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A Fishery Associated with Floating Objects in the Indian Ocean off Southern Sri Lanka

M. M. ARIYARATHNA[1] and U. S. AMARASINGHE*
Department of Zoology, University of Kelaniya, Kelaniya, Sri Lanka
[1]Present Address: District Fisheries Office, Department of Fisheries and Aquatic Resources, Dehiwala, Sri Lanka

Abstract

The present study was carried out from August 2007 to January 2008 in southern Sri Lanka to investigate the catch composition of offshore fisheries from multi-day boats. Some boats were engaged in flotsam associated surrounding net fisheries. The fish landings from 77 boats were classified into three categories: (i) only from surrounding nets (S), (ii) from surrounding nets plus drift gillnetting/longlining (SGL), and (iii) only from drift gillnetting/longlining (GL). The catch estimate in each boat trip was categorised into one of the three groups for every fish species caught.

The Indian scad, *Decapterus russelli* (Rüppell, 1830), rainbow runner, *Elagatis bipinnulata* (Quoy and Gaimard, 1825), common dolphinfish, *Coryphaena hippurus* Linnaeus, 1758 and starry triggerfish, *Abalistes stellatus* (Anonymous, 1798) contributed significantly to catches in S and SGL boats but were insignificant in the catches of GL boats. In flotsam-associated surrounding nets, juvenile tunas, skipjack, *Katsuwonus pelamis* (Linnaeus, 1758) and yellowfin, *Thunnus albacores* (Bonnaterre, 1788) (15-60 cm total length) were also caught. Multivariate statistical analyses revealed that fish catch composition from GL boats differed from that of S and SGL boats. The biological consequences of behavioural changes and vulnerability of fish stocks to overfishing due to aggregation around flotsam require further investigation.

Introduction

Frequently marine pelagic fishes are associated with flotsam (Deudero et al. 1999; Castro et al. 2002; Addis et al. 2006) and artificial floating structures, generally known as fish aggregation devices or FADs (Higashi 1994; Riera et al.1999). FADs are deployed specifically to concentrate pelagic fish for capture. On the other hand, there are numerous small-scale and commercial fisheries associated with drifting objects in many parts of the world (Hunter and Mitchell 1967; Massuti et al. 1999; Fonteneau et al. 2000a, 2000b; Hallier and Gaertner 2008; Miyake et al. 2010). Despite the inherent difficulties of fishing in the open ocean on floating objects that are transient in space and time (Dempster and Taquet 2004), many drifting FADs have been deployed in tropical oceans by purse seiners targeting tunas (Franco et al. 2009). Tropical tuna purse seine fisheries using FADs are reported to take bycatch including vulnerable species such as elasmobranchs and sea turtles (Franco et al. 2009; Dagorn et al. 2012a). Franco et al. (2009) and Dagorn et al. (2012a, 2012b) have highlighted the need to use ‘ecological FADs’ that reduce bycatch.

In Sri Lanka, offshore fishing associated with flotsam is a recent development along with the rapid expansion of the multi-day fleet primarily responsible for the growth of the offshore

*Corresponding author. E-mail address: zoousa@kln.ac.lk

fisheries sector (MOFAR 2007). For the multi-day boats based in Galle fisheries harbour in southern Sri Lanka, the main gear types are large mesh (15 cm stretched mesh) drift gillnets with 24 ply filament thickness and tuna longlines. In addition, almost all multi-day fishing boats in this fisheries harbour carry surrounding nets, locally known as "Kotan dela" along with drift gillnets and tuna longlines. The fishing grounds of all multi-day boats based in the Galle fisheries harbour are located between latitudes 0° and 8°N and longitudes 75° and 80°E in the East Arabian Sea region and between latitudes 0° and 15°N and longitudes 80° and 85°E in the Bay of Bengal region of the Indian Ocean (Fig. 1). When a boat encounters floating objects such as floating trees, discarded ropes, nets, the surrounding net is used to encircle the floating object to harvest fish attracted to them. The catches of these surrounding nets are regularly landed at Galle fishery harbour in southern Sri Lanka.

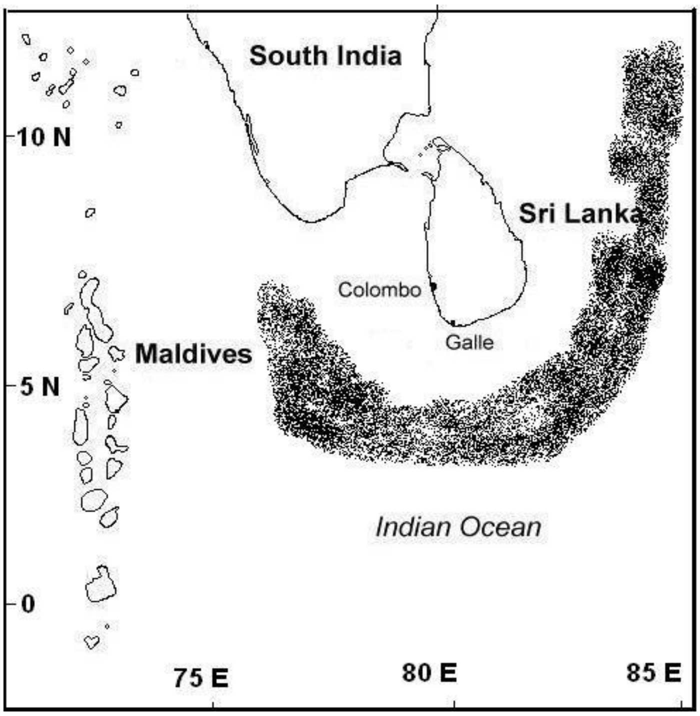

Fig.1. Location of Galle fisheries harbour in Sri Lanka and fishing areas (stippled) associated with flotsam.

In the Indian Ocean, fisheries associated with artificial reefs and FADs have been reported by IPFC (1991) and fishing on FADs was stated to generate approximately five times more total bycatch (in weight) than fishing on free-swimming schools (Romanov 2002). The pelagic fish species attracted to FADs and flotsam differ from those caught by conventional fisheries such as drift gillnetting and tuna longlining (Deudero 2001; Dempster and Taquet 2004).Information about the catch rates and species composition of the landings from the flotsam-associated fisheries is scanty in Sri Lanka. Sønvisen et al. (2005) suggested that fishing for pelagic species aggregating around floating objects should be explored in Sri Lanka. The present study was therefore carried out to investigate the flotsam-associated fishery in southern Sri Lanka with a view to recommending broad management strategies and identifying research needs for sound scientific management.

Materials and Methods

Based on the fishing gears used the boats were categorised into three groups; (i) boats with catches only from surrounding nets (S), (ii) boats with catches from surrounding nets plus drift gillnetting/longlining (SGL), and (iii) boats with catches only from drift gillnetting/longlining (GL). Catch valuation (in kg) for each boat trip was estimated for the three fishing categories separately. As the length of each fishing trip (10-15 days) was consistent, catch rate expressed as kg per boat trip was used in the present analysis.

Structure of surrounding net

The surrounding nets that are carried by multi-day boats in Galle fisheries harbour are similar in design to purse seine nets. Each net is about 200 m long and is hung between the head rope and lead line. The depth of the net varies from 65-75 m. The head rope is of 8 mm diameter nylon rope and the lead line is of 8 mm kuralon. Floats (F-1 type) are attached to the head rope at 50 cm intervals, while, in the bunt area, the intervals range from 20-25 cm. About 130 D-S 1 buoys are also attached to the head rope at equal intervals. The floats and buoys are attached to head rope by a separate 4 mm diameter nylon rope. Cylindrical lead weights of 20 mm diameter and 60 mm length are attached to the lead line at 10 cm intervals. These weights are usually attached to the middle area of the bottom rope at about 50 m from either end of the net.

The purse ring bridles of 12 mm diameter kuralon are attached to the lead line at 7 m distance. The purse rings are made of brass of 100 mm diameter and each weighs 300-900 g. The purse line of 12 mm diameter kuralon is passed through these purse rings.

The netting in the wing area is 25 mm mesh and 6 ply and, in the bunt area, the mesh is 18 mm of 9 ply. The wing is about 175 m long and the bunt is about 45 m long. The greatest depth of the net is about 75 m. The netting is hung to the head and bottom ropes by a 15 ply salvage net of 12 meshes of 25 mm mesh size.

Fishing operation

When a multi-day boat encounters a floating object and on investigation finds sufficient fish beneath the floating object the boat then encircles the floating object using a surrounding net. The fish caught are removed with a large scoop net. When the boat’s storage capacity is filled, the skipper invites another boat operating in the area to harvest the remaining catch. The second boat however, has to pay the first boat 33% of the income derived from the surrounding net catches from the floating object.

For each boat, the net profit from the landings is shared by the boat owner, skipper and crew members according to a mutually agreed procedure. According to the boat owners, the most common profit sharing formula is, 50% of the net income goes to the boat owner and 50% to the crew members.

Data Collection

Investigations were carried out from August 2007 to January 2008 in the fisheries harbour in Galle (Fig. 1). As the departure and arrival dates of individual multi-day boats are recorded at the security point of “Dakshina” naval base, these details were obtained from the log-books of the Sri Lanka Navy to calculate total fishing duration for individual boats. For logistical reasons, such as arrival of lorries to load the landed fish and access to routine harbour services, the multi-day boats registered in Galle fisheries harbour do not land in any other fisheries harbour of the country except in case of emergencies.

During the study period, the landing site in the Galle fisheries harbour was visited on 3-5 randomly selected dates in each month. The study involved more than 26 sampling days comprising catches from 77 boats being 16.4% of the 469 multi-day boats operating during the study period (Table 1).

On each sampling date, all multi-day boats that landed were visited and the gear types recorded and the catch composition was examined at the point of unloading. The total number of boats engaged in drift gillnetting and longlining and those operating surrounding nets were recorded. From the receipt books of boat owners, weights of each species sold were recorded. At the landing point in Galle fisheries harbour, species-specific weight data could not be recorded because crew members, who work for wages, were reluctant to provide catch data without permission of boat owners. As selling price is species-specific, and even size-specific in the case of tunas, accurate information of catch composition could be gathered from the receipt books of boat owners. However, gear-wise catch composition of SGL boats could not be recorded as the entire catch was stored in the storage chambers of the boat. According to crew members, there were no discards at sea.

Table 1. Number of boats unloading their catches in each month, number of sampling days and number of boats sampled in each month in Galle fisheries harbour. All these boats fall into one of the three categories mentioned in the text.

Month	Number of boats landed during the month	Number of sampling days	Number of boats sampled
Aug 2007	81	4	14
Sep 2007	74	5	16
Oct 2007	92	5	16
Nov 2007	68	4	11
Dec 2007	93	4	9
Jan 2008	61	4	11
Total	469	26	77

Species caught in surrounding nets and those which were caught in drift gillnetting/longlining were examined and their size ranges were recorded. Some species such as yellowfin, *Thunnus albacares* (Bonnaterre, 1788) and skipjack, *Katsuwonus pelamis* (Linnaeus, 1758) were caught in drift gillnetting/longlining as well as in surrounding net fishing.

Data Analysis

The Bray-Curtis similarity matrix of the group averages of sampled boats (Bray and Curtis 1957; Clarke and Warwick 1994; Clark and Goorley 2001) was also calculated in order to investigate the level of similarity between the multivariate data sets. Here, species-wise mean catches per boat-trip were ln-transformed (ln X+1) for the landings by the three categories of boats S, SGL and GL before analysis to reduce non-normality of data. Catch per unit effort is generally log-normally distributed (Gulland 1983).

Multivariate statistical analysis was carried out using PRIMER (version 5) statistical package.

Results

Of the 77 multi-day boats observed in Galle fisheries harbour during the study period, 54 boats were either in S group or in SGL group (Table 2). The data from the boats sampled and estimates of catches from all boats indicate that for the monthly landings of multi-day boats in Galle fisheries harbour, 46 to 84% was derived from surrounding net catches.

Table 2. Number of boats of three categories observed during the sampling period in Galle fisheries harbour. Estimated monthly total catches of 469 multi-day boats landed during the study period and estimated percentage contribution of flotsam associated surrounding net catches to the total landings are also given here.

	Aug2007	Sep2007	Oct2007	Nov2007	Dec2007	Jan2008
Number of GL boats observed	4	7	3	3	2	4
Number of SGL boats observed	5	9	4	5	5	5
Number of S boats observed	5	0	9	3	2	2
Estimated total monthly catch from multi-day fishing (in MT, 469 boats)	1650	1435	1710	1748	2203	1334
Estimated percentage contribution of surrounding net catches to monthly landings	68%	46%	84%	67%	74%	63%

In the landings sampled from multi-day boats of Galle fisheries harbour, a total of 17 fish species/species groups were encountered (Table 3). Interviewees reported that none of the species/species group caught was discarded at sea and thus the species/species groups are reported to be complete for the study period. For each category of boat, the catchabilities of each species differed. For two species (*K. pelamis* and *T. albacares*), only the smaller size classes were present in surrounding net catches, and larger individuals were only present in the catches of the GL and SGL boats (Table 3). However, *T. albacares* of intermediate size range (60-90 cm) was not caught in any of the three categories of boats.

Table 3. List of fish species landed in three categories of multi-day boats in Galle fisheries harbour during August 2007-January 2008. The total length and price ranges of fish species are also shown. S – Surrounding net boats; SGL – Surrounding net plus drift gillnetting/longlining boats; GL - Gillnetting/longlining boats.

Family/species	Size range (cm)	Price range (SL Rs.)	Boat category		
			S	SGL	GL
Carangidae					
Decapterus russelli	15-60	60-170	+	+	-
Elagatis bipinnulata	15-30	60-170	+	+	-
Caranx spp	05-10	80-220	+	+	-
Coryphaenidae					
Coryphaena hippurus	15-150	80-150	+	+	-
Balistidae					
Abalistes stellatus	05-30	40-140	+	+	-
Belamidae					
Strongylura leiura	15-120	80-160	+	+	-
Scombridae					
Auxis thazard	15-60	60-200	+	+	-
Acanthocybium solandri	15-90	180-240	+	+	-
Scomberomorus spp	15-60	140-300	+	+	-
Katsuwonus pelamis	15-60	50-120	+	+	-
	60-90	140-220	-	+	+
Thunnus albacares	15-60	60-180	+	+	-
	90-150	200-280	-	+	+
Thunnus obesus	90-180	640-700	-	+	+
Carcharnidae					
Carcharhinus spp	15-240	40-200	+	+	+
Xiphiidae					
Xiphias gladius	90-240	190-360	-	+	+
Istiophoridae					
Makaira spp	90-240	190-360	-	+	+
Istiophorus spp	90-240	190-360	-	+	+
Myliobatidae					
Raja spp	90-240	40-200	-	+	+

The mean catch per boat-trip for different species in the three categories of boats (Fig.2) also indicate that in the landings of surrounding net fishing associated with flotsam, species such as the Indian scad, *Decapterus russelli* (Rüppell, 1830), rainbow runner, *Elagatis bipinnulata* (Quoy and Gaimard, 1823), common dolphinfish, *Coryphaena hippurus* Linnaeus, 1758 and starry triggerfish, *Abalistes stellatus* (Anonymous, 1798) were caught in large quantities and that these species were insignificant in the landings of the boats of drift gillnetting/longlining. All *K. pelamis* and *T. albacares* caught in surrounding nets (Figs 2a and 2b) were juveniles (15-60 cm total length).

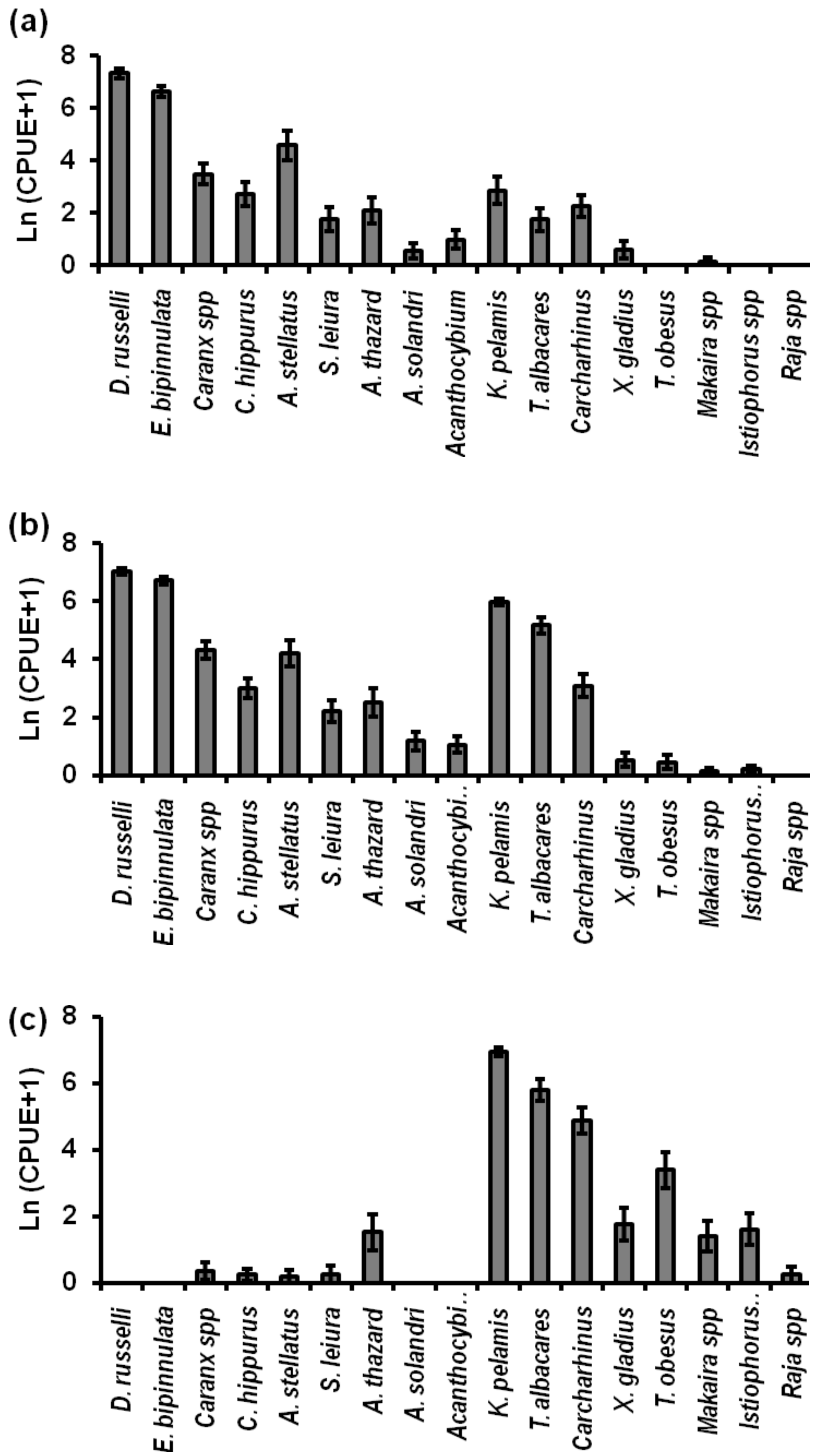

Fig. 2. Mean Ln (CPUE + 1) expressed as catch per boat-trip for different species in the three categories of boats. (a) – S boats; (b) – SGL boats; (c) – GL boats. Vertical bars are ± SE.

In the dendrogram based on the Bray-Curtis similarity, GL boats formed one cluster while the boats of Sand SGL categories formed another cluster at about 50% similarity level (Fig. 3).

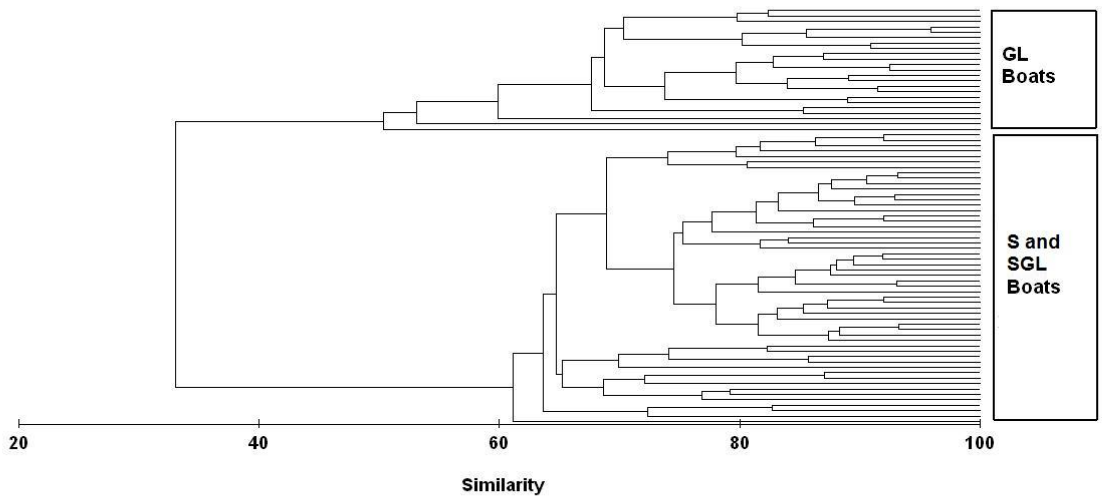

Fig.3. The Bray-Curtis similarity of the group averages of species composition of landings in the three boat categories.

Discussion

The landings of flotsam associated fisheries are not reported as distinct fishing gear categories in the official fisheries production statistics (Dissanayake and Hewapathirana 2011; www.fisheries.gov.lk/statistics.html). Yet, this is a significant fishery as shown by this study that 46-84% of the multi-day boats landed in Galle fisheries harbours were engaged in surrounding net fishing associated with flotsam.

The catches of surrounding net fishing consisted of fish species such as *D. russelli*, *E. bipinnulata*, *C. hippurus* and *A. stellatus* which are not generally caught in other fisheries that are concurrently practised such as gillnetting and longlining. Apparently, these species occur around moored or natural FADs. Under a pilot project carried out in 1982-83 to design, construct, deploy and monitor FADs in Sri Lankan waters (Weerasooriya 1987; Atapattu 1991), *E. bipinnulata* and *C. hippurus* were reported to be caught in high numbers in the inshore FADs (Joseph 1993). As these species are not generally caught in other fishing methods (Samaranayake 2003; Dissanayake and Hewapathirana 2011), these fish species as mentioned by Joseph (1993), can be considered as underexploited. The species caught in the fisheries associated with floating objects in Sri Lanka are similar to those species caught around floating objects in other regions. For example Massuti et al. (1999) and Addis et al. (2006) reported *E. bipinnulata* and *C. hippurus* in the purse seine catches near floating objects in the Mediterranean Sea.

From the present study, it was evident that juvenile tunas (15-60 cm TL) were caught in flotsam-associated surrounding nets as they aggregated around floating objects in offshore areas. Holland (1996) has indicated that although the data are scanty, there appears to be vertical stratification of tuna species at FADs depending on the species present, the size of individuals, and the thermal stratification of the ocean. Absence of *T. albacares* of intermediate size range

(60-90 cm) in the catches of GL and SGL boats may be due to gear selection. However, the reason for their absence in the catches of flotsam-associated surrounding nets is not clear. It is therefore necessary to investigate the impact of flotsam-associated surrounding nets on the exploitation of stocks of small sized tunas. This is of particular importance because the tunas are known to be predominantly associated with FADs during the daytime and leave for various lengths of time at night (Holland 1996), a behavioural pattern that can potentially be utilised for differential exploitation.

Due to the high proportions of bycatch in the purse seining associated with FADs targeting tropical tuna, incorporation of ecosystem management approaches is necessary to reduce bycatch (Franco et al. 2009; Dagorn et al. 2012a). Hallier and Gaertner (2008) have shown that food intake by tuna associated with FADs, regardless of size and the time of day, is always lower than the food intake of tuna from free schools, supporting the hypothesis that the attraction and the retention of tuna around drifting FADs affect them negatively in terms of growth and condition. As it is evident from the present study that juvenile tunas are attracted to flotsam, implications of flotsam-associated fisheries on tuna stocks should be investigated. As floating objects are known to aggregate pelagic fish, they are considered to affect migratory behaviour of fish and in turn, their overall biology as a result of maladaptation to the artificial habitat, or what Dagorn et al. (2010) have termed the ecological trap hypothesis. However, Dagorn et al. (2012b) stressed that there is no unequivocal empirical evidence that FADs represent an ‘ecological trap. The analysis of the changes of behavioural patterns due to attraction to flotsam and biological consequences of behavioural changes such as growth and body condition of fish therefore need to be investigated.

Due to the high operational costs of fishing, fisheries activities especially in the deepsea/offshore sector, are driven by economic factors. The major operational cost for multi-day boats is fuel (Pauly et al. 2003; Pauly 2009) and short fishing trips and/or long cruising duration relative to fishing time increases the net income from a fishing trip. For sound management strategies, the economic returns in flotsam-associated surrounding net fisheries in comparison with those in drift gillnet/longline fishing operations should be investigated. In the global context, the floating structures of various types such as drifting objects, moored FADs, oil platforms, sea fish cages and others continue to increase (Fonteneau et al. 2000a, 2000b; Fréon and Dagorn 2000; Franks 2000; Dempster et al. 2002), possibly due to high economic returns to compensate the increase of fuel cost associated with conventional offshore fishing operations. Hence, vulnerability of fish stocks to overfishing due to aggregation around flotsam requires further investigation (Dempster and Taquet 2004).

Conclusion

Around Sri Lanka, pelagic fishes are associated with flotsam in the sea. In the multi-day boats based in Galle fisheries harbour in the south, offshore fishing associated with flotsam is carried out. *Decapterus russelli*, *E. bipinnulata*, *C. hippurus* and *A. stellatus* contributed significantly to catches in the boats of flotsam associated fisheries. In addition, juvenile *K. pelamis* and *T. albacares* (15-60 cm total length) were also caught in these fisheries. As there is an increasing trend of flotsam-associated fisheries around Sri Lanka, vulnerability of the tuna stocks to overfishing should be further investigated. Moreover, drifting objects are hypothesised to act as ‘ecological traps’ for tropical tunas where population growth is reduced as a result of individuals making a sudden inappropriate habitat choice. Hence, there is a need to examine the ecological implications of flotsam-associated fisheries on tuna stocks.

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