A new protocol to collect verified information and scientific data on catch and bycatch using crew-based observers on small size longline tuna fishing vessels (<24m) in Sri Lanka

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Abstract

Independent scientific data is vital for effective fisheries management. Scientific data provides an independent source of detailed, high quality information on fishing activity and catch at a sufficient level of resolution to be used for analyses, such as the standardization of catch rates, the analysis of non-target species and the need for mitigation measures (IOTC, 2016). Under the IOTC's Regional Observer Scheme (Resolution 11/04) each CPC is required to submit a range of scientific data by Independent Observers, who are deployed on selected vessels for the duration of a fishing trip. The small size of Sri Lankan multi-day fishing vessels registered to fish beyond Sri Lanka's exclusive economic zone (EEZ) (average LO 13.09m) compared to the average of length of the IOT registered fleet (22.84m); the lack of on-board accommodation and sanitary facilities and health and safety concerns precludes the deployment of Independent Observers on Sri Lanka's small scale fishing fleet. In response to this challenge the Government of Sri Lanka has recently evolved a new protocol through which to collect independently verifiable, digital information and scientific data in compliance with the IOTC's Resolution. The new protocol combines existing primary data from each fishing trip collected using DFAR's successful Logbook System; new primary information collected by DFAR officers using a semi-structured interview and visual verification and digital images incorporating spatial and temporal information about the catch. The capital and data collection cost of the new protocol is low. There are no new operation or maintenance costs associated with the protocol. The technology and human resources needed to run the system is already in place. The new protocol has been tested initially with longline fishing vessels and proved to be successful.

KEY WORDS; Sri Lanka, Small Scale, Longline Fisheries Management, Scientific Data, Regional Observer Scheme, Digital Images, Image Processing.

1. Introduction

The collection of accurate, reliable and verifiable fisheries information and data is fundamental for the management of tuna and tuna-like species in the Indian Ocean. The Indian Ocean Tuna Commission (IOTC) Resolution 10/02 sets out the mandatory statistical requirements for IOTC members and Cooperating Non Contracting Parties (CPC). Resolution 10/02 *encourages coastal States and fishing States on the high seas to collect and share, in a timely manner, complete and accurate data concerning fishing activities* specifically nominal catch data, catch and effort data and size data.

In 2011 the members of the IOTC passed Resolution 11/04 (On a regional observer scheme) in recognition of the increasing importance of scientific data to the IOTC's Scientific Committee. The IOTC's Scientific Committee is tasked with improving the management of tuna and tuna like species fished in the Indian Ocean. The objective of the IOTC observer scheme *is 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.* The principal means by which this is to be achieved is for *at least 5% of the number of operations/sets for each gear type by the fleet of each CPC while fishing in the IOTC area of competence of 24 meters overall length and over, and under 24 meters if they fish outside their Exclusive Economic Zone (EEZ) shall be covered by this observer scheme. For vessels under 24 meters if they fish outside their EEZ, the above mentioned coverage should be achieved progressively by January 2013*. The main duties of an observer are *to record and report fishing activities and verify positions of the vessel; observe and estimate catches as far as possible with a view to identifying catch composition and monitoring discards, by-catches and size frequency; record the gear type, mesh size and attachments employed by the master; collect information to enable the cross-checking of entries made to the logbooks (species composition and quantities, live and processed weight and location, where available); and carry out such scientific work (for example, collecting samples), as requested by the IOTC Scientific Committee*.

The Government of Sri Lanka (GOSL) initiated an observer scheme in compliance with Resolution 11/04 through the Department of Fisheries and Aquatic Resources (DFAR) in 2013. The small size of Sri Lankan vessels was immediately highlighted by the observers as a constraint that precludes the safe deployment of independent observers on the majority of Sri Lankan vessels registered to fish in the IOTC's area of competence. In 2020 98.7% of the Sri Lankan vessels registered to fish in the IOTC's area of competence were under 24 meters. The average length overall (LOA) of Sri Lanka's IOTC registered fishing fleet is 13.09m (42.9ft.). The majority of Sri Lankan vessels are simply too small and inadequately equipped (*i.e.* no sleeping quarters, basic sanitation and bathing facilities and meals) to safely deploy an Independent Observer. An alternative approach is necessary to enable Sri Lanka 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* in compliance with Resolution 11/04.

In 2018 the DFAR began to explore the potential of using a local observer protocol (LOP) to collect accurate, reliable and verifiable trip, gear, set, catch and scientific information and data from Sri Lanka's large fleet of under 24m yellowfin tuna (YFT *Thunnus albacares*) longline vessels, registered to fish in the IOTC's area of competence.

2. Methodology

The IOTC's Observer Trip Report template for longline[1] was used as the basis to identify the key variables for inclusion in the LOP information and data collection handbook. Four categories of information and data were identified namely trip information, gear information, set data, catch data and scientific data. The total number of variables included in the LOP data collection handbook increased with each deployment of Local Observers (LO) during the pilot, second and third phase (Table 1).

[1] https://iotc.org/science/regional-observer-scheme-science

Table 1: Details collected via Pilot, 2nd and 3rd stages of the LOP

Category	Pilot	2nd	3rd	Information and data variables
Trip Information	14	14	16	LO's Name, Skipper's Identification No., DFRA Log book No., Name of Vessel, Registration No. (National / IOTC), Operation License (National / High Seas), Length of the Vessel, Gross Tonnage, IRCS No., Number of Crew, Owner's Name, Owner's Address & Contact No., Departure Port - Name, Departure Port - Longitude / Latitude, Arrival Port - Name, Arrival Port - Longitude / Latitude
Gear Information	08	08	10	Main Line Length, Branch Line Length, Total No. Hooks, Total No. Sets, Hook Type, Hook Size, Depth Set, Bait Species, Bait Dead/Alive, Bait Single/Double hooked
Set Data	02	02	02	Setting Points (Longitude / Latitude), Hauling Point (Longitude / Latitude)
Catch Data	01	01	01	No. of fish caught
Scientific Data	12	12	11	Set No. Fish No., Local Name, English Name, IOTC Code, Sex, Fate (Retained, Discarded Alive, Discarded Dead), Weight, Length, Date Caught, Time Caught, Catching Point (Longitude/Latitude)
Total	37	37	40	

Trip information was collected through pre departure briefings with each LO; from the DFAR's mandatory Daily Catch Record Book prepared by the LO, from the IOTC's Record of Authorized Vessels[2] list and using a GPS enabled device; electronic tablets and cameras. Gear information was collected through pre departure briefings with each LO; visual observation of gear; from the DFAR's mandatory Daily Catch Record Book and post arrival debriefings with LO. Set data was collected from records maintained by the LO using a GPS enabled device. Catch data was collected from the DFAR's mandatory Daily Catch Record Book prepared by the LO.

Scientific data was collected by the LO using Rugged Tablets, digital cameras, a whiteboard and flip-board. The set number, fish number, local name and fate were recorded during post arrival debriefings. The English name, IOTC code of each fish was assigned using IOTC Identification Cards[3], FAO Species Identification Guide for Fishery Purposes - The Marine Fishery Resources of Sri Lanka (FAO UN, 1998) and Google.

[2] https://www.iotc.org/vessels
[3] https://iotc.org/science/species-identification-cards

Sex, weight and length data were extracted manually from each digital image. Date, time and catching point data were extracted digitally using a program written in python script.

17 LO were trained and deployed between September 2018 and March 2019 during the pilot phase (seven months). 11 LO were trained and deployed between April and August 2019 during the 2nd phase (five months). 20 LO were trained and deployed between December 2019 and June 2020 during the 3rd phase (seven months).

3. Results

Pilot Phase

The LOP used during the pilot phase enabled the DFAR to collect 81% of the trip, 100% of the gear, 87% of the set, 30% of the catch and 31% of the scientific information and data variables (n = 37) identified for collection during the pilot phase (Table 1). Trip information unavailable during the pilot phase included the vessel's IOTC registration number, the gross tonnage of the vessel and the vessel's international radio call sign (IRCS). No difficulties were encountered collecting gear; six of the 17 vessels did not record the hauling points for every set.

Table 2: Percentage of implementation collected during the three main phases of LOP

Phase	Trip Info.		Gear Info.		Set Data		Catch Data		Scientific Data	
	n	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**
Pilot Phase	14	81%	8	100%	2	87%	1	30%	12	31%
2nd Phase	14	97%	8	100%	2	89%	1	105%	11	97%
3rd Phase	16	96%	10	91%	2	91%	1	114%	11	97%

LO were tasked with collecting catch data (digital images) for the entire catch (*i.e.* all sets) during the pilot phase. 3,157 fish and other captured species were caught, according to the Daily Catch Record Sheets collected from 15 of the 17 vessels, but only 957 digital images (30% were recorded (see right).

Weather conditions, time constraints when the catch rate is high and difficulties collecting images for discards that are not brought onboard the vessel were the reasons given by LO for their inability to record catch data for entire catch. 31% of the scientific data targeted for collection was extracted from the digital images taken by the LO during the pilot phase.

LO were unable to identify the sex of 60% of the fish and other capture species caught or record the length and weight of live discards not brought onboard the vessel. Software malfunctions in some of the tablets meant that not all digital images included geo-location data.

2nd Phase

Several modifications to the LOP were made prior to the deployment of LO under the 2nd Phase. Digital cameras were used in preference to tablets as digital cameras were found to be easier to use, had a longer battery life, were more reliable in capturing geo-location data and easier to extract data from than tablets. Flipboards (see image right) replaced whiteboards as the means to collect verifiable weight and length data. Set number, fish number and outcome (fate) data were collected during the debriefing. The biggest change to the LOP during the 2nd phase was that LO were tasked with collecting catch data from only three sets (1st, 3rd and 5th set) per trip. The improvements made to the LOP prior to the second deployment of LO enabled 97%% of

the trip, 100% of the gear, 89% of the set, 105% of the catch and 97% of the scientific information and data variables (n = 36) to be collected during the 2nd phase (Table 1).

3rd Phase

Only digital cameras were used by LO to collect images from three sets during the 3rd phase. 96% of the trip, 91% of the gear, 91% of the set, 114% of the catch and 97% of the scientific information and data variables (n = 40) were collected using the LOP during the 3rd phase (Table 1).

Spatial Analysis

Set information and scientific data were used to generate maps indicating the fishing grounds (Figure 1), the location of each *T. albacares (Figure 2), as well as* other target species and nationally protected species caught between September 2018 and June 2020.

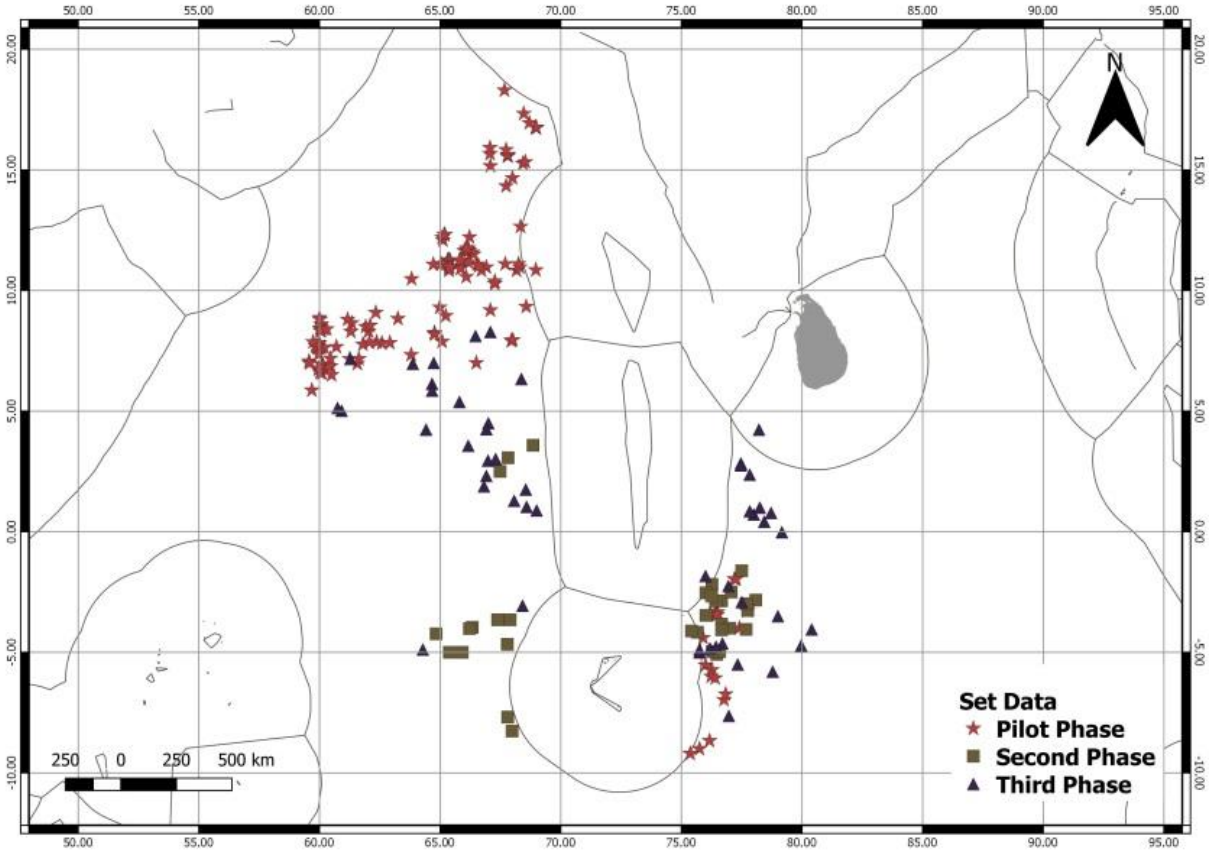

Figure 1 Fishing grounds under the pilot, 2nd and 3rd phase

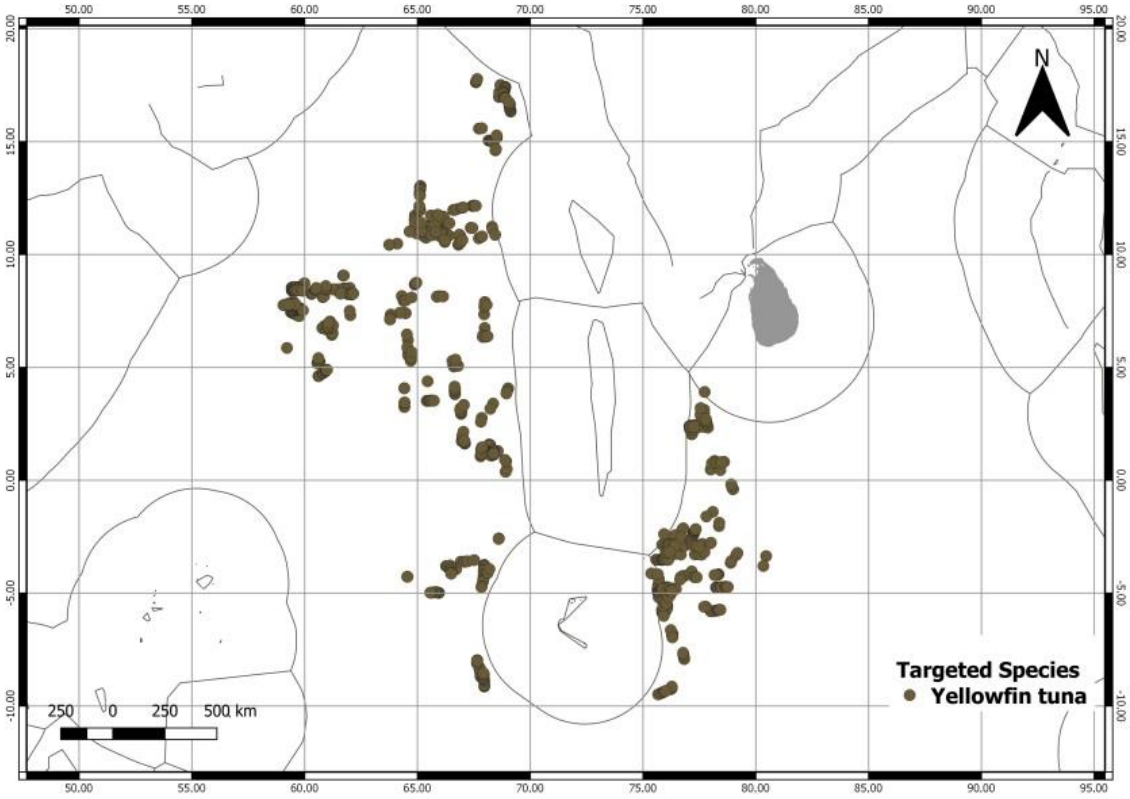

Figure 2 *T. albacares* caught during the three phases

Catch Analysis

Scientific data collected using the LOP during the 2nd and 3rd phases (April 2019 to June 2020) indicates that 1,335 individual fish and other capture species were caught by the 28 vessels participating in the programme, representing 35 species with a total weight of 39.48 tons (Table 3).

The target species *T. albacares* comprised 48.5% of the catch by number and 57.4% of the catch by weight[4]. 129,354 hooks were set by vessels during the 2nd and 3rd phases. The average number of hooks per set was 1,391. The catch per unit effort (CPUE) for *T. albacares* over the two phases was 5 fish or 175.1 kg per 1,000 hooks. Swordfish, bigeye tuna, escolar and black marlin were commonly caught (CPUE 0.50 – 0.99 per 1,000 hooks). Ribbonfish, sailfish, blue shark, blue marlin, silky shark, pelagic stingray, wahoo, albacore tuna, skipjack tuna and

[4] Note the weight was not recorded for all the discarded catch.

dolphinfish were uncommon in the catch (CPUE 0.10 – 0.49 per 1,000 hooks), while the other 19 species were very uncommonly caught (CPUE <0.09 per 1,000 hooks).

Table 3: Details of the fish and other species observed during LOP Phases 2 and 3

SLN	Captured species		n	%	CPUE[5]		kg	%	CPUE
1	Yellowfin tuna		648	48.5 %	5.0		22,654	57.4%	175.1
2	Swordfish		120	9.0%	0.9		2,828	7.2%	21.9
3	Bigeye tuna		110	8.2%	0.9		4,562	11.6%	35.3
4	Escolar		76	5.7%	0.6		342	0.9%	2.6
5	Black marlin		59	4.4%	0.5		2,980	7.5%	23.0
6	Ribbonfish		48	3.6%	0.4		219	0.6%	1.7
7	Sailfish		45	3.4%	0.3		816	2.1%	6.3
8	Blue shark		43	3.2%	0.3		1,363	3.5%	10.5
9	Blue marlin		34	2.5%	0.3		1,454	3.7%	11.2
10	Silky shark		24	1.8%	0.2		318	0.8%	2.5
11	Pelagic stingray		22	1.6%	0.2		65	0.2%	0.5
12	Wahoo		14	1.0%	0.1		119	0.3%	0.9
13	Albacore tuna		12	0.9%	0.1		255	0.6%	2.0
14	Skipjack tuna		12	0.9%	0.1		53	0.1%	0.4
15	Dolphinfish		11	0.8%	0.1		45	0.1%	0.3
16	Crocodile shark		10	0.7%	0.1		33	0.1%	0.3
17	Oceanic whitetip shark		7	0.5%	0.1		39	0.1%	0.3
18	Great barracuda		6	0.4%	<0.1		24	0.1%	0.2
19	Gulper shark		5	0.4%	<0.1		18	0.0%	0.1
20	Atlantic pomfret		3	0.2%	<0.1		20	0.1%	0.2
21	Barracuda		3	0.2%	<0.1		9	0.0%	0.1
22	Devil ray		3	0.2%	<0.1		190	0.5%	1.5
23	Leatherback turtle		3	0.2%	<0.1		230	0.6%	1.8
24	Striped marlin		3	0.2%	<0.1		95	0.2%	0.7
25	Shortfin mako shark		2	0.1%	<0.1		70	0.2%	0.5
26	Smoothtail mobula		2	0.1%	<0.1		110	0.3%	0.9
27	Thresher shark		2	0.1%	<0.1		60	0.2%	0.5
28	Deep-sea shark		1	0.1%	<0.1		1	<0.1 %	<0.1
29	Dolphin		1	0.1%	<0.1		66	0.2%	0.5
31	Mobula *nei*		1	0.1%	<0.1		5	<0.1 %	<0.1

[5] CPUE = catch per 1,000 hooks

SLN	Captured species		n	%	CPUE[5]		kg	%	CPUE
32	Rough triggerfish		1	0.1%	<0.1		-	-	-
34	Spanish mackerel		1	0.1%	<0.1		7	<0.1 %	0.1
			1,335		**10.3**		**39,480**		**305.2**

90.3% of the catch was retained (Table 4). The principal retained species were yellowfin tuna (48.5%), swordfish (9.0%), bigeye tuna (8.2%), black marlin (4.4%), escolar (3.8%), sailfish (3.4%), blue shark (2.9%), blue marlin (2.5%), silky shark (1.8%) and wahoo (1.0%). 3.6% of the total catch was discarded (i.e. bycatch) alive. The main bycatch species discarded alive were pelagic stingray (1.3%) and crocodile shark (0.6%). 6.1% of the bycatch was discarded dead. The main bycatch species discarded dead were ribbonfish (2.9%) and escolar (1.7%)

Table 4: Instances of retained (target) and discarded alive or dead (by-catch) species during LOP Phases 2 and 3. *(Evidence of by-catch species released alive is available from camera photos)*

Target species			By-catch species					
Retained	**1,205**	90.3%	**Discarded Alive**	**48**	3.6%	**Discarded Dead**	**82**	6.1%
Yellowfin tuna	648	48.5%	Pelagic stingray	17	1.3%	Ribbonfish	39	2.9%
Swordfish	120	9.0%	Crocodile shark	8	0.6%	Escolar	23	1.7%
Bigeye tuna	110	8.2%	*Oceanic whitetip shark*[6]	4	0.3%	Blue shark	2	0.1%
Black marlin	59	4.4%	Ribbonfish	4	0.3%	Tiger shark	1	0.1%
Escolar	51	3.8%	Gulper shark	3	0.2%	Atlantic pomfret	3	0.2%
Sailfish	45	3.4%	*Leatherback turtle*	3	0.1%	Pelagic stingray	5	0.4%
Blue shark	39	2.9%	Blue shark	2	0.1%	Crocodile shark	2	0.1%
Blue marlin	34	2.5%	*Thresher shark*	2	0.1%	Deep-sea shark	2	0.1%
Silky shark	24	1.8%	Escolar	2	0.1%	Rough triggerfish	1	0.1%
Wahoo	14	1.0%	Sickle-fin devil ray	1	0.1%			
Albacore tuna	12	0.9%	*Dolphin*	1	0.1%			
Skipjack tuna	12	0.9%	Deep-sea shark nei	1	0.1%			
Dolphinfish	11	0.8%	*Loggerhead turtle*	1	0.1%			
Great barracuda	6	0.4%						

[6] Nationally protected species in red

Ribbonfish	5	0.4%
Striped marlin	3	0.2%
Barracuda	3	0.2%
Shortfin mako shark	2	0.1%
Spanish mackerel	1	0.1%

Five nationally protected species were observed in the catch during the 2nd and 3rd phases. An unknown species of dolphin was foul-hooked on 17/06/2019 by vessel IMULA0818CHW. The dolphin was released alive[7]. Two species of turtle (*Caretta caretta* and *Dermochelys coriacea*) were observed in the catch and released alive after de-hooking[8]. Oceanic whitetip shark (*Carcharhinus longimanus*) and two species thresher sharks and were released alive. Oceanic whitetip shark and thresher shark are protected under Shark Fisheries Management (High seas) Regulations, 2015. Dolphins and turtles are protected under the Fauna and Flora Protection Ordinance, 1942.

1,015 *T. albacares* were observed during the three phases. The length frequency distribution of *T. albacares* caught during the pilot phase and the 2nd and 3rd phase is shown in Figure 3. The minimum and maximum fork length (FL) observed were 64.0cm and 220.0cm respectively. The average size of *T. albacares* caught was 123.83cm (STDEV 18.45cm). The maximum observed FL for *T. albacares* is 239cm (male/unsexed); the common length is 150cm[9]. The average FL on 50% maturity (L_{m50}) for *T. albacares* is 103.3cm with a range of 78 – 158cm (*ibid*). 91.5% of the *T. albacares* caught by Sri Lanka's short longline yellowfin tuna vessels during the survey period were above the L_{m50}.

[7] Video of the live release is available.
[8] Video of the live release is available.
[9] www.fishbase.de

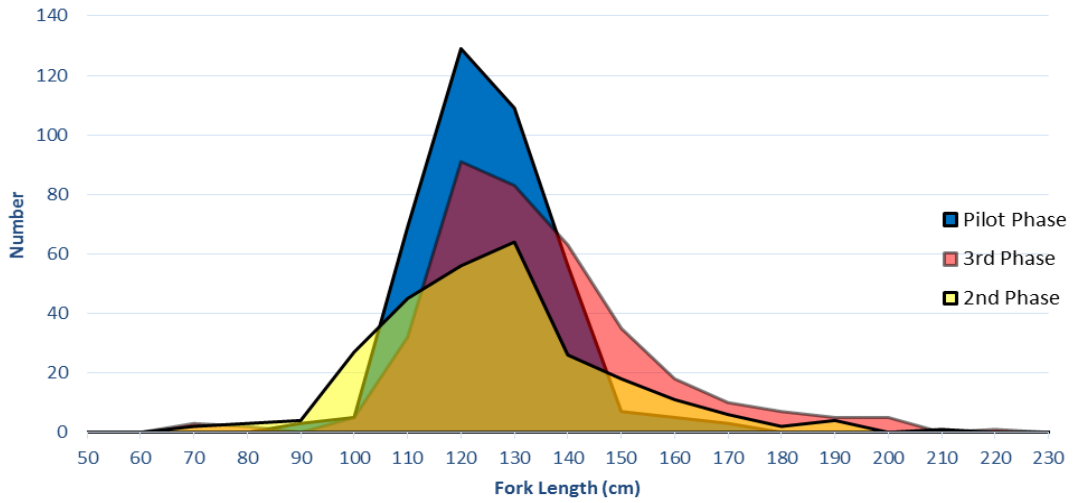

Figure 3 Length frequencies for YFT caught during the three phases of LOP

4. Discussion

Sri Lanka's fleet of authorized vessels is the largest registered with the IOTC to fish in the Indian Ocean beyond the country's jurisdiction (1,847), yet one of the smallest. The average size of a Sri Lankan vessel authorized to fish beyond the county's EEZ is currently 11.65m. Only nine authorized vessels have a LOA exceeding 24m. The GOSL's initial attempt to comply with Resolution 11/04 for vessels under 24m that fish outside its EEZ were unsuccessful due to health and personal safety concerns raised by the observers and the skippers and crew upon whose vessels the observers were deployed. An alternative procedures, mechanism or means therefore needed to be developed to enable the GOSL 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.*

The LOP combines several sources of mandatory secondary sources of trip and gear information and visual observation of the vessel and gear with primary analog and digital data recorded or collected by the LO. Digital data is processed manually and electronically to extract scientific data. The potential to collect verified catch data and other scientific data related to the fisheries from Sri Lanka's under 24m vessels was evident at the end of the Pilot Phase.

Improvements to the protocol significantly enhanced the collection of trip and gear information, set, catch and scientific data during the second deployment of LOs. Three variables were added to the protocol (40) during the third phase and the recovery of verified information and data was improved further. The IOTC's Observer Trip Report template for longline contains 38 trip, 41 gear, 6 set and 28 catch and scientific information and data requirements: 113 variables in total. The LOP currently enables the DFAR to report on more than a third of the IOTC's information and data requirements for longline fisheries on vessels under 24m. The results of the third phase suggest that there is potential to expand the LOP to include almost the IOTC's entire observer reporting requirements for longline fisheries, with the exception of sex, maturity stage and sample. The determination of sex and maturity require a level of technical knowledge beyond that of a LO; while cutting up fish before sale is viewed unfavourably by markets for fresh and frozen *T. albacares* in Sri Lanka.

The digital data collected by the LOs enabled the DFAR to complete a comprehensive spatial analysis of the fishing trip and of the catch by target species and bycatch, including nationally protected species. The spatial analysis of each trip could be further improved by the incorporation of tracking data from each vessel's monitoring system (VMS). Digital data also played a key role in enabling the DFAR to assess the catch by species; the calculation of catch per unit effort; the elucidation of the retained and discarded (dead *or alive)* bycatch catch and shed light on the nationally protected species caught by Sri Lanka's short longline *T. albacares* fishery and the fate of each nationally protected species caught. The collection of digital data by LO was also used to analyse the length frequency of *T. albacares* caught by Sri Lanka's short longline fishery; more than 90% were caught above the L_{m50}.

5. Conclusion

The implementation of the IOTC's Resolution 11/04 for Sri Lanka's large fleet of less than 24m vessels that fish outside Sri Lanka's EEZ is not practically possible, due to the small size of the vessels and the personal health and safety concerns this creates for both the observer and the crew. As a consequence the IOTC's observer scheme was not progressively achieved in Sri Lanka by January 2013 as was envisaged and has not been achieved since. The LOP developed by the DFAR in consultation with boat owners and skippers described herein represents a credible alternative mechanism through which the GOSL can collect verified *and*

independently verifiable information and data from longline yellowfin fishing vessels measuring less than 24m operating in the IOTC area of competence. Further development and systematic implementation of the LOP with boat owners and skippers on all four coasts will enable the GOSL to improve compliance with IOTC's Resolution 11/04, by December 2021.

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