Way forward for an improved data collection and data management system for marine fisheries in Sri Lanka

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Abstract

The coastal and off-shore fisheries in Sri Lanka are rather complex due to its multi-gear, multi-craft and multi-species nature. Collection of fishery dependent data is therefore a challenging task. This paper discusses the existing data collection and data management systems practicing at present in the marine fishery of Sri Lanka: Port Sampling Program (PSP), Log Book Data Collection Programme (LBDCP), Observer Program (OP) and Vessel Monitoring System (VMS). It is also discussed in detail about new PSP, which is currently in progress under Sri Lanka- Norway bi-lateral project.

The existing PSP is a manually adopted offline process, from the collection of data at the landing sites to the entering of data into the database (PELAGOS). Therefore, there was a need for improving the present PSP, especially, introducing Information and Communication Technology (ICT) for fisheries data collection, data storing and data processing. This upgrading is currently being done under the Sri Lanka-Norway bi-lateral project, 2016-2019. There is currently a process of applying for a second phase from 2020-2022.

The first step of the WP I was reviewing the previous reports and publications on improving data collection system. Consequently gaps, weaknesses and other issues associated with the current process were identified. Secondly, a baseline survey was conducted to collect baseline data associated with fish landings such as number of boats operated, boat types, gear types, fish species caught, seasonality of fisheries and fishing time. The data and information of baseline survey were explored and processed in order to prepare new data collection forms, developing a new sampling strategy and developing a mobile data collection application.

By now, the project has reached to several milestones. The new sampling strategy has almost been developed. The manual for port sampling data collection and data reporting forms have been prepared. A mobile application for electronic data collection has been developed. It is expected to start parallel test data collection using both manual data forms the electronic tabs followed by a careful validation process. The collection of data under the new system is ready to implement since 2020.

Establishment of the upgraded system for fisheries data collection, data storing and data processing will support to enhance the efficiency of data collection and data processing and also to improve the quality of fisheries statistics. Finally, this will further support to improve the fisheries management and policy formulation in Sri Lanka as well as to improve the compliance on data related resolutions adopted by the regional and international fisheries management organizations such as IOTC.

Keywords: Port Sampling Program, PELAGOS Database, Information and Communication Technology, Electronic Data Collection, Sri Lanka- Norway bi-lateral Project

1. Current Data Collection and Management Systems

1.1 Observer Program

"The objective of the IOTC observer scheme shall be to collect verified catch data and other scientific data related to the fisheries for tuna and tuna-like species in the IOTC area of competence" (IOTC Resolution 11/04, 2011).

As per the IOTC Resolution 11/04 on regional observer scheme, FAO and IOTC provided two weeks training for twenty six (26) scientific observers in 2018. Currently, Sri Lanka is implementing a scientific observer program on high sea fishing vessels, which are over 24 m by length. The program aims to cover at least 5 % of fishing operations of > 24 m vessels in one calendar year. The data are collected according to the standard data collection formats provided by the IOTC and entered using IOTC ROS-eReporting interface at the DFAR. The table 01 summarizes the status of DFAR's actions to implement IOTC Resolution 11/04 on regional observer scheme on high sea fishing vessels (> 24 m) during last five years.

Table 01. Status of observer coverage during last five years: 2014-2018

Year	Number of Vessels of > 24m	Number of fishing operations	Operations provided observer coverage	% of Observer coverage
2014	Purse Seine - 08	10	02	20
2015	Long line - 02	02	02	100
2016	0	0	0	0
2017	Long Line -02	15	02	13.33
2018	Long Line - 02	09	02	22.22

By now, over one thousand two hundred (1,200) fishing boats of less than 24 m overall length have been registered for high sea fishing operations (DFAR, 2019). Due to the smaller in size, health and safety concerns associated with the deployment of independent observers on such small vessels, Sri Lanka to date is unable to meet the IOTC's minimum independent data reporting requirements for its beyond EEZ fishing fleet under Resolution 11/ 04. Therefore, DFAR has implemented a local observer program for such vessels as an alternative programme.

Under the local observer program skippers record their catch data in the standard DFAR logbook (see 1.2 below). Skippers are also provided with the tablets / digital cameras to collect images of each fish caught while fishing and a simple flip board, with scale on which to record the weight of each fish caught (Figure 01). After the vessels returns to the harbor, data about each individual

fish image are manually recorded in the local observer data collection book by DFAR officers in conversation with the skippers. The photos of individual fish and local observer data collections books are submitted to the DFAR after trip is completed. The information associated with the photos (e.g. year, month, day, time, geo location) are directly extracted to an excel spread sheets using a python program. Thereafter data in the local observer data collection books are entered manually and verified by tallying set number and fish number which are already extracted by photographs and manually recorded in the data collection book. This is done by designated fishery officer at the DFAR. This program was implemented in 2018 expected to be merged with regional observer scheme later. The local observer program aims covers at least 120 trips per year, by 2020.

Figure 01. Use of flip board taking length and weight data during crew-based (local) observer program

1.2 Fisheries Log Books

DFAR has introduced a paper logbook for all multiday fishing vessels operated targeting tuna and tuna like species since 2012 in order to collect spatial and temporal catch statistics. The collection of catch and effort data on-board using a logbook for high sea fishing vessels is an obligatory requirement as per the relevant IOTC resolution and managing logbook data is a crucial part of managing IUU fishing. However, due to some practical issues faced during the usage of paper logbooks, DFAR has made an attempt to introduce an electronic logbook system in 2016/17 in order to avoid or minimize such issues (Gunawardhana, 2016). The new system is a GPS enable mobile-based electronic logbook, which automatically records the position, orientation, acceleration and other required information in a given frequency during the entire voyage, while the skipper has to enter the catch details (Figure 02).

The system is now in place and DAFR is now in the process of introducing and popularizing the system among the fishing skippers, who were not previously provided with eLog books. Up to date, more than 2000 fishing trips were recorded using the e-logbook covering both high seas and coastal multi-day fishing vessels. This new system was approved by the IOTC in 2017 and

was implemented in 2018. It is expected to replace the manual logbook entirely by eLog books by 2021, in particularly for high seas. The possibility of incorporating this with the Electronic Monitoring System (EMS), which is proposed by the IOTC, is also being discussed. By now around 2,400 tabs (powered by Android) have been distributed among the skippers as the first step in the implementation.

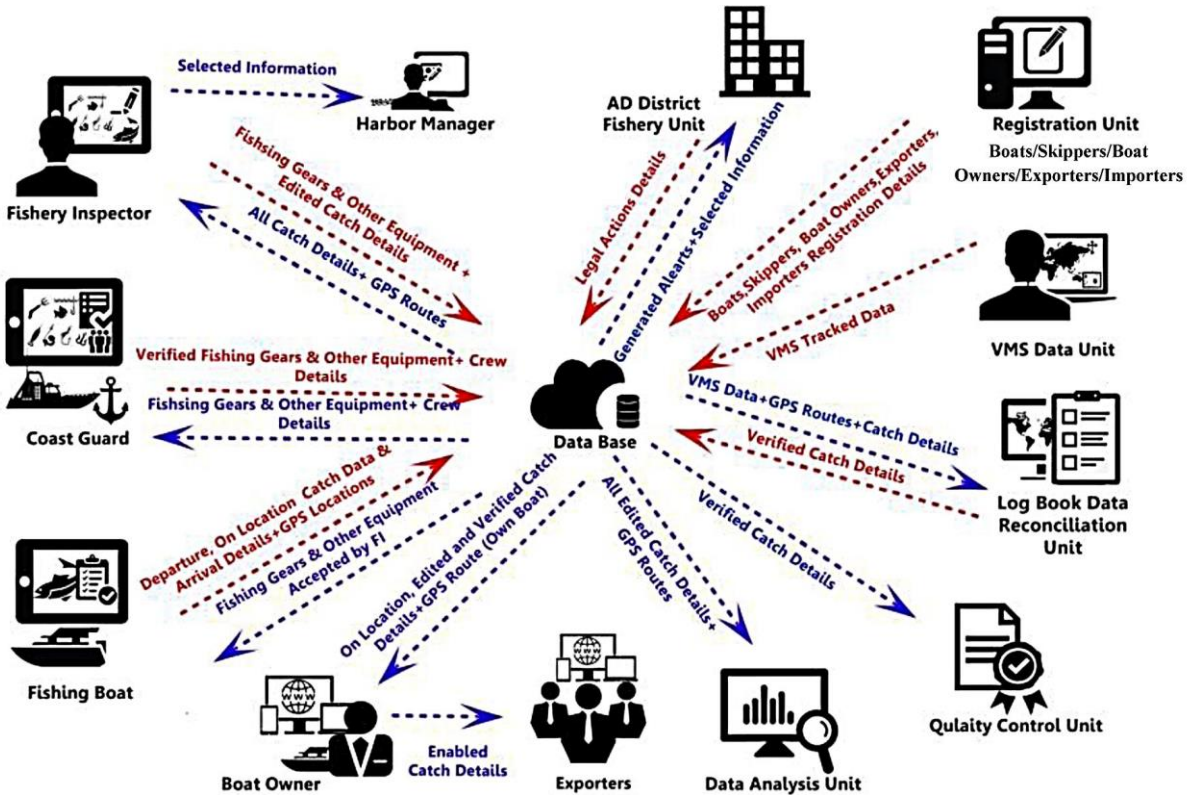

Figure 02. Data flow of the eLog book system (*Courtesy*: Gunawardane, 2016)

1.3 Vessel Monitoring System (VMS)

A satellite-based vessel monitoring system which is directly controlled by a dedicated VMS unit is established at DFAR (Figure 03). All high sea vessels registered under the DFAR must be equipped with a VMS, unless they are not allowed to do any fishing operations in the high seas. All the high sea operating vessels are totally monitored by the VMS, in order to confirm the fishing operations are taken place in compliance with the international laws and conventions of the sea. All the data coming from the VMS are stored in an oracle database.

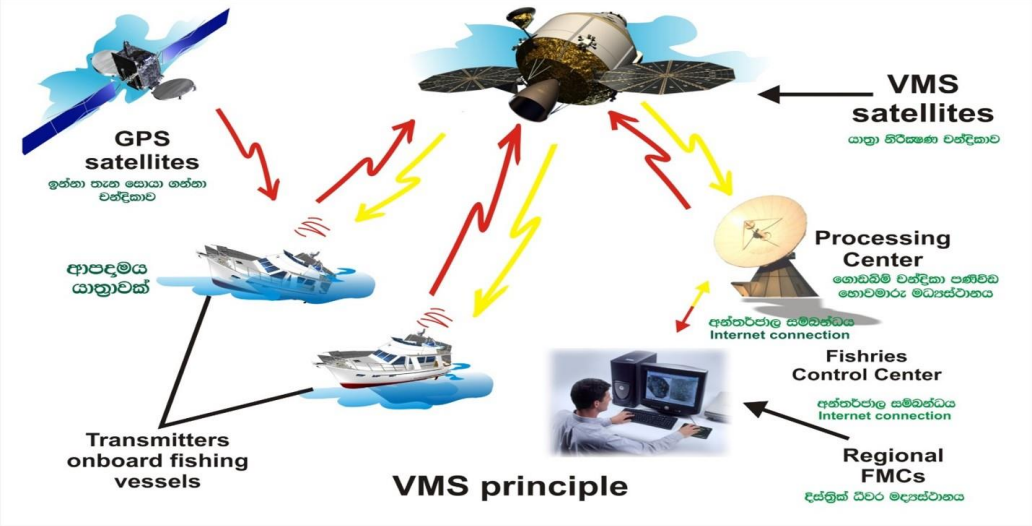

Figure 03. Schematic diagram of the existing architecture of VMS (Image courtesy, DFAR)

1.4 Port Sampling Data Collection Program and PELAGOS Database

The port sampling program for fishery data collection runs back over 30 years down the line. After, establishing NARA in 1981 research staff of Marine Biological Resources Division (MBRD) started the fisheries data collection with particular attention to large pelagic fisheries. Initially, the sampling program was restricted to few major landing sites in the northwest, west, southwest and southern areas (Maldeniya, 2013). A comprehensive sampling program for large pelagic data collection was established under the technical and financial assistance from the Indo-Pacific Tuna Programme (Forster 1987). In 1994, it was further strengthen and extended up to the East coast (Williams, 1995).Twelve samplers were assigned with a task of collecting catch and effort data and length measurements for all tuna species, billfish and seer fish in the large pelagic catch and this was conducted at the major fish landing centers in the West, Southwest, South, Southeast, East and Northeast. Data were collected according to stratified random sampling method, which consists of spatial strata i.e. landing sites, technical information such as vessel categories, gear types etc. and the temporal information i.e. months and years (Maldeniya, 2013).

The sampling programme was updated again in late 2004 with technical and financial assistance from the Indian Ocean Tuna Commission (IOTC) and the Overseas Fishery Cooperation Foundation of Japan (OFCF). The objective of this collaborative project was to strengthen data collection and processing systems of billfish and tuna fisheries and thereby produce more accurate catch and effort estimates (e.g. by gear, area and species). Further, sampling size of the length frequency data of above species was increased (IOTC, 2005).

Currently, NARA has eight (08) fulltime field research assistants and six (06) part time research assistants are involved in collecting fisheries statistics. In addition, twenty eight (28) part time Fisheries Inspectors of DFAR are also participated for large pelagic data collection. Data are collected mainly according to the vessel types and it is determined on the basis of the size of the vessel. This port sampling programme is closely monitored by NARA Scientists and the Assistant Directors of the DFAR (Figure 04).

Sri Lanka is divided in to 15 marine fishery districts, and each district has been subdivided into 4-15 Fisheries Inspector (FI) divisions (148 in total). The data collected by NARA and the DFAR enumerators are stored in the PELAGOS database. The framework of the PELAGOS, ACCESS 2.0 developed by (Williams, 1994), was upgraded to ACCESS 2003 in 2005 under the IOTC/OFCF programme (Dissanayake, 2005). Currently, two identical PELAGOS databases (Access 2013) are separately set up at the Statistics Unit of Ministry of Fisheries and Aquatic Resources Development (MFARD) and NARA which are offline.

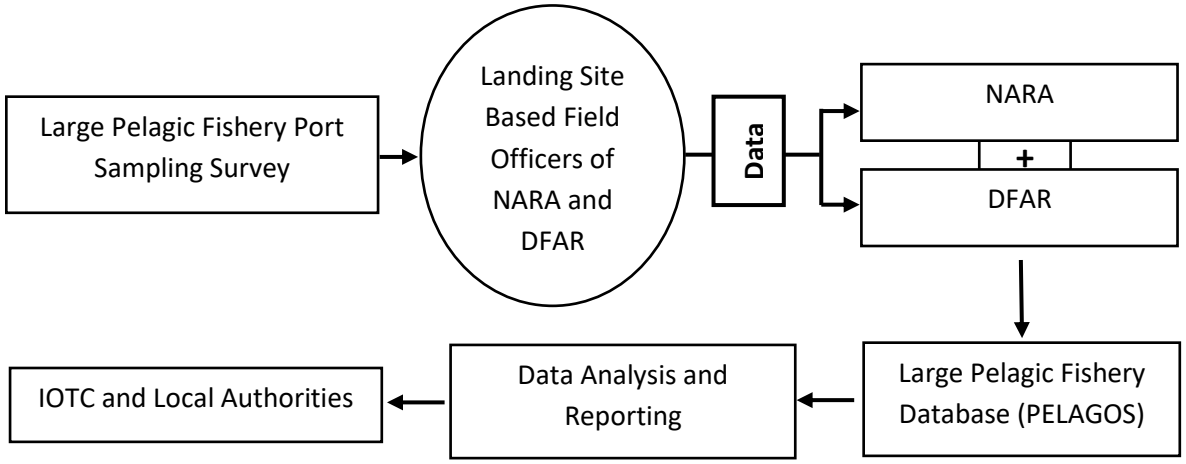

Figure 04. Simplified flow diagram of existing port sampling data collection process

1.5 New port sampling program implementing under Norway - Sri Lanka bi-lateral fisheries project

Sri Lanka and Norway has a long-standing cooperation within the fisheries sector dating back to the beginning of 1970's. In recent years, a fact-finding team prepared the report "Possible Areas for Cooperation within the Fisheries and Aquaculture Sectors between Sri Lanka and Norway" in 2012. Based on this a project was formulated in cooperation between National Aquatic Research and Development Agency (NARA), Sri Lanka and Centre for Development Cooperation in Fisheries (CDCF) at Institute of Marine Research, Norway with focus on two areas; 1) Fish quality, food safety and post-harvest aspects and 2) Oceanographic and hydrographic survey using a newly acquired research vessel in Sri Lanka. That project was initiated in August 2013.

However, in 2014 the project was terminated prematurely due to external factors. By that time, the first project component was completed.

In January 2016, a new request was received from Sri Lanka to continue the cooperation and a new fact finding mission was organised by the Norwegian Agency for Development Cooperation (Norad). This mission defined new priorities for the fisheries cooperation and decided to go forward with two project components within this project.

These were:

1 Assistance to upgrade existing NARA's port sampling programs on fisheries data collection and data processing.
2 Fish stock assessment including resources surveys with RV. Dr. Fridtjof Nansen and provide assistance to NARA on assessment of fisheries resources using their own RV "Samuddrika".

1.6 Rationale

Data from the large pelagic PSP are registered in two identical offline MS Access databases (PELAGOS) established at NARA and MFARD, which are finally merged into one database during the processing of data. Not only that the small pelagic data collected via PSP is also stored in a separate MS Access database. The PELAGOS is the main source of data, which is used for annual catch estimations for the fisheries in the EEZ of Sri Lanka. Currently, almost all processes of PSP are operated manually. Therefore, there is an essential requirement of improving the existing PSP adhering to the modern ICT. Accordingly, shifting to a web-based central database management system linking through the electronic means of collection and registering of data, which are receiving not only from the coastal and offshore fisheries, but also the lagoons. The Sri Lanka-Norway bi-lateral fisheries project is now in place to make this requirement a success.

1.7 Objectives

1. Upgrade existing fisheries dependent data collection to generate scientific data and information for sustainable management of the fisheries resources
2. Setting up a web-based central database for fisheries data in Sri Lanka.

2. Project Activities

2.1 Literature review

Literature review was done to identify the studies, which have already been carried out to improve the fisheries data collection system in Sri Lanka in order to avoid repetitions and to improve the present protocol. Further, the practical issues and weaknesses associated with current data collection process and data management systems were also identified.

2.2 Conduct a baseline survey

Based on the lessons learned from the literature review and the issues and weaknesses identified, which are associated with current data collection process and data management systems, the baseline survey was conducted to cover the coastal fisheries throughout the country to recognize the present situation. This was carried out as a collaborative work with the participation of officials from NARA, DFAR and MFARD in 2017. This was a rapid survey to identify the number of fishermen, fish species caught, boat types, gear types, seasonality of fisheries, fishing times etc. During the survey registration of almost all landing sites was done covering 15 fisheries districts. Further, GPS locations of the all the landing sites were recorded for the purpose of map visualization and facilitating the sampling design.

2.3 Prepare guidelines and data collection forms

The existing large pelagic data collection forms were upgraded according to the data collected through the baseline survey. Further, guidelines and manual of operation for data collection were also prepared.

2.4 Conduct training workshop at national and field level

Several workshops were conducted to train the officials of DFAR and NARA to aware them on the proposed data collection.

2.5 Test the data collection forms in the field

The upgraded data collection forms were tested in the field by field officers of NARA and DFAR in order to identify the practical issues if any. Based on the issues raised during the data collection, the forms were further revised in order to implement a smooth data collection system.

2.6 New database design and database development

Based on the upgraded data collection form a new database was designed. Here, all the relevant data tables to be incorporated with the database were identified and mapped. The technical stuff was done by the Norwegian experts with the support of members of the WPI. The data base design was then communicated to the database developer (a Sri Lankan Company) in order to facilitate the structuring the database. The developer, Epic Lanka was chosen as external system developer from Sri Lanka. The database development includes application for data registration

and database storing of the catch data collected from landings. Catches and landings from all fisheries are included.

2.7 Sampling design

The data and information received from the baseline survey and the information received from the literature survey are currently being incorporated for developing a novel sampling strategy. The aim of the development of the sampling strategy is to ensure proper representation and reliable statistics for all fisheries, including coastal fisheries. Enhancing data quality has been considered important, since development of sound sampling design heavily depends upon baseline survey data analysis and the quality of these data. Therefore, it was suggested that the sampling needs to be done at the landing sites, all types of fishery should be covered (except for ornamental, chank and sea-cucumber fishery conducted by divers), the whole country should be covered throughout the year and a randomised sampling design must be used in order to obtain valid and robust estimates.

Considering the complexity and magnitude of the work sampling must be stratified, such that the most important landing sites and fisheries were allocated more sampling resources than less important sites.Two separate sampling programs; 1) for the large pelagic fishery that is landed in the major ports, and 2) the rest of the Sri Lankan fishery, landed at all types of landing sites were suggested. Simulations are being performed to facilitate a robust sampling design.

2.8 Mobile application, test data collection and validation

Based on the upgraded data collection sheets mobile application is being developed. The upgraded data collection sheets were transferred into software applications for tablets, in order to register data electronically at the landing sites using tablets. The application is included with all the data registering records which are identical to the records in the paper sheet. Application is being developed and powered by Android. Test data collection using mobile device is expected to be carried out before ending the year. During this process data is also collected using the paper sheets followed by a validation process. The issues, which may be encountered during the first use of the application shall be identified and fixed accordingly.

2.9 Setting up a central database

Together with testing of the mobile application, a central database is being established. After establishing the CDb all the data registered in the mobile application are stored in the CDb via an online system. The exiting vessel registry is also integrated with the CDb. The system expected to be accessed at the DFAR, MFARD and NARA by the authorized officers when the verifications, data extraction and analysis are required. This part is in progress.

2.10 Trainings on statistics and data management

Courses on fisheries statistical data analysis and data management are to be conducted in order to increase the competence levels in these fields among the officials of NARA, DFAR and MFARD.

2.11 Establish an inter-agency mechanism between NARA and DFAR for integration of data collection

Here, it is expected to increase the manpower from both sides, NARA and DAFR to ensure enhanced sampling coverage around the island. In this case a common field program is to be established without unnecessary data collection overlapping, leading to a better integration of data collection. This process is in progress.

3. Results

3.1 Baseline Survey

It was a prerequisite conducting a baseline survey at the beginning of the project as information on the coastal fisheries has not been updated throughout the country recently. Due to multi-gear, multi-vessel and multi species nature of Sri Lanka fishery, the distribution of landing sites was rather high in number, which covers almost the total coastal belt around the Sri Lanka. The baseline survey discovered around 900 landing sites covering 15 fisheries districts around Sri Lanka. Figure 05 shows the distribution of landing sites around the coastal belt of Sri Lanka.

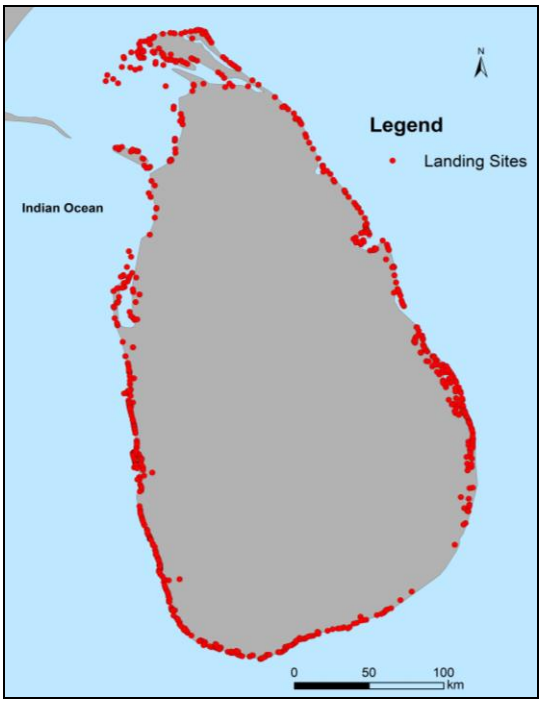

Figure 05. Location map of the fisheries landing sites around the country, recorded during baseline survey

3.2 Prepare guidelines and data collection forms

Preparation of new data collection forms has been completed. A data collection manual is also prepared. As compared to the existing large pelagic data forms, the new forms are rather detailed. In addition to the catch and effort, gear, length etc. new forms are included with socio economic data too. Further, the new forms will include not only large pelagic data instead collect the data on other fisheries such as small pelagic, demersal and lagoon fishery.

3.3 Sampling Design

According to the data collected during the baseline survey and its analysis following two sampling programs were suggested with possible strata (Table 02).

Table 02. Sampling programs/strata suggested for the Sri Lanka fishery

Strata	Sampling program	Sampling effort
	Program 1 – Large pelagic fishery Like today's coverage but including all main harbours, and randomized sampling. Strata defined from logbook data.	Six sites sampled per sampling day (approximately 1200 sites x days per year). Effort stratified.
A1	Large pelagic fishery in main harbours	
A2	Large pelagic fishery in medium harbours	
A3	Large pelagic fishery in small harbours	
	Program 2 – Rest of SL fishery (small pelagic, demersal etc.) Randomized sampling in all harbours and landing sites. Strata defined from baseline survey and adjusted according to season.	Six sites sampled per sampling day (approximately 1200 sites x days per year). Effort stratified.
B1	All types of fishery – large landing sites	
B2	All types of fishery – medium landing sites	
B3	All types of fishery – small landing sites	

The sampling design is still in progress. Therefore, here we present the initial results obtained only for large pelagic fishery, which is also being discussed.

Program 1 – Large pelagic fishery **-** the available logbook data that gives total catch landed per harbour per month. These data can be used to allocate sampling resources, is a good way so that the largest harbours are sampled more frequently than the smaller ones. Figure 06 (left) suggests that there is some seasonality in landed quantity. Based on the very large differences in quantity landed per harbour/month it can be suggested to divide the sampling effort in three strata as generated by the red lines in Figure 07 (right) ((0-50) tons per month; (50-500) tons per month; (Over 500) tons per month). 500 tons per month corresponds to approximately the 75 percentile of the total dataset, while 50 tons corresponds to approximately the 35 percentile.

Figure 06 gives a monthly overview of total landings per month and harbour from the same dataset. Even though some of the harbours fall into different strata on different months it can be suggested simplifying this and allocate the same strata throughout the year, based on an overall judgment. This stratification is based on only 12 months of logbook data and will vary from year to year and may be adjusted yearly.

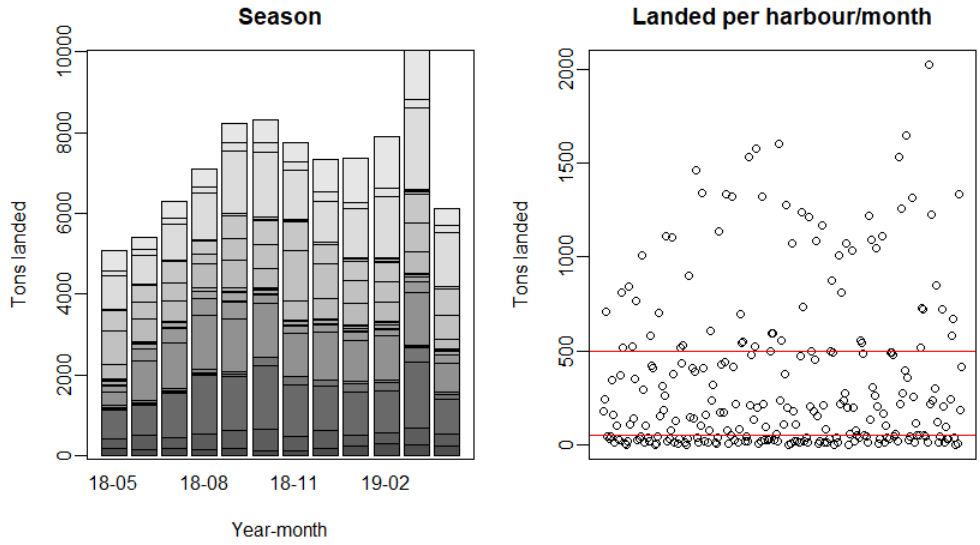

Figure 06. Data from logbook 2018-2019. Left panel show the monthly landings of large pelagic species by month. Different colours of the bars indicate different harbours (legend not shown). In the right panel each point represents landed quantity in one harbour one month. Red lines are suggested strata limits.

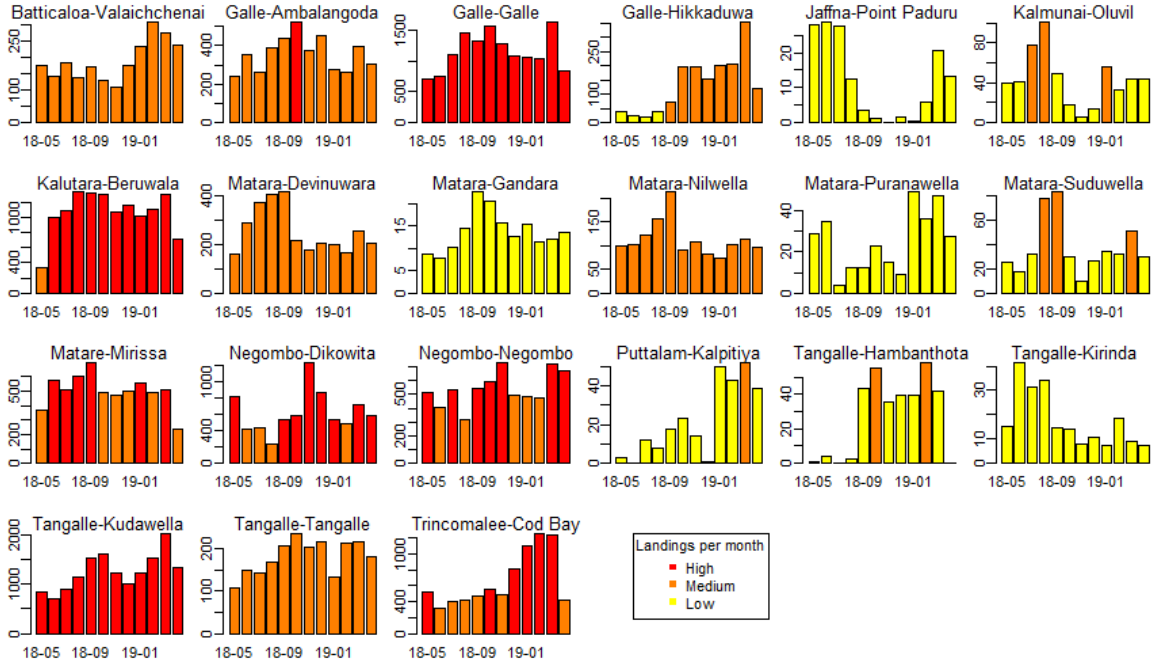

Figure 07. Data from logbook 2018-2019. Total catch per harbour and month are shown in each panel. Bars are coloured according to the catch that month, using the strata limits suggested in the text. Y-axis is tons landed per month, and axis range differs between plots.

According to this initial analysis results following strata can be suggested for large pelagic fishery;

A1 – *High sampling intensity*: Galle, Beruwala, Mirissa, Dikowita, Negombo, Kudawella, Cod Bay

A2 – *Medium sampling intensity*: Valaichchenai, Ambalangoda, Hikkaduwa, Devinuwara, Nilwella, Suduwella, Tangalle

A3 – *Low sampling intensity*: Point Paduru, Oluvil, Gandara, Puranawella, Kalpitiya, Hambanthota, Kirinda

3.1 Database design and development

Initial mapping of data table has been completed (Annex 01). Landing data is planned to be part of an integrated fisheries data system, which incorporates other data sources as well, for example vessel registry, licences, and fishermen's registry. Integration of different related data sources into one system is considered a major strength, since it will enable coherent validation of data and more flexibility to analysis and reporting outputs. The final database would be a SQL database.

3.2 Mobile Application

Mobile application has almost been completed and ready for test data collection using android tabs. The test data collection followed by a validation is expected to be done before end of this year. Figure 08 shows current development of the mobile application in the form of access interfaces for electronic data collection and registration.

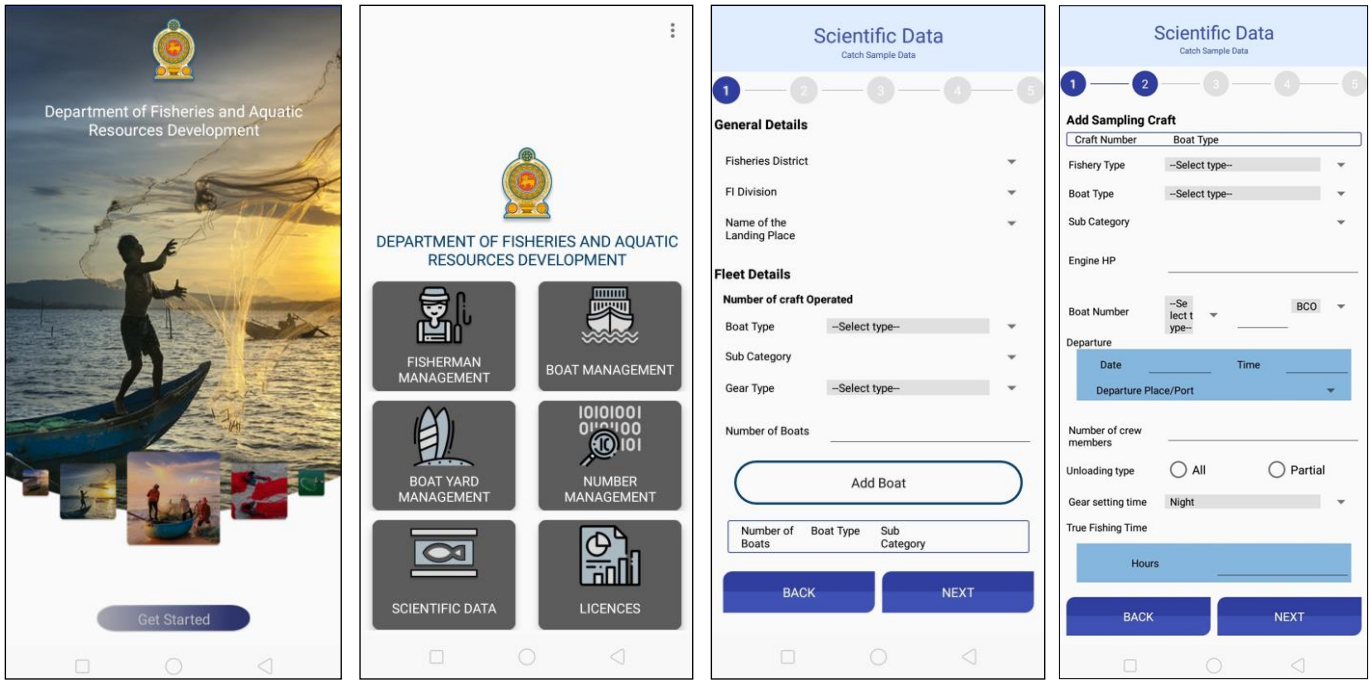

Figure 08. Sample snaps to show the current status of the mobile application being developed for the collection of data under improved PSP. See the annex 02 for complete set of access interfaces

4. Conclusion

Establishment of the upgraded system for fisheries data collection, data storing and data processing will support to enhance the efficiency of data collection and data processing and also to improve the quality of fisheries statistics. Finally, this will further support to improve the fisheries management and policy formulation in Sri Lanka as well as to improve the compliance on data related resolutions adopted by the regional and international fisheries management organizations such as IOTC.

5. Further Work

The project activities are not fully completed and still continuing. A second phase of the Sri Lanka-Norway project is expected to be continued 2020-2022, in order to ensure implementation, monitoring, and to make necessary improvements and adjustments. The data collection under new PSP is due to commence from the beginning of next year.

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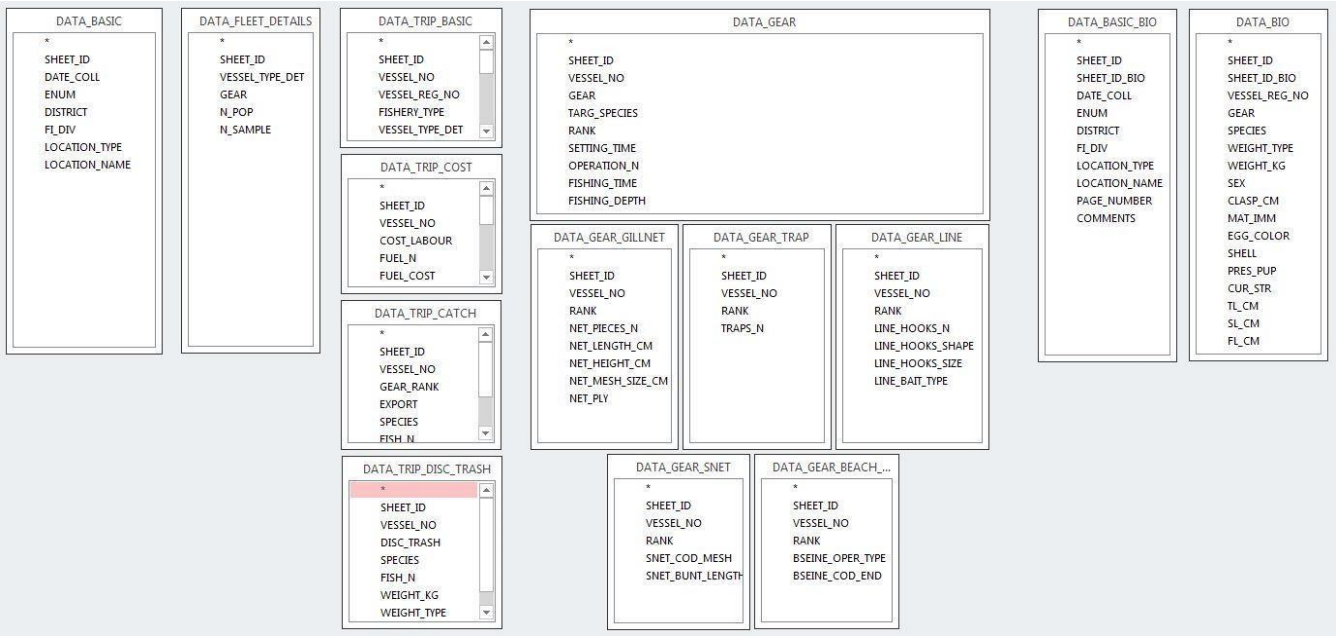
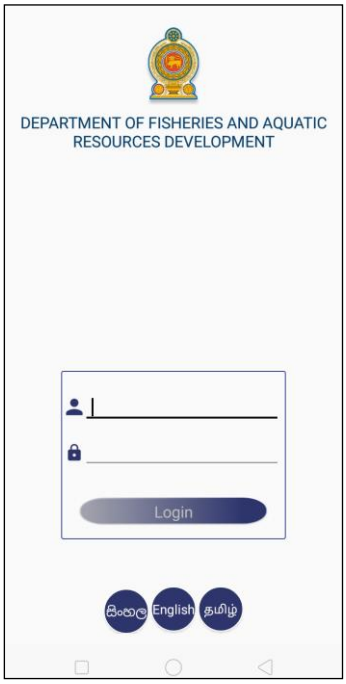
Annex 01

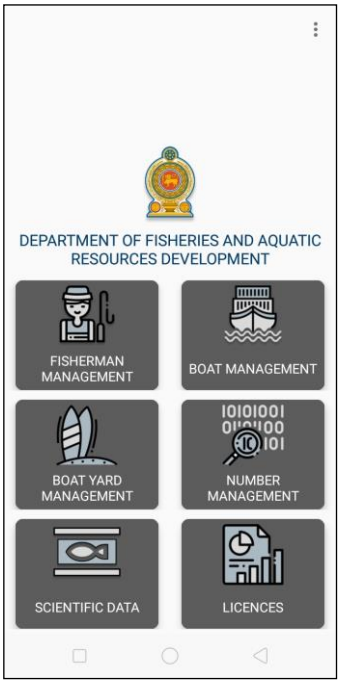
Initial Proposed Database Design for Landing Data in a Central Database System

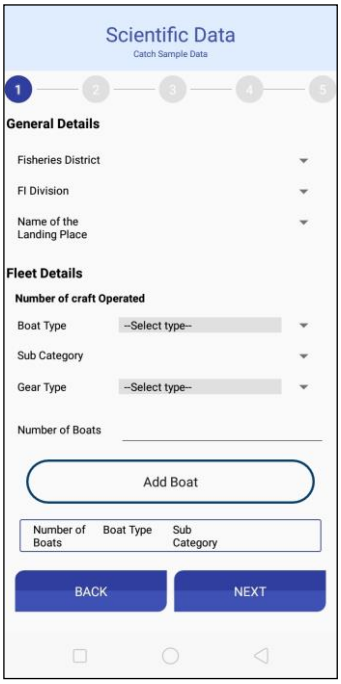


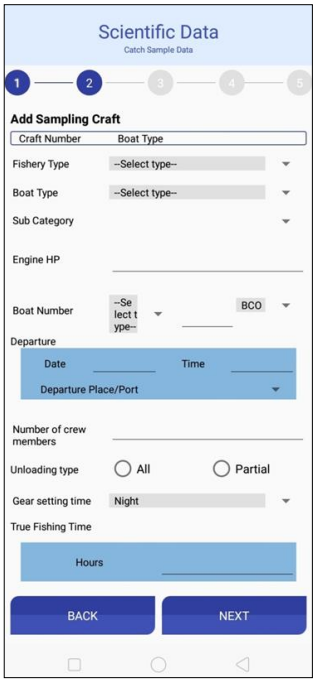
Annex 02

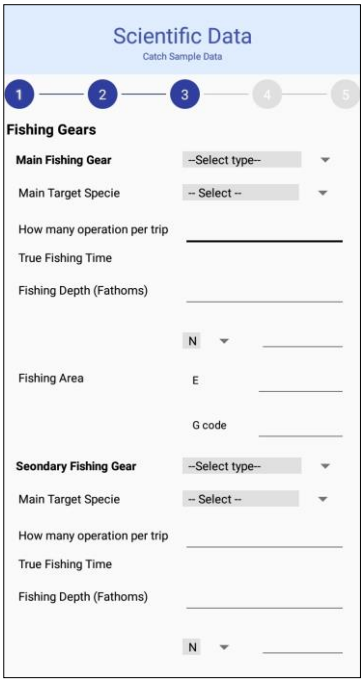
Current Status of Mobile Application for upcoming improved PSP

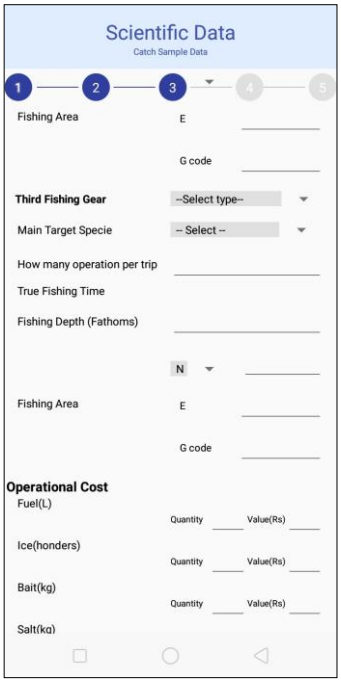


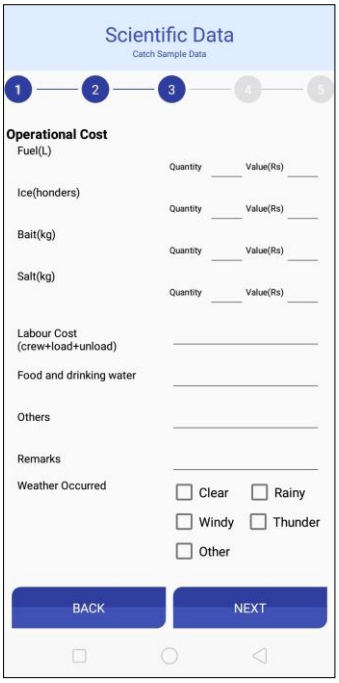


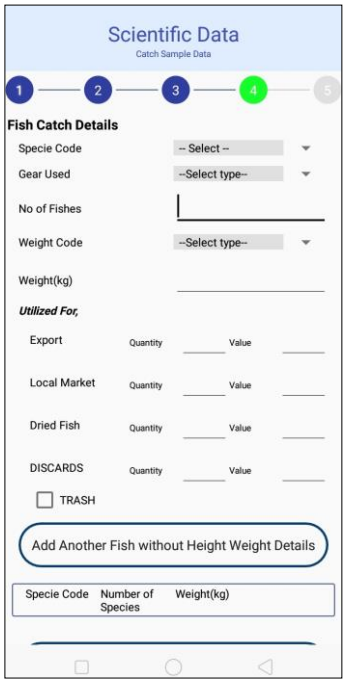


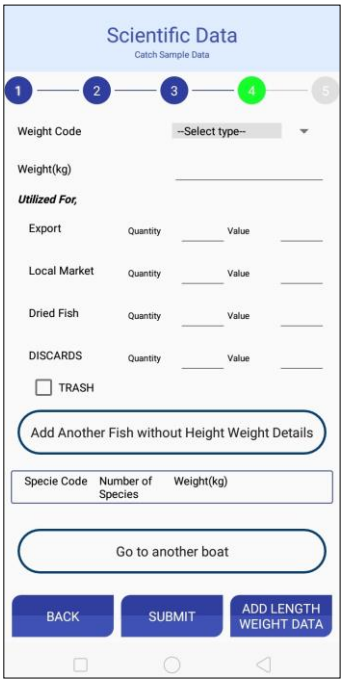


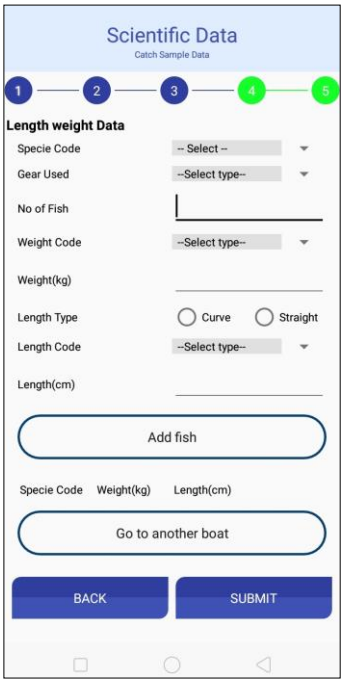







Scientific Data
Catch Sample Data
1 2 3 4 5
Fish Catch Details
Specie Code
-- Select --
Gear Used
--Select type--
No of Fishes
Weight Code
--Select type--
Weight(kg)
Utilized For,
Export
Quantity
Value
Local Market
Quantity
Value
Dried Fish
Quantity
Value
DISCARDS
Quantity
Value
TRASH
Add Another Fish without Height Weight Details
Specie Code
Number of Species
Weight(kg)


Scientific Data
Catch Sample Data
1 2 3 4 5
Weight Code
--Select type--
Weight(kg)
Utilized For,
Export
Quantity
Value
Local Market
Quantity
Value
Dried Fish
Quantity
Value
DISCARDS
Quantity
Value
TRASH
Add Another Fish without Height Weight Details
Specie Code
Number of Species
Weight(kg)
Go to another boat
BACK
SUBMIT
ADD LENGTH WEIGHT DATA


Scientific Data
Catch Sample Data
1 2 3 4 5
Length weight Data
Specie Code
-- Select --
Gear Used
--Select type--
No of Fish
Weight Code
--Select type--
Weight(kg)
Length Type
Curve
Straight
Length Code
--Select type--
Length(cm)
Add fish
Specie Code
Weight(kg)
Length(cm)
Go to another boat
BACK
SUBMIT