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Analyses of the non-target catch from the Egyptian Mediterranean trawlers, off Port Said

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ABSTRACT

The present study aimed to analyze the non-target catch in the Egyptian Mediterranean waters, off Port Said, during the period from spring 2017 to winter 2018. The analysis revealed that from 75 non-target species, fish constituted about 69.4% of the total catch weight, whereas invertebrates reached about 30.6%. For non-target fish, 51 fishes were identified (50 bony fishes and one elasmobranch), of which 17 lessepsian species were found. The high percentage of fish (82.67%) was with an average length between 4.0 and <9.0 cm. The highly represented fish species by numbers were: *Engraulis encrasicolus* (25.608%), *Herklotsichthys punctatus* (23.711%), *Terapon puta* (9.572%), *Equulites klunzingeri* (9.342%), *Gobius niger* (7.177%), *Argyrosomus regius* (6.280%), *Alepes djedaba* (4.155%), *Gobius paganellus* (3.397%), *Sardinella aurita* (2.525%), *Ariosoma balearicum* (1.093%) and *Diplodus annularis* (0.803%). Total analysis, seasonal analysis and an index of diversity (H′) for the non-target catch species were provided. On the other hand, length-weight relationship, condition factor and age composition were described for the most dominant species. For non-target invertebrates, 24 species were identified among which 13 lessepsian species were found. Shrimps and mantis shrimp *Erugosquilla massavensis* were the main constituents during the period of study. The authors propose to change the cod end mesh size from 2.5 cm to 4.0 cm to minimize the high percentage of non-target catch and preserve recruits of valuable species from over fishing along the Egyptian coast of the Mediterranean Sea while doing experiments to ensure the best results. Further, continuous monitoring and managements of trawlers must be put into consideration.

Introduction

Trawling is an important fishing method due to its low selectivity and its catch that contains a huge amount of non-target species. About one-third of the total fish catch from the Mediterranean is contributed by trawlers (Mehanna, 2014). Shrimp trawlers stood alone at the top of the highest discarded percentages of catch (Alverson et al., 1994; Clucas, 1997; Mahmoud et al., 2015) and are logically responsible for the bulk of non-target catch. The volume of the non-target fishery in the Mediterranean is in the order of 230 000 tons' per year, or about 18% of the total catches and more than 40% for the bottom trawler with a medium percentage of about 15–39% in the Eastern Mediterranean area (FAO, 2018).

Egyptian Mediterranean trawlers (1098 trawlers) (GAFRD, 2014) use the Italian type nets by the stretching cod end of a 2.5 cm (Alsayes et al., 2009). The trawling constitutes more than 70% of the total catch with about 15–20% non-target catch from the total trawling catch at Port Said fishing area (El-Mor et al., 2002), which is considered as one of the important fishing ports in Egypt due to its location in the Northeast of the Egyptian Mediterranean Sea, at the northern end of the Suez Canal. Its catcher vessels contribute about 20% of the total Egyptian Mediterranean catch (GAFRD, 2014).

From many references (Alverson et al., 1994; Hall, 1996; Clucas, 1997; Mahmoud et al., 2015; FAO, 2018) identifying the non-target catch, trash, by-catch and discarded, the authors restricted the use of the term "non-target catch" and identify it as a target catch that is not targeted in the fisheries due to its size, species and/or sex. Whereas fish catch can be classified into two main portions, the target and non-target catches. According to Alverson et al. (1994), target catch is the catch of mainly sought species or multi-species assemblage in the fishery, while incidental catch or non-target catch is the part of the catch that retained the non-targeted species. On the other hand, the part of the catch that was not retained on board and was discarded at sea is the discarded catch (Mehanna, 2014; Alverson et al., 1994). Additionally,

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both discarded catch and non-target catch are considered to be a by-catch (Alverson et al., 1994).

According to our knowledge, there are few documented studies of non-target catch in Egypt, especially from Port Said. El-Mor et al. (2002) studied the trash catch from the Port Said coast, Further; Alsayes et al. (2009) studied the by-catch and discarding of trawl fisheries on the Mediterranean coast of Egypt. Lastly, Rizkalla et al. (2016) provided information on the non-target catch from bottom trawl off Alexandria that lies in the northwest of the Egyptian Mediterranean Sea and the authors built a database about the non-target catch in that region.

Thus, the aim of studying is to highlight the non-target catch from bottom trawling off Port Said and to gain a better understanding in evaluating the fish stock in this important region.

Material and methods

Random samples were collected seasonally from Port Said landing center using commercial bottom trawlers, which were dragged along the bottom near Port Said coast (31° 37′ 25′′ N, 32° 25′ 55′′ E) (Fig. 1), during the period from spring 2017 to winter 2018. Specimens of 90 kg were studied (about 62.5 Kg fish and 27.5 Kg invertebrates). In the laboratory, fishes were sorted and identified according to Whitehead et al. (1986), Bauchot and Poisons (1987) and Lloris and Rucabado (1998) and the immigrant species were identified according to Golani et al. (2010) and Halim and Rizkalla (2011). The classification and nomenclature were described according to Akel and Karachle (2017) and World Register of Marine Species (2017) as well as the invertebrates' identification were according to Fischer et al. (1987).

The total length (cm) and total weight (g) was recorded for the fish specimens, but only the total weight (g) of the invertebrate species. Species composition, catch composition and seasonal composition were determined, as well as, the seasonal analysis and some biological parameters for the most dominant species in the non-target catch (length-weight relationship, condition factor and age determination) were also studied. The data were computed and statistically analyzed using Microsoft Excel 2010.

The seasonal diversity of species was calculated using the equation developed by Shannon and Weaver (1949):

$$H' = -\sum_{i}^{s}(ni/N)Ln(ni/N)$$

where the N = total number of fish in all seasons, ni = number of fish of i^{th} species per season, s = total number of species per season.

Fig. 1. A map showing Port Said where the non-target catches were collected during 2017–2018.

The length-weight relationship was estimated according to Lagler (1967) using the following equation:

$$W = aL^b$$

where the W = weight of fish (g); L = total length (cm), "a" and "b" are constants estimated by the least square method.

Biley's *t*-test (Snedecor and Cochran, 1967) was employed to find out whether "b" value is significantly derived from the expected value of 3:

$$t = b - 3/Sb$$

where b = regression coefficient and Sb = standard error of "b".

The condition factor (K) was calculated according to the equation of Fulton (1902):

$$K = 100\,W/L^3$$

where W = total weight in gram; L = total length (cm).

Age composition, by using the length frequency distribution, was estimated according to Bhattacharya (1967).

Results

Species composition

It is clear from Table 1 that 75 non-target species were recognized in the study. For non-target fish, 50 bony fishes and one elasmobranch belonging to 11 orders and 36 families were identified. From that, 17 lessepsian species (33.33%) and 1 species of Atlantic origin (1.96%) were found. For non-target invertebrates, 24 species belonging to 8 orders and 15 families were identified, of which 12 lessepsian species (50.00%) and 1species of Atlantic origin (4.17%) were found.

Catch composition

Fish constituted about 69.4% of the total catch by weight, and invertebrates reached about 30.6%. The total number of non-target fish individuals reached 13,070 with a total weight of about 62418 g (Table 2). The percentages in number and weight of the dominant fish species graphically are represented in Fig. 2.

From Table 2, individuals of 24 species had a mean length ranging from 4.0 to < 9.0 cm constituting 82.67% by number and 64.19% by weight of the total non-target fish. However, individuals of 31 species had an average weight <10 g constituting 96.03% and 83.50% by number and weight of the total non-target fish, respectively. Furthermore, *Engraulis encrasicolus*, *Herklotsichthys punctatus* and *Terapon puta* are considered the most common species with low mean length and weight.

As regards to invertebrates (Table 3), the total weight was 27492 g throughout the year. The crustacean species constituted high weight of non-target invertebrates (89.87%). However, *Erugosquilla massavensis* formed 45.98%, followed by crabs (28.79%) and shrimps (15.1%).

Seasonal distribution

Table 4 reports the seasonal occurrence of the non-target fishes and it shows that 9 species were recorded in the four seasons of the year, namely: *Engraulis encrasicolus*, *Herklotsichthys punctatus*, *Terapon puta*, *Equulites klunzingeri*, *Alepes djedaba*, *Sardinella aurita*, *Ariosoma balearicum*, *Cepola macrophthalma* and *Cynoglossus sinus arabici*. On the other hand, the majority of species were recorded in winter (33 species) and autumn (30 species), then in summer (27 species) and spring (14 species). Clearly from Fig. 3, the majority of fish were recorded in winter (38.52% and 34.19% by number

Table 1
Species composition of the non-target catch obtained from bottom trawlers operated off Port Said during 2017–2018.

Species
Phylum Chordata
Class: Elasmobranchii
Order: Rajiformes
Family: Rajiidae
Raja miraletus (Linnaeus, 1758)
Class: Actinopteri
Order: Anguiliformes
Family: Congridae
Ariosoma balearicum (Delaroche, 1809)
Conger conger (Linnaeus, 1758)
Family: Muraenidae
Muraena helena (Linnaeus, 1758)
Family: Ophichthidae
Ophichthus rufus (Rafinesque, 1810)
Order: Atheriniformes
Family: Atherinidae
Atherina boyeri (Risso, 1810)
Order: Clupeiformes
Family: Clupeidae
Herklotsichthys punctatus (Rüppell, 1837) *
Sardinella aurita (Valen., 1847)
Sardina pilchardus (Walbaum, 1792)
Sardinella maderensis (Lowe, 1838)
Family: Dussumieriidae
Dussumieria elopsoides (Bleeker, 1849) *
Family: Engraulidae
Engraulis encrasicolus (Linnaeus, 1758)
Order: Aulopiformes
Family: Synodontidae
Synodus saurus (Linnaeus, 1758)
Order: Mugiliformes
Family: Mugilidae
Liza aurata (Risso, 1810)
Order: Perciformes
Family: Apogonidae
Apogonichthyoides pharaonis (Bellotti, 1874) *
Ostorhinchus fasciatus (White, 1790) *
Jaydia smithi (Kotthaus, 1970) *
Family: Callionymidae
Callionymus filamentosus (Valenciennes, 1837) *
Family: Carangidae
Alepes djedaba (Forsskål, 1775) *
Caranx crysos (Mitchill, 1815)
Trachinotus ovatus (Linnaeus, 1758)
Family: Cepolidae
Cepola macrophthalma (Linnaeus, 1758)
Family: Gobiidae
Gobius paganellus (Linnaeus, 1758)
Gobius niger (Linnaeus, 1758)
Family: Leiognathidae
Equulites klunzingeri (Steindachner, 1898) *
Family: Moronidae
Dicentrarchus punctatus (Bloch, 1792)
Family: Mullidae
Mullus surmuletus (Linnaeus, 1758)
Upeneus asymmetricus (Lachner, 1954) *
Family: Nemipteridae
Nemipterus randalli (Russell, 1986) *
Family: Pomatomidae
Pomatomus saltatrix (Linnaeus, 1766)
Family: Sciaenidae
Argyrosomus regius (Asso, 1801)
Family: Scombridae
Scomberomorus tritor (Cuvier, 1832)
Family: Serranidae
Epinephelus aeneus (Geoffroy Saint-Hilaire,1817)
Family: Siganidae
Siganus rivulatus (Forsskål & Niebuhr, 1775) *
Family: Sparidae
Diplodus annularis (Linnaeus, 1758)
Oblada melanura (Linnaeus, 1758)
Family: Sphyraenidae
Sphyraena chrysotaenia (Klunzinger, 1884) *
Family:Terapontidae
Terapon puta (Cuvier, 1829) *
Pelates quadrilineatus (Bloch, 1790) *
Family: Trichiuridae
Trichiurus lepturus (Linnaeus, 1758)
Order: Pleuronectiformes
Family:Cynoglossidae
Cynoglossus sinusarabici (Chabanaud, 1931) *
Family: Soleidae
Solea aegyptiaca (Chabanaud, 1927)
Pegusa impar (Bennett, 1831)
Solea vulgaris (Linnaeus, 1758)
Order: Scorpaeniformes
Family: Dactylopteridae
Dactylopterus volitans (Linnaeus, 1758)
Family: Platycephalidae
Platycephalus indicus (Linnaeus, 1758) *
Order: Siluriformes
Family: Plotosidae
Plotosus lineatus (Thunberg, 1787) *
Order: Tetraodontiformes
Family: Balistidae
Balistes capriscus (Gmelin, 1789)
Family: Monocanthidae
Stephanolepis diaspros (Fraser-Brunner, 1940) *
Stephanolepis hispidus (Linnaeus, 1766)
Family: Tetraodontidae
Sphoeroides pachygaster (Müller & Troschel, 1848)**
Phylum: Arthropoda
Subphylum: Crustacea
Class: Malacostraca
Order: Decapoda
Family: Portunidae
Portunus segnis (Forskål, 1775) *
Callinectes sapidus Rathbun, 1896 **
Charybdis hellerii (A. Milne-Edwards, 1867) *
Family: Polybiidae
Liocarcinus vernalis (Risso, 1827)
Family: Alpheidae
Alpheus glaber (Olivi, 1792)
Family: Scyllaridae
Scyllarides latus (Latreille, 1803)
Family: Penaeidae
Metapenaeus monoceros (Fabricius, 1798) *
Metapenaeus stebbingi (Nobili, 1904) *
Parapenaeus longirostris (Lucas, 1846)
Penaeus japonicus (Spence Bate, 1888) *
Penaeus kerathurus (Forskål, 1775)
Penaeus latisulcatus (Kishinouye, 1896) *
Trachysalambria curvirostris (Burkenroad, 1934) *
Family: Euryplacidae
Eucrate crenata (De Haan, 1835)*
Family: Leucosiidae
Myra fugax (Fabricius, 1798) *
Order: Stomatopoda
Family: Squillidae
Erugosquilla massavensis (Kossmann, 1880) *
Phylum: Mollusca
Class: Bivalvia
Order: Venerida
Family: Veneridae
Paphia textile (Gmelin, 1791) *
Class : Cephalpoda
Order: Myopsida
Family: Loliginidae
Loligo reynaudii (d'Orbigny [in Ferussac & d'Orbigny], 1839–1841)
Order: Octopoda
Family: Octopodidae
Octopus vulgaris (Cuvier, 1797)
Order: Sepiida
Family: Sepiidae
Sepia officinalis (Linnaeus, 1758)
Class: Gastropoda
Order: Neogastropoda
Family: Muricidae
Murex brevispina (Lamarck, 1822)
Thais carinifera (Lamarck, 1822) *
Order: Littorinimorpha
Family: Rissoinidae
Rissoina bruguieri (Payraudeau, 1826)
Family: Naticidae
Notocochlis dillwynii (Payraudeau, 1826)

* Lessepsian migrant ** Atlantic Ocean origin

and weight, respectively). Furthermore, the high diversity index (H') of species was recorded in winter and autumn (0.3642 & 0.3586).

Table 5 shows the seasonal distribution of number, length range, average length, weight range and average weight for dominant non-target fish species caught off Port Said during 2017–2018.

The seasonal occurrence of invertebrates revealed that *Erugosquilla massavensis* was present in the catch during the whole year (Table 6). The majority of the species was recorded in winter (16 species) and summer (14 species) followed by 7 species in autumn and 4 species in spring. The winter season acquired the highest weight of invertebrates caught (44.16%) while spring season had the least weight (0.98%) (Table 7).

Biological studies

Length weight relationship and condition factor "K" for the most dominant fish species are provided in Table 7 and their determined age is represented in (Table 8).

It is obvious that, the values of "b" showed positive allometric growth for only 3 species (*Argyrosomus regius*, *Gobius paganellus* and *Ariosoma balearicum*), while the remaining species showed negative allometric growth. Conversely, no species with the

Table 2
Catch composition of non-target catch (number percentages, length range in cm, average length in cm, weight percentages and average weight in gram) obtained by bottom trawlers operated off Port Said during 2017–2018.

Species	No.	%	L. range (cm)	Av. L (cm)	Wt. (g)	%	Av. Wt. (g)
Engraulis encrasicolus	3347	25.608	5 – 10	7.5	7201.0	11.537	2.15
Herklotsichthys punctatus	3099	23.711	5 – 9	6.3	9627.0	15.423	3.11
Terapon puta	1251	9.572	4–13	8.2	12430.0	19.914	9.94
Equulites klunzingeri	1221	9.342	3–9	5.6	3717.5	5.956	3.04
Gobius niger	938	7.177	3–12	8.5	2568.0	4.114	2.74
Argyrosomus regius	781	5.976	8–11	9.1	6010.0	9.629	7.70
Alepes djedaba	543	4.155	3–15	10.3	3245.0	5.199	5.98
Gobius paganellus	444	3.397	4–12	7.5	1985.0	3.180	4.47
Sardinella aurita	330	2.525	5 – 19	10.0	2431.0	3.895	7.37
Caranx crysos	138	1.056	6 – 17	12.0	2017.0	3.231	14.62
Ariosoma balearicum	136	1.041	15–25	20.7	1659.0	2.658	12.20
Diplodus annularis	105	0.803	6 – 11	8.3	735.0	1.178	7.00
Stephanolepis diaspros	88	0.673	2 – 8	4.1	144.2	0.231	1.64
Trichiurus lepturus	86	0.658	13 – 41	21.3	2542.0	4.073	29.56
Oblada melanura	75	0.574	4 – 7	5.8	267.0	0.428	3.56
Cepola macrophthalma	70	0.536	4–18	12.3	299.5	0.480	4.28
Cynoglossus sinusarabici	67	0.513	4 – 11	8.1	264.2	0.423	3.94
Solea aegyptiaca	60	0.459	5 – 22	6.9	513.0	0.822	8.55
Liza aurata	45	0.344	9 – 17	12.3	634.0	1.016	14.09
Sardinella maderensis	37	0.283	11 – 17	11.6	774.0	1.240	20.92
Upeneus asymmetricus	31	0.237	4 – 8	5.3	46.0	0.074	1.48
Solea vulgaris	31	0.237	8 – 24	16.8	1056.0	1.692	34.06
Sardina pilchardus	18	0.138	6 – 15	8.7	86.0	0.138	4.78
Siganus rivulatus	14	0.107	4 – 17	8.7	160.0	0.256	11.43
Synodus saurus	13	0.099	9 – 12	10.4	92.0	0.147	7.08
Sphyraena chrysotaenia	12	0.092	9 – 15	12.1	83.0	0.133	6.92
Atherina boyeri	11	0.084	7 – 12	8.0	69.0	0.111	6.27
Pomatomus saltatrix	9	0.069	7 – 10	9.0	56.0	0.090	6.22
Apogonichthyoides pharaonis	7	0.054	5 – 8	7.0	51.0	0.082	7.29
Callionymus filamentosus	7	0.054	5 – 15	8.3	64.0	0.103	9.14
Platycephalus indicus	7	0.054	7 – 38	18.3	603.0	0.966	86.14
Ostorhinchus fasciatus	6	0.046	5 – 11	6.7	39.0	0.062	6.50
Mullus surmuletus	5	0.038	5 – 8	7.0	17.0	0.027	3.40
Dactylopterus volitans	5	0.038	8 – 12	9.4	40.0	0.064	8.00
Dussumieria elopsoides	4	0.031	8 – 14	11.8	44.0	0.070	11.00
Plotosus lineatus	4	0.031	6 – 21	11.5	84.0	0.135	21.00
Sphoeroides pachygaster	4	0.031	7 – 11	8.2	52.0	0.083	13.00
Jaydia smithi	3	0.023	5 – 7	5.7	12.5	0.020	4.17
Trachinotus ovatus	2	0.015	11 – 12	11.5	21.0	0.034	10.50
Dicentrarchus punctatus	2	0.015	8 – 13	10.5	22.0	0.035	11.00
Nemipterus randalli	2	0.015	10 – 11	10.5	30.0	0.048	15.00
Scomberomorus tritor	2	0.015	20–21	20.5	95.0	0.152	47.50
Stephanolepis hispidus	2	0.015	4 – 7	5.5	9.0	0.014	4.50
Conger conger	1	0.008	20	20.0	8.0	0.013	8.00
Muraena helena	1	0.008	28	28.0	230.0	0.368	230.00
Ophichthus rufus	1	0.008	34	34.0	193.0	0.309	193.00
Epinephelus fasciatus	1	0.008	5	5.0	2.0	0.003	2.00
Pelates quadrilineatus	1	0.008	11	11.0	16.0	0.026	16.00
Pegusa impar	1	0.008	18	18.0	54.0	0.087	54.00
Balistes capriscus	1	0.008	9	9.0	16.0	0.026	16.00
Raja miraletus	1	0.008	6	6.0	4.0	0.006	4.00
Total	13,070				62417.92		

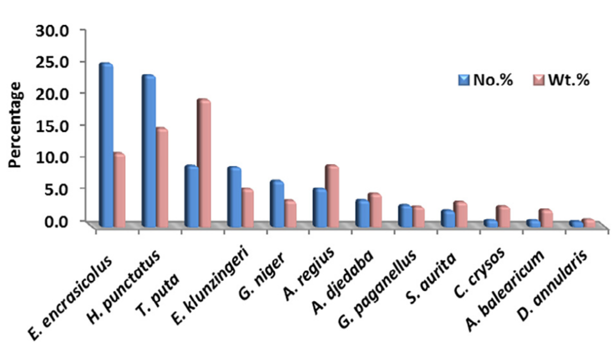

Fig. 2. Number and weight percentages of dominant non-target fish species from Port Said, 2017–2018.

isometric growth rate was found. In addition, the Bailey's *t*-test showed a highly significant value of b for all species.

On the other hand, the values of calculated condition factor showed a high range from the lowest value for *Ariosoma balearicum* (0.1477 ± 0.012) to the highest value for *Equulites klunzingeri* (2.0390 ± 0.265).

The estimated ages of non-target fishes showed that 7 species out of 12 were found with the age group I and 4 species with age group II (*Alepes djedaba*, *Gobius paganellus, Sardinella aurita* and *Ariosoma balearicum*). While *Caranx crysos* was the only species found in age group III.

Discussion

The non-target catch have become a component of target catch of generic trawl effort (Alverson et al., 1994). Thus, the

Table 3
Seasonal weight and percentages of the invertebrates of the non-target catch, during 2017–2018.

Category	Spring		Summer		Autumn		Winter		Total	
	Wt. (g)	%	Wt. (g)	%	Wt. (g)	%	Wt. (g)	%	Wt. (g)	%
Crustacea (Decapoda)										
Shrimp	250	6.02	1034	24.91	242	5.83	2625	63.24	4151	15.1
Crabs	–	–	3176	40.12	4238	53.54	502	6.34	7916	28.79
Crustacea (Stomatopoda)										
E. massavensis	19	0.15	971	7.68	3791	29.99	7860	62.18	12,641	45.98
Mollusca										
Gastropoda	–	–	1612	58.49	–	–	1146	41.55	2758	10.03
Bivalvia	–	–	18	69.23	–	–	8	30.77	26	0.001
Total	269	0.98	6811	24.77	8271	30.08	12,141	44.16	27,492	

Table 4
Seasonal percentage of occurrence of non-target catch from Port Said, during 2017–2018.

Species	No.	Spring %	Summer %	Autumn %	Winter %
Engraulis encrasicolus	3347	10.49	48.19	0.81	40.51
Herklotsichthys punctatus	3099	23.72	35.37	8.07	32.85
Terapon puta	1251	12.63	3.84	82.49	1.04
Equulites klunzingeri	1221	11.47	68.63	14.33	5.57
Gobius niger	938		4.69	3.73	91.58
Argyrosomus regius	781				100
Alepes djedaba	543	29.10	55.06	12.15	3.68
Gobius paganellus	444		12.61	17.34	70.05
Sardinella aurita	330	4.24	49.39	20.61	25.76
Caranx crysos	138				100
Ariosoma balearicum	136	91.91	1.47	0.74	5.88
Diplodus annularis	105		1.91	5.71	92.38
Stephanolepis diaspros	88		14.77		85.23
Trichiurus lepturus	86		1.16	81.4	17.44
Oblada melanura	75	100			
Cepola macrophthalma	70	1.43	55.71	10	32.86
Cynoglossus sinusarabici	67	61.19	7.46	10.45	20.9
Solea aegyptiaca	60		10		90
Liza aurata	45	68.89			31.11
Sardinella maderensis	37			100	
Upeneus asymmetricus	31		100		
Solea vulgaris	31				100
Sardina pilchardus	18				100
Siganus rivulatus	14		14.29	50	35.71
Synodus saurus	13			100	
Sphyraena chrysotaenia	12		83.33	16.67	
Atherina boyeri	11		63.64	36.36	
Pomatomus saltatrix	9			11.11	88.89
Apogonichthyoides pharaonis	7	57.14	28.57	14.29	
Callionymus filamentosus	7		28.57	57.14	14.29
Platycephalus indicus	7		28.57		71.43
Ostorhinchus fasciatus	6				100
Mullus surmuletus	5	100			
Dactylopterus volitans	5	100			
Dussumieria elopsoides	4		25	75	
Plotosus lineatus	4		25	50	25
Sphoeroides pachygaster	4		75	25	
Jaydia smithi	3				100
Trachinotus ovatus	2				100
Dicentrarchus punctatus	2		50		50
Nemipterus randalli	2			100	
Scomberomorus tritor	2			100	
Stephanolepis hispidus	2			100	
Conger conger	1			100	
Muraena helena	1				100
Ophichthus rufus	1				100
Epinephelus fasciatus	1		100		
Pelates quadrilineatus	1			100	
Pegusa impar	1				100
Balistes capriscus	1			100	
Raja miraletus	1				100
Total	13,070	1843	4288	1905	5034

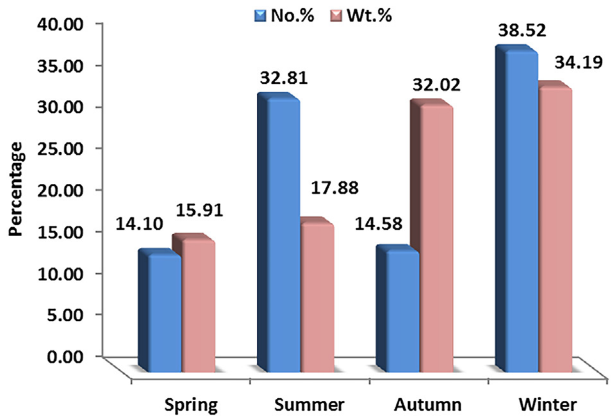

Fig. 3. Seasonal number and weight percentages of non-target fish from Port Said, 2017–2018.

identification of non-target catch as target catch which not targeted in the fisheries is essential. In Port Said the non-target catch constitutes undersized marketable species, not only due to the generic fishing effort, but also because of using nets not conforming to the identity mesh sizes stretched cod end (2.5 cm) of the trawlers operated in Egypt to collect more fish. This method of fishing is collecting and killing huge amounts of non-target species and young ones of commercially valuable species. Unfortunately, the fishermen succeed to sell the small fish to fish farms and therefore they do not hesitate to catch it.

As shown by Alverson et al. (1994), Hall et al. (2000), Machias et al. (2001) and Rochet and Trenkel (2005) many variables affect the non-target catch extent, including gear, fishing method practiced, fishing ground, fishing season, depth, duration of the trip, duration of the haul, the market situation, and the abundance fluctuation of juvenile fish.

The present work revealed that the majority of fish (24 species and 82.67% of the total non-target catch) ranged between 4.0 – < 9.0 cm and these fish species were captured before reaching the first sexual maturity except for *Engraulis encrasicolus* (anchovies) and a non-economic one, *Equulites klunzingeri*. The finding range agrees with that given by Bennett (1989) and El-Mor et al. (2002) who mentioned that the juveniles of fishes may stay in the nursery ground before leaving the area for adult habitat. Furthermore, our results of the average lengths of the dominant fish species during spring and summer (ranged from 4.66 cm to 22.5 cm) in Port Said are in agreement with the work of Rizkalla et al. (2016) who recorded a similar range in Alexandria (between 6.33 cm and 21.7 cm) during the same season. However, our results are in disagreement with Rizkalla et al. (2016) in what concerns the total percentage of small fish where only 20.85% were < 9.0 cm and 18.84% were < 10 g by number. It is worthy to note that the percentages of Rizkalla et al. (2016) were calculated from giving average lengths and average weights of only 90.8% and 89.9% of fish by number and weight, respectively. From the structural point of view, the previous comparison confirms that

Table 5
Seasonal distribution of number, length range, average length, weight range and average weight for dominant non-target species caught off Port Said, 2017–2018.

Species	Season	No.	L. range (cm)	Av. L (cm) ± SD	Wt. range	Av. Wt (g) ± SD
Engraulis encrasicolus	Spring	351	8–10	8.65 ± 0.631	2.5–5.0	3.21 ± 0.740
	Summer	1613	5–9	6.69 ± 1.024	1.5–4.0	1.84 ± 0.618
	Autumn	27	6–9	7.19 ± 0.611	1.3–2.1	1.85 ± 0.230
	Winter	1356	6–9	7.45 ± 0.684	1.2–3.6	2.26 ± 0.512
Herklotsichthys punctatus	Spring	735	6 – 9	7.51 ± 0.845	2.3–8.0	4.05 ± 1.743
	Summer	1096	5 – 9	6.31 ± 1.497	1.9–5.8	3.01 ± 1.315
	Autumn	250	6 – 8	6.72 ± 0.640	2.9–5.3	3.06 ± 0.767
	Winter	1018	5 – 8	6.72 ± 0.716	1.5–3.7	2.54 ± 0.590
Terapon puta	Spring	158	7 – 11	9.00 ± 0.757	3.8–13.3	8.32 ± 1.638
	Summer	48	4 – 10	6.98 ± 1.550	1–9.5	4.13 ± 1.976
	Autumn	1032	7 – 11	9.73 ± 1.012	4.1–14.4	10.57 ± 2.816
	Winter	13	4 – 13	6.92 ± 2.362	1–21	4.30 ± 5.215
Equulites klunzingeri	Spring	140	5 – 9	6.40 ± 0.911	1.7–10.2	3.78 ± 1.665
	Summer	838	3 – 7	4.66 ± 1.033	0.6–5.9	2.46 ± 1.370
	Autumn	175	4 – 9	6.06 ± 1.128	1.4–14	5.68 ± 3.175
	Winter	68	3 – 8	5.40 ± 1.362	0.4–4.9	1.95 ± 1.190
Gobius niger	Summer	44	3 – 9	6.86 ± 1.268	1–8	3.75 ± 1.630
	Autumn	35	9 – 12	10.34 ± 0.765	8.5–18	12.24 ± 2.793
	Winter	859	5 – 11	8.18 ± 1.195	1–9.3	2.30 ± 0.691
Argyrosomus regius	Spring	781	8 – 11	9.12 ± 0.914	5.0–17.0	7.70 ± 3.254
Alepes djedaba	Spring	158	12–15	13.67 ± 1.000	20–44.5	34.61 ± 11.763
	Summer	299	3 – 12	6.14 ± 1.745	0.7–15.0	3.51 ± 2.751
	Autumn	66	6 – 14	9.94 ± 1.587	3.0–26.5	9.80 ± 5.917
	Winter	20	10 – 14	11.60 ± 1.095	7.0–22.0	11.75 ± 3.531
Gobius paganellus	Summer	56	4 – 9	6.73 ± 1.183	0.5–9.5	3.65 ± 1.945
	Autumn	77	5 – 12	9.77 ± 1.327	1.5–19.3	12.47 ± 3.817
	Winter	311	4 – 8	6.25 ± 0.992	0.5–2.9	1.55 ± 0.754
Sardinella aurita	Spring	14	9 – 15	12.14 ± 2.107	5.0–22.5	14.71 ± 5.737
	Summer	163	6 – 14	7.74 ± 1.601	1.0–19.0	4.52 ± 3.627
	Autumn	68	10 – 19	13.21 ± 1.873	7.7–35.5	17.75 ± 6.195
	Winter	85	5 – 10	7.19 ± 1.160	1.3–9.0	3.31 ± 1.351
Caranx crysos	Winter	138	6–17	11.97 ± 1.879	2–40	14.62 ± 7.646
Ariosoma balearicum	Spring	125	17–23	20.00 ± 1.902	6–20	12.19 ± 4.601
	Summer	2	20–25	22.50 ± 2.500	14–20	17.00 ± 3.000
	Autumn	1	21	21.00	14	14.00
	Winter	8	15–23	19.25 ± 2.582	4–17	10.88 ± 4.755
Diplodus annularis	Spring	97	6–11	8.19 ± 1.140	3.3–14.3	6.44 ± 2.783
	Summer	2	7	7.00		5.50
	Autumn	6	8–11	9.83 ± 1.169	9.0–22.5	16.50 ± 5.310

Table 6
Seasonal distribution of non-target invertebrates obtained by bottom trawlers, off Port Said, during 2017–2018.

Species	Spring	Summer	Autumn	Winter
Portunus segnis			+	+
Callinectes sapidus				+
Charybdis hellerii			+	+
Liocarcinus vernalis		+	+	+
Alpheus glaber		+		+
Scyllarides latus				+
Metapenaeus monoceros	+	+		
Metapenaeus stebbingi		+		+
Parapenaeus longirostris		+		
Penaeus japonicus		+		
Penaeus kerathurus				+
Penaeus latisulcatus	+			
Trachysalambria curvirostris	+			+
Eucrate crenata			+	
Myra fugax		+		
Erugosquilla massavensis	+	+	+	+
Paphia textile		+	+	+
Loligo reynaudii		+	+	+
Octopus vulgaris		+		
Sepia officinalis		+		
Murex brevispina		+		+
Thais carinifera		+		+
Rissoina bruguieri				+
Notocochlis dillwynii				+

Table 7
Length weight relationship parameters, regression coefficient and condition factor for some dominant species of the non-target catch from Port Said, during 2017–2018.

Species	No.	Length range (cm)	a	b	R^2	K ± S.D
Engraulis encrasicolus	3347	5 – 10	0.0093	2.7703	0.9964	0.5388 ± 0.0263
Herklotsichthys punctatus	3099	5 – 9	0.0430	2.2060	0.9990	1.0068 ± 0.253
Terapon puta	1251	4 – 13	0.0330	2.5263	0.9900	1.1248 ± 0.074
Equulites klunzingeri	1221	3 – 9	0.0431	2.6292	0.9889	2.0390 ± 0.265
Gobius niger	938	3 – 12	0.0692	1.9871	0.9546	0.4916 ± 0.152
Argyrosomus regius	781	8 – 11	0.0023	3.6857	0.9413	0.9679 ± 0.102
Alepes djedaba	543	3–15	0.0410	2.3342	0.9740	1.2887 ± 0.417
Gobius paganellus	444	4–12	0.0038	3.6217	0.9970	0.7658 ± 0.246
Sardinella aurita	330	5–19	0.0160	2.6261	0.9920	0.8506 ± 0.114
Caranx crysos	138	6–17	0.0214	2.6727	0.9730	0.7889 ± 0.153
Ariosoma balearicum	136	15–25	0.0001	3.7910	0.9983	0.1447 ± 0.012
Diplodus annularis	105	6–11	0.0320	2.7165	0.9881	1.1797 ± 0.156

Table 8
Estimated ages using length frequency distribution for some dominant non-target fish species caught from Port Said during 2017–2018.

Species	No.	Length (cm) ± SD at each year of life		
		Age group I	Age group II	Age group III
Engraulis encrasicolus	3347	7.06 ± 1.07		
Herklotsichthys punctatus	3099	7.0 ± 0.91		
Terapon puta	1251	9.74 ± 1.16		
Equulites klunzingeri	1221	4.96 ± 0.64		
Gobius niger	938	7.22 ± 0.84		
Argyrosomus regius	781	8.89 ± 0.94		
Diplodus annularis	105	7.9 ± 0.89		
Alepes djedaba	543	5.22 ± 0.84	11.63 ± 1.00	
Gobius paganellus	444	5.81 ± 0.66	7.5 ± 0.53	
Sardinella aurita	330	7.38 ± 0.72	13.24 ± 1.74	
Ariosoma balearicum	136	17.32 ± 0.540	19.84 ± 1.040	
Caranx crysos	138	7.5 ± 1.2	11.89 ± 1.04	15.19 ± 0.52

fishermen still use trawl nets with end cod mesh size < 2.5 cm. During 1997, El-Mor et al. (2002) showed that the mesh size in a small cod was from 1.5 to 2.5 cm, thus the continuous monitoring and management of trawlers are necessary to be taken into consideration.

Moreover, fish constituted about 69.4% of the total non-target catch, whereas invertebrates reached about 30.6% by weight. Previously, Rizkalla et al. (2016) described that these percentages reached 97.8% and 2.18%, respectively in Alexandria. This difference is mainly related to the fishing ground, which is muddy in Port Said and appropriate for crustacean, while it is sandy in Alexandria and appropriate for fish.

The highest recorded number of 30 lessepsian species (17 fish species and 13 invertebrate species) in this area (40% by number of species) revealed that those immigrant species succeeded in establishing populations in the Mediterranean Sea. This result is in agreement with Galil and Zenetos (2002) and might be an agent of the enrichment in species and the ensuing improvement of biodiversity (Lasram et al., 2008). Besides, the area of study was at the northern end of the Suez Canal and may be ascribed to the unabated influx through the Suez Canal, which is considered as the corridor of migration from the Red Sea.

In general, the multi-species trawlers have a poor selectivity resulting in the capture of a huge amount of non-target species. Furthermore, they have both direct and indirect impacts on the marine ecosystem and biodiversity as well as mechanically disturbing the sea bottom (Watling and Norse, 1998). Beverton and Holt (1956) have solved the problem when they mentioned that the increase in the cod end mesh size would reduce the capture of juveniles and unwanted organisms while improving the exploitation patterns of fished stocks. Also, the General Fisheries Commission for the Mediterranean (GFCM) has been recommending the use of a minimum 40 mm square mesh cod end or at least 50 mm for a diamond mesh size (REC. CM - GFCM/33/2009/2) (FAO, 2018). Thus, the increase of cod end mesh size is classically considered as a powerful system.

Finally, the authors propose to change the cod end mesh size from 2.5 cm to 4.0 cm to minimize the high percentage of non-target catch and preserve recruits of valuable species from over fishing along the Egyptian coast of the Mediterranean Sea. This must be done after doing experiments to insure the best biological and socioeconomic results of such measure in the region. Also, continuous monitoring and managements of trawlers must be put into consideration.

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