
Ingestion of microplastics by some commercial fishes in the lower Gulf of Thailand: a preliminary approach to ocean conservation

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Abstract Microplastics have been acknowledged as evolving marine contaminants of noteworthy apprehension, due to their ubiquity, persistence and toxic potentiality. It is very urgent and important to study about microplastic pollution not only in Thailand but also for the world because of its harmful effects on marine biota as well as for human health. The study focused on the presence of plastic debris in the stomach contents of some economically important fish caught in the lower Gulf of Thailand between January to April 2018. Size and weight range of the samples were 7.6 to 21.9 cm and 4 to 99 gm. Results highlighted the ingestion of plastics in the 54.29% samples. The ingested plastics were microplastics (27.27%; <5 mm), mesoplastics (69.88%; 5-25 mm) and macroplastic, (2.85%; >25 mm). Fibres were the major forms of plastics found during this study. These preliminary findings underlined the ubiquitous presence of microplastics in the lower Gulf of Thailand marine biota, as well as the water column where pelagic fish live, and feed and it also represented an urgency to reduce the use of plastics or to ensure the proper recycling it.

Keywords: Microplastics, marine litter, plastic ingestion, plastic debris, marine pollution, ocean conservancy

Introduction

Plastic pollution is the gathering of plastic substances in the environments which have several hostile effects on wildlife, wildlife habitat as well as on human beings (Moore, 2017; Parker, 2018). Plastic production by human are high because of its durability, light weight, attractive appearance and low cost (Hester and Harrison, 2011; Thompson *et al.*, 2004; Jambeck *et al.*,

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2015). As of 2018, approximately 380 million tonnes of plastic are manufactured worldwide every year. From the 1950s up to 2018, an estimated 6.3 billion tonnes of plastic has been produced globally, of which an estimated 12% has been ignited and another 9% has been recycled. The rest has been abandoned in landfills or the natural environment (The Economist, 2018).

Plastic contamination can distress land, waterways and ocean. Several living organisms, mostly marine organisms, can be affected either through disclosure to chemical toxicants within plastics that intervene with their physiology or by mechanical effects, for example, harms related to ingestion of plastic rubbish or entanglement in plastic substances. Above 660 marine species were known to be oppressed worldwide by plastic debris directly or indirectly (Dias and Lovejoy, 2012). Nearly 92% of all adverse encounters between marine litter and organisms occurs because of plastic waste (Gall and Thompson, 2015).

According to several studies, plastics that act as pollutants are categorized into micro-, meso-, or macro-plastics, based on size (Hammer *et al.*, 2012; Browne, 2010; Fendall and Sewell, 2009). Following to a recent investigation, size range of microplastics are <5 mm to 0.1 μm (Lippiatt *et al.*, 2013). Plastic matters gradually breakdown into minor trashes due to oxidation, ultraviolet (UV) radiation and mechanical forces, which is lower than 5 mm in diameter, termed microplastic (Barnes *et al.*, 2009; Cole *et al.*, 2011; Lippiatt *et al.*, 2013). Microplastics are extensively distributed, in deep sea sediments and surface water (Song *et al.*, 2015; Woodall *et al.*, 2014), from lakes to open sea water (Eriksen *et al.*, 2014; Imhof *et al.*, 2013), and in numerous marine organisms through the trophic levels (Boerger *et al.*, 2010; De Witte *et al.*, 2014; Murray and Cowie, 2011; Van Cauwenberghe and Janssen, 2014; Van Franeker *et al.*, 2011). Several studies focused on the induction of plastic and other anthropogenic rubbish in marine domiciles and food web through ingestion by varied marine organisms, ranging from zooplankton to vertex predators (Fossi *et al.*, 2012, 2014; Ivar Do Sul and Costa, 2014). The zones with convergence currents and where anthropogenic debris was accumulated, the consequence of debris assimilation by marine wildlife was more obvious (Moore *et al.*, 2001).

The influence of microplastic assimilation on diverse marine entities with miscellaneous feeding mechanisms has been studied in different parts of the world (Thompson *et al.*, 2004; Leslie *et al.*, 2013; De Witte *et al.*, 2014). Furthermore, these earlier investigations indicated that the eco-toxicological situations of certain species were associated to the environmental stress levels in their territories (Nayar *et al.*, 2004). Nevertheless, there was no investigation performed in Southern Thailand.

According to prior explorations, striking extents of plastics accumulated into the marine environment and coastline ecosystems were predominantly from Asian countries including Thailand which had soundly extraordinary economic progress rates (Jambeck *et al.*, 2015). Moreover, Plastics have also been acknowledged as one of vital constituent in Municipal Solid Waste (MSW) composition of Thailand (Kaosol, 2009; Chiemchaisri *et al.*, 2006). In this manner, land based plastics can be the primary source of plastic pollution in coastal water (Jambeck *et al.*, 2015). Furthermore, Thailand is one of the five countries which dump more plastic (60%) into the oceans than the rest of the world combined and the other countries are China, Indonesia, the Philippines and Vietnam (GlobalPost, 2016). Even so, there was no investigation done on microplastic pollution in marine fish, especially, in the lower Gulf of Thailand.

Sathing Phra District, located in the northern part of Songkhla Province in the lower Gulf of Thailand, is one of the most rapid industrialized development areas in Songkhla Province. Thus, these quick expansions of man-made activities pose a possible threat of plastic pollution in this and neighboring areas. That's why this investigation have certain noteworthy significance in terms of knowing the extent of plastic pollution in these areas and resolving it.

The objective of the study was to investigate occurrence, frequency, amount, and forms of plastics ingested by some commercial and abundant fishes in the lower Gulf of Thailand: Panna croaker *Panna microdon* (Bleeker, 1849), Goatee croaker *Dendrophysa russelli* (Cuvier, 1829), Sharpnose hammer croaker *Johnius borneensis* (Bleeker, 1851) and Weber's croaker *Johnius weberi* (Hardenberg, 1936). Considering the hazard associated to the plastic pollution, this study provides an imperative involvement to the knowledge and understanding of plastic occurrence in these commercial fishes.

Materials and methods

Species selection and sampling site

A total of 27 Panna croaker (*Panna microdon*), 41 Goatee croaker (*Dendrophysa russelli*), 30 Sharpnose hammer croaker (*Johnius borneensis*) and 7 Weber's croaker (*Johnius weberi*) were collected during January to May, 2018 from Sathing Phra District, Songkhla Province in the Lower Gulf of Thailand (Figure 1). These four diverse species (2 demersal and 2 pelagic) belonging to the family Sciaenidae were preferred because of their abundance and commercial significance and the study site represents the coast with different anthropogenic activities.



Figure 1. Geographical location of the study site in Songkhla Province, the Lower Gulf of Thailand

Sampling and species identification

Immediately after collection of fishes, certain details of the samples and the sampling site were noted. Then the samples were taken to the laboratory in an icebox with sufficient ice in it and preserved at $-20\text{ }^{\circ}\text{C}$ for further analysis purpose.

For species identification, particular information (trophic level and sex) were assigned with the help of fishermen and then verified according to the standard taxonomic keys of Talwar and Jhingran (1991); Froese and pauly (2018), SEAFDEC (2014).

Investigative techniques and avoidance of adulteration

In the laboratory, at first, each fish was thawed gradually and cleaned by filtered water to dispel sediments and impurities from the extraneous veil. Then, specimens were measured (total length) and weighed (total body weight). Each fish was dissected from the upper part to the oesophagus to remove the stomach according to the methods published elsewhere (Claessens *et al.*, 2013; Lusher *et*

al., 2013; Rocha-Santos and Duarte, 2015). Gut contents were then distinctly placed inside petri dishes and examined in order to distinguish plastic debris, which were counted, assembled by color, measured by the Stereo Zoom Microscope (OLYMPUS SZ2-ILST). The ingested plastics were categorized as microplastics (<5 mm), mesoplastics (5-25 mm) and macroplastics (>25 mm) following the method of Galgani *et al.* (2013). To determine the length of each particle of debris, all photographed were digitally measured using the software package ImageJ 1.4.3.6 (public domain).

Conspicuous protection was taken to prevent sample contamination throughout the whole investigation such as during dissection, extraction, sorting and visual identification. This technique includes several stages to avoid technical contamination, cross- contamination and/or misidentification of natural debris (e.g., shells, algae, and coral) as plastic debris.

Statistical analysis

The frequency of plastic debris occurrence ($F\%$) in these fish samples was estimated by the proportion of the examined individuals where plastic debris were present in the stomach contents. All data analysis was accomplished by Microsoft excel for mean, minimum and maximum. One-way ANOVA was performed to compare results among the groups. Differences at $p < 0.05$ were considered statistically significant.

Results

Entirely, 105 discrete fishes (68 demersal and 37 pelagic individuals) were perused for the presence of plastic debris throughout this investigation. Among them, 57 individuals (54.29%) have plastic debris in their stomach in different size and shape (Table 1). In detail, some sorts of ingested plastic debris present in the 35 individual demersal fishes (51.47%) and 22 individual pelagic fishes (59.46%) were found (Table 2).

The mean values and range of total length, body weight and stomach weight together with the information on trophic level and sex ratio of examined fishes were exhibited in Table 1.

The average number of plastic debris per stomach of fishes including the range together with the information on stomach containing different amounts of plastic debris was found. In particular, *Johnius borneensis* shows the highest (60.00%) and *Panna microdon* shows the lowest (44.44%) frequency of occurrence of plastic debris in the stomach content of fishes

(Table 2). Average number of plastic debris per stomach and per g of stomach were briefly presented in Figure 2.

Plastic debris had different shapes and colors; transparent, black and pink plastic debris present in all the fish examined species in this exploration. Several circumstantial information on plastic debris found in the stomach content were presented in Table 3. Entirely, pelagic fish species shows longer (9.93 mm) plastic debris than that of the demersal (8.59 mm) ones (Figure 3).

Color and form of plastic debris found in the stomach content of the examined fishes were presented in Figure 4. Transparent debris (35%) were found the most common whereas the green (2%) were the least common plastic debris found in the stomach content of the fishes (Figure 4). Furthermore, fibre type plastics (84%) were the most dominant form of plastic debris found throughout this investigation (Figure 4).

The plastic debris were different in size in each species of fishes as reported in Figure 5. Mesoplastics were the most abundant (69.88%) size group found and about 28% of all the plastic debris found were microplastics which were less than 5 mm in diameter (Figure 5). Percentages of plastic debris according to their size group were indicated in Figure 5.

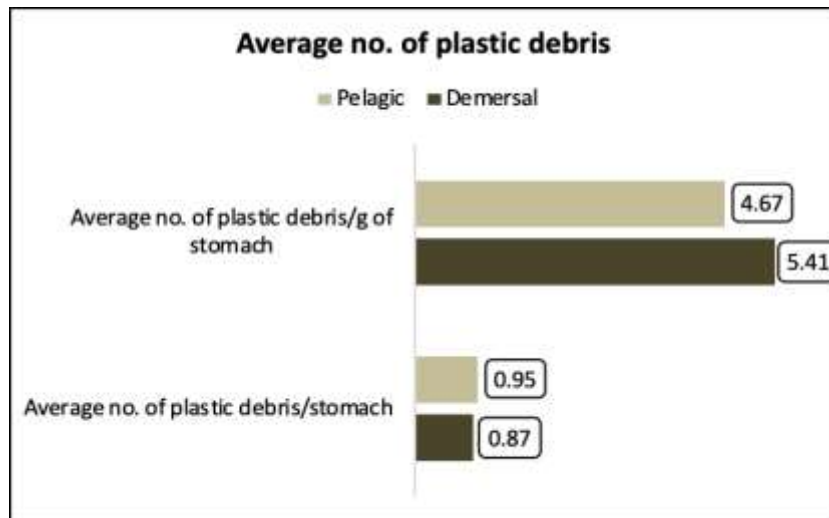


Figure 2. Average number of plastic debris per stomach and per g of stomach of different group of fishes

Table 1. Mean and range of total length, body weight and stomach weight for each fish species with their trophic level

Fish species	Trophic level	Sample (M:F)	Total length (cm)		Body weight (g)		Stomach weight (g)	
			Mean±SD	Range	Mean±SD	Range	Mean±SD	Range
<i>Panna microdon</i> (Bleeker, 1849)	Demersal	27 (24:3)	13.20±4.34	21.9 - 7.6	28.04±25.98	99.0 - 4.0	0.16±0.10	0.57 - 0.03
<i>Dendrophysa russelli</i> (Cuvier, 1829)		41 (9:32)	13.56±0.92	15.0 - 11.7	32.90±8.53	52.0 - 18.0	0.16±0.06	0.3 - 0.05
<i>Johnius borneensis</i> (Bleeker, 1851)	Pelagic	30 (25:5)	13.86±1.59	16.4 - 10.9	34.33±14.36	65.0 - 14.0	0.27±0.21	0.91 - 0.02
<i>Johnius weberi</i> (Hardenberg, 1936)		7 (7:0)	16.30±1.56	18.4 - 14.2	42.29±13.24	63.0 - 28.0	0.19±0.08	0.38 - 0.14
Total		105 (65:40)						

M= Male, F= Female, SD= Standard deviation

Table 2. Average No. of plastic debris found in the stomach of the examined fishes

Trophic level	Fish species	No. of stomach examined	No. of the stomach with plastic debris	No. of pieces of plastic debris/stomach average±SD, range	Frequency of occurrence (%)
Demersal	<i>Panna microdon</i> (Bleeker, 1849)	27	12	0.85±1.06, 3 - 0	44.44
	<i>Dendrophysa russelli</i> (Cuvier, 1829)	41	23	0.88±1.12, 5 - 0	56.10
Pelagic	<i>Johnius borneensis</i> (Bleeker, 1851)	30	18	0.90±0.88, 3 - 0	60.00
	<i>Johnius weberi</i> (Hardenberg, 1936)	7	4	1.14±1.21, 3 - 0	57.14

Table 3. Length, width, color and form of plastic debris found in the stomach content of fishes

Trophic level	Fish species	Detail info of plastic debris found in the stomach of fishes			
		Length range (mm) (Mean \pm SD)	Width range (mm) (Mean \pm SD)	Color	Form of plastic debris
Demersal	<i>Panna microdon</i> (Bleeker, 1849)	2.08 – 23.48 (8.50 \pm 5.56)	0.04 – 1.71 (0.27 \pm 0.46)	Transparent, Blue, Brown, Black, Pink, Violet, Green	Fibre, Fragment
	<i>Dendrophysa russelli</i> (Cuvier, 1829)	1.46 – 20.99 (8.64 \pm 5.00)	0.04 – 3.85 (0.54 \pm 1.02)	Transparent, Black, Blue, Green, Pink, Violet	Fibre, Fragment
Pelagic	<i>Johnius borneensis</i> (Bleeker, 1851)	1.23 – 38.22 (10.02 \pm 8.86)	0.06 – 2.72 (.36 \pm 0.64)	Transparent, Black, Pink, Red, Violet, Blue, Brown	Fibre, Fragment
	<i>Johnius weberi</i> (Hardenberg, 1936)	2.12 – 16.75 (9.60 \pm 4.99)	0.06 – 0.62 (0.18 \pm 0.18)	Transparent, Black, Brown, Pink	Fibre, Fragment

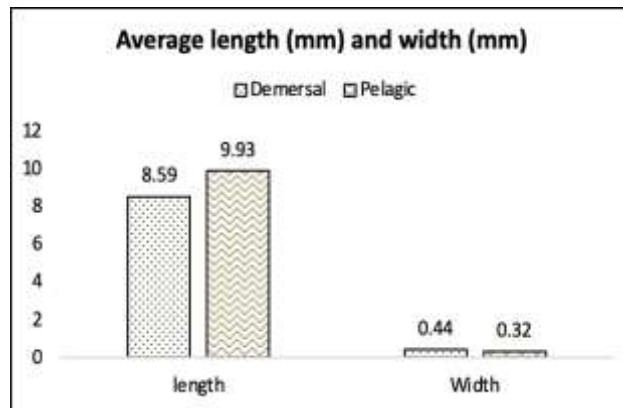


Figure 3. Average length (mm) and width (mm) of plastic debris in the stomach content of different groups of fishes

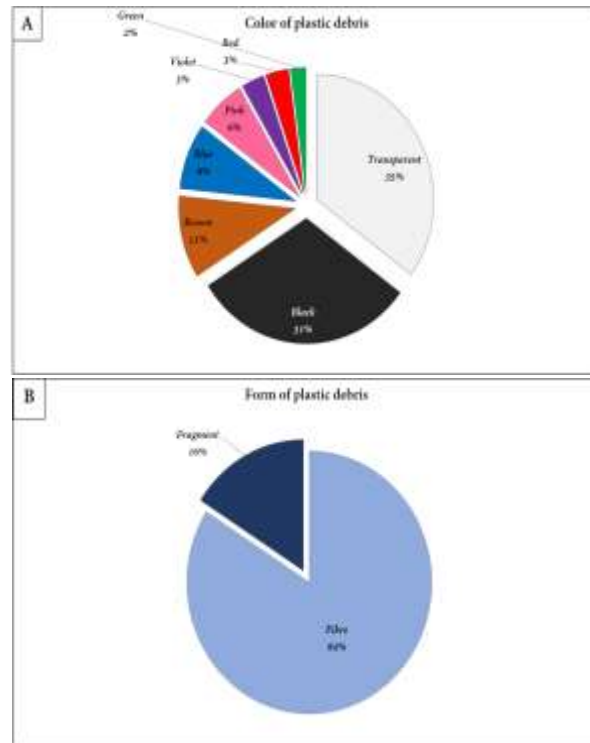


Figure 4. Percentages (%) of color and form of plastic debris found in the stomach of fishes. (A) % of color groups, (B) % of form of plastic debris

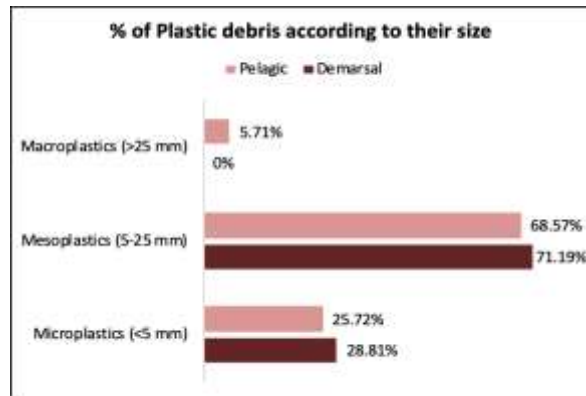


Figure 5. Percentages (%) of plastic debris according to their size group

Different colors (transparent, black, blue and green) and forms (fibre and fragment) of plastic debris found throughout the research were presented in Figure 6.

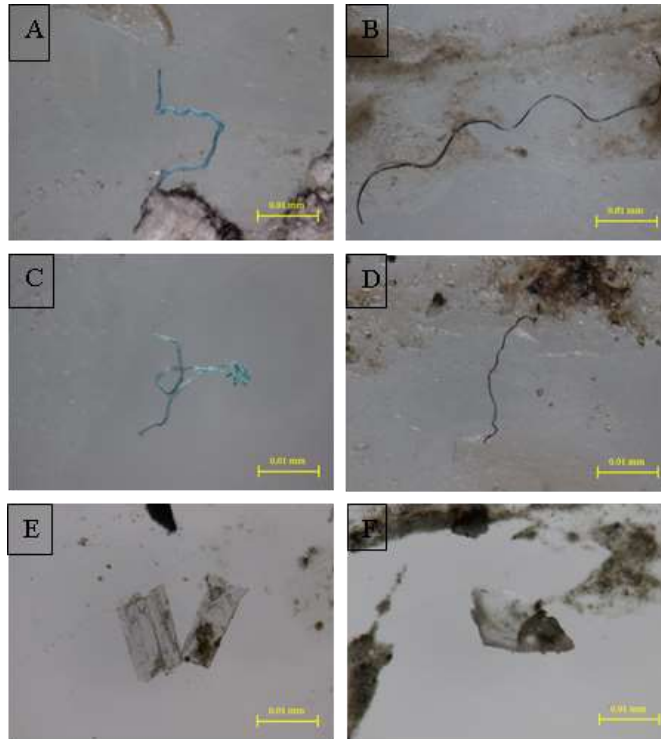


Figure 6. Photographs of fibre (A-D) and fragment (E-F) types of plastic debris found in the stomach contents of fishes under stereo zoom microscope

Discussion

This present enquiry publicized various vital evidence on plastic debris together with the data on frequency of occurrence, amount, forms of plastic debris and specific brief info on the plastic debris found in the gastrointestinal contents of some commercial marine fishes from the lower Gulf of Thailand (Figure 1). Previously, there were very few studies on plastic pollution in Thailand (Thushari *et al.*, 2017), especially there wasn't any investigation done on fishes in lower Gulf of Thailand. Recent studies (Fossi *et al.*, 2012) shown data on the effects of microplastic on huge filter-feeding individuals such as baleen whales and sharks in the Mediterranean Sea, which could probably gulp microplastic punk. Total length and body weight of the examined fishes range from 7.6 to 21.9 cm and 4 to 99 g. Stomach weight of the samples range from 0.03 to 91 g (Table 1). Out of 105 investigated fish stomachs, 57 (54.29%) stomachs contained plastic debris (Table 2). In particular, this involved of 35 individual demersal fishes (51.47%, out of 68 individuals) and 22 individual pelagic fishes (59.46%, out of 37 individuals). The average frequency of

occurrence (%) for demersal fish species was 51.47%, which was lower than the average frequency of occurrence of the observed pelagic fishes (59.46%)(Table 2). As stated in Figure 2, the average number of plastic debris per g of stomach for demersal fishes was 5.41, which was slightly higher than that of the pelagic species (4.67). Contrariwise, pelagic fish species showed higher (0.95) average number of plastic debris per stomach than that of the demersal ones (0.87). Therefore, it was obvious that the pelagic fish species possessed more plastic debris than the demersal fishes. This may be because of the luxuriant presence of plastic debris in the surface level of marine water bodies. Meanwhile most of the plastic debris tend to levitate on the surface level of the water because of their solidity and structure behavior, pelagic fishes gulp the plastic debris mistakenly as food. According to several studies (WWF, 2018), 80% of plastic in our ocean is from land sources and it can come to our ocean in three main ways such as throwing plastic in the bin when it could be recycled, littering and products that go down the drain. Once in the ocean, plastic stays in the surface level of the water bodies for certain period of times, breaks down into tiny pieces and then travels to other trophic level of the water bodies such as middle level and finally to the bottom level. This can be one of the vital reasons behind the copiousness of plastic debris in the stomach contents of pelagic fishes. Since the present study is one of the preliminary studies on plastic ingestion by fishes from the lower Gulf of Thailand, there isn't any other study in Thailand to associate with. Comparable investigation was performed by Romeo *et al.* (2015), who worked on the existence of plastic rubbish in the stomach of 3 large pelagic fishes (*Xiphias gladius*, *Thunnus thynnus* and *Thunnus alalunga*) in the Mediterranean Sea and 18.18% of the investigated fish stomach contained certain types of plastic offal, which was inferior than those of the current study.

The length of the plastic offal found in the stomach contents of the examined fishes ranged from 1.46 to 23.48 mm and 1.23 to 38.22 mm in terms of demersal and pelagic fishes, respectively. Moreover, for demersal ones, width ranged from 0.04 to 3.85 mm and 0.06 to 2.72 mm for pelagic species (Table 3). On average, highest length (9.93 mm) of plastic debris was reported in pelagic species (Figure 3). In particular, *Johnius borneensis* showed the longest plastic debris in their stomach content, which was 38.22 mm in length (Table 3).

Though the plastic debris obtained from the stomach contents were either fibre or fragment type, most of them (84%) were fibre type (Figure 4). Meanwhile, Plastic debris found in the stomach of the examined fishes had different shapes and color. Transparent, black and pink colored plastic debris were found in all the groups of fishes. Among all the plastic debris found,

transparent (35%) colored plastic debris was the most abundant one and black color (31%) was the neighboring one (Figure 4). Oppositely, Green colored (2%) plastic debris was the least common one found in the stomach content of the examined fishes (Figure 4). Since transparent color is almost impracticable to ascertain in the water, aquatic organisms mainly fishes erroneously consume this sort of plastic offal while filter-feeding ones, gulp and consume it as their food. Even sometimes, fishes inadvertently ingest plastic debris as a live foodstuff as well. Similar investigation was done by Romeo *et al.* (2015), who reported various color of plastic rubbish such as transparent, white, blue and so on. The plastic debris found in that study ranged from 0.63 to 164.50 mm in length and 0.69 to 60.57 mm in width from the stomach contents of pelagic fishes.

Size of the plastic debris found in the stomach contents of the fishes were also been characterized. Mesoplastics (69.88%, 5-25mm) were the most abundant size group of plastic debris obtained throughout the investigation, which is higher than the amount of microplastics (27.27%, <5 mm) found by approximately two times (Figure 5). Rest of the plastic debris found were macroplastics (2.85%, >25 mm). In particular, 25.72% and 28.81% of microplastic debris were obtained from pelagic and demersal fish species, respectively. Contrariwise, pelagic and demersal species showed 68.57% and 71.19% mesoplastics respectively in their stomach contents (Figure 5). Only 5.71% macroplastic was found from the pelagic fish throughout the investigation, while no macroplastics were obtained from demersal fishes. Furthermore, there was a number of more scientists who also obtained microplastic debris in fish gastrointestinal tract (Lusher *et al.*, 2013; Murphy *et al.*, 2017; Phillips and Bonner, 2015; Tanaka and Takada, 2016).

Findings of the present investigation highlight prevalent presence of plastic rubbish and high frequencies of meso and micro-plastics in the marine fishes from the lower Gulf of the Thailand and signify a further cautionary sign for marine conservation as well as for the consciousness of human well-being. It is absolutely suggested that microplastic pollution in marine organisms and their food chain in other neighboring provinces must be discovered to make sure the safety situations of environment and human health. These ultimate conclusions denote a vital preliminary point in discovering certain ecotoxicological aspects such as the probable effects related to the transmission of pollutants on human health and the valuation of the presence and effect of plastic debris on other types of marine entities. Additionally, operative management plans in the study area and adjoining areas for the plastic contamination are instantly mandatory.

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