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Preliminary estimates of bycatches in the western equatorial Indian Ocean in the traditional multifilament longline gears (1961-1989)

by

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ABSTRACT

Historical bycatch trends in the pelagic longline fisheries are analysed based on data collected during long-term research program in the Indian Ocean. Preliminary results suggest decline in the CPUE and mean weight for elasmobranch species, while same parameters for lancetfish demonstrate increasing trend. CPUE for swordfish is table while mean weight sharply decreased during 1970s. It was suggested that reconstruction of historical bycatch data series should be based on CPUE and effort analysis. Ratio of target catch/bycatch cannot be recommended for this purpose due to it unpredictability.

Keywords: Pelagic longlines, bycatch, sharks, rays, lancetfish

INTRODUCTION

Large-scale tuna longline fisheries in the Indian Ocean were started in 1952 by Japanese fishing boats and rapidly expanded to entire Indian Ocean following than by Chinese (Taiwan Province) in 1954, Soviet in 1964 and Korean boats in 1965 (IOTC catch statistics data). Although pelagic longlining targeting only few species of tropical and temperate tuna from *Thunnus* genus, recently swordfish *Xiphias gladius* and rarely sharks, it yields numerous species of epipelagic predatory community: scombrids, billfish, sharks and rays, other teleost fish, reptiles, and birds. However most of the bycatches are poorly documented even for recent years and catch data for non-target species usually absent for historical LL fisheries.

There are growing concerns on the stock status of many top-predators, especially elasmobranch harvested by pelagic fisheries due to their particular life-history characteristics: long live-span, late maturity, low fecundity and big sizes (Dulvy et al., 2008). Some studies suggest major decline of abundance among open ocean top predators community (Myers, Worm, 2003).

However most of the studies available are based on analysis of commercial **C**atch **P**er **U**nit of **E**ffort (CPUE) trends, while widely recognized limitations of such approach due to numerous unaccountable factors affected longline CPUE (Bach et al., 2008 in press). Along its history commercial pelagic fishing gears and fishing strategy undergo numerous changes such as gear modification (monofilament gears, hook shape, gear length and total number of hooks, fish attracting devices – light steaks), deployment strategy (deep longline, day vs. night, soaking time) (Ward and Hindmarsh, 2007), and spatial shift of fishing effort toward habitat of target species (tropical vs. temperate tuna vs. swordfish). Such modifications changed gear overlap with habitat both target and non-target species and/or affected gear catchability (Ward, 2008). All this changes makes extremely difficult of even impossible to quantify variations in catchability and fishing power of longline gear despite numerous attempts to do that based on various approach to CPUE standardization.

Absence of data for major bycatch species makes estimates of population demography extremely difficult, since extrapolation of recent data from scientific observation programs recently launched by many fishing nations are tricky due to mentioned changes in fishing gears and fishing tactics.

In this context rare long-term series obtained during scientific research cruises may provide valuable insights to the trends in bycatch population level and information for reconstruction of the historical catches of non-target species by major longline fleets.

This paper represents a first preliminary attempt to assess overall level of bycatch and historical trends in the western Indian Ocean longline fisheries based on the data obtained during Soviet Indian Ocean Tuna Longline Research Programme (SITRLLP) (Romanov et al., 2006). This research programme extended over 30 years (1961-1989) used non-modified gears and fishing tactics mostly corresponds to the fishing technology of major fleets till late 1990s. Then, further reconstructions of historical bycatch level by species are made possible.

MATERIAL AND METHODS

Source database, sampling platforms and general sampling methodology is presented in Romanov et al. (2006). Spatial distribution of LL sets during the program is presented at the Fig. 1 and sets used in this study are at the Fig. 2.

Sampling gears and methods. As sampling gear was used standard multifilament Japanese-type pelagic longline (replicated in the USSR from Japanese longline gears). Longline baskets comprised 6 sections of 50 m length with 5 branchlines attached to mainline in the joints of the sections. Hence length of regular basket was 300 m. Length of buoyropes varied 20-21 m and length of branch lines were 21 m. In some cruises (generally during 1960s and early 1970s) there were used original Japanese longlines with 6 sections of 54 m length (total basket length 324 m) with 5 branch lines. Length of buoyropes was 20-22 m and length of branchlines was 20-21 m. All the longlines used wire leaders (konoyama) 1.8-2.0 mm in diameter and 3-4 m in length, which were attached to intermediate section of the branchline (sekiyama) made from wire 2.0-2.2 mm in diameter and 7 m length bounded with tarred cotton or synthetic fibre. Baskets were set as ‘regular’ longline, with 5 hooks between floats or as deep longline either with ‘double’ baskets (10-11 hooks between floats) or ‘triple’ baskets (15-17 hooks between floats). In some cruises basked were modified to fish at shallow depth (close to shore or over oceanic shoals) with 3 sections between floats (total length of the sections 150 m) and with 5-6 hooks. Most of the longlines were set before dawn, usually between 03:00-06:00 local time, 75.6% of sets (89.6% of sets started from midnight to 07:00) and retrieved from noon 12.00-13.00 (59.7%) till late afternoon or evening (depending on the speed of hauling) (Fig. 2). Few longlines were set as ‘nigth sets’ i.e. before sunset (2.5% between 16:00-20:00 local time) and retrieved in the morning (5.8% between 07:00-09:00) (Fig. 3).
During these experiments small pelagic fish were usually used as primary bait (i.e. bait occupied 90-95% of hooks) (Fig.4). Small carangids (*Decapterus, Trachurus. Selar* genera) and clupeids (*Sardina pilchardus, Sardinops* spp., other clupeids) were used in the 50% and in 21% of operations respectively. Hooks were baited with scombrids (*Scomber* spp., *Rastrelliger* spp.) in 5% of operations, with Atlantic and Pacific sauries (*Scomberesox saurus* and *Cololabis saira*) – in 2%. Unknown bait (presumably small pelagic fish) was used in 21% of operations. Other fish, including demersal species were used in approx 1% of operations, while squids in less than 1%. Secondary bait (occupied 5-10% of hooks) was used in 28% of operations, generally small pelagic fish (91%), demersal fish (4%) and squids (1.5%). So fishing bait was more or less consistent during all the period of study.

All marine animals interacted with longline (i.e. caught, caught but damaged by predators, escaped during handling, entangled) were recorded, identified to species (or lower possible taxon), and hook which caught fish was recorded for further estimate of the depth of catch. Animals hauled onboard were measured, weighted and analysed.

Data stratification.

Data were stratified regionally and spatially within regions. In the regional stratification we followed to the general pattern of Longhurst’ biogeographic provinces (Longhurst, 1998) and availability of data. Among 5 regions suggested by Romanov et al. (2007) we analysed data for western Indian Ocean monsoon province, which represent better spatial and temporal coverage by sampling effort (Fig.2). Within this area two uniform oceanic pelagic domains were chosen: oceanic waters within 200-miles economic zones (except seamounts and oceanic shoals lies within 200-mile border) and high seas (area beyond 200-mile border without seamount area[1]). Grouping of LL sets by domains or ecoregions were used based on the starting position of LL shooting. Bottom depth at this position and its distance from 1000 m isobath was calculated based on GEBCO 1-minute global bathymetric grid (IOC, IHO and BODC, 2003).

Methods

At this preliminary stage we performed only exploratory analysis using pooled samples and nominal fishing effort. No depth and/or seasonal stratification were applied and all sets were treated as homogeneous. Therefore all results should be treated with caution and will be subject for re-analysis in the nearest future.

As target catch were considered cumulative catch (in number and weight) of three tuna species: yellowfin *Thunnus albacares*, bigeye *Thunnus obesus*, albacore *Thunnus alalunga*, and non-identified tunas of *Thunnus* genus. The rest of species caught were considered as bycatch. For calculation catch in numbers we considered all species interacted with longline: caught, bitten by predators and hauled onboard and escaped (alive or dead).

Target catch to bycatch rate (TBR) were calculated as follows:

$$TBR = (TC – BY)/T*100\%,$$

where TC – target catch, BY is bycatch, and T is total catch. This index may vary from -100% (all catch are non-target species) to 100% (no bycatch). It is 0 when target catch and bycatch are equal.

RESULTS

Research fishing operations in the analysed area/starta were carried out from 1964 to 1988. There are several gaps in the research effort (1965, 1971, 1975) and periods with low fishing effort (below 10000 hooks) 1964 and 1973-76.

A total of 75 species/group of species/taxa were recorded, while only 4 of them are considered as target species (Table 3). Among them only 11 species were recorded every year: yellowfin tuna, bigeye tuna, skipjack tuna, swordfish, sailfish, blue shark, oceanic whitetip shark, shortfin mako, pelagic stingray, great barracuda and lancetfish. Occurrence of other species is broadly varied.

Target species dominates in the catch both in numbers (62.8%) and in weight (66.7%) (Fig. 5). However TBR was highly variable for analysed period (both in numbers and weight) from -39 to +80% (Fig. 6) suggesting that in some years bycatch species dominated over target.

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[1] Oceanic shoals and seamounts (from the peaks to 50 miles distance from 1000 m isobaths around seamount or shoal)

Dominant bycatch groups (in numbers) are sharks and rays, lancetfish and billfish. Among single species lancetfish is dominate (11.3%) following by blue shark (3.5%) and pelagic stingray (2.8%).

CPUE indexes for target species group showed unclear trend (possible major decline) for 1960-1977 and relatively stable values for 1979-1987. Mean weight of tuna demonstrate declining trend however slope of decline is very low. In contrast both CPUE and mean weight shows major decline for all principal shark species. Declining CPUE recorded also for pelagic stingray.

CPUE and mean weight of lancetfish did no show any clear temporal trend showing similar level from the start of research.

CPUE of swordfish are broadly fluctuated, suggesting however increasing level, which highly contrasted with strong decline for the mean weight.

DISCUSSION

A particular attention has been paid worldwide on pelagic longline fisheries, as they catch considerable amount of bycatch of different group of species some of them being very sensitive to fishing pressure such as seabirds, turtles, sharks, etc… If bycatch mitigation methods have been developed in emergency for seabirds and seaturtles (Hall and Mainprize, 2005 ; Swimmer et al 2006), our knowledge of levels of bycatch for fishes in the past and nowadays are very poor.

Analysis of historical series of bycatch data is urgently needed. Our preliminary study is carried out in this context. The principal result suggests that because the large variability and unpredictability in TBR estimates of bycatch level based on target species catch may result in high unaccountable bias. However this conclusion concerns the analysis of gross data and therefore such approach is not recommended. As different studies have clearly shown that specific composition of catches were representative of fishing strategy (gear deployment/fishing ground/season), we believe that stratified analysis of both CPUE of target species and bycatch could be a preliminary way for further reconstructions of historical bycatch level by species in longline fisheries. Relating to this last point, long-term CPUE data series shows consistent trend for dominant bycatch species and could be recommended for estimates of historical level of bycatches after further analysis and standardization using habitat-based approach.

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Table 1

Data used for analysis of bycatch

Period	Sets total	Hooks total	Positive sets	Hooks in positive sets	Species/taxa records	Individuals interacted with LL gear	Individual caught (non damaged)
1964-1968	1346	664475	1246	623010	75	15875	14630

Table 2

Data stratification by the oceanic zones, note only domains 3 and 6 of the western Indian Ocean monsoon province were used in the study

No	Clause	Domain code	Zone	Strata
1.	Distance from the coast < 100 miles AND depth < 1000 m	**1**	Coastal	'Shallow' waters
2.	Distance from the coast < 100 miles AND depth > 1000 m AND distance from 1000 m isobath 0-10 miles	**2**		'Coastal' beyond shelf
3.	Distance from the coast < 100 miles AND depth > 1000 m AND distance from 1000 m isobath 10-50 miles	**2**		
4.	Distance from the coast < 200 miles AND depth > 1000 m AND distance from 1000 m isobath 50-100 miles	**3**	Oceanic waters within 200 mile zones	'Mid-oceanic' waters
5.	Distance from the coast < 200 miles AND depth > 1000 m AND distance from 1000 m isobath 100-150 miles	**3**		
6.	Distance from the coast < 200 miles AND depth > 1000 m AND distance from 1000 m isobath 150-200 miles	**3**		
7.	Distance from the coast > 100 miles AND depth < 1000 m	**4**	Oceanic shoals, seamounts	Tops of 'seamounts', shoals,
8.	Distance from the coast > 100 miles AND depth > 1000 m AND distance from 1000 m isobath ≤ 10 miles	**5**		Waters around 'slopes of shoals' and seamounts
9.	Distance from the coast > 100 miles AND depth > 1000 m AND distance from 1000 m isobath 10-50 miles	**5**		
10.	Distance from the coast > 200 miles AND depth > 1000 m AND distance from 1000 m isobath > 50 miles	6	High seas	'High seas'

Table 3

List of species/taxa interacted with pelagic longlines

Taxonomic groups	Subgroups	Family	Latin name	English common name	Alfa3 code	Number of individuals recorded	%
Scombrids	Target species	Scombridae	*Thunnus obesus*	Bigeye tuna	BET	4565	28.76
			Thunnus albacares	Yellowfin tuna	YFT	4496	28.32
			Thunnus alalunga	Albacore	ALB	571	3.60
			Thunnus spp	True tunas nei	TUS	176	1.11
	Scombrids bycatch		*Katsuwonus pelamis*	Skipjack tuna	SKJ	384	2.42
			Acanthocybium solandri	Wahoo	WAH	48	0.30
			Scomberomorus commerson	Narrow-barred Spanish mackerel	COM	3	0.02
			Scomberomorus spp	Seerfishes nei	KGX	2	0.01
			Thunnus tonggol	Longtail tuna	LOT	1	0.01
			Gymnosarda unicolor	Dogtooth tuna	DOT	1	0.01
			Auxis thazard	Frigate tuna	FRI	1	0.01
Billfish	Swordfish	Xiphiidae	*Xiphias gladius*	Swordfish	SWO	250	1.57
	Marlins and sailfish	Istiophoridae	*Makaira spp*	Marlin		198	1.25
			Istiophorus platypterus	Indo-Pacific sailfish	SFA	174	1.10
			Makaira mazara	Indo-Pacific blue marlin	BLZ	161	1.01
			Tetrapturus audax	Striped marlin	MLS	144	0.91
			Makaira indica	Black marlin	BLM	67	0.42
			Makaira spp+Tetrapturus audax			63	0.40
			Tetrapturus angustirostris	Shortbill spearfish	SSP	7	0.04
			Tetrapturus spp			1	0.01
			Istiophoridae	Marlins,sailfishes,etc. nei	BIL	1	0.01

Taxonomic groups	Subgroups	Family	Latin name	English common name	Alfa3 code	Number of individuals recorded	%
Sharks	Blue shark	Carcharhinidae	*Prionace glauca*	Blue shark	BSH	556	3.50
	Oceanic whitetip shark		*Carcharhinus longimanus*	Oceanic whitetip shark	OCS	303	1.91
	Silky shark		*Carcharhinus falciformis*	Silky shark	FAL	110	0.69
	Other whaler sharks		*Carcharhinus obscurus* **?**	Dusky shark	DUS	41	0.26
			Carcharhinus limbatus **?**	Blacktip shark	CCL	23	0.14
			Carcharhinus albimarginatus	Silvertip shark	ALS	19	0.12
			Carcharhinus plumbeus	Sandbar shark	CCP	14	0.09
			Carcharhinus remotus **?**			7	0.04
			Carcharhinus leucas **?**	Bull shark	CCE	2	0.01
			Carcharhinus sorrah **?**	Spot-tail shark	CCQ	1	0.01
			Carcharhinus menisorrah **?**			1	0.01
			Carcharhinus galapagensis **?**	Galapagos shark	CCG	1	0.01
			Carcharhinus spp			311	1.96
			Galeocerdo cuvier	Tiger shark	TIG	6	0.04
			Carcharhinidae	Requiem sharks nei	RSK	1	0.01
	Hammerhead	Sphyrnidae	*Sphyrna zygaena*	Smooth hammerhead	SPZ	6	0.04
			Sphyrna mokarran	Great hammerhead	SPK	5	0.03
			Sphyrna spp	Hammerhead sharks nei	SPN	5	0.03
			Sphyrna lewini	Scalloped hammerhead	SPL	3	0.02
	Lamnids	Lamnidae	*Carcharodon carcharias* **?**	Great white shark	WSH	1	0.01
			Isurus oxyrinchus	Shortfin mako	SMA	316	1.99
			Isurus spp	Mako sharks	MAK	32	0.20
			Isurus paucus	Longfin mako	LMA	7	0.04
		Pseudocarchariidae	*Pseudocarcharias kamoharai*	Crocodile shark	PSK	2	0.01
	Tresher	Alopiidae	*Alopias vulpinus*	Thresher	ALV	84	0.53
			Alopias superciliosus	Bigeye thresher	BTH	70	0.44
			Alopias pelagicus	Pelagic thresher	PTH	1	0.01
			Alopias spp	Thresher sharks nei	THR	13	0.08
	Sharks n.i.		*CPGI*			3	0.02
			Selachimorpha(Pleurotremata)	Various sharks nei	SKH	24	0.15

Taxonomic groups	Subgroups	Family	Latin name	English common name	Alfa3 code	Number of individuals recorded	%
Rays	**Rays**	**Dasyatidae**	*Pteroplatytrygon violacea*	Pelagic stingray	PLS	446	2.81
			Dasyatis spp	Stingrays nei	STI	33	0.21
		Rajidae	*Rajidae*	Rays and skates nei	RAJ	2	0.01
		Mobulidae	*Mobula spp*			1	0.01
Epipelagic fish	**Epipelagic fish**	**Sphyraenidae**	*Sphyraena barracuda*	Great barracuda	GBA	129	0.81
			Sphyraena jello	Pickhandle barracuda	BAC	6	0.04
			Sphyraena spp	Barracudas nei	BAR	7	0.04
		Coryphaenidae	*Coryphaena hippurus*	Common dolphinfish	DOL	67	0.42
		Carangidae	*Scomberoides lysan*	Doublespotted queenfish	OBY	1	0.01
			Carangidae	Carangids nei	CGX	4	0.03
	Lancefish	**Alepisauridae**	*Alepisaurus ferox*	Long snouted lancetfish	ALX	1794	11.30
			Alepisaurus spp	Lancetfishes nei	ALI	28	0.18
Meso- bathypelagic fish	**Meso-bathypelagic fish**	**Lampridae**	*Lampris guttatus*	Opah	LAG	3	0.02
		Gempylidae	*Lepidocybium flavobrunneum*	Escolar	LEC	13	0.08
			Gempylus serpens	Snake mackerel	GES	8	0.05
			Ruvettus pretiosus	Oilfish	OIL	4	0.03
		Bramidae	*Brama brama*	Atlantic pomfret	POA	6	0.04
			Brama spp		BRA	7	0.04
			Taractes longipinnis	Bigscale pomfret		2	0.01
			Taractes spp			1	0.01
			Bramidae	Pomfrets, ocean breams nei	BRZ	2	0.01
Fish n.i.	**Fish n.i.**		*Pisces*			27	0.17
Seaturtles		**Dermochelyidae**	*Dermochelys coriacea*	Leatherback turtle	DKK	1	0.01
			Chelonidea			1	0.01
			Total			15875	100.0
			Groups			75	
			Target			9808	61.8
			Bycatch			6067	38.2

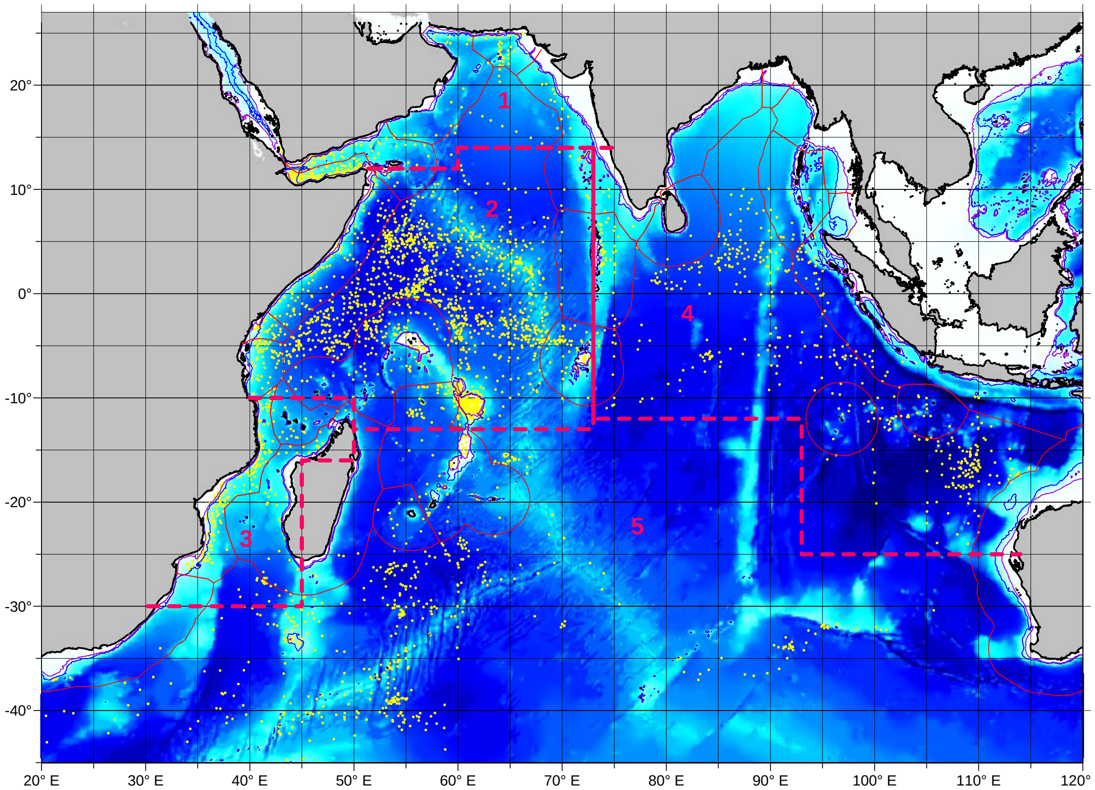

Figure 1. Distribution of LL sets during SIOTLLRP.

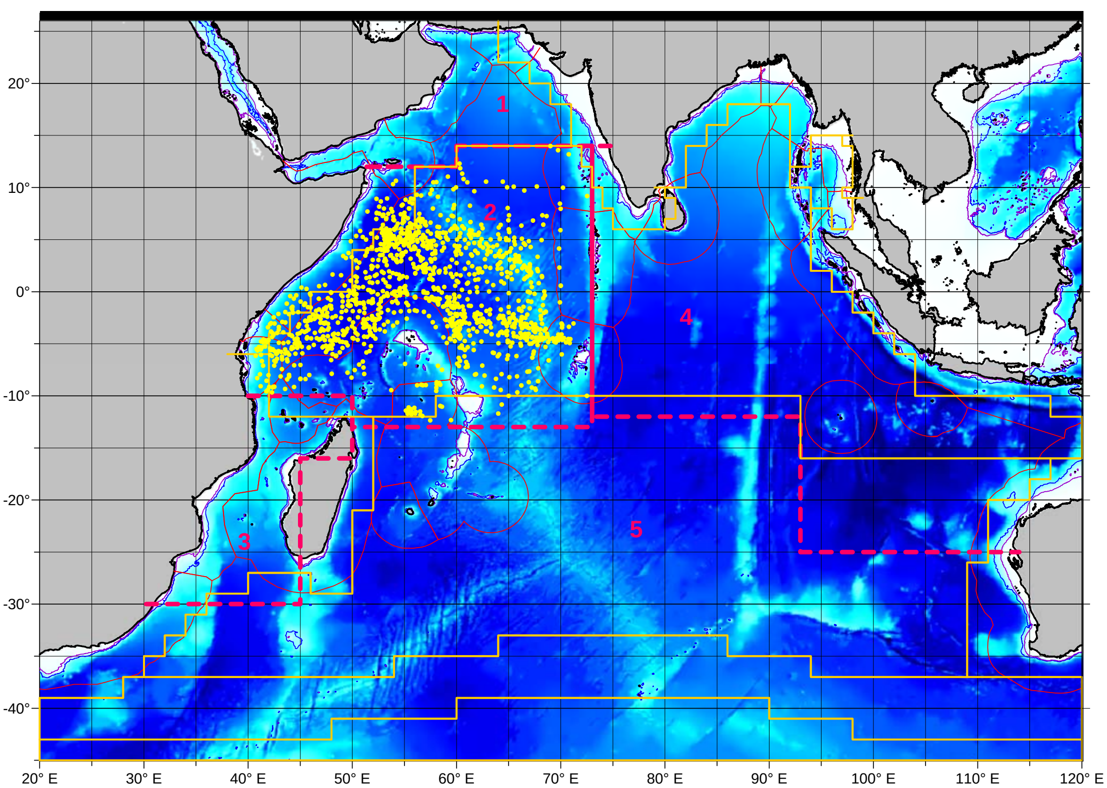

Figure 2. Distribution of LL sets used during this analysis.

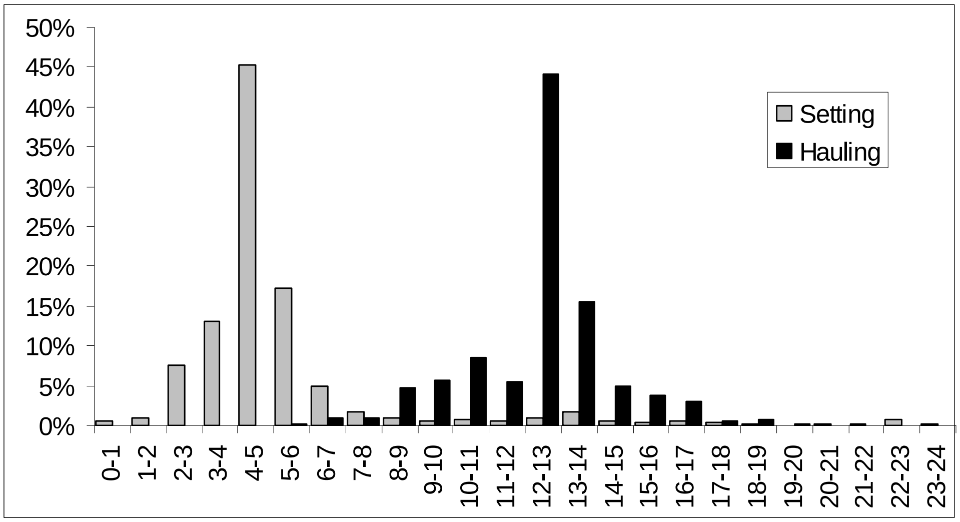

Figure 3. Temporal distribution of the starting time of LL setting and hauling (number of sets, %).

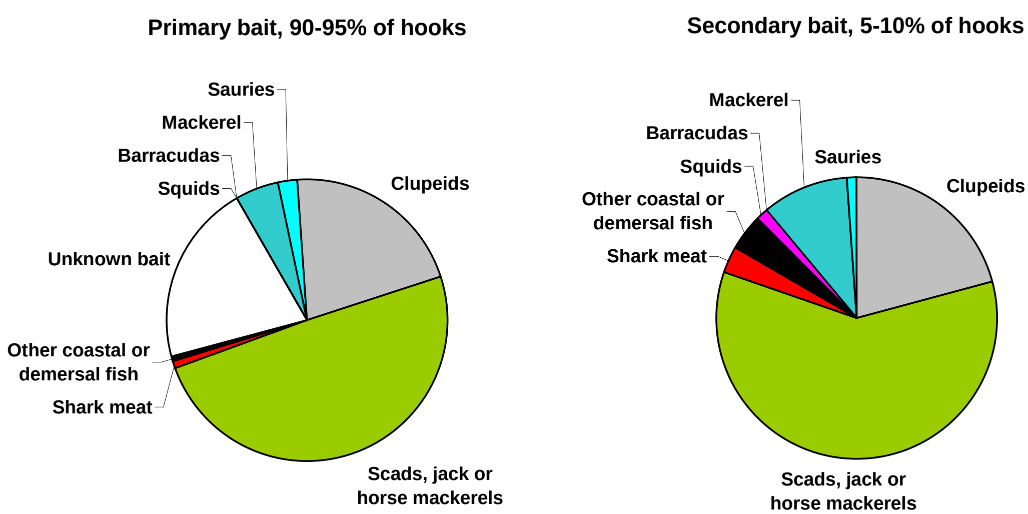

Figure 4. Types of bait used during SIOTLLRP.

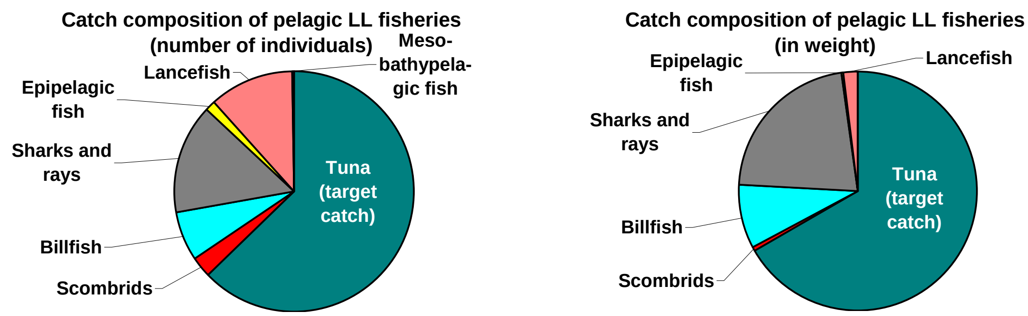

Figure 5. Catch composition in number in weight obtained during SIOTLLRP.

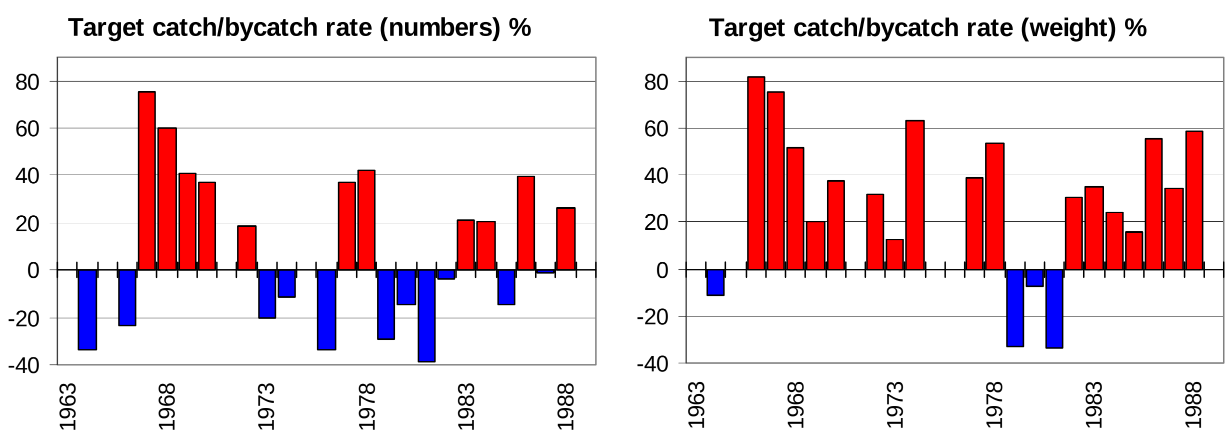

Figure 6. Annual variability of target catch/bycatch rate.

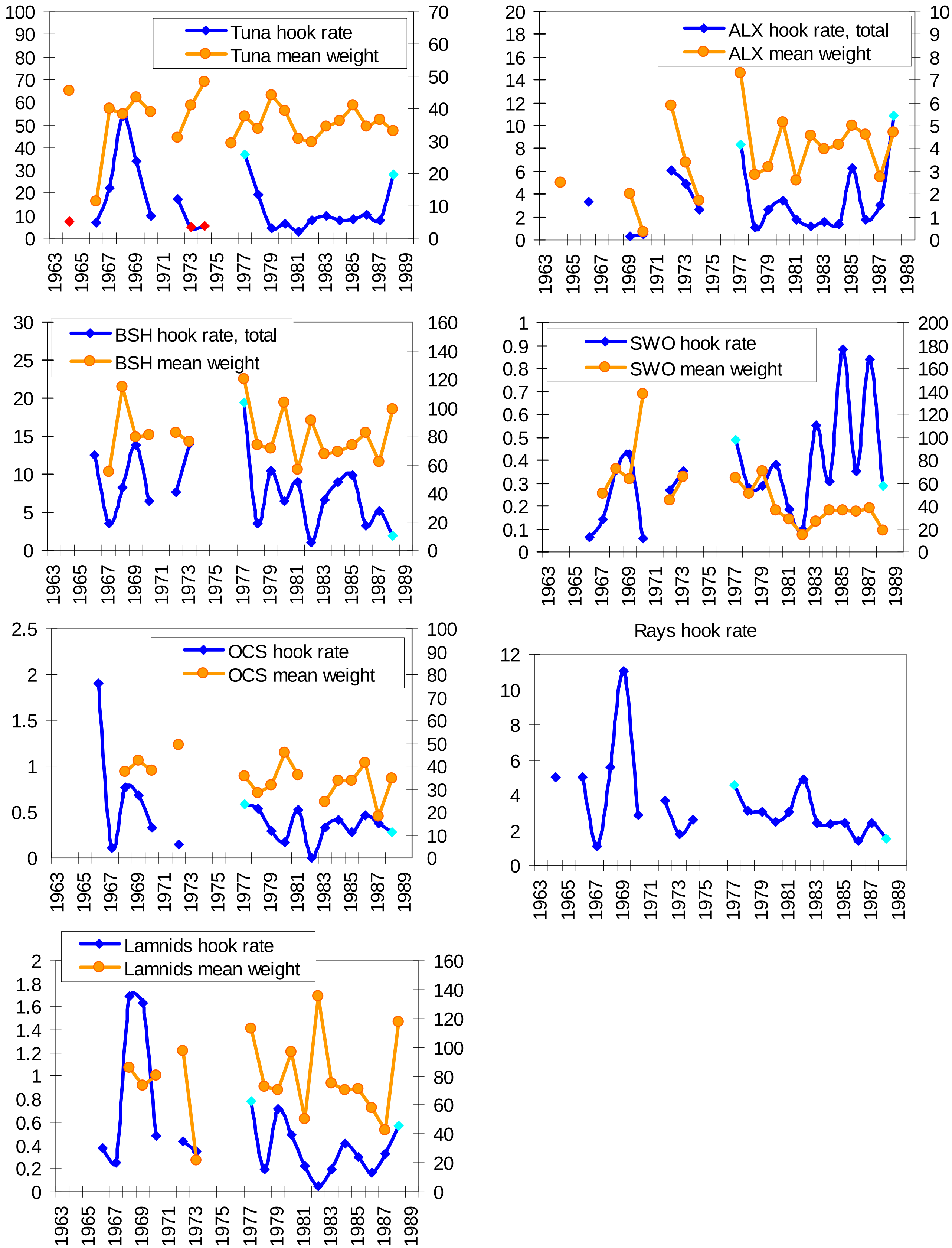

Figure 7. Nominal CPUE (hook rate, ind. per 1000 hooks) and mean weight of individuals caught for tuna, blue shark (BSH), oceanic white-tip shark (OCS), lamnid shark (*Isurus* spp.), longnose lancetfish (ALX), swordfish (SWO) and rays (principal species *Pteroplatytrygon vilacea*). Left axis is for CPUE, right axis for mean weight.