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Research Article

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An Assessment of Length-Weight Relationship, Length Frequency Distribution, Abundance and Biomass of Fish Species

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Abstract This study was done in Belgium (North Sea, Middelkerre-Oostende) as part of excursion in 2013. The objective was to compare the fishes' body weight (W), length (L), biomass and total catch of the two gears (otter and beam trawl) used to collect the fishes. The relationship between total length (L) in cm and total weight (W) in kg for all fish species was expressed by the equation $\mathbf{W = aL^b}$, a (intercept) and **b** (slope) are species specific constant. Two tailed t-test and Mann Whitney U-test were used to compare the length frequency distribution (LFD) between two gears within species. More than 10 fish species were collected from each fishing gear; nevertheless, 8 common species from every gear were used for this analysis. The biomass, abundance, LFD and length weight relationship (LWR) varied among species and between gears. The main species in terms of biomass were *L. limanda* and *P.platesa*, which together accounted for 81% and 89% of the total biomass in otter and beam trawl respectively. *S. spratus, L. dupurator* and *L. limanda* in otter trawl were the main species in terms of abundance accounting together for 54%. LWR was positively correlated for all eight species in both gears. *S. sprattus, L. limanda, S. solea, O. eperlanus, Gobiidae spp, C. crangon* and L. *depurator* showed no significant difference in LFD between gears within species ($p>0.05$) and *P. platessa* showed a significant difference in LFD between gears ($p<0.05$).

Keywords Fish species, Length-weight relationship, Length frequency distribution, Abundance, Biomass, Total catch, Bycatch

Introduction

It is known that the length and weight data are essential as well as useful standard information of fish sampling programs. These kinds of data are important for several studies, for instance they can be used to estimate growth rates, age structure and other aspects of fish population dynamics [1, 2]. Study of the size structure (length frequency) of fish species tells many about ecological and life-history qualities such as the water body health, stock conditions and breeding period of the fish [3]. The size structure of a fish population at any point in time can be considered a 'snapshot' that reflects the interactions of the dynamic rates of recruitment, growth and mortality.

Additionally, Madrid-Vela et al., [4] stated that the analysis of the structure of the fish community is important for the understanding of the regional processes and the functioning of the ecosystem.

Fishery researchers have been assessing the energetic condition of fishes based on weight at a given length relative to body size [5]. Fishes are affected by environmental factors that limit their biomass and total length, these factors includes predation, pollution and nutrients competition [6]. The relationship between length and weight differs among fish species based to their body shape and within a species according to the condition of individual fish (www.fishbase.org).

This paper presents information on the length frequency distribution (LFD) and weight-length relationship (LWR), abundance (catch per unit effort, CPUE) and biomass of fish species trawled from North Sea during excursion, on 30/4/l 2013 and this paper is a side result of that work. As stated before, these parameters are useful for estimating growth rates, reproduction, healthiness, age structure and other aspects of fish population

dynamics [3]. For instance, species maturity can be determined by increase in size with age [1]. On the other hand, these parameters provide information on the size structure of the underlying fish population [7].
The objective of this work was to (i) compare biomass, abundance, LFD and LWR among species and between fishing gears (otter and beam trawl), to describe the length frequency distribution of the fish species (ii), (iii) to evaluate and interpret the fish health based on length frequency distribution and (iv) compare the total catches and species composition of fishing gears.

Materials and Methods

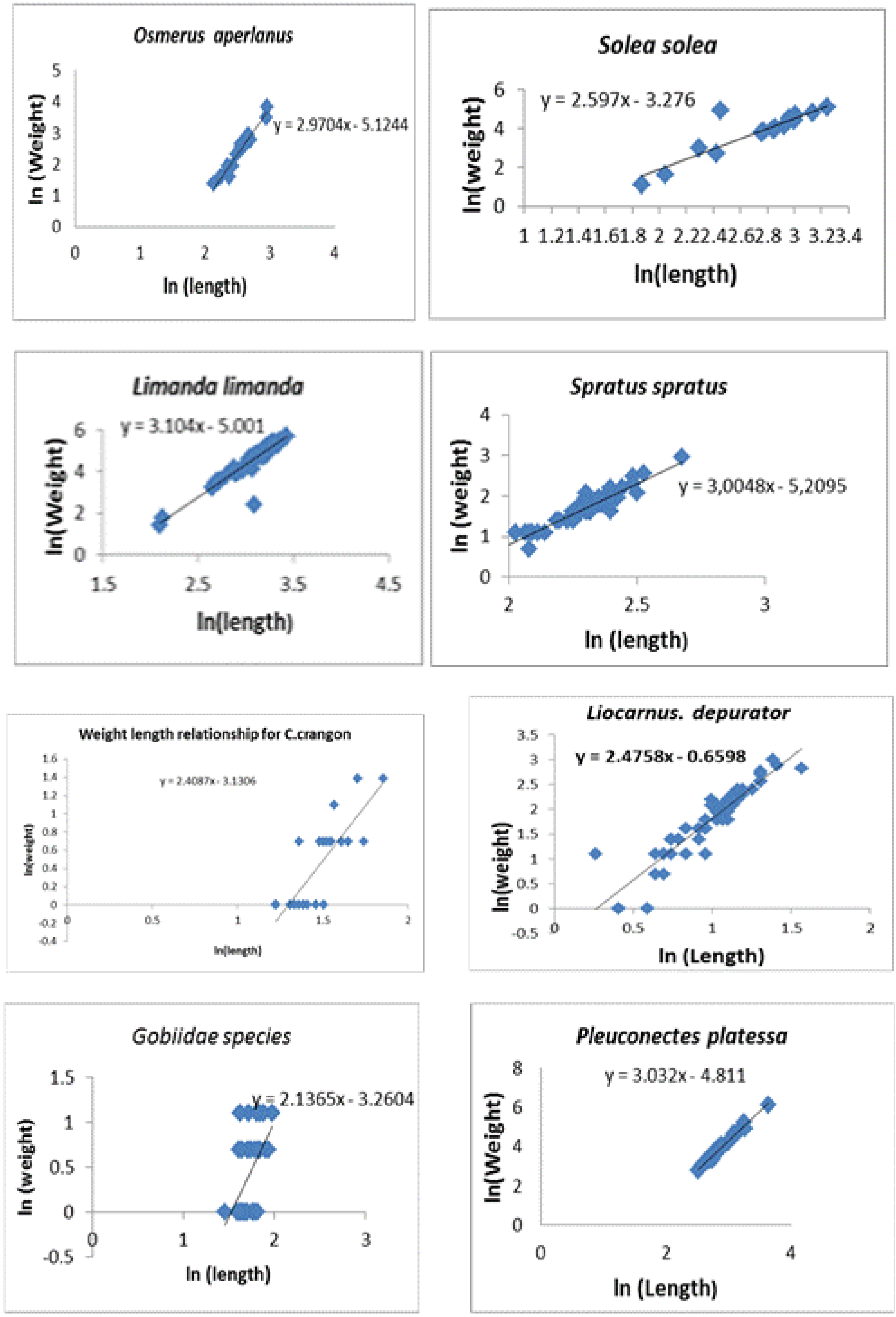
Fishes were collected from North Sea, Middelkerre-Oostende in Belgium for two days using otter (8m width) and beam (10m width) trawl, the former gear covered a distance of 4200 m (51°11.48N, 2°47.91E and 51°12.39N, 2°47.76E) and the latter 3300 m (51°12.43N, 2°50.22E and 51°11.39N, 2°47.76E). The beam trawl was dragged along the sea bed and thus more possibility of collecting both bottom and sea bed fish species including many invertebrates. While the otter trawl was dragged along the bottom or up in the water column. The total length (TL) and subsample weight were measured and each species weighed > 0gm was recorded. The total standard and fork lengths of fish species were measured including the carapace width of crabs, using ruler, and vernier calliper. Only 40 individuals of shrimps from subsamples of both gears were randomly sampled whereas all crabs and other fishes were measured. Data were analysed using Microsoft excel and Statistica software. The relationship between total length (L) in cm and total weight (W) in kg for all fish species was expressed by the equation $W = \mathbf{a}L^{\mathbf{b}}$, **a** (intercept) and **b** (slope) are species specific constant. In order to compare LFD between two gears within species two tailed t-test for normally distributed data and Mann Whitney U-test for non-normally distributed data were used.

Results

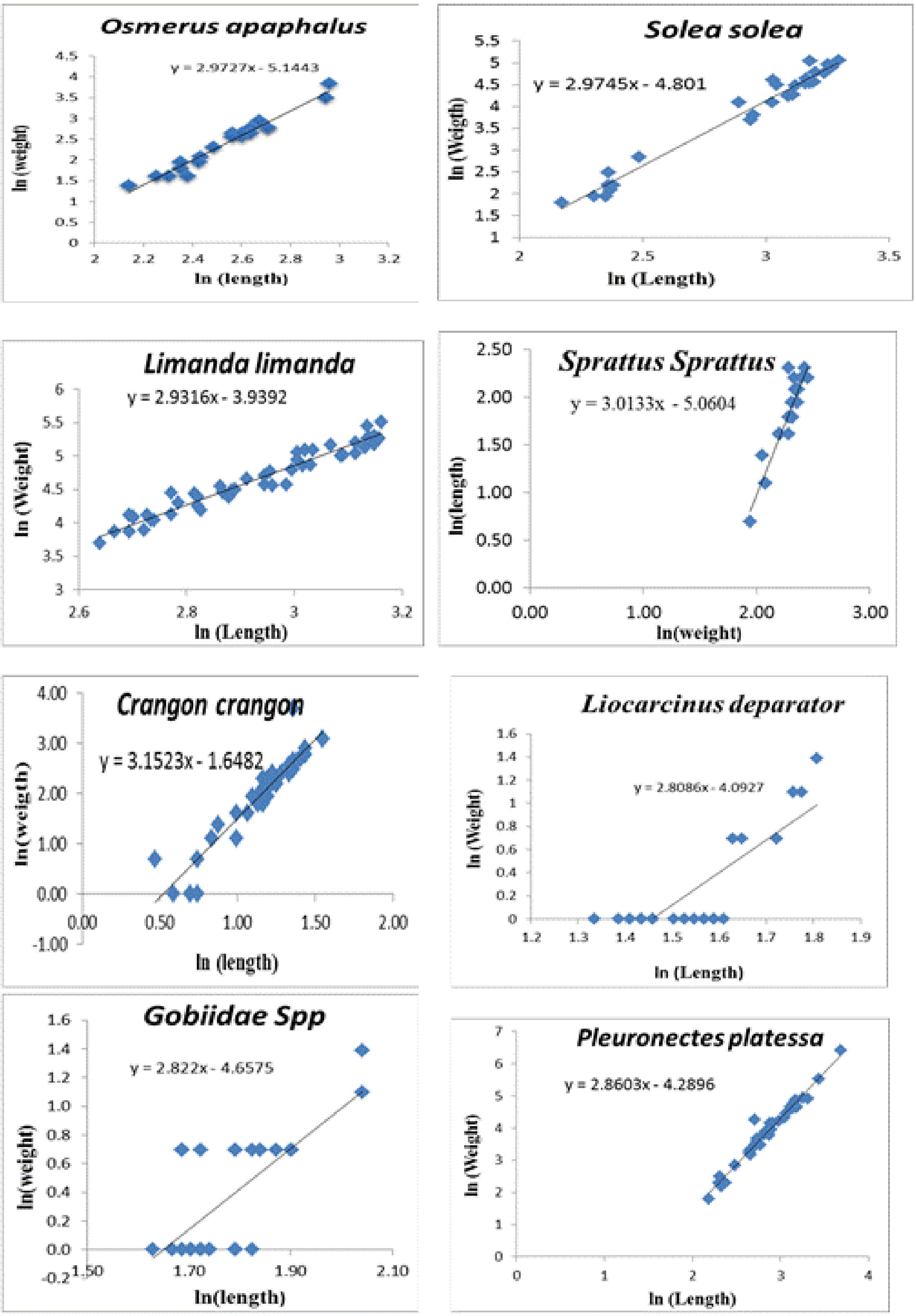
It was found that the total catch and bycatch for otter trawl were 29kg and 6kg whereas beam trawl were 23kg, and 11kg respectively. More than 10 fish species were collected from each fishing gear; however, 8 common species from every gear were used for this analysis (Table 1). The biomass, abundance, LFD and LWR varied among species and between gears (Figure 1and 2, Table 1). The main species in terms of biomass were *L. limanda* and *P.platesa*, which together accounted for 81% and 89% of the total biomass in otter and beam trawl respectively (Table 1 and 2). *S. spratus, L. dupurator* and *L. limanda* in otter trawl were the main species in terms of abundance accounting together for 54% (Table 1). Furthermore, *L. depurator* and *L. limanda* were the main species accounting together for 42% of the total abundance in beam trawl (Table 2). However, *C. crangon, Gobiidae spp, O. eperlanus* and *S. sprattus* were the least in terms of biomass in beam trawl, while the first two species were the least in the otter trawl. *S. solea* (in beam trawl) and *O. acephalus* (in otter trawl) were the least species in terms of abundance (Table 1 and 2). LWR was positively correlated for all eight species in both gears (Figure 1a and 1b). The total carapace width of crabs was between 4.8 cm to13 cm, though, the TL of all species were between 1.6 cm and 43.2 cm in both gears. Other fish species collected but were not used in analysis includes 21 squids, 2 anemone spp and 11 pipe fishes, whereas the large pipe fish was the lengthiest. The b values in $W= aL^b$ varied between 2.409 and 3.152. Parameters of LWR (‘a’ and ‘b’), statistical tests and r^2 are given in Table 1, 2 and 3. *S. sprattus, L. limanda, S. solea, O. eperlanus, Gobiidae spp, C. crangon and L. depurator* showed no significant difference in LFD between gears within species ($p>0.05$) and *P. platessa* showed a significant difference in LFD between gears ($p<0.05$) (Table 3).

Discussion

The LWR was positively correlated for all species in both gears (Figure1a, 1b). This shows that fishes in the study area have good health and food resources are available and so promote their growth [7, 8]. In this case it may be said that these species were healthier and had enough prey because measures of fish condition based on weight at a given length relative to body size are thought to be reliable indicators of the energetic condition or energy reserves of fish [5, 9]. According to Orhan et al., [10] fish shows positive or negative allometric growth if $b>3$ or $b<3$ respectively, whereas, isometric growth $b=3$. Hence our result shows no actual isometric growth since there is no exactly value of $b=3$. Nevertheless, slope ‘b’, intercept ‘a’ and r^2 varied among species (Table 1and 2).
Normally, the weight increases with the total length and age [8]. For instance, *S. solea* reach maximum length of 70 cm and weight of 3kg at age of 26 years and *L. limanda* attain 1.0kg weight, length of 40 cm and 12 years (www.fishbase.org), below this length and age they weigh less. Orhan et al., [10] in his study, showed all 16 fish species caught from the eastern black sea coast of Turkiye displayed a positive linear LWR. The data of this study displayed similar trend, the TL increases with weight (Figure 1 and 2).



(a) Otter trawl



(b) Beam trawl

Figure 1: Length weight relationship (LWR)

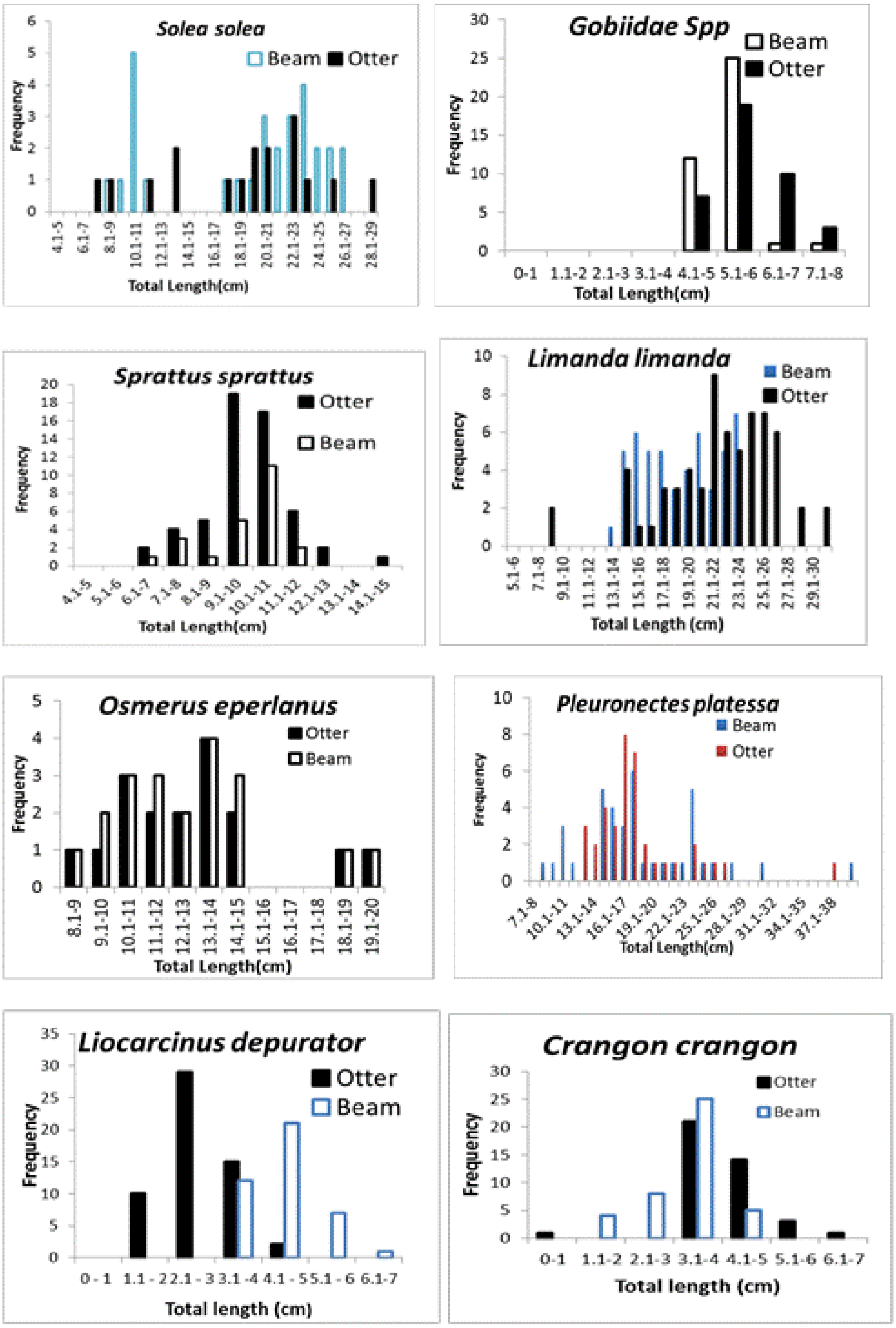


Figure 2 : LFD of species in otter and beam trawl

Table 1: Weight, biomass, frequency and abundance of fish species collected using otter trawl

Otter Trawl/Species	Weight(g)	Biomass	Frequency	Abundance	a	b	r^2
Sprattus sprattus	340	3%	56	17%	0.005	3.005	0.386
Limanda limanda	7526	61%	65	20%	0.007	3.104	0.865
Pleuconectes platessa	2486	20%	38	12%	0.008	3.032	0.987
Solea solea	1144	9%	17	5%	0.038	2.597	0.789
Osmerus acephalus	242	2%	17	5%	0.006	2.97	0.959
Crangon crangon	44	0%	40	12%	0.044	2.409	0.657
Liocarcinus depurator	404	3%	56	17%	0.517	2.476	0.857
Gobiidae spp.	65	1%	40	12%	0.038	2.1365	0.313
Total	**12251**	**100%**	**329**	**100%**			

Table 2: Weight, biomass, frequency and abundance of fish species collected using beam trawl

Beam Trawl/species	Weight(g)	Biomass	Frequency	Abundance	A	b	r^2
Sprattus sprattus	147	1%	23	10%	0.006	3.013	0.857
Limanda limanda	5975	59%	50	23%	019	2.932	0.947
Pleuronectes platessa	3060	30%	40	18%	0.014	2.86	0.967
Solea solea	439	4%	7	3%	0.008	2.975	2.972
Osmerus eperlanus	29	0%	3	1%	0.006	2.973	0.96
Crangon crangon	42	0%	40	18%	0.192	3.152	0.876
Liocarcinus depurator	393	4%	41	19%	0.017	2.808	0.715
Gobiidae	39	0%	16	7%	0.009	2.822	0.491
Total	**10124**	**100%**	**220**	**100%**			

Table 3: A comparison of LFD of a species between beam and otter trawl

Sprattus sprattus	P(T<=t) two-tail	0.20497	No significant	P>0.05
	t Critical two-tail	2.13145		
Limanda limanda	P(T<=t) two-tail	0.421999	No significant	P>0.05
	t Critical two-tail	2.032245		
Pleuronectes platessa	U=13		Significant	P<0.05
Solea solea	P(T<=t) two-tail	0.134741	No significant	P>0.05
	t Critical two-tail	2.030108		
Osmerus eperlanus	P(T<=t) two-tail	0.644021	No significant	P>0.05
	t Critical two-tail	2.073873		
Crangon crangon	P(T<=t) two-tail	0.951732	No significant	P>0.05
	t Critical two-tail	2.178813		
Liocarcinus depurator	P(T<=t) two-tail	0.685733	No significant	P>0.05
	t Critical two-tail	2.200985		
Gobiidae spp	P (T<=t) two-tail	0.107711	No significant	P>0.05
	t Critical two-tail	2.364624		

The main species in terms of biomass were *L. limanda* and *P. platesa*, which together accounted for 81% and 89% of the total biomass in otter and beam trawl respectively (Table 1and 2). *S. spratus*, *L. dupurator* and *L. limanda* in otter trawl were the main species in terms of abundance accounting together for 54% (Table 1), however, *L. depurator* and *L. limanda* were the main species in terms of abundance accounting together for 42% in beam trawl (Table 2). The *C. crangon*, *Gobiidae spp, O. eperlanus* and *S. sprattus* were the least in biomass in beam and otter trawl (first two species). *S. solea* and *O. acephalus* species were the least species in terms of abundance in otter and beam trawl respectively (Table 2). According to Madrid-Veraa et al., [4] high biomass and abundance indicate good health condition of fish species and habitat quality. Thus species with high biomass and abundance suggest that they are healthier and had enough food (Fisher et al., 1996). Species composition between two gears did not differ significantly (Table 1 and 2); however existing differences between gears might be attributed by short distance between two sampling sites, depth sampled or environmental factors.

The TL of all *S. sprattus* was between 6.1- 15 cm. Many individuals were in otter trawl in length category 9.1-11cm, therefore high LFD than in beam trawl (Figure 2). Data in fish base (www.fishbase.org) shows that the species mature at length of 11.5 cm while maximum TL is 16 cm. Therefore mature *S. sprattus* are between 11.1cm to 15 cm length, many being in otter trawl. It also indicates that many were juvenile having total length of < 11.1 cm. Difference in LFD may be caused by gears selectivity, age and health condition of fish species or environmental factors [5, 11].

For *L. limanda*, the TL was between 8.1- 31 cm (Figure. 2). The highest number was in otter trawl in length category 21.1-22 cm, this can be due to gears selectivity, because the otter trawl targets fishes that stay above the sea bed, therefore it is possible to sample healthier/adult individuals capable of swimming up in the water column while the beam trawl targets mainly shrimps and fishes staying on the bottom, for instance, juveniles incapable of swimming and thus short total length (www.fao.org). Mature *L. limanda* has a TL of 26 cm and maximum length 40 cm (www.fishbase.org). So individuals with length of >25cm sampled were adults. The *P. platessa* reach maturity at total length of 30.8cm and its maximum length is 100 cm (www.fishbase.org). This results show that all individuals together were having TL between 8.1 cm and 40 cm (Figure 2) and the highest length frequency being in otter trawl in category 16.1-17 cm than the beam trawl (Figure 2). The variation in LFD may be caused by health status differences of individuals, maturity differences and/or environmental factors [5].

The TL of *S. solea* was between 7.1 cm and 29 cm (Figure 2). Many fishes were in beam trawl in length category 10.1-11cm, because the species lives in shallow water with sands covering the bottom and for beam trawl is easy to sample them as it is dragged on sea bed [11]. The species reach maturity at length of 30 cm and maximum TL 70 cm (www.fishbase.org) this means that trawled individuals were all juvenile, <30 cm.

The *O. eperlanus* individuals were with total length ranging from 8.1 cm to 20 cm (Figure 2). Its maximum and adult TL is 40 cm and 12.8 cm respectively (www.fishbase.org). Thus *O. eperlanus* with total length of > 12.8 cm were adults. The highest number of fish was in length category of 13.1-14 cm in both gears and all *O. eperlanus* and *S. solea* were below maximum length. The difference may be due to individual's health and gears selectivity.

For the *Gobiidae spp* the TL was between 4.1 cm and 7.8 cm and many individuals were in length category 5.1-6cm in both gears (Figure 1). The minimum and maximum TL is 1cm and 50 cm respectively (www.fishbase.org). According to www.fishesofaustralia.net.auto, the adult's size is 1.5-50cm; this means that all *gobiidae spp* in both gears were mature. However numerous *Gobiidae* adults were in otter trawl than beam trawl, comparing with fish base data (www.fishbase.org) all fishes were below the maximum TL. Difference in LFD can be caused by health condition of fishes [2].

All *C. crangon* showed a TL between 1cm to 7 cm and many individuals were in the length category 3.1-4cm in the beam trawl (Figure 2). Beam trawl has high LFD than otter trawl because is designed to catch fishes living in the bottom especially shrimps, the *C. crangon*. According to FAO and Sea Life Base (www.sealifebase.org), *C. crangon* has a maximum TL of 8.9 cm and maturity length of >3 cm. On the other hand *L. depurator* individuals were having total carapace length between 1.1cm and 7cm; many were in length category 2.1-3cm in the otter trawl with short carapace length (Figure 1) because the gear was dragged within the specie's depth preference (5m-300m+) (www.marlin.ac.uk) hence more possibility of collecting many individuals especially the active swimming young crabs. While the beam trawl collected individuals with maximum carapace length than the otter trawl probably more adult and old crabs (females with eggs) at the bottom. Many crabs (*L. depurator)* were adult with reference to www.marlin.ac.uk which shows that maximum TL is 5.6cm (male) and 5.1cm (female).

Despite the variation in LFD of species in two gears statistical test showed no significant difference in LFD between gears within species ($p > 0.05$) except *P. platessa* that showed a significant difference in LFD between two gears ($p < 0.05$) (see table 1).

Conclusion and Recommendation

Conclusively, this study and their results are useful to fisheries scientist and managers and to our knowledge. The difference in length frequency, biomass and abundance may be caused by gear's selectivity, depth sampled, health status of species and other factors including food and preys. Moreover, for fish species with good health condition, enough food (prey), less predation and suitable habitats tend to have a linear length-weight relationship, more biomass and abundance. Hence to ensure all these, our water bodies should be well managed and controlled from pollution.

Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this work.

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