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Levels of DDTs and indicator polychlorinated biphenyls in Whiting (*Merlangius merlangus euxinus* N. 1840) and Horse mackerel (*Trachurus mediterraneus* S. 1868) from the İzmit Bay, Turkey

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Abstract

The concentrations of indicator polychlorinated biphenyls (PCBs) and 1,1,1-trichloro-2,2-bis-chlorophenyl-ethane (DDT) and its metabolites were determined in whiting (*Merlangius merlangus euxinus* N. 1840) and horse mackerel (*Trachurus mediterraneus* S. 1868) from the İzmit Bay, Turkey. The results showed that the levels of the total PCBs ranged from 1.49 to 39.69 ng/g fresh weight in whiting, and from 5.61 to 58.61 ng/g fresh weight in horse mackerel. Total DDTs concentrations were found from 1.08 to 66.73 ng/g fresh weight in whiting, and 4.69 to 116.25 ng/g fresh weight in horse mackerel. Concentrations of PCBs and DDTs in horse mackerel were found higher than those in whiting. Congeners IUPAC Nos. 52, 101, 153 were found frequently in whiting and horse mackerel samples. Analysis of DDT and its metabolites showed that *p,p'*-DDE was dominant in both of the fish species. Total PCB and DDT concentrations in fish samples were found lower than the maximum residue limits fixed by legislations.

Keywords: Fish, organochlorine contaminants, Marmara Sea.

Türkiye'de İzmit Körfezi'nden Yakalanan Mezgit (*Merlangius merlangus euxinus* N. 1840) ve İstavrit (*Trachurus mediterraneus* S. 1868) Balıklarında DDT'lerin ve Poliklorlu Bifenillerin Seviyeleri

Özet

Türkiye'de İzmit Körfezi'nden yakalanan mezgit (*Merlangius merlangus euxinus* N. 1840) ve istavrit (*Trachurus mediterraneus* S. 1868) balıklarında indikatör poliklorlu bifeniller (PCBs) ile 1,1,1-trichloro-2,2-bis-chlorophenyl-ethane (DDT) ve metabolitleri tespit edilmiştir. Total PCB'lerin konsantrasyonları mezgit balıklarında 1,49-39,69 ng/g yaş ağırlık olarak bulunurken, istavrit balıklarında ise 5,61-58,61 ng/g yaş ağırlık olarak tespit edilmiştir. Total DDT konsantrasyonları ise mezgit balığında 1,08-66,73 ng/g yaş ağırlık olarak bulunurken, istavrit balıklarında 4,69-116,25 ng/g yaş ağırlık olarak bulunmuştur. PCB ve DDT konsantrasyonları istavrit balığında mezgit balığına kıyasla daha yüksek bulunurken, her iki balık türünde de tespit edilen en baskın bileşenler PCB52, PCB101, PCB153 ve *p,p'*-DDE'dir. Sonuç olarak total PCB ve DDT konsantrasyonları tebliğlerde belirtilen maksimum kalıntı limitlerinin altında bulunmuştur.

Anahtar Kelimeler: Balık, organik klorlu bileşikler, Marmara Denizi.

Introduction

Organochlorine compounds such as polychlorinated biphenyls (PCBs) and 1,1,1-trichloro-2,2-bis-chlorophenyl-ethane (DDT) and its metabolites are ubiquitous toxic contaminants, due to their bioaccumulative capacity and persistence and specific physico-chemical properties (Everaarts *et al*., 1998). Polychlorinated biphenyls belong to Persistent Organic Pollutants (POPs) group of chemicals primarily used in transformers, capacitors, paints and printing inks, and also in many other industrial applications. They are amongst the industrial chemicals banned and included in the list of priority contaminants to be monitored regularly in the western countries (Babu-Rajendran *et al.*, 2005). They have been reported to cause variety of effects including immunologic, teratogenic, carcinogenic, reproductive and neurological problems in organisms (Kodavanti *et al*., 1998). In addition, some congeners have shown some effects on the endocrine system such as reducing serum concentrations of the thyroid hormones (Koopman-Esseboom *et al.*, 1994). Chlorinated pesticides such as DDT are effective pest

control chemicals, used in agriculture and public health activities (malaria eradication, etc.) worldwide for the past several decades and are still in use in many developing countries. Similar to PCBs, DDTs also cause endocrine disruption and are hazardous to human and/or environmental health (Babu-Rajendran *et al*., 2005). Organochlorines accumulate in fats of species throughout the food chain (Barrie *et al*., 1992). Animal diet is generally one of the major routes of contaminants into the human body. In particular, an important significance in this context has been attributed to fish and seafood (Alcock *et al*., 1998).

Bay of İzmit, located south of İstanbul on the southeast of the Marmara Sea, is the most important semi-enclosed body of water on the sea of Marmara. Sea of Marmara is an inland basin located between the Black Sea and Aegean Sea, and has a two-layer stratification (Algan *et al*., 1999). İzmit Bay is one of the most polluted areas in Turkey. It is about 50 kms in length, 2-10 kms in width and has a surface area of 310 km^2. It consists of three district parts which behave semi-independently. The Eastern sector (inner part) is very shallow (30 m) and consists of the most polluted part of the Bay. While the industries of petroleum are based in the Central part, the entrance to the Marmara Sea through a wide and deep channel is located in the Western part (outer part) which is less polluted because of better water exchange (Okay *et al*., 2003). The Central part is highly affected by the heavy industries discharging their wastewaters through Dil River into the Bay (Morkoç *et al*., 2007). There are more than 140 large industrial plants scattered around the Bay and commissioning of these and, particularly, the consequent urbanisation of the coastal landscape have completely destroyed Bay of İzmit (Telli-Karakoç *et al*., 2002). The largest wastewater contribution comes to the Bay from İzmit. Direct estimates of industrial inputs vary from 0.1 kg/day to over 10 t/day for the industry around the İzmit city (Legovic *et al*., 1995).

On August 17, 1999, a powerful earthquake struck the Marmara region and the Bay ecosystem was strongly affected by the quake and subsequent refinery fire as well as the settlements and industrial regions (Okay *et al*., 2003). The most widely publicised and spectacular damage to any industrial facility occurred at the massive refinery near the town Körfez operated by the state-owned oil company, Tüpraş. Following the earthquake the tank farm of the refinery burned out of control for several days (Tolun *et al*., 2006) and following the refinery fire caused by the earthquake, the surface waters of the Bay were partly covered by thick petroleum layers and by a film (Morkoç *et al*., 2007). After the earthquake, most of the industrial treatment plants had been damaged and the refinery fire caused an increase in the levels of pollutant discharge through Petkim Channel. The results of the long term monitoring studies have shown that the waste inputs via the Dil River and other sources to the bay drastically affected the inner bay ecosystem. Consequences of the 1999 earthquake in the bay have shown a temporary occurence of a two-layer ecosystem with a very low oxygen content in the lower layer. Such a system has been shown to have a limited self purification capacity for organic and nutrient inputs (Morkoç *et al*., 2007).

In this research, whiting and horse mackerel samples collected from İzmit Bay were analyzed monthly between December-2003 and November-2004 to determine the contamination level of indicator polychlorinated biphenyls and DDT compounds threatening environment and human health in İzmit Bay. İzmit Bay is the most important industrial area of Turkey and is heavily urbanized. Most of the toxicology studies in the İzmit Bay have focused on the polycyclic aromatic hydrocarbons and heavy metals (Tolun *et al*., 2001; Okay *et al*., 2003), however very little is known on the PCB and DDT contamination in the biota of the İzmit Bay. PCB levels in mussels from the İstanbul strait and the most industrialized bay of the Marmara Sea were published and also found to be high (Telli-Karakoc *et al*., 2002; Tolun *et al*., 2007, Okay *et al*., 2009). Indicator PCBs and total DDTs were determined in different fish species caught from Marmara Sea, Turkey. The results were 209.36 and 455.09 ng/g fat weight for horse mackerel, 363.85 and 577.43 ng/g fat weight for whiting respectively (Coelhan *et al*., 2006). In another study PCBs and DDTs were determined in different fish species in Black Sea. Total PCB and DDT concentrations were found as 140 and 280 ng/g wet weight for whiting, 210 and 490 ng/g wet weight for horse mackerel respectively (Tanabe *et al*., 1997a). High concentrations of toxic coplanar PCBs and other isomers were detected in the fishes that were used as porpoises' feed. The results were 50 ng/g wet weight and 140 ng/g wet weight for European anchovy and whiting respectively. It is concluded that the elevated levels of PCB concentrations of samples were because of the contamination of the countries around the Black Sea (Tanabe *et al*., 1997b). Fish are an excellent indicator organism for pollution in aquatic ecosystems, where trace contaminants are difficult to analyze directly. They also generally possess a low metabolism for organochlorines and should reflect the levels of pollution in the aquatic environment (Muir *et al*., 1990). However, studies of persistent pollutants in species from the İzmit Bay are very scarce. Because of the reasons mentioned above, present study aims to evaluate the occurence of the most important organohalogenated pollutants, such as DDTs and PCBs, in whiting and horse mackerel fish samples from the İzmit Bay.

Materials and Methods

Fish Samples

Whiting (*Merlangius merlangus euxinus*

N.1840) and horse mackerel (*Trachurus mediterraneus* S.1868) fish samples were taken in the Central Fish Market of the İzmit city between December 2003-November 2004 in five replicates (ten individuals for each replicate of fish). Fishes were caught from the İzmit Bay. The fish samples were wrapped in aluminum foil and maintained at <4°C in dark until they were returned to the laboratory and stored at <-10º C in dark until analyzed (USEPA, 1999).

Standards

Reference PCBs (7 congeners and mix, each at 10 ng/µl) and DDTs (7 metabolites and mix, each at 10 ng/µl) were obtained from Dr. Ehrenstorfer. Working solutions were prepared by diluting the stock solutions with hexane to prepare solvent and matrix matched calibration solutions for GC analyses in the range of 10-500 ng/ml.

Sample Extraction

Edible parts (muscle and skin) of fish samples were minced and 10 g of homogenized fish samples were mixed with anhydrous sodium sulphate and then extracted in 250 ml petroleum ether for 8 hours in a Soxhlet extractor. Following Soxhlet extraction, the extracts were evaporated to dryness, and the lipid contents were determined. All results for fish samples were reported on a fresh weight basis. The lipid extracts were redissolved in petroleum ether and residues were partitioned into acetonitrile, and then concentrated extracts were purified by passing through florisil packed column using 200 ml mixture of petroleum/diethyl ether (94:6) as elution solvent with the flow rate of 5 ml/min. All the extracts were concentrated by rotary evaporator and gentle nitrogen blow, and then dissolved in 1 ml n-hexane (CEN, 1996).

Analyses

PCB and DDT determination was carried out on Hewlett Packard (HP) 6890 gas chromatoraph with a micro electron capture detector (µECD). An Agilent 19091S-433, HP-5MS, 30 m 5% phenyl-methylpolysiloxane capillary column, 0.25 mm i.d. and 0.25 µm film thickness was used with helium as the carrier gas at a pressure of about $1.5x10^5$ Pascal and nitrogen as the purge gas at a velocity of about 40 ml/min. Injection port was maintained at 250°C, and the sample was injected in splitless mode. Detector temperature was 350°C. Column temperature was held at 90°C for initial 4 min, and then programmed at 35°C/min to 160°C, held for 1 min, ramped at 3°C/min to 244°C and held for 10 min (CEN, 1996). The peaks were identified by matching the retention times of the peaks in the sample with those of authentic standards in the calibration solution. PCB/DDTs in samples were confirmed by GC/MS using primarily a HP 6890 gas chromatograph fitted with an HP 5973 quadropole mass spectrometer and a Agilent 19091S-433, HP-5MS, 30 m 5% phenyl-methylpolysiloxane capillary column, 0.25 mm i.d. and 0.25 µm film thickness was used with helium as the carrier gas at a flow rate of about 1.9 ml/min. Injection port was maintained at 250°C, and the sample was injected in splitless mode. Column temperature was held at 70°C for initial 2 min, and then programmed at 25°C/min to 150°C, held for 0 min, ramped at 3°C/min to 200°C and held for 0 min, ramped at 8°C/min to 280°C and held for 10 min (Meng and Szelewski, 2000). And secondly Varian CP3800 gas chromatograph with an electron capture detector was also used for confirmation.

Quality Assurance

Before analysis, relevant standards were run to check column performance, peak area, height and resolution, and limits of detection (LoD). For each set of samples to be analysed, a field blank, a procedural blank and a standard mixture were run in sequence to check for contamination, peak identification and quantification.

Compounds were identified mainly by their retention times. To assure quality control, spiked samples were analysed for each set of samples (Von Holst *et al*., 2000; Von Holst and Müller, 2001; EC. SANCO., 2004). Recoveries of spiked whiting and horse mackerel samples were 72-107% and 70-111% respectively. The detection limits for whiting and horse mackerel samples were determined as 1 ng/g and 1 ng/g (fresh weight) respectively for both PCB congeners and DDT metabolites. In addition, the errors involved in sampling were assessed by carrying out five replicate sampling of fish samples.

Results and Discussion

The concentrations from the analyses of the whiting and horse mackerel fish samples for the indicator PCBs and DDT metabolites are listed in Tables 1 and 2 on a fresh weight basis together with summaries of collection time, length and lipid content data. The percentage lipid was determined according to CEN (1996). Among the PCB congeners 52, 153, 101 and 138 congeners were found dominant in both fish species. Chlorination of organic chemicals often increases both their persistence and their lipid solubility. Therefore PCBs bioaccumulate especially well. Increasing number of chlorines increases both lipid solubility and bioaccumulation. However, the optimal bioaccumulation capacity is at about 6 chlorines, probably because higher chlorinated congeners (esp. octa-) are so poorly water soluble that their bioavailability is low (Tuomisto *et al*., 1999). Our results are also in accordance with this finding. In particular, the ranges of total PCB (∑ICES7)

Table 1. The concentrations of PCBs and DDTs in whiting fish samples (ng/g fresh weight) from İzmit Bay in Turkey (2003-2004)

Whiting (Mean±SE)	Collection times											
	December 2003	January 2004	February 2004	March 2004	April 2004	May 2004	June 2004	July 2004	August 2004	September 2004	October 2004	November 2004
PCB congeners												
PCB28	2.86±0.75	n.d*	n.d.	n.d.	2.48	n.d.	2.53±0.69	4.46±1.64	1.42±0.19	n.d.	2.28	n.d.
PCB52	6.95±1.84	2.75±0.24	2.02±0.63	2.29	5.34±4.23	4.53±0.37	12.01±4.97	21.78±7.91	9.56±1.43	n.d.	11.18±8.07	14.26±11.42
PCB101	12.56±2.69	2.66±0.69	n.d.	n.d.	4.94±2.52	n.d.	2.01±0.76	1.88±0.18	3.19±1.43	1.49±0.16	n.d.	1.03
PCB118	3.52±0.31	n.d.	n.d.	n.d.	n.d.	n.d.	1.48±0.06	1.25±0.03	n.d.	n.d.	3.85	n.d.
PCB138	4.21±1.16	1.24	n.d.	n.d.	4.37±0.64	n.d.	3.35±0.56	2.13±0.35	1.28±0.08	n.d.	1.60±0.07	n.d.
PCB153	6.41±1.45	1.35±0.31	n.d.	1.06	5.16±0.79	1.37±0.09	4.30±0.48	3.94±0.80	2.79±0.34	n.d.	1.44±0.10	n.d.
PCB180	3.19±0.38	n.d.	n.d.	n.d.	2.92±0.01	n.d.	1.39±0.20	1.15	n.d.	n.d.	n.d.	1.87
ΣICES7PCB	39.69	8.00	2.02	3.35	25.19	5.90	27.06	36.59	18.24	1.49	20.34	17.15
DDT metabolites												
o,o'-DDE	10.83±3.19	n.d.	n.d.	n.d.	1.50±0.21	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
o,p'-DDE	8.46±2.31	n.d.	1.40	n.d.	3.68±2.16	n.d.	3.43±1.20	n.d.	n.d.	1.48±0.22	n.d.	1.08
p,p'-DDE	25.56±4.98	9.03±1.32	5.06±1.38	5.15±1.10	14.80±2.17	n.d.	13.61±3.23	7.86±1.83	2.93±0.47	n.d.	13.27±0.77	n.d.
o,p'-DDD	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
p,p'-DDD	14.66±3.87	3.52±0.75	3.35±0.32	2.06±0.28	5.49±1.83	2.60±0.09	8.37±1.33	3.32±0.35	n.d.	5.80	4.68	n.d.
o,p'-DDT	1.89±0.44	n.d.	n.d.	n.d.	1.51	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
p,p'-DDT	5.33±1.44	1.30±0.28	1.47±0.20	1.61±0.05	2.70±0.07	n.d.	4.99±2.09	n.d.	n.d.	n.d.	3.50	n.d.
ΣDDTs	66.73	13.85	11.27	8.82	29.67	2.60	30.40	11.18	2.93	7.28	21.45	1.08
p,p'-DDE / Σ*p,p'*-DDTs	0.56	0.65	0.51	0.58	0.64	-	0.50	0.70	-	-	0.62	-
Lipid content (%)	2.61±0.0	1.78±0.01	1.69±0.01	1.23±0.0	1.16±0.0	1.05±0.0	0.95±0.0	1.11±0.01	1.22±0.0	1.57±0.05	1.95±0.01	2.30±0.0
Length (cm)	30.0±0.1	31.6±0.2	30.5±0.2	31.1±0.2	32.2±0.2	32.0±0.2	31.8±0.2	33.0±0.3	32.4±0.2	32.5±0.2	31.1±0.1	30.4±0.1

*not detected

Table 2. The concentrations of PCBs and DDTs in horse mackerel fish samples (ng/g fresh weight) from İzmit Bay in Turkey (2003-2004)

Horse mackerel (Mean±SE)	Collection times											
	December 2003	January 2004	February 2004	March 2004	April 2004	May 2004	June 2004	July 2004	August 2004	September 2004	October 2004	November 2004
PCB congeners												
PCB28	n.d.*	n.d.	n.d.	n.d.	1.57±0.39	3.99	4.06±1.28	4.19±0.53	3.28±0.69	1.49±0.32	n.d.	n.d.
PCB52	2.58±0.78	2.75±0.45	13.66±3.89	6.48±1.35	5.96±1.53	n.d.	8.58±0.72	25.82±6.90	10.37±0.69	n.d.	13.75±10.21	1.82±0.09
PCB101	1.65±0.28	2.44±0.68	1.30	n.d.	2.39±0.35	n.d.	8.59±1.56	9.92±2.67	3.17±1.05	4.26±0.98	3.34±0.23	n.d.
PCB118	1.39±0.17	2.32	n.d.	n.d.	n.d.	n.d.	2.98±0.38	2.82±0.38	n.d.	n.d.	n.d.	1.79
PCB138	2.71±0.57	2.16±0.74	n.d.	n.d.	n.d.	n.d.	5.52±0.46	3.89±0.57	2.15±0.36	1.66±0.34	n.d.	2.31±0.07
PCB153	3.14±0.47	2.16±0.54	1.10	n.d.	1.29±0.02	1.63±0.05	8.02±0.88	10.56±4.76	4.28±0.59	2.34±0.21	20.57	3.21±0.47
PCB180	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	1.90±0.27	1.41±0.12	1.88±0.44	n.d.	n.d.	n.d.
ΣICES7PCB	11.48	11.83	16.05	6.48	11.19	5.61	39.64	58.61	25.14	9.75	37.66	9.13
DDT metabolites												
o,o'-DDE	n.d.	1.19±0.12	2.01±0.62	n.d.	n.d.	1.54	2.53	2.23	n.d.	3.43±1.92	1.13±0.05	4.83±1.61
o,p'-DDE	n.d.	2.12±0.99	n.d.	n.d.	2.20±0.64	n.d.	13.52±3.19	14.31±2.40	8.53±2.03	5.53	2.23±1.09	n.d.
p,p'-DDE	43.27±6.46	26.00±11.03	7.41±1.43	4.47±0.84	6.29±0.83	15.59±0.37	36.92±3.47	25.84±3.55	10.58±1.36	31.43±12.31	n.d.	7.43±0.71
o,p'-DDD	3.28±0.50	5.47±0.69	1.58±0.30	1.33±0.07	n.d.	n.d.	14.39±8.61	33.99±10.14	n.d.	14.94±1.43	1.34±0.12	n.d.
p,p'-DDD	17.44±3.33	15.30±4.94	5.19±1.18	3.80±0.45	3.96±0.95	14.21±0.71	45.99±6.00	31.83±6.42	13.85±2.56	n.d.	n.d.	3.36±0.08
o,p'-DDT	2.20±0.39	21.54±5.44	n.d.	n.d.	1.04	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
p,p'-DDT	9.80±2.09	4.36±0.05	2.59±0.53	n.d.	n.d.	n.d.	2.91±0.48	2.93±0.78	n.d.	5.05±2.02	n.d.	n.d.
ΣDDTs	75.99	75.97	18.79	9.60	13.48	31.33	116.25	111.12	32.96	60.36	4.69	15.62
p,p'-DDE / Σ*p,p'*-DDTs	0.61	0.57	0.49	0.54	0.61	0.52	0.43	0.43	0.43	0.86	-	0.69
Lipid content (%)	14.14±0.14	11.04±0.06	9.44±0.09	8.01±0.05	7.71±0.03	6.25±0.02	6.06±0.01	5.37±0.03	4.57±0.01	6.66±0.06	10.95±0.10	13.14±0.04
Length (cm)	15.2±0.2	16.1±0.1	15.8±0.1	15.7±0.1	16.0±0.1	15.1±0.1	15.0±0.1	15.3±0.2	14.9±0.1	14.8±0.1	14.7±0.2	15.3±0.2

*not detected

concentrations in fish samples were 1.49 (September 2004) - 39.69 (December 2003) ng/g fresh weight in whiting and 5.61 (May 2004) - 58.61 (July 2004) ng/g fresh weight in horse mackerel respectively. Among the DDT metabolites *p,p'*-DDE, *p,p'*-DDD and *p,p'*-DDT metabolites were found dominant in both fish species. In particular, the ranges of total DDT (sum of the seven metabolites) concentrations in fish samples were 1.08 (November 2004) - 66.73 (December 2003) ng/g fresh weight in whiting and 4.69 (October 2004) - 116.25 (June 2004) ng/g fresh weight in horse mackerel respectively. In marine mammals, a ratio of *p,p'*-DDE/∑*p,p'*-DDTs (∑*p,p'*-DDTs=*p,p'*-DDT+ *p,p'*-DDE+*p,p'*-DDD) below 0.6 has been considered as fresh DDT exposure (Aguilar, 1984; Coelhan *et al*., 2006). In the present study, the ranges of this value in fish samples was 0.50-0.70 in whiting and 0.43-0.86 in horse mackerel respectively. The values are listed in Tables 1 and 2. In general total DDT concentrations were found higher than total PCB concentrations in both of the fish species. Moreover, the concentrations of PCBs and DDT metabolites showed that the residual levels in fish samples were always below the MRLs fixed by legislations of various countries (Hietaniemi and Kumpulainen, 1995; USEPA., 2000; EC. ELICC., 2004; Julshamn *et al*., 2004).

The results obtained show the presence of low concentrations of DDT metabolites and indicator PCBs in both fish species caught in the İzmit Bay, Turkey. Regarding the content of the DDT metabolites and PCB congeners only *p,p'*-DDE, *p,p'*-DDD, PCB 52 and PCB 153 were found in almost all fish samples. The presence of *p,p'*-DDE could be correlated to a previous use of DDT in agricultural activity, to high environmental persistence because of their chemical and thermal stability, to different climatic environmental conditions, to marine currents, to different migratory habits of aquatic organisms and to different feeding habits as Di Bella *et al*. (2006) mentioned. The bioaccumulation of organochlorine compounds is a complex phenomenon governed by either physico-chemical properties of these compounds or ecological and biological factors such as feeding behaviours, growth rate, habit, age, sex, state of health as well as the lipid composition of an animal's tissue or organs (Barlas, 1999; Robertson and Hansen, 2001; Storelli *et al*., 2004; Di Bella *et al*., 2006).

In the present study, there is no correlation between the concentration of contaminant and the amount of lipid in the fish. Stow *et al*. (1997) determined that lipid content is not a variable in PCB body burdens among species. Our results are in accordance with this observation. This situation may reflect relatively rapid changes in lipid content within individual fish as compared to the slow uptake and depuration of persistent organic contaminants within the same fish as Manchester-Neesvig *et al*. (2001) mentioned. Also the lipid content of whiting was low, 1.55±0.53%, and did not change significantly throughout the year.

Contamination levels in horse mackerel samples show values, in terms of total DDT concentration, similar to those found by Coelhan *et al*. (2006) in horse mackerel and lower than those reported by Tanabe *et al*. (1997a), but in whiting higher than those reported from the Marmara Sea in Turkey (Coelhan *et al*., 2006) and lower than those reported by Tanabe *et al*. (1997a) from the Black Sea. This study about contamination in horse mackerel shows values, in terms of total indicator PCB concentration, lower than those found in horse mackerel from the Marmara Sea in Turkey (Coelhan *et al*., 2006) but in whiting higher than those reported by Coelhan *et al*. (2006) and lower than those reported by Tanabe *et al*. (1997b). In general, DDTs and indicator PCBs contamination is lower in samples from the İzmit Bay than in samples from the Black Sea. Some studies indicate that DDT is still used illegally in agriculture and has been used intensively in recent years in the countries around the Black Sea (Tanabe *et al*., 1997a; Tuncer *et al*., 1998; Barlas, 1999; Fillmann *et al*., 2002; Coelhan *et al*., 2006).

In conclusion, generally higher concentrations were determined in horse mackerel samples than whiting samples but the low residual levels of PCB congeners and metabolites of DDT in fish samples at concentrations below legislation limits indicate a situation without toxicological risks for animal and human health.

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