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Initial study on catch, species composition and reproductive biology of fishes off the south-west coast of Sri Lanka, targeted by ring nets while utilizing natural floating objects

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Summary

This study evaluates the catch rates, species composition and reproductive biology of flotsam-associated fishes targeted by ring nets off the southwest coast of Sri Lanka. Catch and number of multiday boats operating with ring nets were collected at Beruwala fishery harbor on the southwest coast of Sri Lanka, March to October 2013, by making fortnightly field visits. Fish samples were collected randomly from the unloaded ring net catches to analyze reproductive biology. Twelve fish species belonging to four major families: Scombridae, Carangidae, Coryphaenidae and Balistidae were identified in the ring net catches and five species, *Decapterus russelli, Katsuwonus pelamis, Thunnus albacares, Elagatis bipinnulata and Canthidermis maculatus* were predominant. An average of 25 ± 12% multiday boats landing at the Beruwala fishery harbor operated with ring nets each month, with an average monthly catch rate fluctuating from 730 ± 101 to 3924 ± 1094 kg per boat per trip. Catch rates of tunas and carangids were significantly higher than the other fish groups (ANOVA; d.f. = 3, $P < 0.05$). Total fish landed by ring nets at the Beruwala fishery harbor during the study period was 1456 tonnes. Species belonging to the family carangidae had the highest percentage contribution (46.6%) to the ring net landings followed by tuna (34%). Similar-size individuals ranging from 24 to 31 cm were landed by ring nets, with all landed individuals belonging to *K. pelamis, T. albacares* and *E. bipinnulata* having immature gonads. The findings of this study will be useful locally as well as regionally to manage the ring net fishery and to aid in implementing measures to manage the highly migratory tuna species.

Introduction

Floating objects are considered as a type of Fish Aggregating Devices (FADs), which can be regarded as temporary habitats shared by several fish species for recruitment, nursery and feeding purposes (Kingsford, 1993; Deudero et al., 1999). The small-scale fishers throughout the world have taken advantage of this aggregation behavior of pelagic fish in order to maximize their catches (Kojima, 1956; Galea, 1961; Massuti and Vidal, 1997). Artificial objects of human origin such as slabs of cork and rafts have also been known to attract pelagic fish in great numbers and diversity (Hunter and Mitchell, 1967; Deudero, 2001). These structures have been deployed throughout the world's oceans, especially in tropical oceans by purse seiners to attract tuna and tuna-like species (Samaranayake, 2003).

The use of the ring net, which is a type of surrounding net to exploit fish schools associated with naturally floating objects is a recent development in the marine fisheries sector of Sri Lanka (Ariyarathne and Amarasinghe, 2012). Initially, the ring net fishery was started in the sea areas off the southwest coast of Sri Lanka (Samaranayake, 2003). However, at present most of the multiday boats (boats that stay at sea more than 1 day) operating from Sri Lanka frequently carry ring nets along with drift gillnets and tuna long-lines (Ariyarathne and Amarasinghe, 2012). Further, it is evident that most of the multiday boats that have been operating for targeting tuna and tuna-like species using gill nets and long lines are shifting to ring nets, as the ring net catches generate more profit than just catching tunas.

Although ring net fishing activities have expanded into many geographical areas off the coastal waters of Sri Lanka, information on catch rates, species composition and the size structure of targeted species is still unknown. Rapid expansion of ring nets targeting huge schools of fish associated with natural floating objects in the Indian Ocean, especially off the southwest coast of Sri Lanka, might cause some adverse impacts on target fish stocks as well as on other fish species, both locally and regionally. Therefore, an in-depth study to evaluate the status of ring net fishery was carried out to determine and understand the:

a temporal variation in the number of multiday boats operating ring nets targeting flotsam-associated fish schools off the southwest coast of Sri Lanka
b fluctuation in ring net catch rates and total fish landings
c species composition, size structure and reproductive biology of flotsam-associated fish species targeted by the ring nets

Methods

Catch and effort data

Catch data and the total number of multiday boats operating with ring nets targeting flotsam-associated fish schools were

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collected at the Beruwala fishery harbour (6.4433138 N; 78.9766982 E), southwest coast of Sri Lanka where almost all associated catches are unloaded.

Data were collected on bi-weekly field visits to Beruwala from March to October 2013. On each sampling day, 50–60% of unloaded multiday boats operating with ring nets were sampled randomly in the fishery harbor. Samplings were made as soon as the catches were unloaded. The total number of multiday boats landed (total fishing effort) and those operating with ring nets (fishing effort for ring nets) were counted and recorded each sampling day (Table 1). Skippers who used ring nets as their principal fishing gear were interviewed for information on the number of days at sea (trip duration), the actual number of fishing days, vessel size, plus other types of fishing gear used except ring nets during each fishing operation.

Collected catch and fishing effort data were used to calculate the ring net catch rates (CPUE). In this analysis, the catch per boat per trip (kg) was taken as the CPUE by assuming that there were no partial landings of unloaded boats. Monthly total fish landings (MTP) of ring nets were estimated using the equation:

$$MTP = CPUE \times NFO \times MRD$$

Where, MTP – Monthly total fish landings from ring nets; CPUE – Mean catch per multiday boat (operated for ring nets) per trip; NFO – Average number of multiday boats with ring net catches landed at the Beruwala fishery harbour per day; MRD – Total number of days that multiday boats with ring net catches unloaded at the Beruwala fishery harbor each month.

Catch rates by species and their monthly total landings were calculated and their statistical significance was determined using ANOVA. Percentage multiday boats operated with ring nets per month was computed and compared with respect to the total number of multiday boats landed at the Beruwala fishery harbor.

Catch samples were taken randomly from the unloaded multiday boats with ring net catches to analyze the reproductive biology of each species. The samples were packed in ice and transported to the laboratory of the University of Sri Jayewardenepura, Colombo, Sri Lanka for further analysis.

Table 1
Sampling dates, number of landed and sampled multiday boats operating with ring nets, March–October 2013, along the southwest coast of Sri Lanka and total number of individuals collected from sampled boats, Beruwala fishery harbor, during study period

Sampling date (day/month/year)	Number of multiday boats at Beruwala fishery harbor using ring nets		Total number of fish measured from sampled boats per sampling day
	Landed	Sampled	
05.03.2013	2	2	243
25.03.2013	2	1	268
05.04.2013	2	2	205
23.04.2013	3	2	296
09.05.2013	2	2	254
31.05.2013	3	2	247
07.06.2013	3	2	179
28.06.2013	4	2	313
02.07.2013	2	1	289
26.07.2013	2	2	237
07.08.2013	2	2	276
21.08.2013	5	5	203
03.09.2013	4	2	193
16.09.2013	4	3	189
11.10.2013	4	3	203
31.10.2013	3	2	237

Morphometric data

Morphometric data of five species: *Katsuwonus pelamis, Thunnus albacares, Decapterus russelli, Elagatis bipinnulata* and *Canthidermis maculatus* predominant in the ring net catches during the study period were collected. In the laboratory, total length (TL) of each specimen was measured to the nearest 0.1 cm using a measuring board and total body weight (BW) taken to the nearest 0.1 g.

Reproductive biology

The five dominant species (*K. pelamis, T. albacares, D. russelli, E. bipinnulata* and *C. maculatus*) observed in the ring net catches were considered in this analysis. Firstly, morphometric parameters of fish from each species were measured and dissected. Sex and gonad maturity stage of each individual were determined by observing their gonads macroscopically; gonad weight and somatic weight were measured separately. Gonado Somatic Index (GSI) was calculated using the equation (Barber and Blake, 2006):

$$GSI = \left(\frac{\text{Gonad weight}}{\text{Somatic weight}}\right) \times 100$$

Monthly variation in sex ratio of each species was estimated and differences were compared statistically using a chi-square test (χ^2). Mean total lengths (TL) of males and females from each species were compared using the Mann–Whitney test. All statistical analyses were performed using the MINITAB (version 14) software package for windows.

Results

Ring net fishery

Fishing gear and method. Most of the multiday boats operated from Sri Lanka tend to carry gill net, longline and ring net as their major fishing gear. Among these, multiday boat fishers who fish off the southwest coast of Sri Lanka use ring nets extensively.

The ring net structure is very similar to the purse seine net. The net is around 200 m long and is hung between the head rope and lead line. The head rope is made of 8 mm Ø nylon while the lead line is made of 8 mm kuralon. Floats are attached to the head rope at 50 cm intervals, but in the bunt area the interval ranges from 20 to 25 cm. Around 120–130 buoys are attached to the head rope at equal intervals. Both floats and buoys are attached to the head rope by a separate nylon rope. Cylindrical lead weights, each 20 mm Ø 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 are made of 12 mm Ø kuralon and are attached to the lead line at 7 m distance. The purse rings are made of 100 mm Ø brass, and each weight ranges from 300 to 900 g. The 12 mm Ø kuralon purse line passes through these purse rings. The length of the wing and bunt is circa 160 and 40 m, respectively. Greatest depth of the net is about 80 m. The size of the multiday boats that are used to operate ring nets range from 32 to 56 feet (circa 9.8–17 m) and the average trip is around 8–10 days long.

Ring net fishers normally seek naturally drifting objects, such as logs in the sea. When such objects are sighted, they are encircled by a ring net and fish are captured using large scoop nets. When there are more fish than the storage capacity of the boat, the skipper notifies other nearby multiday ring net boat skippers via a radio telecom system to catch the remaining harvest. However, in such a situation, the second boat pays 50% of the income generated through the ring net catch to the first boat. In some instances, fishermen carry logs on their vessels to float in the sea and attract pelagic fish schools. Once the fishing operation is finished, the used log is sold to a nearby vessel and thereby the weight of the vessel is reduced and an additional income is generated.

Usually 3–4 fishermen are on-board in the ring net multiday fishing boats. From the total income, 50% goes to the boat owner and the remainder is distributed equally among the crew members.

Major fish species landed by ring nets. Twelve fish species belonging to four major families: Scombridae, Carangidae, Coryphaenidae and Balistidae, were identified in the ring net catches during the study period (Table 2). Of these twelve species, seven species belonged to the family Scombridae, and three to the family Carangidae.

Variations in fishing effort, catch rates and total fish landings of ring nets. On average, 25 ± 12% multiday boats landed at the Beruwala fishery harbor were operated for flotsam-associated ring net fishery off the southwest coast of Sri Lanka each month. However, there were some large fluctuations in a number of ring net-operated multiday boats over time, with the highest percentage reported in August (44%) and the lowest in April (13%).

Monthly variation in catch rates of multiday boats operating with ring nets ranged from 730 ± 101 to 3924 ± 1094 kg per boat per trip, with the lowest in April and the highest in September. Catch rates showed an increasing trend from March to September. The total ring net fish landings at the Beruwal fishery harbor during the study was 1456 tonnes (t) (Table 3).

Monthly variations in average catch rates of the four major fish groups in the family scombridae (tuna), carangidae (scads and runners), coryphaenidae (dolphinfishes) and balasidae (trigger fish) were compared. The highest catch rate was in species belonging to the family carangidae, followed by scombridae; it was evident that those catches were significantly higher than in the other two groups (ANOVA; d.f. = 3, $P < 0.05$).

Table 2
Major fish species (scientific + common names in English) landed by ring nets at Beruwala fishery harbor, southwest coast of Sri Lanka, March–October 2013

Family	Species	English name
Scombridae (Tuna and tuna-like sp.)	*Katsuwonus pelamis* (Linnaeus, 1758)	Skipjack tuna
	Thunnus albacares (Bonnaterre, 1788)	Yellowfin tuna
	Thunnus obesus (Lowe, 1839)	Bigeye tuna
	Auxis thazard thazard (Lacépède, 1800)	Frigate tuna
	Auxis rochei rochei (Risso, 1810)	Bullet tuna
	Euthynnus affinis (Cantor, 1849)	Kawakawa
	Rastreliger kanagurta (Cuvier, 1817)	Indian mackerel
Carangidae	*Decapterus russelli* (Rüppell, 1830)	Indian scad
	Elagatis bipinnulata (Quoy & Gaimard, 1824)	Rainbow runner
	Sela crumenophthalmus (Bloch, 1793)	Bigeye scad
Coryphaenidae	*Coryphaena hippurus* (Linnaeus, 1758)	Dolphinfish
Balistidae	*Canthidermis maculatus* (Mitchill, 1815)	Roughtrigger fish

Species belonging to the family carangidae had the highest percentage contribution (46.6%) to the total ring net landings at the Beruwala fishery harbor. The percentage contribution of tuna to the total ring net landings was 34% and that of trigger fish and dolphin fishes were 15.5% and 3.1%, respectively. Seer fishes followed by ray species were dominant in the category 'others'.

The highest tuna landings from ring nets were reported in October (143.3 t) followed by August; lowest landings were in April (17.4 t). Species belonging to the family caragidae also showed the lowest landings in April (17.4 t), but with the highest total landings in September (279.2 t). Trigger fish were dominant in ring net catches from May to September, with the highest landings observed in September (114.0 t). Dolphinfishes were not predominant in the ring net catches and their monthly total production varied from 0.2 to 14.7 t (Table 3).

Catch composition of major fish species landed by ring nets. Among the seven reported tuna species, *K. pelamis* was predominant in the ring net catches landed at the Beruwala fishery harbour (Fig. 1); the highest landings were 103.0 t in August. Except for August and October, monthly total ring net landings of *K. pelamis* ranged from 10 to 30 t. On average, *K. pelamis* contributed 57% to the total ring net tuna landings at the Beruwala fishery harbor from March to October 2013 (Fig. 2). The highest landings of *T. albacares* were 51 t in October, with an average contribution to the

Table 3
Monthly variations in total catch (tonnes) and (*CPUE*: kg boat^{-1} trip^{-1}) major fish groups landed by ring nets at Beruwala fishery harbor, southwest coast of Sri Lanka, March–October 2013

Month	Major fish groups: Tuna	Scads & runners	Trigger fish	Dolphin fish	Others	Total
March	24.6 *(442 ± 183)*	35.1 *(628 ± 38)*	0.2 *(4.0 ± 3)*	3.2 *(58 ± 27)*	8.4 *(150 ± 89)*	72 *(1281 ± 397)*
April	17.4 *(362 ± 54)*	17.4 *(363 ± 52)*	0.0 *(0.0)*	0.2 *(5 ± 6)*	0.0 *(0.0)*	35 *(730 ± 101)*
May	33.1 *(625 ± 87)*	35.3 *(667 ± 54)*	6.0 *(113 ± 35)*	3.7 *(70 ± 85)*	0.1 *(3 ± 3)*	78 *(1477 ± 230)*
June	25.8 *(349 ± 265)*	52.3 *(707 ± 266)*	53.4 *(722 ± 142)*	6.6 *(89 ± 108)*	0.0 *(0.0)*	138 *(1867 ± 488)*
July	86.2 *(1541 ± 220)*	55.1 *(985 ± 73)*	25.1 *(448 ± 175)*	8.4 *(150 ± 71)*	0.0 *(0.0)*	175 *(3123 ± 523)*
August	121.7 *(1242 ± 286)*	80.9 *(826 ± 212)*	26.5 *(271 ± 309)*	8.3 *(84 ± 87)*	0.0 *(0.0)*	237 *(2422 ± 645)*
September	43.1 *(385 ± 74)*	279.2 *(2493 ± 201)*	114.0 *(1018 ± 244)*	0.0 *(0.0)*	3.1 *(28 ± 16)*	440 *3924 ± 1094*
October	143.3 *(1463 ± 179)*	123.4 *(1259 ± 250)*	0.0 *(0.0)*	14.7 *(150 ± 108)*	0.0 *(0.0)*	281 *(2871 ± 705)*
Total production	**495.48**	**678.9**	**225.2**	**45.0**	**11.7**	**1456.25**
Total (%)	**34.0**	**46.6**	**15.5**	**3.1**	**0.8**	

Italic value indicates CPUE of each species in kg per boat per trip ± SD.
Bold values indicate total ring net production of each group and their % contribution for total ring net landings in Beruwala fishery harbour.

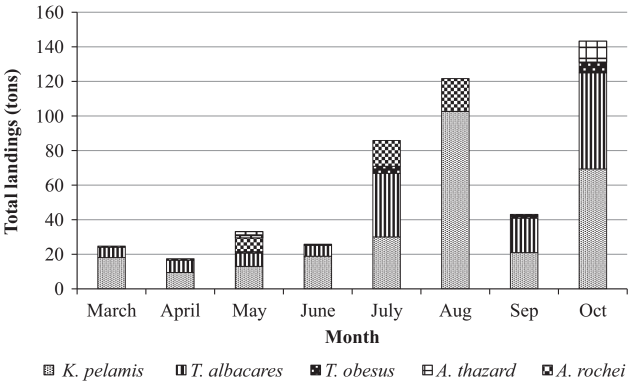

Fig. 1. Monthly variation in total landings of major tuna species by ring nets at Beruwala fishery harbor, southwest coast of Sri Lanka (March–October 2013)

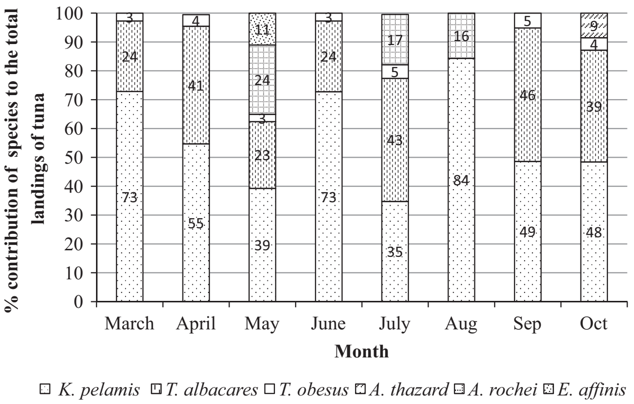

Fig. 2. Percentage contribution of major tuna species to total tuna landings by ring nets, Beruwala fishery harbor, southwest coast of Sri Lanka (March–October 2013)

total ring net tuna landings at Beruwala of around 25%. *A. thazard, A. rochei* and *E. affinis* were reported seasonally in the catches, with *A. thazard* only in October with 12 t. *A. rochei* was recorded in May, July and August, with total

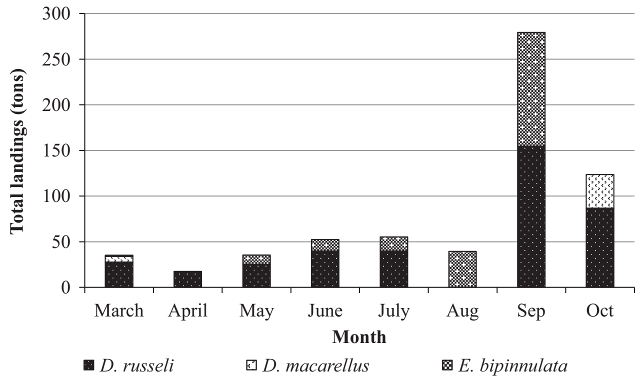

Fig. 3. Monthly variations in total landings of major carangid species by ring nets, Beruwala fishery harbor, southwest coast of Sri Lanka, March–October 2013

ring net tuna landings from 8 to 19 t, and the highest in May. *E. affinis* was the least abundant tuna species in the ring net catches, with only 4.0 t landings in May.

Among the three reported carangid species, *D. russelli* was predominant in the ring net catches followed by *E. bipinnulata*. Average contribution of *D. russelli* to the total carangid ring net landings during the study was 61%, with the highest landings in September (154 t). The highest landings of *E. bipinnulata* were also recorded in September (125 t); their average contribution to the total carangid landings by ring net was 32%. *D. macarellus*, was recorded only in March and October, with the highest reported production of 37 t (Fig. 3).

Trigger fish were dominant in the ring net catches during June to September. Although, dolphinfishes were frequently reported in catches, their monthly production was less than 20 t.

Morphometric parameters

Total length and total weight ranges of fish species landed by ring nets are summarized in Table 4. It was evident that same-size individuals aggregated around naturally floating

Table 4
Total length (TL; range, mean ± SD), and total weight (TW; range, mean ± SD) of five dominant fish species landed by ring nets, Beruwala fishery harbor, southwest coast of Sri Lanka, March–October 2013

Species	Length range TL (cm)	Mean length (±SD in cm)	Weight range (TW in g)	Mean weight (±SD in g)
K. pelamis	17.2–36.1	27.7 ± 5.2	220.5–789.4	514.4 ± 120.9
T. albacares	16.5–32.5	25.6 ± 4.0	267.8–534.5	379.2 ± 67.0
D. russelli	17.9–37.3	28.5 ± 5.9	180.7–341.1	270.9 ± 106.2
E. bipinnulata	22.1–39.8	31.3 ± 4.4	221.6–467.1	344.4 ± 46.3
C. maculatus	17.5–34.6	24.4 ± 3.9	190.3–536.8	371.7 ± 62.5

Table 5
Total length (mean ± SD), somatic weight (mean ± SD), gonad weight (mean ±SD) and % GSI of male, female, and respective P value (Mann–Whitney test) of major fish species landed by ring nets, Beruwala fishery harbor, southwest coast of Sri Lanka, March–October 2013

Species		Total length cm (mean ± SD)	Somatic weight (g) (mean ± SD)	Gonad weight (g) (mean ± SD)	GSI (%)
K. pelamis	Male	29.2 ± 4.6	524.6 ± 139.9	3.4 ± 0.9	0.71
	Female	25.0 ± 5.4	503.1 ± 104.6	3.1 ± 1.3	0.63
	P value	0.0203	0.4892	0.1470	0.203
T. albacares	Male	24.1 ± 3.0	351.9 ± 39.8	5.5 ± 6.1	1.51
	Female	24.9 ± 4.6	368.3 ± 68.7	11.3 ± 10.2	2.76
	P value	0.1364	0.4737	0.3466	0.1402
D. russelli	Male	30.2 ± 3.5	274.2 ± 40.3	6.6 ± 1.6	2.41
	Female	27.5 ± 5.7	273.4 ± 50.1	4.9 ± 2.5	1.86
	P value	0.1868	0.7289	0.0747	0.0333*
E. bipinnulata	Male	32.9 ± 3.3	345.7 ± 62.3	32.2 ± 6.5	9.69
	Female	28.9 ± 4.4	325.6 ± 70.2	24.3 ± 7.5	8.08
	P value	0.0068*	0.4763	0.0017*	0.0804
C. maculatus	Male	25.7 ± 6.1	374.0 ± 122.8	12.9 ± 10.4	3.37
	Female	23.3 ± 5.8	377.7 ± 93.7	11.4 ± 9.3	2.89
	P value	0.1768	0.6871	0.4995	0.4205

*Significant difference at a level of 95%; P < 0.05.

objects off the southwest coast of Sri Lanka, with mean length ranges of 24–31 cm. Although the mean length ranges were similar, there were differences in mean weight. Highest mean weight was for *K. pelamis* (514.4 ± 120.9), and the lowest mean weight for *D. russelli* (270.9 ± 106.2).

Reproductive biology

The highest female : male sex ratio was recorded for *K. pelamis* and *E. bipinnulata* (1 : 1.5) while the normal ratio of 1 : 1 was reported for *D. russelli*. However, the sex ratio was not significantly different in any of these species (χ^2 test, P > 0.05).

Mean length comparison of males and females of each species landed by ring nets showed that male *E. bipinnulata* had significantly higher mean lengths than did females (Mann–Whitney test, P < 0.05, Table 5). It was also found that the mean gonad weight of male *E. bipinnulata* was significantly higher than in females (P < 0.05: Mann–Whitney test, Table 5). Further, a significantly higher %GSI value was observed for *D. russelli* males than females (P < 0.05, Mann–Whitney test, Table 5).

It was found that all individuals belonging to *K. pelamis, T. albacares* and *E. bipinnulata* landed by ring nets had immature gonads. Mature gonads were recorded in *D. russelli* and *C. maculatus,* while spent gonads were recorded only in *D. russelli* (Fig. 4).

Discussion

It was evident that all fish associated with floating objects are fully exploited by ring net users, hence it can be assumed that ring net landings may represent the real structure of fish populations associated with floating objects off the southwest coast of Sri Lanka.

This study showed that 12 fish species belonging to four major families were dominant in the ring net catches. Previous studies have reported the presence of the same species in association with floating objects in the Indian Ocean (Weerasooriya, 1987; Atapattu, 1991; Ariyarathne and Amarasinghe, 2012). Further, according to Massuti et al. (1998), similar species have been caught around floating objects in other regions such as in the Mediterranean Sea by purse seiners.

Previous studies have reported that fish species belonging to the family carangidae scombridae, sphyraenidae, mullidae, mugilidae, monacanthidae and balistidae frequently aggregate around floating objects (Kingsford, 1993; Druce and Kingsford, 1995; Deudero, 2001). Even in the present study, species belonging to the family carangidae showed the highest percentage contribution to the total ring net landings, followed by scombridae and balistidae. However, some species like *A. thazard, E. affinis,* and *S. crumenophthalmus* were seasonally recorded in ring net catches. This may be due to the seasonality of their aggregation around floating objects (De Bruin et al., 1994) as well as due to variable environmental

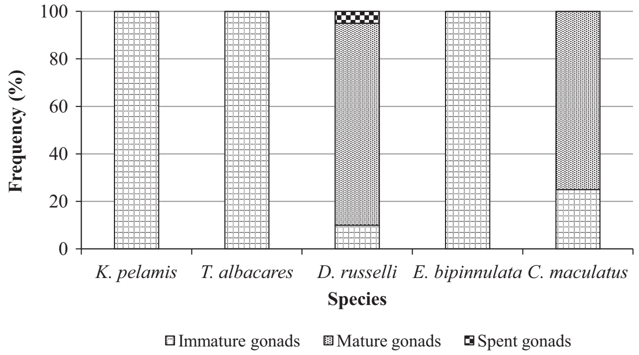

Fig. 4. Percentage frequency, gonad maturity stages, *K. pelamis* (n = 625), *T. albacares* (n = 575), *D. russelli* (n = 777), *E. bipinnulata* (n = 535) and *C. maculatus* (n = 605) caught by ring nets off southwest coast of Sri Lanka, March–October 2013

parameters such as the monsoon pattern, food availability, water currents, changes in migratory routes, or changes in fishing grounds. However, due to lack of detailed information on the variability of oceanographic parameters and migratory patterns of most of these species, it is difficult to determine the exact reasons for their seasonality; further studies are therefore needed.

The remarkable variations in ring net catch rates observed during the study period may be due to either differences in the aggregation behavior of fish around flotsam or variations in the number of multiday boats operating with ring nets.

The sex ratio of major fish species landed by ring nets did not differ significantly throughout the study period. Therefore, sexual segregation for reproduction might not be the reason for their aggregation around flotsam. It was observed that the mean lengths of fish species landed by ring nets are within the same length range, confirming that similar size individuals from different species tend to aggregate around floating objects.

Length at first sexual maturity of *K. pelamis, T. albacares, D. russelli, E. bipinnulata* and C. *maculatus* ranged from 40 - 45, 78–158, 14–44.5, 90–180 and 35–50 cm, respectively, (De Bruin et al., 1994; Fishbase, www.fishbase.org). The present study findings revealed that, except for *D. russelli* and *C. maculatus,* the length ranges of all other species landed by ring nets were less than their reported length at first sexual maturity. Further, a reproductive biological study also highlighted that all *K. pelamis, T. albacares* and *E. bipinnulata* individuals caught by ring nets off southwest Sri Lanka have immature gonads. Deudero (2001) also showed that carangid, scombrid, monacanthid and balistide juveniles are the commonly aggregated ichthyofauna under floating objects. Previous studies have suggested that different species of pelagic fish appear to be associated with floating objects only during their early life stages (Hunter and Mitchell, 1967; Kingsford, 1993; Renones et al., 1998) and our study supports their findings.

According to the present study, massive schools of immature tuna species like *K. pelamis* and *T. albacore* mainly aggregated around floating objects, whereby these schools were ring net targets. These tuna species are highly migratory and they are shared by different coastal nations in the Indian Ocean. Hence, the findings of this study will be useful to Regional Fishery Management Organizations (RFMOs) when implementing management plans for tuna species. It is our understanding that this is the first detailed study of the ring net fishery in Sri Lanka, hence these findings will be useful for implementation of measures to manage the ring net fishery in a sustainable manner.

This study does have some limitations, as the ring net fishing efforts were estimated by considering the number of multiday boats landed at fishery harbor. However, more precise catch and effort information as well as fishing positions and size structure of floating objects could be collected if researchers were on-board. Further time series data on catch and effort would be useful to address some issues such as observed seasonality of some fish species, and future fluctuations of CPUE.

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