Training Program (UNU-FTP), and Indian Ocean Tuna Commission (IOTC) provide equipment
- 2007 – 2009 – FAO Custom Training Courses Project/UNU-FTP develop this training course

Introduction – Bottlenecks in data collection

- Lack of human and financial resources
- Lack in capacity/knowledge in fisheries monitoring at local level
- Lack of appropriate, cost-effective data collection systems
- Lack of reliable, adequate and accurate information
- Gaps in data collection, processing and analysis
Introduction - Capacity Building

★ Capacity building is needed at all three levels
  – Senior staff
  – DFO’s
  – Data Collectors

This course can only deal with the last two levels
INTRODUCTIONS TO THE MODULES

DFOs material-Opening of course

**Objective of the training course:** To provide a refresher course on fisheries data collection and analysis for District Fisheries Officers (DFOs) and to provide them with the skills to train data collectors at the landing sites

The training

The training will be given through the following 7 modules:

**Module 1: Why collect data**
Why do we collect data? Data are needed to make rational decisions, and to evaluate performance in relation to objectives. In this module objectives of data collection will be discussed and put in the framework of overall policy objectives.

**Objective:** DFOs understand the need for data collection and the use of data in fisheries management and policy development

**Module 2: What to collect;**
Once data collection is related to overall policy objectives, the indicators and data to be collected can be identified

**Objective:** DFOs understand what they have to collect, and how the collected data can be used in fisheries management

**Module 3: How to collect data**
Once we know what data we need, the strategy and methods of data collection can be identified. A major topic to address is the sustainability of data collection as often funds and human resources are limited.

**Objective:** DFOs understand that samples need to be collected according to statistical protocols so as to obtain reliable data and to reduce the risk of bias and they realize what can go wrong at various stages of the data collection process

**Module 4: National data collection systems**
In this module the National data collection system of Tanzania will be presented and discussed

**Objective:** To ensure that DFOs have a clear understanding of how the national data collection system is structured

**Module 5: Roles in data collection**
In this module the roles of data collector, supervisors and others are discussed

**Objective:** The DFOs get a clear picture on their roles and responsibilities in the data collection system

**Module 6: Reporting**
In this module the reporting procedures for the National fisheries data collection system of Tanzania will be discussed

**Objective:** The DFOs know their responsibilities in data reporting and understand data flow from landing site to Headquarters (HQ).

**Module 7: Training of enumerators**
During this module training of fishers in data collection through BMUs will be discussed

**Objective:** To prepare the DFOs for training of enumerators at the landing sites and provide training material for one or 1.5 day of training
The training method

The training will be participatory to ensure that DFOs draw on their own experience, to which they can relate the training. The exercises and questions are designed to get people to think, draw on their experience and learn from each other. These are supplemented by the material provided by the trainers.

The training will consist of presentations, hand out of printed material, plenary group discussion and working group sessions using card storming techniques.
The Modules of the training Course

1: Why collect data
2: What to collect;
3: How to collect data
4: National data collection systems
5: Roles in data collection
6: Reporting
7: Training of enumerators

Course Setup

Training course will be participatory
Your experience is needed
Training methods
- Presentations
- Handouts/Manual
- Group sessions/Card storming
- Plenary meetings
- Exercises
MODULE 1 -WHY COLLECT DATA

Objective: DFOs understand the need for data collection and the use of data in fisheries management and policy development

Module 1- DFOs material Background

Do you know the Code of conduct for responsible fisheries?
Do you know what a fish stock is?
Do you know what could be the impact of fishing on a fish stock?

In this module we discuss why you are collecting data and will use for the first time the card storming technique

Box 1: Card storming Technique

DFOs are organised into small groups; each group is given a pile of A5 cards and asked to write ideas, issues or suggestions, using one card for each of these.

There are 3 rules:
1. Clearly state one idea in a sentence
2. Write one (1) idea per card
3. Write clearly and large

The cards will be posted up on a board for everyone to see. The cards/ideas will then be sorted into categories and further explored in small group and whole group discussion.

Posting your ideas

Clustering
Module 1: Why collect data

- Why are you collecting data?
- We will get you card storming and then we can discuss
- What is card storming?

Card storming

- Three rules to follow:
  1. Give your idea in one short sentence
  2. One idea per card
  3. Write clearly and large
Card storming

Rule 1: Provide your idea in one short sentence

- **X** Budget
  - With the allocated budget we can not do our work
- **✓** We have to use a large part of our budget for other purposes

Card storming

Rule 2: Only one idea per card

- **X** The budget is not enough. The staff is not qualified and information is not available
- **✓** There are too many fishers in the area
Card storming

Rule 3: Write clearly and large

X

To many fishers in the area

Card storming

Regrouping of cards/ideas

Provide your ideas

Regrouping & Naming

Module 1
Card storming: Why collect data

Why collect data
1. Split in two groups
2. Use card storming
3. Report back in plenary
MODULE 2: WHAT TO COLLECT

Module 2A: DFOs material - Introduction, types of data needed for fisheries management

Objective: The DFOs understand what they have to collect, and how the collected data can be used in fisheries management.

In this module we will only discuss fisheries data needed for the development of fisheries management plans.

We do this through card storming and you are requested to write down on your cards what kind of data is needed for fisheries management.

Module 2A: What to collect

- We collect data for:
  - Fisheries management
  - National policies
  - Regional requirements

  In this module, we will only discuss data to support fisheries management.
Module 2A: What to collect

Card storming

- Split into two groups and come up with the data needed to support fisheries management
- Report back in plenary
Module 2B: DFOs material - What is needed to estimate fishing effort

Objective: The DFOs understand what is effort and what data is needed to estimate fishing effort

In the previous module you identified the data needed for fisheries management. Fishing effort was considered to be one of the data needed for fisheries management.

First questions to be addressed by you:
1. What is fishing effort?
2. What is needed to estimate fishing effort?
3. How is fishing effort used for informing fisheries management decisions?

Use the information you identified for fishing effort in the previous module to answer these questions.

Box 7: Fishing effort exercise

Example 1
Small landing site: Pais Pesca 1
Total numbers of canoes at Pais Pesca from frame survey: **35**
Average number of fishing days per month: **27**
It is possible to monitor all canoes and the average number of canoes active per fishing day is **31**

**Calculate the fishing effort for this example**
(837 canoe fishing days)

Example 2
Large Landing site: Pais Pesca 2
Total number of canoes: **1200**
Average no of fishing days per month: **27**

It is not possible to monitor all canoes, and 120 canoes were sampled of which 90 were active.

Therefore boat activity coefficient (BAC) = 90/120 = 0.75

**Calculate the fishing effort for this example**
(24300 Canoe fishing days)
Module 2B: What is needed to estimate fishing effort

- What is needed to estimate fishing effort?
- How is fishing effort calculated?
- How is fishing effort used in fisheries management?

Small groups with Flip charts
- Discuss in small groups, use info which came up in Module 2A
- Use flip charts
- Report in plenary
Module 2C: DFOs material - Catch per Unit of Effort (CPUE)

Objective: The DFOs understand what data is needed to estimate CPUE.

In the previous module 2A you identified the data needed for fisheries management. Catch per Unit of Effort was considered to be one of the data needed for fisheries management.

Questions to be addressed in small groups,

- What is CPUE?
- Give examples of CPUE
- What are the best measures of CPUE

Use the information you identified for CPUE in the previous module 2A to answer these questions.
Module 2C: Catch per Unit of Effort (CPUE)

Small groups with flip charts
Exercise Catch per Unit of Effort

Exercise 1
Canoe 1  10 kg/day
Canoe 2  5 kg/day
Canoe 3  10 kg/day
Canoe 4  5 kg/day

What is the average Catch per boat per day?

\[ \text{CPUE} = \frac{\text{catch canoe 1} + \text{catch canoe 2} + \text{catch canoe 3} + \text{catch canoe 4}}{\text{No canoes sampled}} \]
\[ = \frac{10+5+10+5}{4} = 7.5 \text{ kg/day} \]

Exercise 2
Canoe 1  7 kg/day
Canoe 2  12 kg/day
Canoe 3  6 kg/day
Canoe 4  10 kg/day
Canoe 5  5 kg/day

What is the Catch per unit of effort?

\[ \text{CPUE} = ? \]

Exercise 3
Canoe 1  5 kg/day
Canoe 2  10 kg/day
Canoe 3  8 kg/day
Canoe 4  10 kg/day
Canoe 5  5 kg/day

What is the Catch per unit of effort?

\[ \text{CPUE} = ? \]

Exercise 4
Canoe 1  50 kg/week
Canoe 2  50 kg/week
Canoe 3  60 kg/week
Canoe 4  30 kg/week
Canoe 5  70 kg/week
Canoe 6  100 kg/week

What is the Catch per unit of effort?

\[ \text{CPUE} = ? \]

Exercise 5
vessel 1  20 kg/fishing trip
vessel 2  35 kg/fishing trip
vessel 3  40 kg/fishing trip
vessel 4  50 kg/fishing trip
vessel 5  10 kg/fishing trip

What is the Catch per unit of effort?

\[ \text{CPUE} = ? \]
Module 2 D: DFOs material - Total catch

Objective: DFOs should be able to calculate total daily, monthly and annual catch from boat-based and gear-based CPUE

In this module we discuss how to calculate total catch

Exercises

Small landing site
Suppose the following data was collected from Wichlum landing site in January 2009;
Total numbers of canoes from frame survey = 180
Number of fishing days in January 2009 = 31
Average number of active canoes on a day = 175
Average CPUE = 6.8 kg/day

What is the total catch for January 2009?
(36,890 kg)

To estimate the total catch an entire district
Total number of fishing boats in Bondo District = 3,200 canoes (F=3,200) is spread over 16 landing sites,
Number of fishing days in January 2009 = 31,
one landing site sampled with 97 out of 100 canoes active
CPUE = 6.93 kg/boat/day (calculated average)
What is the total catch for January 2009?
(666,832 Kilograms or 667 tonnes)

Total catch by species
In the above landing sites the species composition was as followed

<table>
<thead>
<tr>
<th>Species name</th>
<th>Species composition (%)</th>
<th>Total catch by species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nile perch</td>
<td>37</td>
<td></td>
</tr>
<tr>
<td>Tilapia</td>
<td>22</td>
<td></td>
</tr>
<tr>
<td>Omena</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Others</td>
<td>26</td>
<td></td>
</tr>
</tbody>
</table>

Wichlum, small landing site

<table>
<thead>
<tr>
<th>Species name</th>
<th>Species composition (%)</th>
<th>Total catch by species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nile perch</td>
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<td></td>
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<tr>
<td>Tilapia</td>
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<td>15</td>
<td></td>
</tr>
<tr>
<td>Others</td>
<td>26</td>
<td></td>
</tr>
</tbody>
</table>

Bondo district

<table>
<thead>
<tr>
<th>Species name</th>
<th>Species composition (%)</th>
<th>Total catch by species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nile perch</td>
<td>15</td>
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</tr>
<tr>
<td>Tilapia</td>
<td>38</td>
<td></td>
</tr>
<tr>
<td>Omena</td>
<td>22</td>
<td></td>
</tr>
<tr>
<td>Others</td>
<td>25</td>
<td></td>
</tr>
</tbody>
</table>

Calculate the catch by species and fill the form
Module 2D: Total catch

- Total catch can be calculated by multiplying the catch per unit of effort with total fishing effort
  
  \[
  \text{Total catch} = \text{CPUE} \times \text{Fishing effort}
  \]

  As:
  
  \[
  \text{Fishing effort} = \text{BAC} \times F_{\text{cap}} \times A
  \]

  \[
  \text{Total catch} = \text{CPUE} \times \text{BAC} \times F_{\text{cap}} \times A
  \]

- BAC = Boat Activity Coefficient
- BAC = No. of active fishing boats/fishing capacity
- \( F_{\text{cap}} \) = Fishing capacity
- A = Number of fishing days per month
Module 2E: DFO material – CPUE and Fisheries management

Objective: The DFOs understand the value of CPUE for fisheries management and understand the concept of a Schaefer curve

This is an advanced module not given in all training courses
This module will be presented through a lecture by one of the trainers
**MODULE 3: HOW TO COLLECT DATA**

**Module 3 A: DFOs material - Basic Statistical methods and concepts**

**Question no 1**
We have lake Lake Pisces which has the following characteristics:
- Area 100 hectares,
- 20 fishing crafts are operating on the lake,
- All the fishing crafts land at one landing site

You have enough well trained staff, transport and funds available

How would you monitor the fisheries in Lake Pisces?
Make a plan with your neighbour

**Question no 2**
We have lake Victoria which has the following characteristics:
- Area 35,000 km²
- 30,200 fishing crafts are operating on the lake,
- 634 landing site

Limited staff and funds available

How would you monitor the fisheries in Lake Victoria?
Make a plan with your neighbour
Module 3A: Basic Statistical Methods and Concepts

Lake Pisces

- Area 100 hectares, 20 boats, 1 landing sites, well trained staff and unlimited funds
- How do you monitor this small lake to get most accurate results?

Plenary discussion

Module 3A: Basic Statistical methods and concepts

Lake Victoria?

- Area 35,000 km², 30,208 boats, 634 landing sites, limited staff and limited funds
- How would you monitor this big lake to get most accurate result?
Module 3A: Basic Statistical methods and concepts

✦ What are the major issues in sampling

Card storming and Discussion
Module 3B: DFOs material - Sampling techniques and dealing with potential problems

In this module we will discuss what can go wrong during different stages of data collection. This will be done by using your experiences in group and plenary sessions.

Module 3B: How to sample and dealing with potential problems

- Two card storming sessions
  - List problems leading to inaccurate data
    
    Plenary discussion
  
  - What problems can be solved and how
    
    Plenary discussion
MODULE 4: DIFFERENT COMPONENTS OF THE NATIONAL DATA COLLECTION SYSTEMS

Module 4A: DFOs material – Different components of the fisheries data collection system in Tanzania.

During this session the presently used sampling forms will be discussed.

National data collection systems

A) Catch Assessment Survey
The national data collection system of Tanzania involves various stakeholders including District Authorities and Beach Management Units. Data enumerators are employed by the District Authority, while data processing, analysis and management are done by the Fisheries Division. The system is not working properly since Director of Fisheries does not have a mandate to employ the data enumerators. The district authority may decide not to deploy data collectors if the fisheries statistics are not considered a district priority.

Meanwhile the Fisheries Division promotes community participation in fisheries management by establishing collaborative fisheries management. However, data are collected by either district enumerators or beach management units at specific landing sites. Data are collected on 16 sampling days. On every recording day, the enumerators go to the landing sites and record the catch of all fishing vessels that return from fishing. The data are first recorded in form no. 21A then transferred to form 21B. The forms are then delivered to District Fisheries Office for input in the CAS database. The information is transferred to Fisheries Division in electronic form for analysis, processing and dissemination of the report to national and international stakeholders.

B) Frame survey
A frame survey is uses a census approach. Data is collected on all fishing vessels and gear which could potential potentially be used in the fisheries. Supplementary information can also be collected such as seasonal use of certain fishing gear and fishing trip patterns. Data for the frame survey is collected on biannual basis. Before the frame survey, the enumerators (including fishers) are trained on the importance of fisheries statistics and how to collect data. A questionnaire is designed, given to the enumerators who use it for data collection. After checking the data forms, they are taken to the Fisheries Headquarters for inputting into the computer. Data entry is done at head office. The data is analysed and summarised in a table and this is then disseminated to stakeholders.
Module 4: National Data Collection System

**Routine data collected in Tanzania**
- Frame survey
- Catch Assessment survey (CAS)
- Others
  - Export data
  - Import data
  - Other important information in fisheries

---

Module 4: National Data Collection System

**Plenary discussion**
- What is frame survey? (problems, forms)
- What is CAS? (problems, forms)
- National data collection system
- Filling of forms
Module 4: National Data Collection System – Frame Survey

- Frame survey - biannual
  - Inventory
  - Total enumeration
  - Problems / bottlenecks
  - Forms

---

**Fishery Inventory Form**

**Inventory of Fish Producing Factors: Landing Site Approach**

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<td>S.No</td>
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**Total**

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*Name of Recorder: ___________________________*
*Name of Supervisor: ___________________________*
*TEL NO: ___________________________*
*Signature: ___________________________*
*Date: ___________________________*

---

DFO Manual fisheries data collection Tanzania, Part 1
**MINISTRY OF NATURAL RESOURCES AND TOURISM**
**FISHERIES DIVISION**

**FRAME SURVEY FORM**

**SHEET 1: SUMMARY DETAILS OF NUMBER OF CRAFT ON BEACH AND FACILITIES**

1. NAME OF RECORDER .................................................. TEL NO ..............................................
2. STATUS/RANK OF RESPONDENT ........................................
3. DATE ...........................................................................
4. REGION ............................................................... .................................
5. DISTRICT .........................................................................
6. VILLAGE ...........................................................................
7. NAME OF LANDING SITE .....................................................

**CRAFT SUMMARY**

8. TOTAL NUMBER OF CRAFT ON BEACH ................................
9. TOTAL NUMBER OF DERELICT CRAFT .................................
10. TOTAL NUMBER OF TRANSPORT CRAFT (NO FISHING) .......
11. TOTAL NUMBER OF FISHING CRAFT WITH OUTBOARD ENGINE ....
12. TOTAL NUMBER OF FISHING CRAFT WITH INBOARD ENGINE ....
13. TOTAL NUMBER OF FISHING CRAFT USING PADDLES ONLY ...
14. TOTAL NUMBER OF FISHING CRAFT USING SAILS ............

**FACILITIES SUMMARY**

15. BANDA  
   (1) YES (2) NO ......................................................
15b. PERMANENT 
   (1) YES (2) NO ......................................................
16. COLD ROOM  
   (1) WORKING (2) NOT WORKING 
   (3) NONE ..............................................................
17. FREEZER  
   (1) YES (2) NO ......................................................
18. FISH MILK  
   (1) YES (2) NO ......................................................
19. FISHING FACILITIES  
   (1) YES (2) NO ......................................................
20. ALL WEATHER ROAD  
   (1) YES (2) NO ......................................................
20a. IF NO, HOW FAR TO NEAREST  
   (1) < 20 (2) 21 - 40 (3) 41 - 60 (4) 61 - 80 (5) 81 - 100 (6) 101 - 200 (7) 201 - 300 (8) 301 - 400 (9) > 400 ......................................................

21. BOAT BUILDING/REPAIR FACILITIES  
   (1) YES (2) NO ......................................................
22. BEAR MANUFACTURING/REPAIR  
   (1) YES (2) NO ......................................................
23. ELECTRICITY SUPPLY  
   (1) YES (2) NO ......................................................
23a. IF YES, HOW FAR TO NEAREST  
   (1) < 20 (2) 21 - 40 ......................................................
24. WATER SUPPLY  
   (1) WELL (2) TAPE (3) NONE ......................................................

**FISHERIES DEPARTMENT STAFFING:**

25. ARE FD STAFF PRESENT?  
   (1) YES (2) NO ......................................................
26. IF YES, HOW MANY? ......................................................
27. IS BMU PRESENT?  
   (1) YES (2) NO ......................................................

**ADDITIONAL INFORMATION:**

28. NAME THE NEAREST MARKET ...........................................
29. FISH DISTRIBUTION FACILITIES  
   (1) MOTOR VEHICLE ......................................................
   (2) BICYCLE ......................................................
   (3) BOAT ......................................................
   (4) MOKOTENI ......................................................
   (5) BY FOOT ......................................................
30. PRESERVATION METHOD  
   (1) ICING ......................................................
   (2) SALTING ......................................................
   (3) SMOKING ......................................................
   (4) SUN DRYING ......................................................
31. DO FISHERMEN LAND AT THIS BEACH FOR  
   (1) < 5 MONTHS OF THE YEAR ......................................................
   (2) > 5 MONTHS OF THE YEAR ......................................................
32. NUMBER OF FISHING CRAFT ..............
Module 4: National Data Collection System

-Catch Assessment Survey-

✦ Catch Assessment Survey (CAS) – on-going
  - Routine survey for effort and catch data
  - Sampling
  - Estimation
  - Total catch by major species
  - Problems / bottlenecks
  - Forms
Module 4: National Data Collection System - Other data

Other data collected
- Export data
- Import data
- Other important information in fisheries
Module 4B: DFOs material - Species identification

Objective: The DFOs identify species which are difficult to identify

Module 4B: Species identification

- Problems in fish identification
- Two groups (exercise)
- Freshwater
- Marine
- List major species – local names
- Point out the confusion or difficulties in species identification
Module 5: ROLES IN DATA COLLECTION
Module 5: DFOs material - Roles of DFOs and enumerators in data collection

Objective: The DFOs get a clear picture on their roles and responsibilities in the data collection system.
Module 5: Roles In Data Collection

Card storming
MODULE 6: REPORTING
Module 6A: DFOs material - Reporting in Tanzania

Objective: The DFOs know their responsibilities in data reporting and understand data flow from landing site to HQ.

**MODULE 6A: Reporting**

🌟 National reporting and data flow
- Landing site to district
- District to national level
Module 6B: DFOs material - Storage and use of data

Objective: The DFOs know how to store and use data at District level

Not applicable

- At the district all fisheries data are stored in electronic and/or hard copy form at Fisheries Division, Statistics section
- Split into groups. Discuss storage and use of data
- Plenary: Each group describes their finding
- Compare the presentation from different groups and discuss.
- Flip charts
Module 7: TRAINING OF ENUMERATORS

Module 7: DFOs material – Training of enumerators

Objective: To prepare the DFOs for training enumerators at the landing sites and obtain ideas of DFOs for training of enumerators/BMUs

Module 7: Training of enumerators

- Importance of training enumerators
- Why are BMUs involved in data collection?
- How should enumerators be trained?
Training Course
for District Fisheries Officers
Fisheries data collection and analysis,
Tanzania

PART 2 – BACKGROUND MATERIAL FOR MODULES
AND RESULTS OF EXERCISES
OPENING

Ground rules for the course

**Objective:** The DFOs agree on ground rules

At the beginning of each course, participants should agree a list of rules for the conduct of the course, which is a set of points about behaviour and practices during the sessions. These may include points such as:

- All participants should be punctual.
- The trainers and participants should all ensure that the training workshop keeps to time so that all of the material is covered. Participant should appoint a time-keeper.
- Participants must stay at the workshop and not come in and out, which would mean they would miss important points and disrupt the training.
- There must be breaks and each day should finish on time, so that participants have time to rest and recover.
- All participants must listen to and respect each other’s views.
- Mobile phones switched off during training sessions.
- Participants should contribute to the discussion.
- Participants should wear casual clothing during course.
- If needed participants could select a course leader who will act as a mediator between trainers and DFOs.
- No sleeping during the training.
MODULE 1 - WHY COLLECT DATA

Objective: DFOs understand the need for data collection and the use of data in fisheries management and policy development

“The collection of data is not an end in itself, but is essential for informed decision making.”

Data are needed to make rational decisions for:

i) Development of appropriate policies

ii) Evaluation of the fisheries performance in relation to management objectives

iii) Fulfil regional requirements.

Data needs for national policies

Fisheries policies. It is essential to have adequate data to formulate a useful policy for the whole fisheries sector. Fisheries policies should address the fishery sector as a contributor to the food supply and economy at local and national levels, and as a critical component of the ecosystem. Hence, data collection should cover as far as possible all aspects of a fishery, from the natural resources, their exploitation, the needs of local consumers, to industry and trade.

Food security is an over-riding concern for natural living resources policy-makers, planners and administrators, especially in many developing countries. Fish may be the major source of animal protein for many communities. It is essential to be able to quantify the dependence on fish as a food source, so that policies and management ensure sustainable use and sufficient access for dependent communities.

Fisheries contribution to the economy. For national and local policy-making and planning, it is essential to describe the contribution of fisheries to the economy. If managed effectively, fisheries are able to generate substantial economic benefits for the national and local economies. Assessments of the economic contribution of fisheries need to take into account the generation of income for the local community, of returns to the broader community and of foreign exchange from export earnings. Various countries also obtain revenue from charging fees to non-national fishing boats for access to the resource within their Exclusive Economic Zone (EEZ).

Fisheries impact on the ecosystem. Fisheries reduce wild fish populations, decreasing the population sizes below that of the unexploited stock. This may not only affect the exploited population but also the interrelated resources. It is therefore important to monitor changes in the fish community as well as the exploited stock, to ensure the ecosystem is not damaged by the fishery. Catch, effort, discards and biological data are required to monitor the direct effects of exploitation, and fisheries-independent methods and environmental monitoring may also be necessary to track all ecological changes. For inland fisheries, the creation and loss of habitat is often a determining factor in production. Seasonal and long term changes in the area of flooding need to be monitored alongside fishery activities to account for different factors influencing fish stocks. In some cases, special environmental monitoring may be necessary where an inland or marine fishery may cause significant changes to the underlying habitat. This is of special concern for conservation as habitat change is the primary cause of species

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1 Adapted from: Guidelines for routine collection of capture fishery data (FAO Fisheries Technical Paper 382, FAO 1999)

2 FAO Technical Guidelines for Responsible Fisheries 4: Fisheries Management: Article 2, FAO 1997a
extinction. Gears that have a physical impact on benthic habitats, such as bottom trawling and dredges, may require special monitoring.

**Important national policies in Tanzania are:**
The Tanzanian fisheries sector has operated without a specific fisheries policy framework for many years. However this has now changed with the development of the national oceans and fisheries policy that was launched on the 6th April 2009.

Prior to the introduction of the Oceans and Fisheries Policy, key policy statements concerning fisheries resource management have included:

1. Conservation and management to be based on the best scientific evidence available. In its absence a precautionary approach to be adopted.
   The best scientific evidence shall be obtained from direct observations of the resources dynamics to generate data and information that can be used to monitor and help in policy implementation and subsequent reviews. Some of the strategies proposed in the policy document include use of satellite imagery and geographical information systems to aid in decision making.

2. Ecosystem based approach in the management of fisheries resources
   The policy intends to develop management plans for the fisheries taking a holistic view of the ecology of the natural resource system with the active involvement of the stakeholders. To achieve this, data and information availability is crucial.

3. Government to positively seek cooperation with other riparian/coastal states in the management of shared stocks and migratory/straddling stocks.
   This shall be accomplished through joint monitoring of fisheries resource use for example joint frame surveys in Lake Victoria involving all riparian states under the Lake Victoria Fisheries Organization (LVFO) and tuna tagging exercise in the western Indian Ocean program under the Indian Ocean Tuna Commission (IOTC)

4. Development and promotion of recreational and ornamental fisheries
   Very critical data and information is required for the development of this highly lucrative fishery to understand the impacts and effects of fishing on the wild populations as well as the general ecology of the systems in which the fish occur. The data and information thus collected will be important in the development of any regulations that contribute to the sustainable exploitation of ornamental fisheries.

5. Promote the role of Beach Management Units (BMUs) in management of fisheries resources.
   Information and data sharing among the various BMUs is important to achieve a harmonized approach to management

The purpose of collecting data is to gather information to inform decisions regarding activities aimed at fulfilling policy objective and for monitoring policy implementation. Thus data collected should be determined by what the policy objectives are. Below are some examples of policy objectives, and information requirements relating to them. However, only a part of this information is collected by enumerators at landing sites.
<table>
<thead>
<tr>
<th>Policy objective</th>
<th>Information requirement</th>
<th>What to collect</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>To create job opportunities within fishing communities</strong></td>
<td>Socio-economic data</td>
<td># mature and no-mature members in household (hh) level of education of each hh member # employed/unemployed per hh income-level of employed hh members # full-time fishers # people using motorized vessels per community # fish smokers # fishers per ethnic group # workers in processing age distribution in fishing communities</td>
</tr>
<tr>
<td></td>
<td>Cultural data</td>
<td>social constraints preventing people from fishing</td>
</tr>
<tr>
<td></td>
<td>Fishing effort</td>
<td># fishing vessels # active fishing days/trips/hours gear used mesh size used open/closed seasons</td>
</tr>
<tr>
<td></td>
<td>Catch production</td>
<td>catch by species by gear</td>
</tr>
<tr>
<td></td>
<td>Biological data</td>
<td>MSY (calculated) identify endangered species environmental effects on fish populations length frequencies maturity status stomach content otolith abundance biomass CPUE (calculated)</td>
</tr>
<tr>
<td></td>
<td>Enforcement of management measures and regulations</td>
<td>incidents with IUU vessels complaints of artisanal fishers vs industrial fishery</td>
</tr>
<tr>
<td><strong>Sustainable management of aquatic resources</strong></td>
<td>Disposition of fish production</td>
<td>post-harvest loss import-export (volume &amp; value) total fish production effort catch fleet structure</td>
</tr>
<tr>
<td></td>
<td>Consumption pattern</td>
<td>total population per caput consumption projected demand and supply population growth (including migration) Availability of fish products to local population trends of local prices # cold storages per province/state/local government, etc volume of fish to local market storage capacity</td>
</tr>
</tbody>
</table>

*DFO Manual fisheries data collection Tanzania, Part 2*
<table>
<thead>
<tr>
<th>Policy objective</th>
<th>Information requirement</th>
<th>What to collect</th>
</tr>
</thead>
<tbody>
<tr>
<td>To generate foreign earnings</td>
<td>Information on international markets</td>
<td>volume of fish in cold storage, international prices, supply and demand in international markets, trends of international markets, cost of transportation, value and quantity of exported products</td>
</tr>
<tr>
<td></td>
<td>Compliance with international regulations &amp; standards, knowledge on type of products exported, knowledge on the capacity to produce export products</td>
<td>volume of certified exported fish, quantity, nature, destination of fish exports, # processing units, actors, type of end products</td>
</tr>
<tr>
<td>Community development</td>
<td>knowledge of living conditions in fishing communities, knowledge of income generating activities in fishing communities, knowledge of conflicts related to fisheries, level of organization of fishers, disease prevalence, level of nutrition of fisher households</td>
<td>Livelihood profiles, income by activity, average income per fisher, Consumption patterns</td>
</tr>
</tbody>
</table>

Data needs for fisheries management

It is important to manage our fisheries so that they are sustainable, so that in the future we still are able to continue fishing.

Concept of Fisheries Management

**Stock sizes are limited.** Fish stocks are finite resources that have a specific biomass, or number of fish. From this stock (or population), fish are caught and the fish remaining in the stock breed, producing eggs and young which contribute to population growth.

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3 Adapted from PARFISH Guidelines, FAO guidelines
**Box 2: Water jug concept (from ParFish)**

We can imagine a fish stock as a bucket of water, where water is being poured in the top (growth and reproduction of the fish stock) and a tap is taking water out of the bottom (natural mortality and fish catch).

![Diagram of a water jug concept](image)

**Using the water jug concept to explain fish stock dynamics**

The key is that, for a stock that is being fished, the greater the number of fish, the more will be added by reproduction.

**Box 3: The Bau game concept (from ParFish)**

A fish stock can also be demonstrated to the fishers using beans or pebbles in a series of holes. Arrange two rows of holes with the top row representing the stock size and the bottom row representing fish catch and natural mortality. Growth and recruitment are represented by beans entering the top row and, as you move across from left to right, you are moving from one year to the next.

![Diagram of the Bau game concept](image)
This basic concept of fish stock size can be described with the following relation: \[ S_2 = S_1 + (R+G)-(F+M) \]

**Where**
- \( S_2 \): Standing fish stock in year 2
- \( S_1 \): Standing fish stock in year 1
- \( R \): Recruitment
- \( G \): Growth
- \( F \): Fishing mortality
- \( M \): Natural mortality

**Fishing effort has impact on stock size:** From the relation above it becomes clear that fishing mortality is a fundamental variable, representing as it does the proportion of the stock that is removed by fishing and is additional to stock reduction due to natural mortality.

**There is an optimal level of exploitation:** Effective fisheries management aims to keep \( S_2 \) and \( S_1 \) at the same level (if the stock level is optimal) so that we can continue to harvest without destroying the resource. i.e. the stock remains stable with growth/recruitment and catch/natural mortality balancing each other out. If the stock level is overfished, then the aim would be to have \( S_2 \) greater than \( S_1 \) so that the stock has the opportunity to recover to its optimum biomass.

Maximum sustainable yield (MSY) is the largest long-term average catch or yield that can be taken from a fish stock under prevailing conditions. If a catch less than MSY is taken, the stock can be considered as underfished. Optimum if its biomass is at a level that can sustain MSY. Fishing beyond the maximum sustainable level can result in reduced fish catches: This will result in decreased growth/recruitment and in the long term in decreased catches.

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**Box 5: The FAO Code of Conduct for Responsible Fisheries (FAO, 1995)**

**Article 7.2.1:** Recognizing that long-term sustainable use of fisheries resources is the overriding objective of conservation and management, States and subregional or regional fisheries management organizations and arrangements should, inter alia, adopt appropriate measures, based on the best scientific evidence available, which are designed to maintain or restore stocks at levels capable of producing maximum sustainable yield, as qualified by relevant environmental and economic factors, including the special requirements of developing countries.

**Article 7.4.4:** States should ensure that timely, complete and reliable statistics on catch and fishing effort are collected and maintained in accordance with applicable international standards and practices and in sufficient detail to allow sound statistical analysis. Such data should be updated regularly and verified through an appropriate system. States should compile and disseminate such data in a manner consistent with any applicable confidentiality requirements.

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Data needs for regional requirements
Many fish resources, whether marine or freshwater, are highly migratory or straddle boundaries of national jurisdiction and/or the high seas. Their management requires regional coordination and data sharing. Fisheries management of internationally shared stocks implies international obligations for collecting and exchanging fishery data.

Box 6: The FAO Code of Conduct for Responsible Fisheries (FAO, 1995)

**Article 7.3.2:** In order to conserve and manage transboundary fish stocks, straddling fish stocks, highly migratory fish stocks and high seas fish stocks throughout their range, conservation and management measures established for such stocks in accordance with the respective competences of relevant States or, where appropriate, through sub regional and regional fisheries management organizations and arrangements, should be compatible. Compatibility should be achieved in a manner consistent with the rights, competences and interests of the States concerned.

**Article 7.3.4:** States and, where appropriate, sub regional or regional fisheries management organizations and arrangements should foster and promote international cooperation and coordination in all matters related to fisheries, including information gathering and exchange, fisheries research, management and development.

**Article 7.4.6:** States should compile fishery-related and other supporting scientific data relating to fish stocks covered by sub regional or regional fisheries management organizations or arrangements in an internationally agreed format and provide them in a timely manner to the organization or arrangement. In cases of stocks which occur in the jurisdiction of more than one State and for which there is no such organization or arrangement, the States concerned should agree on a mechanism for cooperation to compile and exchange such data.
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Module 1: Summary - Why collect data

Data are needed to make rational decisions for:

- Development of national policies
- Evaluation of the fisheries performance in relation to management objectives
- Fulfilling regional requirements

Module 1: Summary - why collect data

National policies

- Formulation of policies concerning
  - Contribution to economy
  - Maintaining food security
  - Sustaining ecosystem
- Evaluation of policies
- Policies update
Module 1: Summary- why collect data

**Fisheries management**
- Evaluation of fisheries activities
- Fishing effort has impact on fish stock size
- There is an optimal level of exploitation
- Fishing beyond the sustainable level can result in reduced fish catches
- Long-term sustainability-maintain fish stock for future generation

Module 1: Summary- why collect data

**Regional/international requirements**
- Regional coordination
- Data sharing for management purpose etc
- E.g. Lake Victoria Fisheries Organization (LVFO), Indian Ocean Tuna Commission (IOTC) etc. Shared stocks can not be managed by one nation alone
Further reading for Module 1

- Annual Fisheries statistical reports – The reports were disseminated to various stakeholders within and outside the country for use in their planning and management of the fishery resources. The needed data include catch, effort, value, export, import etc.
- Annual fisheries reports – The reports are used by national and international investors to guide the possibility of investment opportunity within the country. The needed data here are catch, effort, contribution to GDP, export, royalty, revenue accrue from fishing,
- Annual Ministry reports – these reports are used by Member of Parliaments to plan and budget the fisheries sector and policy implementation. Data needed include; total catch, total value, number of fishers, number of investors in fishing, GDP, effort data, etc
- International organization reports – These include: FAO, IOTC, WWF etc to disseminate to fishery stakeholders for the purpose of sustainable management of fishery resources world wide. These are specific according to their needs e.g. IOTC requires tuna catches only. FAO has specific format with specific species
MODULE 2: WHAT TO COLLECT

Module 2A: DFOs background material - Introduction, types of data needed for fisheries management

Major data types needed for fisheries management are:

- Fishing Effort (Collected or calculated), routine
- Catch per Unit of Effort (CPUE, collected or calculated), routine
- Species, major species, routine
- Total catch (note calculated, not collected), routine

- Stock assessment data, biological data, length frequencies, acoustic surveys, ad hoc
- Other data, ad hoc

Some of the data needs collected on a routine basis will be discussed in the next modules.

Summary presentations Module 2

Module 2A: Summary-What to collect for fisheries management

- Routine basis data
  - Effort
  - CPUE
  - Species
  - Total catch

- Non routine (Ad hoc) data
  - Stock assessment, length frequencies, acoustic surveys
  - Other data
Module 2B: DFOs background material - What is needed to estimate fishing effort

Fishing effort may be defined conceptually as all the boats, nets, any electronic equipment, and any other gear plus the people using them, actually deployed in a fishery during a specified period of time. In practice we use as a proxy some particular significant measure such as number of boats or the quantity of a particular gear type (e.g., number of traps or metres of gill net).

In fisheries management fishing effort may be used as a measure of fishing mortality, whereby fishing effort is a measure of how much fishing takes place and it is needed to estimate total catch (fishing mortality) for artisanal fisheries.

There is sometimes confusion between fishing effort and fishing power/capacity.

Fishing capacity/power is the potential ability of a fleet to catch fish, i.e., the amount of fishing effort that a fleet of fishing boats could exert, if utilised to their full potential.

Fishing power can be obtained through frame surveys, vessel registers, and fishing licenses. However, it does not tell you how much fishing is actually taking place.

Fishing effort can be considered as composed of two separate elements:

1. a capacity element (vessel and gear characteristics) and
2. an activity element.

\[ \text{Fishing effort per time unit} = \text{Fishing capacity} \times \text{activity level} \]

In order to estimate fishing effort you need to know:
- The total number of vessels/gears in the fishing area (through frame survey)
- The total number of vessels active daily (through activity survey)
- The average number of gears used daily by each vessel (through activity survey)
- The total number of fishing days (through activity survey)

The mathematics to calculate fishing effort

As indicated above the basic formula for fishing effort is:

\[ \text{Fishing effort per time unit} = \text{Fishing capacity} \times \text{activity level} \]

or

\[ \text{Fishing effort} = F_{\text{cap}} \times BAC \times A \]

Where

- \( F_{\text{cap}} \) is the fishing capacity, expressing the total number of fishing units that are potentially operating at all fishing sites. This is obtained from Frame Survey or from artisanal vessel register/license system when complete census (both in space and time) takes place. It should always be calculated from the most recent data. \( F= \text{no of boats from frame survey} \)
- \( \text{BAC} \) is the Boat Activity Coefficient, expressing the probability that any boat (= fishing unit) will be active (= fishing) on any day during the month. \( BAC= \text{average no of active boats/no of boats from frame survey} \),
- \( A \) is a raising time factor expressing total number of days with fishing activities during the month. This can be estimated based on days on which fishing activity takes place at
the sampled landing site. For example the number of holidays and other days when fishing activities do not take place can almost be accurately stated. So the value of “A” changes with different months. For example, the December value is likely to be lower than January of every year. A=no of fishing days

In reality there are two ways to estimate fishing effort and it depends on the number of crafts to be followed.

Small water body or small landing site

In a small landing site it is not difficult to follow all crafts. In above landing site we have 10 canoes of which 7 are active. In January 2009 each canoe went fishing 25 days.

The fishing effort in this case will be: No active canoes*No of fishing days=7*25= 175 canoe days

Using the formula Fishing effort= F_{cap} * BAC * A will give the same results

F_{cap}=10 canoes
BAC= 7/10=0.7
A = 25

or

Fishing effort= 10*(7/10)*25= 175 canoe days

Large water body or large number of crafts to follow
In the above example we have a large water body with 6 landing sites. It is not possible to monitor all the landing sites due to limited staff and funds. One landing site is followed and we need the Boat Activity Coefficient (BAC) to estimate the fishing effort in this water body.

The frame survey indicated that there are 1,100 canoes in the lake. At the landing site we monitor, there are 75 canoes of which 70 are active. Therefore boat activity coefficient (BAC) = 70/75 = 0.93.

In January 2009 each canoe went fishing 27 days.

The monthly fishing effort is calculated as:

\[
\text{Fishing effort} = F_{\text{cap}} \times \text{BAC} \times A
\]

\[
\text{Fishing effort} = 1,100 \times 0.93 \times 27 = 27,720 \text{ Canoe fishing days}
\]
Data needed for estimation of fishing effort
- Boat data - The numbers, sizes and description of the fishing boats and propulsion methods;
- Gear data - This involves the numbers, sizes and types of fishing gears used per fishing boat;
- Fishers data - This involves number of fishers who actually do the fishing per fishing boat;
- Time data – This is the time spent fishing.

Box 7: Fishing effort examples

Example 1
Small landing site: Pais Pesca 1
Total numbers of canoes at Pais Pesca from frame survey: 35
Average number of fishing days per month: 27
It is possible to monitor all canoes and the average number of canoes active per fishing day is 31
Therefore the monthly fishing effort is calculated as:

\[
\text{Fishing effort} = \text{Total no of active canoes} \times \text{No of fishing days}
\]

\[
\text{Fishing effort} = 31 \times 27 = 837 \text{ canoe fishing days}
\]

Example 2
Large Landing site: Pais Pesca 2
Total number of canoes: 1200
Average no of fishing days per month: 27

It is not possible to monitor all canoes, and 120 canoes were sampled of which 90 were active.

Therefore boat activity coefficient (BAC) = 90/120 = 0.75

The monthly fishing effort is calculated as:

\[
\text{Fishing effort} = F_{\text{cap}} \times \text{BAC} \times \text{No of fishing days}
\]

\[
\text{Fishing effort} = 1200 \times 0.75 \times 27 = 24,300 \text{ Canoe fishing days}
\]
Another reality

In a large number of countries Frame surveys and Catch Assessment surveys for the artisanal fleet are carried out. However, often the real activity of the crafts is not monitored. Sometimes there is some notion of the number of fishing days the vessels go out fishing, but this again is often a “guestimate”

The result is that total catch is calculated by:

Total catch= Total number of crafts from frame survey*no of fishing days* average daily catch of each craft

This provides unreliable estimates of the total catch as:
- Not all crafts are active
- The number of fishing days depends on a lot of factors and varies throughout the year

Application of Boat Activity Coefficient is not easy but is essential in migratory and seasonal fisheries

If the difference between the active number of crafts and the number of crafts registered in a frame survey/vessel register/license register is limited, then it may be justified to skip estimation of BAC

However, estimation of the average number of fishing days should never be skipped, also from a budget or staffing point of view there is no reason to do so. By adding one question to the Catch assessment survey form all the info needed is obtained.

You simply ask the owner/fisher of the craft from which you monitor the fish landing, how many days he went fishing last week. If the results of the month January indicate that the fishers go out on an average 5 days a week then the number of fishing days for January would be 5/7*31=22 days. The fishing effort for January would then be: Total number of crafts from frame survey*22

If the results of the month April indicate that the fishers go out on an average 6 days a week then the number of fishing days for January would be 6/7*30=26 days. The fishing effort for January would then be: Total number of crafts from frame survey*26

UNDER/OVER ESTIMATING THE AVERAGE MONTHLY NO OF FISHING DAYS IS A LARGE SOURCE OF ERROR
Module 2B: Summary - What is needed to estimate fishing effort

- Fishing capacity is number of crafts/gears as recorded in frame survey
- Fishing effort is related to number of active crafts as only active crafts catch fish
- Fishing effort = $F_{cap} \times$ Activity level

1 landing site
10 fishing crafts

Monday
MODULE 2B: Summary—What is needed to estimate fishing effort

ONLY ACTIVE BOATS CATCH FISH

- Fishing effort related to the proportion of the Fishing capacity which is active.
- This proportion is called Boat Activity Coefficient (BAC)
- \[ BAC = \frac{\text{No active crafts}}{\text{total number of crafts from frame survey}} \]
- \[ BAC = \frac{\text{No active crafts}}{F_{\text{cap}}} \]
- BAC from example?

Module 2B: Summary—What is needed to estimate fishing effort

- Activity level is related to no of active crafts (BAC)
- And on how many days the active crafts go fishing in a month or the No of Fishing days (A)
Module 2B: Summary—What is needed to estimate fishing effort

- Fishing effort = $F_{cap} \times \text{activity level}$
- Fishing effort = $F_{cap} \times BAC \times A$

Where:
- $BAC =$ Boat Activity Coefficient
- $BAC =$ No. of active fishing crafts/total number of crafts from frame survey
- $BAC = \text{No. of active fishing crafts}/F_{cap}$
- $A =$ Number of fishing days
Module 2B: Summary—What is needed to estimate fishing effort

🔹 Only active boats catch fish
🔹 Lake is too large to follow all boats
🔹 We follow one landing site only
🔹 Boat activity of the sampled landing site is representative for the whole lake

Module 2B: Summary—What is needed to estimate fishing effort

🔹 Large landing sites
  - Fishing effort = $F_{cap} \times (\text{No. of active crafts}/F_{cap}) \times \text{no. of fishing days}$

🔹 Small landing sites
  - Fishing effort = No. of active boats $\times$ no. of fishing days (this only applies if it is possible to monitor all the boats)
Module 2B: How is fishing effort used in Fisheries management

- Could you tell how fishing effort is used in fisheries management?

- In case of over-fishing, effort can be reduced.

Module 2B: Summary - What is needed to estimate fishing effort

- Exercises
Module 2C: DFOs background material - Catch per Unit of Effort (CPUE)

**Definition of Catch Per Unit Effort (CPUE)**

CPUE when calculated = Total catches / Total units of effort

or

CPUE when collected = Average catch of a fishing unit by unit of time

CPUE is the catch of fish in numbers or weight taken by a defined unit of fishing effort. Effort used is quantified in a specified period of time e.g. fishing boat for one day.

CPUE is a measure of efficiency using a certain unit of effort in relation to catches, but there are a few assumptions to be made, which includes that all individuals of the population are evenly distributed throughout the ecosystem and that all individuals have the same probability of being caught by a specified gear.

This efficiency of the gear when used in the correct way is an indicative measure of the gear catchability (the ability of the gear in use to catch a certain amount /quantity of a target species). Big mesh size gears have a very low catchability efficiency for catching small sized fish.

This estimate will help the fisherman to estimate the amount of catch he/she can obtain if using a given type of gear.

Catch in numbers or weight represents the removal of biomass and individuals from the ecosystem, and is the fundamental impact fishing has on fish populations. Catch data are necessary for most stock assessment techniques. Catches should be broken down into categories with as much detail as possible. The priority classification of catches should be by species. Assessment of combined species yields have to rely on methods based on general ecosystem production, which by themselves are unreliable. If catches can be further broken down into categories based on size, maturity, location and date of the catch, it may be possible to develop a wide range of assessment methods leading to more reliable results. A detailed breakdown can also improve economic and socio-cultural analyses. The interpretation of changes in catch is very difficult without additional information on the status of the stock. High catches may be unsustainable, and low catches can result from exploitation rates both above and below the optimum. Additional information on the stock status, such as an index of abundance or size composition of landings, is required to obtain a true assessment of the fishery. Invariably a long time series of comparable catch data is required for any reliable interpretation.

Where discarding takes place, catches will not be the same as the live weight equivalent of the landings. Discarding has significant biological implications and should always be recorded or estimated. Total catch consists of total landings and discards.

Total catch data can be obtained by complete enumeration (census) approaches such as the use of compulsory logbook data. In most small-scale fisheries the amount of information that would be needed regarding total landings, species composition, prices, etc., is so large that the use of census approaches is impractical and sampling techniques are almost invariably employed. In most small scale fisheries the total catch is calculated using the formula

\[ \text{Total catch} = \text{Total fishing effort} \times \text{Catch per Unit of effort} \]

Adapted from XXXXX?
Thus, catch per unit of fishing effort also needs to be calculated.

**Module 2C: Summary - Catch per Unit of Effort (CPUE)**

- **CPUE** = Average catch of a fishing unit by unit of time
  
  Eg.

- Catch by canoes per day
- Catch by fisher per trip
- Catch by gillnet per day
- Catch by trap per day

**Module 2C: Summary - Catch per Unit of Effort (CPUE)**

- **Measure of CPUE**

  CPUE = Amount of Catch per one Fishing Unit by Unit of time
Module 2C: Summary -Catch per Unit of Effort (CPUE)

- Boat based CPUE vs Gear based CPUE

- In artisanal fisheries Boat based CPUE is the most cost effective way to estimate total catch
- For scientific reasons gear based CPUE is more appropriate to use but very difficult to obtain in artisanal fisheries

Module 2C: Summary -Catch per Unit of Effort (CPUE) and Fisheries management

- CPUE use

- Calculate Total catch
- The CPUE may be seen as an indicator of the abundance of exploitable stock of fish (without knowing the exact stock size).
- If the CPUE goes down we assume the stock is decreasing
Module 2C: Exercises - Catch per Unit of Effort (CPUE)

Exercises
### Exercise: Catch per Unit of Effort

#### Exercise 1
- Canoe 1: 10 kg/day
- Canoe 2: 5 kg/day
- Canoe 3: 10 kg/day
- Canoe 4: 5 kg/day

**What is the average Catch per boat per day?**

\[
CPUE = \frac{(\text{catch canoe 1} + \text{catch canoe 2} + \text{catch canoe 3} + \text{catch canoe 4})}{\text{No canoes sampled}} = \frac{(10+5+10+5)}{4} = 7.5 \text{ kg/day}
\]

#### Exercise 2
- Canoe 1: 7 kg/day
- Canoe 2: 12 kg/day
- Canoe 3: 6 kg/day
- Canoe 4: 10 kg/day
- Canoe 5: 5 kg/day

**What is the Catch per unit of effort?**

\[
CPUE = 8 \text{ kg/day}
\]

#### Exercise 3
- Canoe 1: 5 kg/day
- Canoe 2: 10 kg/day
- Canoe 3: 8 kg/day
- Canoe 4: 10 kg/day
- Canoe 5: 5 kg/day

**What is the Catch per unit of effort?**

\[
CPUE = 7.6 \text{ kg/day}
\]

#### Exercise 4
- Canoe 1: 50 kg/week
- Canoe 2: 50 kg/week
- Canoe 3: 60 kg/week
- Canoe 4: 30 kg/week
- Canoe 5: 70 kg/week
- Canoe 6: 100 kg/week

**What is the Catch per unit of effort?**

\[
CPUE = 60 \text{ kg/week}
\]

#### Exercise 5
- Vessel 1: 20 kg/fishing trip
- Vessel 2: 35 kg/fishing trip
- Vessel 3: 40 kg/fishing trip
- Vessel 4: 50 kg/fishing trip
- Vessel 5: 10 kg/fishing trip

**What is the Catch per unit of effort?**

\[
CPUE = 31 \text{ kg/trip}
\]
Module 2 D: DFOs background material - Total catch

**Total catch**

Estimation of the total catch landed is the most appropriate way to arrive at the amount of fish harvested, especially in small-scale fisheries that are very common in African countries. This is so because, as Stamatopoulus (FAO, 425: 2002) states, “In most small-scale fisheries the amount of information on landings, species composition, prices etc, is often large, highly distributed and difficult to collect so that the use of census approaches is impractical and sampling techniques are nearly always used.”

To estimate the total catch, the following data thus are required: catch per unit of effort (CPUE) and effort. It is important to note that often only major species are recorded. For example in Lake Victoria this would be species such as Nile perch (*Lates niloticus*), Tilapia (of various species) and *Rastriniolobola argentea* (Omena), while the remaining, which come in relatively smaller amounts, would be recorded as “others”.

Catch refers to all the landed fish species, usually within a landing site, during a specified period (say a month). It may also refer to amounts harvested using a specific gear, like gill-nets or using a specific fishing craft such as “sese-canoes” (pointed at both ends).

The CPUE may be seen as an indicator of the abundance of exploitable stock of fish. It shows how much fish is harvested using a unit of an effort. For example how much fish (in biomass or numbers) is harvested using 1 boat in 1 day.

Fishing effort can be estimated from either gear or fishing craft in use.

The process of calculating an estimate of the total catch using effort data and CPUE (adapted from FAO fisheries Technical Paper 425) is as follows:

The assumption is made that sampling is done in both space and time. This means that only a few landing sites (for example in a district) are sampled and only for a specific number of days during the entire month. For example in a district where there are 22 legislated beaches, a sample of 5 beaches can be chosen and data can be collected from them over a period of 6 days in a month.

The formula to be used is:

\[ \text{Total catch} = \text{Fishing Effort} \times \text{CPUE} \]

Total effort is first estimated using a boat as a sampling unit. Effort is given by:

\[ \text{Effort} = \text{BAC} \times F_{\text{cap}} \times A \]

Where

- **BAC** is the Boat Activity Coefficient, expressing the probability that any boat (= fishing unit) will be active (= fishing) on any day during the month. **BAC = average no of active boats/no of boats from frame survey**
- **F_{\text{cap}}** is a raising factor expressing the total number of fishing units that are potentially operating at all fishing sites. This is obtained from Frame Survey or from artisanal vessel register/license system when complete census (both in space and time) takes place. It should always be calculated from the most recent data. **F_{\text{cap}} = no of boats from frame survey**
- **A** is a raising time factor expressing total number of days with fishing activities during the month. This can be estimated based on days on which fishing activity takes place at
the sampled landing site. For example the number of holidays and other days when fishing activities do not take place can almost be accurately stated. So the value of “A” changes with different months. For example, the December value is likely to be lower than January of every year. **A= number of fishing days per month**

An example:
Calculation estimating total catch

On a single landing site:

Suppose the following data was collected from Wichlum landing site in January 2009;

Total numbers of canoes from frame survey = 180  
Number of fishing days in January 2009 = 31  
Average number of active canoes on a day = 175

BAC = 175/180 = 0.97  
$F_{cap} = 180$  
$A = 31$

Fishing Effort January 2009  
= total number of canoes*BAC*A  
= 180*0.97*31  
= 5,412 boat-days

The CPUE at the landing site can simply be calculated using the catch of the sampled canoes divided by the effort used to harvest that catch. This can be accurately estimated using the data from the period of sampling alone.

The CPUE at the landing site can also be calculated as the average daily catch of a canoe during the month for which we want to calculate the total catch

In our example the average daily catch (CPUE) obtained through sampling 50 boats in the month of January was 6.8 kg/boat/day

Catch for the month of January 2009 in Wichlum landing site can therefore be estimated as;

Catch = CPUE *Effort  
= 6.8 kg/boat-day *5,412 boat-days  
= 36,890 kg

To estimate the catch for the landings in an entire district

This estimation requires data on:

- Total number of canoes in the district from frame survey,
- Average number of days of active fishing in a month,
- Assumption that the sampled sites are truly representative for all landing sites in the district
- BAC (can be calculated from average number of active boats in the sampled landing sites divided by the total number of boats in the same landing sites)
- CPUE is calculated as the average daily catch of all sampled canoes at all landing sites in the district

Given that:
Total number of fishing boats in Bondo District = 3,200 canoes (F=3,200) is spread over 16 landing sites,

Number of fishing days in January 2009 = 31,
BAC = 0.97 (based on the average for the sampled landing sites),
CPUE = 6.93 kg/boat/day (calculated average)

Fishing Effort \(=\) BAC \(\times\) F\(_{\text{cap}}\) \(\times\) A
\[= 0.97 \times 3,200 \times 31\]
\[= 96,224\text{ boat-days}\]

Therefore the estimate of total catch for the entire district for the month of January is:

Catch \(=\) CPUE\(\times\)Fishing effort
\[= 6.93\text{ kg/boat-days} \times 96,224\text{ boat-days}\]
\[= 666,832\text{ Kilograms or 667 tonnes}\]

This can be calculated for every riparian district of Lake Victoria and the total catch from the lake calculated by adding the individual values.

Idea of sampling

Whenever information is needed about a group of people or events, the most accurate way would be to gather data from each of the individuals in the group or event. But it is also possible to arrive at accurate conclusions by examining only a small part of the group. It is this assessment of the small group that is called \textbf{sampling}. Sampling helps reduce operational costs because time for the process and geographical coverage are reduced. It is also easier to manage smaller groups. (Sampling will be dealt with in more detail in module 3).

Total catches by species

Total catch by species can be calculated in two ways:
1. Based on the same fishing effort as given in the examples above, in the calculation the CPUE is replaced by the average daily catch for each species CPUE\(_{\text{species}}\) or;
   \[\text{Total catch}_{\text{species}} = \text{Fishing effort} \times \text{CPUE}_{\text{species}}\]
2. After the total catch has been calculated, the total catch by species is calculated by using the proportion of the species in the catch obtained from a sampling programme.
   \[\text{Total catch}_{\text{species}} = \text{Total catch} \times \%\text{spec}\]
### Total catch by species

#### Exercises

<table>
<thead>
<tr>
<th>Species name</th>
<th>Species composition (%)</th>
<th>Total catch</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nile perch</td>
<td>37</td>
<td>=0.37*36890=13,649 kg</td>
</tr>
<tr>
<td>Tilapia</td>
<td>22</td>
<td>=0.22*36890=8,116 kg</td>
</tr>
<tr>
<td>Omena</td>
<td>15</td>
<td>=0.15*36890=5,534 kg</td>
</tr>
<tr>
<td>Others</td>
<td>26</td>
<td>=0.26*36890=9,591 kg</td>
</tr>
</tbody>
</table>

**Wichlum, small landing site**

<table>
<thead>
<tr>
<th>Species name</th>
<th>Species composition (%)</th>
<th>Total catch</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nile perch</td>
<td>15</td>
<td>=0.15*666832=100,025 kg</td>
</tr>
<tr>
<td>Tilapia</td>
<td>38</td>
<td>=0.38*666832=253,396 kg</td>
</tr>
<tr>
<td>Omena</td>
<td>22</td>
<td>=0.22*666832=146,703 kg</td>
</tr>
<tr>
<td>Others</td>
<td>25</td>
<td>=0.25*666832=166,708 kg</td>
</tr>
</tbody>
</table>

**Bondo district**

#### Module 2D: Total catch

**Boat as a sampling unit**

Total Catch = Fishing capacity * activity level * CPUE

\[
\text{Total catch} = F_{\text{cap-boat}} * A * BAC * CPUE_{\text{boat}}
\]

**Gear as a sampling unit**

Total Catch = Fishing capacity * activity level * CPUE

\[
\text{Total catch} = F_{\text{cap-gear}} * A * GAC * CPUE_{\text{gear}}
\]
Module 2E: Total catch by species

- Total catch by species is calculated by the proportion of the species in the catch obtained from a sampling programme.
- \( \text{Total catch}_{\text{species}} = \text{Total catch} \times \text{proportion species} \)
Catch per Unit of effort (CPUE) or catch rate is frequently the single most useful index for long term monitoring of a fishery. CPUE is often used as index of stock abundance, as there is a relation assumed between CPUE and stock abundance. The CPUE, for example the quantity of fish caught per trawl hour, is a quantity which can be assumed to be proportional to the quantity of fish in the sea. Intuitively, it is not hard to accept that if there are twice as many fish in the sea, twice as many will be caught by fishing operations using the same fishing effort.

This assumption has been used in the development of surplus production fish stock assessment models. The objective of the application of surplus (harvestable) production models is to determine the optimum level of fishing effort, which is the effort that produces the maximum yield that can be sustained without affecting the long-term productivity of the stock, referred to as the maximum sustainable yield (MSY).

Surplus (harvestable) production models are the simplest analytical methods available that provides a full stock assessment. They are relatively simple to apply partly because they pool the overall effect of recruitment, growth and mortality into a single production model. The stock is considered solely as undifferentiated biomass, that is, age- and size-structure, along with sexual and other differences, are ignored.

The biomass model was written as above (page 21) as:

\[
\text{New biomass} = \text{Old biomass} + \text{recruitment} + \text{growth} - \text{catch} - \text{natural mortality}.
\]

A variation of this are the surplus production models where the variables; recruitment, growth and natural mortality are combined in “production” (i.e. recruitment + growth – natural mortality). A surplus production model can be written as:

\[
\text{New biomass} = \text{old biomass} + \text{surplus production} - \text{catch}
\]

The Schaefer Production Model

What is involved in maximizing fish production on sustainable basis?

Let us assume there is no fish in Lake Victoria and the Lake is being stocked now. Once the Lake is stocked, the fish population will grow in weight until it approaches the maximum carrying capacity of the Lake, after which its increase in weight ceases as the stock size (B) comes (Fig on page 2) closer to the carrying capacity of the Lake. Lets call the carrying capacity Bo.

The Bo more or less corresponds to the virgin stock or unfinished biomass. If fishing was to start taking place, we will have changes as follows:

Relative change of B with time = Additive factors of Biomass increase from growth - Subtractive factors of Recruitment as function of fishing effort and Mortality

As fishing continues, the yield (or production) will change and the effort relationship will be as follows:-
The fishing effort, which reduces $B_0$ to half its original value, will produce the highest net growth of stock and will be the maximum surplus yield available from the Lake. This maximum surplus yield can be sustained indefinitely hence the term maximum sustainable yield, MSY, as long as the biomass of the exploited stock is maintained at $B_0/2$ and we maintain the fishing effort at $F_{\text{optimal}}$.

What the above graph shows is that there exists an effort level which destroys the stock. So that production of capture fisheries has a limit at which a particular ecosystem can be sustained.

This surplus production model was developed by Schaefer (Schaefer, 1954, 1957)
The Schaefer model describes the relation between catch and effort through

\[ \text{Catch/effort} = a + b \times \text{effort} \]

With

\[ F_{\text{msy}} = -0.5a/b \]
\[ \text{MSY} = -0.25a^2/b \]

We explain this in an example of bream fisheries in Pais Pesca. This fishery started in 1985 when gill nets became available in Pais Pesca. In the period 1985 – 1988 the fisheries gradually started to use gillnets. In 1990 about 12,000 canoes were using gill nets for catching 27,350 kg of Bream per year on the average. The fishery is highly profitable and over time the number of canoes increased to about 31,000 in 2008. However, over the same period the average annual catch decreased to about 8,500 kg/year.

<table>
<thead>
<tr>
<th>Year</th>
<th>Catch (kg)</th>
<th>effort - '000 boats</th>
<th>CPUE in kg/boat</th>
</tr>
</thead>
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<td>1985</td>
<td>10,000</td>
<td>10.5</td>
<td>952</td>
</tr>
<tr>
<td>1986</td>
<td>20,000</td>
<td>10.5</td>
<td>1,905</td>
</tr>
<tr>
<td>1987</td>
<td>75,000</td>
<td>10.1</td>
<td>7,426</td>
</tr>
<tr>
<td>1988</td>
<td>150,000</td>
<td>10.1</td>
<td>14,851</td>
</tr>
<tr>
<td>1989</td>
<td>295,000</td>
<td>12.2</td>
<td>24,180</td>
</tr>
<tr>
<td>1990</td>
<td>320,000</td>
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<td>27,350</td>
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<td>1991</td>
<td>329,000</td>
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<td>1994</td>
<td>280,000</td>
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<td>1995</td>
<td>275,000</td>
<td>12.1</td>
<td>22,727</td>
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<td>1996</td>
<td>329,000</td>
<td>15.8</td>
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<td>380,000</td>
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<td>22,754</td>
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<td>382,000</td>
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<td>16,828</td>
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<td>2001</td>
<td>315,000</td>
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<td>13,519</td>
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<td>2002</td>
<td>347,000</td>
<td>23.3</td>
<td>14,893</td>
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<td>2003</td>
<td>352,000</td>
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<tr>
<td>2004</td>
<td>350,500</td>
<td>23.5</td>
<td>14,915</td>
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<tr>
<td>2005</td>
<td>292,000</td>
<td>29.3</td>
<td>9,966</td>
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<td>2006</td>
<td>260,000</td>
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<td>2007</td>
<td>263,000</td>
<td>31.4</td>
<td>8,376</td>
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<tr>
<td>2008</td>
<td>270,000</td>
<td>31.5</td>
<td>8,571</td>
</tr>
</tbody>
</table>

This data can be used to estimate the Maximum Sustainable Yield (MSY) for bream and its related fishing effort. For this we plot the CPUE (Y-axis) against the fishing effort (X-axis) and we calculate the regression line for: 

\[ \text{CPUE} = a + b \times \text{no of canoes} \]

This plot and the regression line is presented Figure 1 below.

---

6 The mathematical background is provided in Annex 1
Figure 1: Relation between fishing effort and CPUE (Schaefer curve) of Bream fisheries in Pais Pesca. The first 4 years are excluded from the analysis (unfilled rings) as the fisheries was in development phase.

The regression can be described with: \( \text{CPUE} = 35709 - 875 \times \text{No of canoes} \)

and

\[
\text{Fmsy} = -0.5a/b = -0.5 \times 35709 / -875 = 20000 \text{ canoes per year}
\]

\[
\text{MSY} = -0.25a^2/b = -0.25 \times 35709^2 / -875 = 364300 \text{ kg/year}
\]
Box 8: History Nile Perch fisheries Lake Victoria

The naturally occurring fish fauna of Lake Victoria was modified during the 1950s following the introduction of four non-indigenous tilapias namely Oreochromis niloticus, Oreochromis leucostictus, Tilapia zillii and Tilapia rendall and the Nile perch (Lates niloticus). This was a major turning point in the fisheries of Lake Victoria with adjustments of fishing effort made to exploit the introduced fish species. Drastic changes in occurrence, abundance and distribution patterns happened amongst all the fish taxa in the lake which coincided with the establishment of Nile perch. The Nile perch started dominating the catches around 1978 (Ogari, 1985) and in the 1980s all parts of the lake experienced an upsurge of their population (Acere, 1985; Ogutu-Ohwayo, 1990a).

Along with the massive increase in Nile perch catches, landings of all other species dropped, with the exception of Oreochromis niloticus, another introduced species and the native Rastrineobola argentea (Acere, 1995)

![Figure 2: Kenyan catch data indicating trends (Kenya Fisheries Department)](image)

**Figure 2: Kenyan catch data indicating trends (Kenya Fisheries Department)**

The fisheries resources of Lake Victoria make significant contributions to the local and national economies of the states sharing the lake. This is particularly true for the Nile perch fishery which generates considerable foreign exchange and provides employment and incomes for very many fishermen, fish traders and processing staff in the employment of local processors. The Nile perch fishery is a principal driver of a diverse array of businesses at landing sites and beyond that are dependent on the wealth generated by the fishery.
However, over the period catches and effort for the Nile perch fisheries in Lake Victoria increased considerably and since the early 90's the average annual catch per canoe started to decline rapidly.

![Figure 3: The rapid increase in the CPUE of Nile perch in Lake Victoria followed by its decline during the 1990s. (CPUE in kg/canoe/year, Effort in No of Canoes '000)](image)

**Module 2F**

**CPUE and fisheries management**

- **Catch per Unit of effort** is often the single most useful index for long term monitoring of a fishery.
- CPUE is often used as an index of stock abundance, as there is a relation assumed between CPUE and stock abundance.
- E.g. if there are twice as many fish in a lake, twice as many will be caught by the same fishing effort.
Module 2F
CPUE and fisheries management

This assumption has been used in the development of surplus production fish stock assessment models.

The objective of surplus production models is to find optimum level of fishing effort, which produces maximum sustainable yield (MSY).

Module 2F
CPUE and fisheries management

Surplus production models are relatively simple to apply as they pool the overall effect of recruitment, growth and mortality into a single parameter called production.

The whole fish stock is considered as a homogenous biomass, age-, size-, sex- and other differences are ignored.
**Module 2F**

**CPUE and fisheries management**

* In Module 1 we introduced the biomass model:

\[ \text{Biomass}_{\text{year}2} = \text{Biomass}_{\text{year}1} + \text{Recruitment} + \text{Growth} - \text{Natural mortality-Catch} \]

* Surplus models combine all three parameters in grey into one “surplus production”:

\[ \text{Biomass}_2 = \text{Biomass}_1 + \text{surplus production} - \text{Catch} \]

---

**Module 2F**

**CPUE and fisheries management**

* Biomass\(_2\) = Biomass\(_1\) + surplus production - Catch

* The basic idea is that if we maintain the catch equal to the surplus production (i.e. they cancel out), then the biomass remains the same between years (Biomass\(_2\) = Biomass\(_1\)), and we have a sustainable yield
Module 2F
CPUE and fisheries management

- Maximum Sustainable Yield (MSY) in a surplus production model is estimated through a Schaefer curve
- In a Schaefer curve we plot CPUE against effort and with the estimated parameters of the regression line we can calculate MSY and $F_{msy}$

The Schaefer model

- Assume a lake with fish stock of unflushed biomass $B_0$
- Then we start fishing
- As fishing effort is increased yield increases and the biomass decreases up to a point, where the Biomass is halved ($B_0/2$)

- At $B_0/2$ the highest growth rate of the stock (and MSY) are reached
- Increasing effort beyond 5.5 reduces both biomass and catch again and is not sustainable
Schaefer curve

<table>
<thead>
<tr>
<th>Year</th>
<th>Catch</th>
<th>Effort</th>
<th>CPUUE in kg/boat</th>
</tr>
</thead>
<tbody>
<tr>
<td>1985</td>
<td>10000</td>
<td>10.5</td>
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<tr>
<td>1986</td>
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</tr>
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\[ y = \frac{256.3}{b} - \frac{37060}{W} \]

Module 2F

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<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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</thead>
<tbody>
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<td>( m )</td>
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</tr>
<tr>
<td>( F_{\text{max}} )</td>
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</tr>
<tr>
<td>( M_{\text{ST}} )</td>
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DFO Manual fisheries data collection Tanzania, Part 2
Module 3: HOW TO COLLECT DATA

Module 3 A: DFOs background material - Basic Statistical methods and concepts.

Full census vs sampling

There are two ways of collecting data on fisheries:

1. Census, a complete enumeration or coverage of all elements in a population (i.e. the landings of all vessels are covered completely, everyday, at all landing sites)
2. Sampling, selecting only a few measurements and using these to calculate the estimated average value

A census approach is only appropriate for national population/expenditure surveys, frame surveys, etc. A census approach can be used when the fleet is relatively small, for example, the industrial fleet where logbooks or questionnaires could be used. The key advantage of a census is that (assuming perfect compliance) the results are known with certainty.

For small-scale fisheries a census or complete enumeration of landings and fishing effort is not possible, not even if reporting of catches using catch logbooks could be implemented. Landings are normally not concentrated in a few big ports but are dispersed over a large number of sites. Maybe there will be 100 or more landings for small to middle scale commercial fisheries at any particular landing site, concentrated in only a short period in the day.

For any given landing site (and there will be many different landing sites for small to medium size boats) it would be necessary to have large numbers of data collectors to be able to perform a census throughout the year!

A census approach can provide very accurate results. However, the costs in both staff and money will be very high. In complicated fisheries, and where in inland or coastal fisheries is the situation not complicated, with many gears, fishermen and landing sites, a census is practically impossible.

The alternative to a census is to measure only a few landings and use the average weight from these landings to estimate the total landed weight. This is called sampling and it means to measure some of the landings only at certain landing sites and on certain days. This method will be far cheaper and easier to implement than any census approach. To collect enough information to make our estimation of the total fish production only a few staff members will be needed for each district.

What is sampling?

Sample surveys involve the collection of data from a sample rather than all individuals in the target population. The key advantage of the sample survey is that less data needs to be collected and analysed. A key assumption of the sample survey is that the sample is representative of the target population as a whole.

Bias, Random sampling and systematic sampling

It is necessary to consider carefully how individuals are selected for measurement, whether it is selecting fish from a catch, vessels landing their catch from all those landing at a particular port, or fishers for interview. Therefore, to draw out the relationship between the whole population and the sample, the sampling methodology needs to be based on sound statistical methods and fully documented.

---

7 See Appendix 2

DFO Manual fisheries data collection Tanzania, Part 2
An eventual problem in sampling can be the existence of bias. Bias, in this case, is the tendency for estimates to centre on a value different from the true value as data accumulate. This can occur if, for example, data collectors tend to choose larger fish or vessels when sampling. The simplest theoretical way to avoid bias is to use random sampling. Under this scheme it is ensured that all individuals (fish, vessels etc.) within a stratum have an equal chance of being selected.

In practice, this is often difficult to achieve, and therefore a systematic sampling scheme (every third vessel, or tenth box of fish etc.) is used, which guards against the worst forms of bias. However, it should be borne in mind that most analytical methods assume random sampling, and therefore the possible effects of other sampling methodologies need to be considered in interpreting results.

**Stratified sampling**

Only if we have information on a certain population that is relevant to the data we want to collect can we improve on ‘random sampling’ by stratification of the population. The aim of stratification is to divide the populations in non-overlapping groups that internally are more homogeneous, thereby reducing the variation and consequently the number of samples required. In catch assessments, separating boats according to size classes, gear classes or into motorised versus non-motorised vessels, often makes sense as size, gear or the presence of a motor influences which fishing grounds are fished, and thus what species or what sizes are caught.

For stratification to work, some information about the fishery is required, on gear use, number of boat-gear combinations, or on location of fishing grounds. This information should be collected separately, by talking to key informants, by conducting a frame survey, or by using existing census or sample information. Stratification of the fishery to be covered by the statistical data collection programme will include decisions on:

1. Administrative strata
2. Logical strata (estimation contexts)
3. Sampling locations (homeports and landing sites)
4. Classification of the units that will be measured, including:
   a. Boat and gear categories
   b. Species and species groups
   c. System units (i.e. weight, currency and effort units)

For any given fishery two types of strata are identified

**Major strata**

These are defined by administrative boundaries. Data collection will have to follow administrative boundaries as the fisheries staff at a local level will have to be mobilized; this stratification is only for practical organizational and reporting purposes, and is not introduced for statistical reasons.

Major strata often conform to district or provincial boundaries and are in fact a bit of a nuisance as natural strata, such as sub-basins or ecosystems, normally do not conform to any administrative divisions.

**Minor strata**

Within each major stratum there are sub-divisions that are logical, i.e. they make sense from a sampling point of view and can be either spatial or temporal. These sub-divisions are called minor strata and they form the basis of the estimation process. Minor strata are not necessarily limited to geographical areas. They can also refer to any other logical estimation context including sub-periods within a month/year to fishing grounds or fishing vessels. An important fishing location can itself constitute a minor stratum, if estimates are required at that level.
Minor strata are controlled by the survey designers, and their purpose is to improve the quality and utility of estimates.

However, as the required sampling is established at the minor strata level, increasing the amount of strata too much (i.e. adding too many boat-gear categories, increasing the level of detail for which separate estimates are available) will increase also the amount of sampling required to be able to obtain reliable estimates.

**Sample sizes and accuracy**

An important decision to make is on the number of samples to take, both in terms of planning and for estimating the survey costs. The number of samples to be taken in order to obtain a reliable estimate depends on the variability in the population which is sampled. Let’s explain this through some examples.

If in one sample scheme canoes operating gill-nets and canoes operating traps are sampled in one sample survey, there is likely to be a large variation in the catch (Figure 1). This would be so as average catches of gill-nets are much larger (150 kg) than the average catches of traps (50 kg). The combined average catch would be about 100 kg. But due to the high variation caused by combining traps and gill-nets we need a large number of samples to correctly come to a reliable estimate of 100 kg.

![Figure 1: Catch distribution if gill nets and traps are sampled together](image)

The only way to both reduce the number of samples and reduce variation is to sample gill-nets and traps separately through stratification (Figure 2)
Sample sizes needed can be calculated once the variability is known and this is done through the relation between sample size and relative error.

The sample size depends on the margin we accept, the certainty that we need that the resulting estimate falls in the margin of error we have specified and the variation in the parameter to be estimated (see Appendix 2 on relative error).

From the examples we see that if we sample gill nets and traps together it will be difficult to obtain a relative error of 5%. By stratifying, i.e. sampling them separately (Figure 2) and taking about 10 samples for gill nets and about 45 for traps, we would obtain a relative error of about 5% (see Box 9).

**Box 9: Relative Error for gill nets and traps**

As illustration below the relation between relative error and sample sizes is presented for the previous examples:

- Sampling gill nets and traps at the same time
- Sampling gill nets
- Sampling traps

In practice we often use a rule of thumb or use empirically established sample sizes. For example, for catch assessment, a sample size of 30 per minor strata, spread out over 5-6 days per month is often sufficient to obtain reliable data.
Table 2: Rule of thumb for sampling catch. Source: FAO Fisheries Technical Paper 425, page 90.

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Referring to the table, an adequate sample size is interpreted as follows: For a desired accuracy level of 95%, for 3,000 total landings (=100 boats x 30 days): 123 landings should have been sampled by the end of the month.

Assuming that sampling occurs during 10 days then about 13 landings should be sampled on each sampling day at the sampling sites.

At a lower accuracy level of 90%, for the same number of 3,000 landings, the corresponding safe sample size is 32

Assuming that sampling occurs during 10 days then about 4 landings should be sampled on each sampling day from the sampling sites in the minor stratum.

Note that in these examples we assume that all the boats are of similar size and use the same gears. If boats and gears differ greatly, they must be split into two or more strata.
Module 3A: Basic Statistical methods and concepts

Conclusion

Lake Piscie: Small area, limited no of boats, you can cover completely: Full Enumeration or Census

Lake Victoria: Large area, large numbers of landing sites, large number of boats: Sampling is essential.

Module 3A: Basic Statistical methods and concepts

- Major issues in sampling
  - What is sampling
  - Design/select sample sites/stratification
  - Sample size
  - Sampling frequency
  - Sample methods
  - Others/Resources
What is sampling?

Sampling is a ‘short-cut' method for investigating a whole group.

What is sampling?

Let’s say it costs 1$ to investigate one square of the puzzle.

Cost of sample = 4$

Total cost = 16$

Good estimate
**What is sampling?**

Can we reduce the cost and still get an acceptable estimate?

![Fish and cost calculations](image)

Total cost = 16$

**Sampling in Time and Space**

- At some sites, boats are sampled (Space)
- Sampling is done at certain days only (Time)
Random sampling (i.e. not choosing) is the best scientific way to sample. If not possible or practical use stratification.

8 LANDING SITES, WHERE AND WHAT DO WE SAMPLE?

make six with dice
Module 3A: Basic Statistical methods and concepts

We select at Random?
- Random picking of two landing sites -> high probability of only picking red sites
- It can work for the boats but absolutely not for landing sites
- So we use systematic site selection through stratification

Module 3A Summary: Basic Statistical methods and concepts

Stratification
- Major strata – are done for Administrative classification, e.g. Region, District
- Major substrata – Ecological purpose - water bodies, rives, dams, lakes etc
- Minor strata – to improve sampling for higher accuracy and to reduced costs! e.g boat types, gear types
Module 3A: Basic Statistical methods and concepts

Example

**Major stratum:** Kilimanjaro District

**Major substratum:** Lake Mayan Mara

**Minor strata:**
- Boats with traps
- Boats with gillnets

Structure of sampling

1. Similar boats and similar gear are already grouped and counted separately in Frame survey
**Structure of sampling**

1. Similar boats and similar gear are already grouped and counted separately in Frame survey.

2. Samples are taken from all gear and boat groups, so that all fish species and all fish sizes have a chance to be included.
Structure of sampling

1. Similar boats and similar gear are already grouped and counted separately in Frame survey.

2. Samples are taken from all gear and boat groups, so that all fish species and all fish sizes have a chance to be included.

Minor Strata

Sample Size and frequency?
What is your opinion on sampling sizes?
### Sample size?

<table>
<thead>
<tr>
<th>Total number of landings</th>
<th>Number of landings to be measured</th>
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### Conclusions for sample size

**Minimum requirement**

**Per landing site**

- 30 type of boats or gears sampled per month!, 90% accuracy,
- 125 type of boats or gears sampled per month, 95% accuracy, if enough funds are available
Sampling Frequency

- Refers to how often sampling is done
- Since your sample size should be a minimum of 30, then; you have to take either 1 sample per day for 30 days or 30 samples once in a month or 5 landings in 6 days
- The rule is you should end up with at least 30 landings in a month

Why this stratification?

- Combined sampling of traps and gill nets
- Large variation
Why this stratification?

✦ Even if you take a lot of samples from Traps and Gillnets combined you still wouldn’t get accurate estimates
✦ By separating Traps and Gillnets you get a more accurate estimate for less costs (smaller samples needed)
Module 3B: DFOs background material – Monitoring, Sampling and dealing with potential problems

Monitoring techniques – Monitoring means an on-going process of checking the data collection process with an aim of ensuring that it is appropriately undertaken using the laid down standards and guidelines. Monitoring can involve the officer in charge of a station visiting the landing site during data collection and checking the process as it is done by the enumerators. The aim of this should be to check whether the enumerators understand what they are expected to do and are doing it correctly.

Incorrect data can result from a range of reasons:
- catches of some boats in the sample missing (e.g., because of landings during nights or at other beaches)
- multi-gear problems in stratified sampling
- when a zero catch in the sample is not recorded
- recording errors
- bias arising from motives of enumerators (e.g., choosing bigger boats)
- Cooked data

Cleaning data - Cleaning data is a process of identifying discrepancies in the collected data and devising means of correcting the discrepancies. For example, during frame survey data entry one might come across a boat which was targeting *Rastrineobola argentea*, yet the gear indicated to have been used is a gill net of mesh 3 inches. In this case, either the target species was *not* *Rastrineobola argentea* or the gear was small seine of mesh size 3 mm. In such a case, a ground truthing exercise has to be performed to establish the truth. Ground truthing involves going back to the actual landing site where such data was obtained and verifying the data.

Ethics, confidentiality, attitude, reluctant respondents, unexpected events Whenever data is collected from the fishers and the fishing communities, it is important to ensure that certain ethical issues need to be given upfront consideration so that data got from such respondents is reliable and also that the entire process is undertaken with more cooperation among the participating parties. Confidentiality of the respondents, their privacy, should be taken into consideration for the success of data collection (Mugenda and Mugenda, 2003). And despite the fact that the government has the right to obtain the information it requires concerning the state of the fisheries, the government agencies tasked with data collection should always try to gain the acceptance of the fishing communities from which the data will be collected. This can be done by simply organising community meetings and getting them to understand the necessity of accurate and appropriate data for effective management of the fisheries resources. This would ensure that reluctance by some to give data is reduced to a minimum or totally eradicated. At the same time, confidentiality of the information given by the fishers must be adhered to by the enumerators. The enumerators should not quote names of the respondents as this may reduce the validity of the data. The respondents must be assured that the information so given would be used specifically for the purpose of management and not for punitive action.

The enumerators also must ensure they collect accurate data from the field as any deviation from this would not only be unethical but also indicate lack of commitment to the needs of effective management of the resource in question. This would be reduced by training the enumerators and ensuring they actually appreciate the need for accurate data.

Design problems:
- **Sample is not representative of population (biased sample)** Choosing a sample that is not representative of the survey population often leads to bias in the sample. In a biased sample, the results of the survey do not reflect the true state of the survey population, leading to misleading results.
- **Poor sampling plan**
  This is often the cause of sampling bias. It involves only choosing samples that tend to exhibit certain features considered desirable for the enumerator/data collector. An enumerator may on a number of occasions insist on including specific fishing crafts in the sample without adequate reason or consideration to the others.

- **Appropriate sample size (according to staff and budget available)**
  This is the key to attaining both validity and reliability of data collected by the instruments of data collection. It is important to note that samples that are too small would not be representative but at the same time, very large samples may just be costly while not significantly improving the statistical reliability of the data. It is advisable to stick, therefore, to the guidelines outlined by the FAO (see Box 9 and Table 2). The sample size chosen will ultimately remain dependent on the budget and the number of staff/ enumerators to undertake the task.

- **Lack of proper stratification**
  Stratification normally results in more homogenous strata and a reduction in operational costs. Lack of proper stratification on the other hand will mean larger samples are needed in order to achieve the same degree of accuracy. In other words, there will be greater heterogeneity in the strata (FAO Fisheries Technical Paper, 382:46) which is likely to result in a higher number of errors.

- **timing of sampling – e.g. accommodating night landings**
  The timing of sampling has been noted to account for a good proportion of the problems to do with data collection. Various catches are landed at different times. For instance, Omena is landed very early in the morning, while Nile Perch and Tilapine fishes are landed any time during the day. Some Tilapines are landed in the night. The timing normally depends on the target species and the gear used. At such times considered inconvenient like at night, there may be no enumerator to collect data as such. Relying on landings made during day time or any other convenient time may result in the sample not being representative of the survey’s targeted population.

**Implementation problems**

- **Lack of clear precise instructions for enumerators**
  Failure to give clear precise instructions for enumerators can lead to incorrect entries being made in the data collection forms. They must know precisely what they are going to do while in the field or else the process turns out to be a waste of money and time. Before embarking on data collection, the enumerators must be able to confidently display their knowledge and ability to do the actual data collection. All questions they have must be addressed prior to going out to the field. Normally training them ensures that they are better prepared to make the activity more successful.

- **Lack of guidance and supervision**
  Whenever there is no guidance and supervision then data collection is bound to experience some problems, especially if the enumerators are not highly skilled and experienced. Guidance and supervision are most important during the actual data collection. This would involve the DFO or the officer in-charge checking to confirm that the enumerators are doing the right thing. Whenever problems arise during the process, they should be able to help the enumerators overcome them. It is important not to assume that the enumerators actually know every thing in terms of data collection. This may lead to invalidity of collected data but consequently to it being unreliable.

- **Conflict of interest – for enumerators**
  Conflicts of interest may also pose a serious threat to the validity of data. For instance, an enumerator who may be involved either directly or indirectly in the fishing activities and knows that there are illegal gears in use may be reluctant to record the type of gears used by a vessel for fear of retribution from the governing authorities. Alternatively an enumerator who benefits in some way from illegal fishing activities may not readily disclose the information required which he/she may feel would jeopardise his/her life or job. They are likely, therefore, to make invalid entries in to the survey forms. This greatly reduces the accuracy of data and undermines its usefulness.

- **Lack of motivation**
Motivation refers to the psychological behaviour that impels one to do something. This can either be intrinsic (internal) or extrinsic (external). It is motivation that would make the enumerators, such as members of the BMUs who are not on government’s payroll, collect data knowing they would not draw a salary at the end of the exercise. It is important to note, however, that some kind of motivation is necessary since not every one draws his/ her motivation from within. Therefore, while planning for a data collection exercise, some funds need to be set aside for the purpose of remunerating those involved and especially those outside government’s payroll.
Module 3B: Summary - How to sample and dealing with potential problems

- Monitoring techniques
- Cleaning data
- Ethics, confidentiality, attitude, reluctant respondents
- Design problems
- Implementation problems

Module 3B: Summary - How to sample and dealing with potential problems

- Monitoring techniques
  - A on-going process of checking the data collection process.
- Cleaning data
  - Identifying discrepancies in the collected data, verifying and ground truthing the data
- Ethics, confidentiality, attitude, reluctant respondents
  - To gain the acceptance of the fishing communities from which the data will be collected
Module 3B: Summary - How to sample and dealing with potential problems

- **Design problems**
  - Biased sample
  - Poor sampling plan
  - Inappropriate sample size

- **Implementation problems**
  - Unclear instructions for enumerators
  - Conflict of interest
  - Lack of motivation
MODULE 4: DIFFERENT COMPONENTS OF THE NATIONAL DATA COLLECTION SYSTEMS

Module 4A: DFOs background material – Different components of the fisheries data collection system in Tanzania.

All needed information is provided in Part 1
Module 4B: DFOs background material - Species identification

The major species in Tanzania are listed below

(a) Marine Waters

<table>
<thead>
<tr>
<th>No.</th>
<th>Common /English Name</th>
<th>Latin /Scientific Name</th>
<th>Swahili Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Thumbprint emperor</td>
<td><em>Lethrinus rhodopterus</em></td>
<td>Changu</td>
</tr>
<tr>
<td>2.</td>
<td>Peacock grouper</td>
<td><em>Cephalopholis argus</em></td>
<td>Chewa</td>
</tr>
<tr>
<td>3.</td>
<td>Yellowfin fusilier</td>
<td><em>Caesio xaenithonotus</em></td>
<td>Mbono</td>
</tr>
<tr>
<td>4.</td>
<td>Dogtooth tuna</td>
<td><em>Gymnasada nuda</em></td>
<td>Jodari</td>
</tr>
<tr>
<td>5.</td>
<td>Slender silver-biddy</td>
<td><em>Gerres oblongus</em></td>
<td>Chaa</td>
</tr>
<tr>
<td>6.</td>
<td>Giant tiger prawn</td>
<td><em>Penaeus bubulus</em></td>
<td>Kamba mti</td>
</tr>
<tr>
<td>7.</td>
<td>Ornate spiny lobster</td>
<td><em>Panulirus ornatus</em></td>
<td>Kamba koche</td>
</tr>
<tr>
<td>8.</td>
<td>Blue- tail mullet</td>
<td><em>Oedalechilus kesteveni</em></td>
<td>Mkizi</td>
</tr>
<tr>
<td>9.</td>
<td>Freckled gotfish</td>
<td><em>Upeneus oligospirus</em></td>
<td>Mkundaji</td>
</tr>
<tr>
<td>10.</td>
<td>Japanese threadfin bream</td>
<td><em>Nemipterus japonicus</em></td>
<td>Koana</td>
</tr>
<tr>
<td>11.</td>
<td>White-spotted octopus</td>
<td><em>Octopus chromat</em></td>
<td>Pweza</td>
</tr>
<tr>
<td>12.</td>
<td>East African sardinella,</td>
<td><em>Sardinella neglecta</em></td>
<td>Dagaa-papa</td>
</tr>
<tr>
<td>13.</td>
<td>Carolines parrotfish</td>
<td><em>Carrotomus spinidens</em></td>
<td>Pono</td>
</tr>
<tr>
<td>14.</td>
<td>King fish</td>
<td><em>Scomberomorus plurilineatus</em></td>
<td>Nguru</td>
</tr>
<tr>
<td>15.</td>
<td>Indian Mackerel</td>
<td><em>Restrelliger chrysozonus</em></td>
<td>Vibua</td>
</tr>
<tr>
<td>16.</td>
<td>Indian Squids</td>
<td><em>Loligo Dvauceli</em></td>
<td>Ngisi</td>
</tr>
<tr>
<td>17.</td>
<td>Silky shark</td>
<td><em>Carcharinus falciformis</em></td>
<td>Dagaa-Papa</td>
</tr>
<tr>
<td>18.</td>
<td>Commerson’s anchony</td>
<td><em>Anchoviella commersonii</em></td>
<td>Dagaa-mcheli</td>
</tr>
<tr>
<td>19.</td>
<td>White–spotted spine foot</td>
<td><em>Siganus oramin</em></td>
<td>Tasi</td>
</tr>
<tr>
<td>19.</td>
<td>Obtuse barracuda</td>
<td><em>Sphyraenella chrysotaenia</em></td>
<td>Msusa/Mzia</td>
</tr>
<tr>
<td>20.</td>
<td>Tille travelly</td>
<td><em>Caranx cynodon</em></td>
<td>Kolekole</td>
</tr>
<tr>
<td>21.</td>
<td>Sleek unicornfish</td>
<td><em>Naso hexacanthus</em></td>
<td>Puju</td>
</tr>
<tr>
<td>22.</td>
<td>Giant catfish</td>
<td><em>Arius serratus</em></td>
<td>Hongwe</td>
</tr>
<tr>
<td>23.</td>
<td>Milk fish</td>
<td><em>Chanos chanos</em></td>
<td>Mwatiko</td>
</tr>
<tr>
<td>24.</td>
<td>White-fin Wolf herring</td>
<td><em>Chirocentrus dorab</em></td>
<td>Mkonge</td>
</tr>
<tr>
<td>25.</td>
<td>Cock grunter</td>
<td><em>Pomadasys multimaculatum</em></td>
<td>Karamamba</td>
</tr>
<tr>
<td>26.</td>
<td>Black- barred halfbeak</td>
<td><em>Hemiramphus commersonii</em></td>
<td>Chuchunge</td>
</tr>
<tr>
<td>27.</td>
<td>Sword fish</td>
<td><em>Xiphas gladius</em></td>
<td>Nduwaro</td>
</tr>
<tr>
<td>28.</td>
<td>Unicorn leatherjacket</td>
<td><em>Alutera monoceros</em></td>
<td>Kikande</td>
</tr>
<tr>
<td>No.</td>
<td>Common / English Name</td>
<td>Latin / Scientific Name</td>
<td>Swahili Name</td>
</tr>
<tr>
<td>-----</td>
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</tr>
<tr>
<td>29.</td>
<td>Cobia</td>
<td>Rachycentron canadum</td>
<td>Songoro</td>
</tr>
<tr>
<td>30.</td>
<td>Feathertail stringray</td>
<td>Hypolophus sephen</td>
<td>Taa</td>
</tr>
<tr>
<td>31.</td>
<td>Jarbua terrapin</td>
<td>Holocentrus servus</td>
<td>Kui</td>
</tr>
<tr>
<td>32.</td>
<td>Bengal snapper</td>
<td>Lutjanus bengalensis</td>
<td>Janja</td>
</tr>
</tbody>
</table>

(b) Freshwaters (Lakes, Dams and Rivers)

<table>
<thead>
<tr>
<th>No.</th>
<th>Common / FAO Name</th>
<th>Latin / Scientific Name</th>
<th>Swahili Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Nile perch</td>
<td>Lates niloticus</td>
<td>Sangara</td>
</tr>
<tr>
<td>2.</td>
<td>Tilapia</td>
<td>Oreochromis niloticus</td>
<td>Sato/Perege</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tilapi zilli</td>
<td>Sato</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Oreochromis rukwaensis</td>
<td>Sasala</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Oreochromis leucostictus</td>
<td>Satu, Ngege</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Balirius tanganicae</td>
<td>Mbasa</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tilapia rendalli</td>
<td>Kayabo</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cintharinus gibbosus</td>
<td>Imbasa, Kukulu</td>
</tr>
<tr>
<td>3.</td>
<td>Catfish</td>
<td>Clarias theodora</td>
<td>Kambale</td>
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<tr>
<td></td>
<td></td>
<td>Clarias liopephalus</td>
<td>Kambale</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Clarias gariepinus</td>
<td>Kambale</td>
</tr>
<tr>
<td>4.</td>
<td>Protopterus</td>
<td>Protopterus aethiopicus</td>
<td>Kamongo, Kambale mamba</td>
</tr>
<tr>
<td>5.</td>
<td>Luciolates</td>
<td>Luciolates stappersii</td>
<td>Mgebuka</td>
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<tr>
<td>6.</td>
<td>Lake Victoria</td>
<td>Astatotilapia rubidae</td>
<td>Furu</td>
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<td></td>
<td>Haplochromines</td>
<td>Haplochromis pallidus</td>
<td>Furu</td>
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<tr>
<td></td>
<td></td>
<td>Haplochromis obesus</td>
<td>Furu</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Haplochromis bloyeti</td>
<td>Furu</td>
</tr>
<tr>
<td>7.</td>
<td>Spider prawns</td>
<td>Nematopalaemon tenuipes</td>
<td>Uduvi</td>
</tr>
<tr>
<td>8.</td>
<td>Lake Tanganyika Sprat</td>
<td>Strothrissa tanganicae</td>
<td>Dagaa</td>
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<tr>
<td>9.</td>
<td>Lake Tanganyika Sardine</td>
<td>Limnotherisa miodon</td>
<td>Dagaa</td>
</tr>
<tr>
<td>10.</td>
<td>Lake Victoria sardine</td>
<td>Ostrothrissa miodon</td>
<td>Dagaa</td>
</tr>
<tr>
<td>11.</td>
<td>Lake Victoria sardine</td>
<td>Rastrineobola argenteae</td>
<td>Dagaa</td>
</tr>
</tbody>
</table>
MODULE 5: ROLES IN DATA COLLECTION

Module 5: DFOs background material - Roles of DFOs and enumerators in data collection

The functions of a DFO at national, district and local levels

- DFOs provide the link between centre and grass roots (e.g. Community and enumerators), and should ensure good communication during the preparation for data collection.
- DFOs play a key role in linking the Fisheries Division with district officials, as data collectors are employed by the district authority. Whatever the Fisheries Division wants data collectors to do (e.g. receive training), it has to liaise with their employer, the District Authority.
- Implement data communication policies – An objective of the fisheries policy is to strengthen fisheries information in which enumerators play a key role.
- Ensure that a sustainable data collection system is in place – Make sure that data are collected continuously.
- The DFO is responsible for custody of the field returns (questionnaires/forms) – All of these are filled in at the field, not in the office.
- Ensure facilities and tools for record management are in place – Recording forms, weighing scales, bicycles, note books, pen, rain coats etc.
- Transporting or sending raw data to Hqs. (in electronic form for those with computers.)
- Writing reports on the performance of the data collection system
- Simple analyses of data at local levels.

Role of DFOs in relation to enumerators:

- Supplying enumerators with data collection tools/inputs – Acquire weighing scales, recording forms, bicycles, gum boots, rain coats, pen, notebooks,
- Supervise data collection processes – Make sure that data are recorded according to the agreed process.
- Ensure quality data is collected – Make sure that recorded data are accurate through monitoring the work of enumerators.
- Encourage enumerators to report to them on the performance of the system.
- Training enumerators
- Feed back of data to enumerators fishing communities
Module 5: Roles In Data Collection

- **DFOs roles in data collection**
  - At the local level
  - At the district level
  - At the national level
  - In relation to enumerators/Feed back to communities

Module 5: Summary - Roles In Data Collection

- **The functions of a DFO at local levels**
  - Link between district office and grass roots
  - Implement data communication policies – Make sure that, data are collected continuously and safely stored
  - Ensuring raw data collected reaches the district office in time
  - Feedback to communities
  - Train Enumerators
Module 5: Summary - Roles In Data Collection

- The functions of a DFO at district levels
  - Link between Fisheries Headquarters and district officials.
  - Implement data communication policies – Make sure that, data are continuously submitted to relevant authorities in time.
  - Responsible for custody of field returns.
  - Feedback to communities

Module 5: Summary - Roles In Data Collection

- The functions of a DFO at national levels
  - Sending fisheries data to Fisheries Headquarters.
  - Sending fisheries data to other relevant organizations.
  - Feedback to communities.
Module 5: Summary - Roles In Data Collection

✦ Roles of DFOs in relation to enumerators

- Supply data collection tools/inputs
- Ensure quality data is collected
- Supervise data collection processes
- Train enumerators
MODULE 6: REPORTING

Module 6A: Background material - Reporting in Tanzania

Objective: The DFOs know their responsibilities in data reporting and understand data flow from landing site to HQ.

Data flow

Landing site to district to national level

Fisheries data always flows from the source to Hqs. After collection, enumerators send data to DFO’s for input in the computer. Then the raw data in is sent in electronic form for uploading into the CAS database. It is sent to Fisheries Hqs, for analysis, management decisions and reporting. Then summary data are disseminated to various stakeholders. However, the Fisheries Division is trying to change the system in such a way that, if all district fisheries officers will have computers, data will be analysed at the district level in the CAS Database and they will produce their own summary reports. These results can be valuable at district level. The raw data will continue to be delivered to Fisheries HQ in electronic form in order for the Fisheries Division to continue to produce summary reports on the fisheries for the country as a whole.

Meeting deadlines:
It has been advised that, the raw data should reach to District Fisheries Officer not later than 10th day of each month. For example the data for January should reach to DFO not later than 10th February. The electronic data should reach the Fisheries Hqs. after every quarter i.e. January, March, June and September.
Module 6A: Background material - Reporting in Tanzania

Data flow

Landing site to district to national level

Fisheries data always flows from the source to Hqs. After collection, enumerators send data to DFO’s for input in the computer. Then the raw data in is sent in electronic form for uploading into the CAS database. It is sent to Fisheries Hqs, for analysis, management decisions and reporting. Then summary data are disseminated to various stakeholders. However, the Fisheries Division is trying to change the system in such a way that, if all district fisheries officers will have computers, data will be analysed at the district level in the CAS Database and they will produce their own summary reports. The raw data will continue to be delivered to Fisheries HQ in electronic form in order for the Fisheries Division to continue to produce summary reports on the fisheries for the country as a whole.

Meeting deadlines;
It has been advised that, the raw data (Form 21A) should reach to District Fisheries Officer not later than 5th day of each month. For example the data for January should reach to DFO not later than 5th February. The electronic data should reach the Fisheries Hqs. after every quarter i.e. January, March, June and September.
**Data flow**

**Module 6A: Reporting**

**Meeting deadlines**
- The raw data (Form 21B) should reach the District Fisheries Officer not later than the 5th day of each month.
Module 6B: DFOs background material - Storage and use of data

**MODULE 6B: Storage and use of data**

- At the district all fisheries data are stored in electronic and/or hard copy form at Fisheries Division, Statistics section
- Split into groups. Discuss storage and use of data
- Plenary: Each group describes their finding
- Compare the presentation from different groups and discuss.
- Flip charts

**MODULE 6B: Summary storage and use of data**

- Data enumerators collect information about fish catch from all vessels/boats landed in their respective landing sites
- At the site, form no 21A is used, thereafter the data is transferred to form 21B
**MODULE 6B: Summary storage and use of data**

- The recorded forms have to be sent to the respective DFO
- If computer is available, the DFO enters the data into CAS database
- On a monthly basis the DFO will send an electronic or hard copy of the collected data to the Fisheries Division Headquarters to be joined to the main CAS Database

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**MODULE 6B: Summary storage and use of data**

- The information of fish production will be disseminated to DFOs, cross sectors, institutions and other stakeholders
MODULE 7: TRAINING OF ENUMERATORS

Module 7: DFOs background material – Training of enumerators

Importance of the training of Enumerators

Which topics are important for training of enumerators/BMUs

Topic 1: Why is data needed

Definition of Fisheries Management
The integrated process of information gathering, analysis, planning, consultation, decision making, allocation of resources and formulation and implementation, with enforcement as necessary of regulations or rules which govern fisheries activities in order to ensure the continued productivity of the resources and accomplishment of other fisheries objectives.

The meaning of Fisheries Management
Fisheries management entails a complex and widely embracing set of tasks aimed at ensuring that the optimal benefits are obtained for the local users, state or regions from the sustainable utilization of the living aquatic resources to which they have access.

Importance of Fisheries Management
Setting policies and objectives for each fishery or stocks to be managed, taking into account the biological characteristics of the stock, the nature of existing or potential fisheries and other activities related to or impacting the stock and the potential economic and social contribution of the fishery to national or local needs and goals.

In consultation with the users, regularly reviewing the management objectives and measures to ensure they are still appropriate and effective.

Reporting to governments, users and the public on the state of resources and management performance.

Collaborative Fisheries Management (CFM), Objectives of CFM, the roles and responsibility of CFM.
Collaborative Fisheries Management (CFM) or Co-management refers to management of fishery resources by Government in collaboration with fishing communities. It means that, all responsibilities in fisheries management are under Fisheries Division and other stakeholders including District Authorities, fishing communities and resources users themselves.

Among the objectives of establishment of CFM is to involve communities in fishery policy implementation, to promote and develop sustainable resource use, to build capacity in fisheries management so as improve their livelihood.

Within the BMU organization chart, there is one sub committee which is responsible in collecting fisheries information and disseminate to stakeholders. This is why BMU were involved in fisheries data collection. Most of the District Authorities do not have enough enumerators thus BMU will help.

Topic 2: Why data collection
Data and information are the basis of good management in any fishery;

They evaluate progress of the fishery and updating policy and plans to provide continuous improvement of the fishery. It is essential to have adequate data to formulate a useful policy for the whole fisheries sector and effective management plans for particular fisheries.
Data are collected for the purpose of enabling the Division and the Government as a whole to plan, develop and manage the country's fisheries resources in a rational manner for the benefit of present and future generations.

**Topic 3: Identification of species, gears, boats**
Enumerators should be well trained on identification of species, gears and vessels

**Topic 4: What to collect ?**

**Topic 5: How to collect ?**
The data will be collected on a sampling basis, where by only few days will be selected on a month. Few landing sites should also be selected from the total number of landing sites we have from our frame surveys. On selection of number of boats to sample, there is a need to meet all of the three countries to agree on how many sample we can have on our sample.

**Topic 6: Problems enumerators encounter ?**

**Inadequate facilities for data collection**
During data collection in the field it was observed that most landing sites have no weighing scale as a result enumerators’ estimate the weight of catches

Most of the fishing vessels anchored away from the landing site due to low level /tide of water especially in marine waters which affect data recording since enumerators are not able to see the catches

There are no proper sequences during auction of fish landed which means that fish landed are sold differently at the same landing site and the same time

Many registered fishing vessels do not print their registration numbers on the vessel side which causes problems during data collection because fishermen don’t remember their vessel registered numbers and this may cause repetition during data collection

Instrument error: Most weighing scales are not calibrated for a long time and may cause error which is not necessary

Poor communication/infrastructure between the landing site and district head office, inevitably happen and take time to be solved

Some enumerators report to district and may be assigned to other duties without replacement and cause data collection exercise to be ignored by other District Executives

Lack of transport facilities- Bicycles for data enumerators
Module 7: Training of enumerators

- Importance of training enumerators
- Why are BMUs involved in data collection?
- How should enumerators be trained?

Module: Training of enumerators

- Implementation of training
  - DFOs organise the training
  - Train in groups
  - Train only the basics not the difficult matters
Module 7: Training of enumerators

- List of topics to be covered
  - Fisheries management
  - Co-management
  - Why data collection
  - Species/boat/gear identification
  - What data to collect
  - How to collect
  - Problems associated with data collection
APPENDIX 1: DRAFT GUIDELINES FOR MAJOR MARINE FISH IN TANZANIA

Not yet available
APPENDIX 2: SURPLUS PRODUCTION MODELS

Surplus production models

The basics

The objective of the application of surplus (harvestable) production models is to determine optimum level of fishing effort, which is the effort that produces the maximum yield (MSY) that can be sustained without affecting the long term productivity of the stock.

Surplus (harvestable) production models are the simplest analytical methods available that provides a full stock assessment. They are relatively simple to apply partly because they pool the overall effect of recruitment, growth and mortality into a single production model. The stock is considered solely as undifferentiated biomass, that is, age- and size-structure, along with sexual and other differences, are ignored.

Surplus production models and Maximum Sustainable Yield (MSY) are based on the theory of density dependent growth of biomass \( g(B) = dB/dt \) described by the sigmoid logistic growth curve:

\[
g(B) = \frac{dB}{dt} = r_mB\left(1 - \frac{B}{B_\infty}\right)
\]  

(2)

\( B_\infty \) is the theoretical maximum biomass that can be attained also known as carrying capacity, which is mainly determined by available food and space. The parameter \( r_m \) is the intrinsic rate of natural increase in biomass.

However, in this equation biomass loss due to fishing is not yet included, this is done by including the catch or yield (\( Y \)) in the equation:

\[
g(B) = \frac{dB}{dt} = r_mB\left(1 - \frac{B}{B_\infty}\right) - Y
\]  

(3)

When biomass does not change (\( dB/dt=0 \)), then the surplus production is equal to the yield and the stock is said to be in equilibrium. Assuming equilibrium, Schaefer (1954, 1957) developed one of the first surplus production models demonstrating a theoretical link between stock size and expected catches.

Under equilibrium conditions when \( dB/dt=0 \), Yield can be expressed from equation 3 as:

\[
Y = r_mB\left(1 - \frac{B}{B_\infty}\right)
\]  

(4)

From basics fisheries equations Yield can also be expressed as

\[
Y = F.B
\]  

(5)

Further

\[
F = q.f
\]  

(6)

---

\(^8\) Taken/derived from King, 1995, Sparre and Venema, 1998, Haddon 2001 and Larsen et al., 2003
Whereby $F$ is the fishing mortality, $q$ is the catchability and $f$ is the fishing effort. $Y/f$ is equivalent to CPUE and combining equation 5 and 6 gives

$$B = \frac{CPUE}{q} \quad (7)$$

Substituting equation 7 in equation 4 gives:

$$Y = f \cdot (CPUE) = r_m \left( \frac{CPUE}{q} \right) \left[ 1 - \left( \frac{q}{CPUE_m} \right) \right] \quad (8)$$

or

$$CPUE = CPUE_m - \left( \frac{qCPUE_m}{r} \right) f \quad (9)$$

Which is a straight line with a slope $b=\left( -\frac{CPUE_m}{q/r} \right)$, and intercept $a= CPUE_m$; that is a line of the form $CPUE = a + bf$, where $a$ and $b$ are constants. Thus providing the basics of the "Schaefer curve", with a direct relation between "fishing effort" and "CPUE".

Multiplying the CPUE with fishing effort $f$ provides yield and gives $Y = af + bf^2$ suggesting that yield is related to fishing effort by a symmetrical parabola.

Being rather simple to apply, the Schaefer model and later versions (Pella and Tomlinson 1969, Fox 1970, Schnute, 1977) have been extensively used in the last decades. However as any model which tries to describe biological complex interaction through mathematic also the Surplus production models encountered serious constraints.

**Constraints of Surplus Production models**

**Equilibrium.** One of the basic assumptions of Surplus production models is *equilibrium* (equation 4). i.e. for each level of fishing effort there is an equilibrium sustainable yield. The stock is assumed to be at some equilibrium level of biomass producing a certain quantity of surplus production. If the fishing regime is changed the stock is assumed to move immediately to a different stable biomass with its associated surplus-production. However fish stocks are rarely in equilibrium and nowadays it is even argued that ecosystems are in a constant and ever changing stat of non-equilibrium due to considerable variation of variables external to the system. Assuming equilibrium and applying surplus production models consistently overestimate sustainable yield and can lead to the collapse of the stocks (Boerema and Gulland, 1973; Larkin, 1977; Hilborn, 1979).

An ad hoc solution is to use the weighted average of a number of years fishing effort for each year instead of just observed effort for that year. However, developments continued and Surplus production models no longer need the assumption of equilibrium to be fitted (Haddon, 2001). The most common approach nowadays is the use of observation error estimation and fitting with least squares or maximum likelihood methods.
**CPUE reflect relative abundance of fish stock.** All fishing gears are species and size selective: especially in multi species small scale fisheries where one type of gear may catch a set of species, while another gear or the same gear used in a different way or different area may catch another set. This means that all fishing gears are only able to catch a certain portion of the total (multi species) fish community present. The use of catch rate as index of abundance of a fish stock is therefore complicated by the selectivity of the gear and is only valid under the assumption that all specimens within a (multi-species) stock at some stage during their life become part of the fishable stock.

**Multi species and relative abundance.** Surplus production models are mainly developed as single species models and it can be doubted whether the dynamics of aggregated species in a multi species fisheries is similar to that of a single species. Problems are certainly encountered if the fishers operating a single gear switch from target fish due to economic reason this would lead to a decline in CPUE of the not preferred species and an increase of the CPUE of the preferred species irrespective of the relative abundance of both species.

A second example is replacement under exploitation of one species by another. This replacement restricts the use of the MSY concept as effort increases and the “mining” of one species after another proceeds, does not necessarily lead to parabolic plots of "catch" on “effort” but rather to flat tipped curves with no discernable maximum (Pauly, 1994, Welcome, 2000) In such replacement fisheries slow growing and late maturing species (K strategists) are often replaced by fast growing and early maturing species (r-strategists) (Pauly 1004, de Graaf, 2001, de Graaf et al 2000) and this phenomenon stresses the importance of following individual species in a multi-species fisheries.

**System variability or human impact only.** Surplus production models are mainly based on the assumption that human intervention i.e. fishing or fishing effort is the only variable influencing the ecosystem/biomass. However, over the years a number of experiences, especially in inland fisheries indicated that this concept is too rigid as other abiotic factors such as water level, water temperature proved to be an important impact on biomass and consequently CPUE (de Graaf and Ofori Danson, 1997, de Graaf, 2002, Larsen et al, 2003). If the other variables are not considered as only minor “disturbances”, but as factors that may alter the dynamics of the ecosystem in a significant way, then one cannot a priori say how changes in fishing effort will affect the eco system, since the effect of fishing effort will vary according to the state of the abiotic variables (Larsen et al, 2003). Multivariate analyses and modeling is therefore an important tool in catch and effort analyses.

**Changes in catchability.** The major assumption in the use of surplus production models is that the relation between catch rates and stock biomass is constant (C/f=qB or C=q.f.B). This relationship implies that the catchability coefficient q remains constant through time. Catchability also called gear efficiency or fishing power depends on biological and technological factors (Larsen et al, 2003):

**Biological factors include:**
Fish availability on fishing ground, migratory behavior
Fish behavior towards fishing gear
Size, shape and external features of the fish
Where some of these factors again are depending on season, age, environmental and other factors

**Technical factors include:**
Gear type, design, colour and material
Gear position duration and handling
Experience of fisher
Where again these factors are depending on biological changes

The catchability coefficient or probability of a fish being caught is therefore a composite and very complicated factor. Conceptually, however, “fish catchability” implies primarily changes in fish behavior, whereas “fishing efficiency” indicates changes in fishing practices or in relative fishing power. As fishers tend to improve continuously their fishing gear and fishing practices it means that fishing efficiency increases through time.

So even if the nominal fishing effort \( f \) (no of fishing days, number of boat days, no of hooks set, no of meters of gill net set) can be followed, which is not always that easy, then changing catchability makes application of standard surplus production models over long data sets still complicated, with a risk of systematical over estimation of abundance.

This is why “fishing effort” is often replaced by “Fishing mortality” For the latter Csirke and Caddy (1983) developed a Surplus production model based on fishing mortality in stead of fishing effort. This model is a good alternative for standard surplus production models. However, the major disadvantage is the data requirements as fishing mortality or total mortality has to be estimated annually. The latter is normally done through the application of length or age based stock assessment programmes (growth, age, catch curves, cohort analyses)

A second approach is to compare catch rates from commercial and research fishing where the catchability of the research fishing is kept constant from year to year:

\[ \frac{CPUE_{\text{fishery}}}{CPUE_{\text{research}}} = \frac{q_{\text{fishery}}}{q_{\text{research}}} \] (10)

This method requires several years of data in order to detect relative changes in the efficiency of the commercial fishery. This lag time, before eventual changes are discovered, will lead to over estimation of stock size if the commercial efficiency or fishing power is rising

A third alternative is to define catchability \( q \) as a variable and add them in fitting procedures in non-equilibrium surplus production models (Prager 1994, Haddon, 2001)

Conclusions

After being relatively unpopular in the 1980s Surplus production models continued to progress and due to its relatively small data requirement they are most likely the major tool for the resource assessment of small scale multi-species fisheries. The present status of the models and its applicability is well provided by Haddon (2001):

“Now that surplus-production models have moved away from their equilibrium-based origins they provide a useful tool in the assessment of stocks for which there is only limited information available. Their simplifying assumption implies that any conclusions drawn from their outputs should be treated with caution. Nevertheless, given the constraints of only considering the total stock biomass, they can provide insights as to the relative performance of the stock through time. Surplus production models have now surprising flexibility and can be used in risk assessment\(^9\) and to produce management advice that goes well beyond the old traditional performance indicator notion of MSY and F\(_{\text{MSY}}\).

\(^9\) through Baysian statistics/modelling
APPENDIX 3: RELATIVE ERROR

Assuming that it is possible to obtain a random sample, how many canoes, \( n \), would we need to sample to obtain a pre-specified accuracy?

Suppose that we require an estimate of the mean catch not deviating more than 7% from the true mean catch and that we want to be 95% certain of this. We then would require the upper and lower 95% confidence limits not to deviate more than 7% from the estimated mean, \( X \). So that the deviation \( t_{n-1} \frac{s}{\sqrt{n}} \) should have a maximum value of 0.07\( X \), or

\[
 t_{n-1} \frac{s}{\sqrt{n}} = 0.07 \bar{X} \quad \text{or more general} \quad t_{n-1} \frac{s}{\sqrt{n}} = \varepsilon \bar{X}
\]

Where \( \varepsilon \) stands for "maximum relative error" (in this case \( \varepsilon = 0.07 \) or 7%)

Solving this equation with respect to \( n \) gives

\[
 n = \left[ \frac{t_{n-1} \varepsilon}{\varepsilon \bar{X}} \right]^2
\]

In order to calculate the number of samples needed we must already know the standard deviation, \( s \) and the mean catch, \( \bar{x} \), from previous samples.

The relative error, \( \varepsilon \), is related to the sample size, and will reduce with increasing numbers of samples taken. This function can be described as:

\[
 \varepsilon = \frac{s \times t_{n-1}}{\bar{x} \times \sqrt{n}}
\]

The maximum relative error, \( \varepsilon \), is shown as a function of the sample size, \( n \), and please note that we gain only a little by increasing the number of samples when \( n > 50 \).