PCB Pattern in two Fish Species from the Gulf of Akaba, Jordan

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Because of their relevance to human nutrition, fish have often been the subject of PCB and organochlorine investigations. In Germany, fish monitoring programes[1] based on the determination of six „food-relevant"[2] congeners were carried out. Because of environmental changes of PCB mixtures, mostly through metabolism of animals, the determination of all congeners in a routine analysis was the wishful thinking of scientists over years. With the help of such a method, the calculation of real PCB values, instead of estimation, of environmental samples, including fish, gets possible. Besides this food-relevant aspect, also the biological importance of different PCB mixtures with respect to toxicity of different CBs is known.

In this paper we show the PCB pattern of fish caught in waters of developing countries. Besides the difference of the patterns between the fish, the total PCB burden of these species and possible conclusions to a release of PCB into the environment in this region were investigated.

Material and Method

The fish were collected in the Gulf of Akaba, totally six mullets (Fam. Mullidae, Upeneus spec.), feeding on benthic organisms and five algae or coral feeding parrotfish (Fam. Scaridae, Callyodon spec.). Collecting dates and fat content of the individual fish are given in Tab. 1.

Table 1: Collecting dates and fat content of the individual fish

Mullets			**Parrotfish**		
Number	**Date**	**Fat content**	**Number**	**Date**	**Fat content**
1060	09.03.1991	5.10 %			
1050	05.06.1991	3.25 %	1051	05.06.1991	0.24 %
1052	21.09.1991	3.32 %	1053	21.09.1991	0.46 %
1054	01.11.1991	2.49 %	1055	01.11.1991	0.42 %
1056	—.01.1992	3.60 %	1057	---.01.1991	0.55 %
1058	01.12.1992	3.60 %	1059	01.12.1992	0.53 %

Each sample was measured separately, 10 g of the dorsal muscle between back and upper fin were weighed into a separatory funnel, homogenized and extracted after a published method[3], slightly modified[4]. After evaporation over night the weight of the remaining extracted lipids was determined and the fat content calculated. A column chromatography step on silica gel followed, which is described in detail[5] and modified[4].

The identification and quantification method of the CBs with GC-MS was published[6], the publishing of the necessary application parameters is in preparation[7]. The numbering of the CBs was published[8].

Results and Discussion

The sum PCB values for the mullets were between 4894.75 and 8069.15 ppb/lipid weight (LW) with an average of 6417.86 ± 1090.57 (Tab. 2). Between 54 and 69 single congeners were detectable (detection limit: ~1.1 ng). In the parrotfish samples, sum PCB values between 1533.26 and 4739.39 ppb/LW were measured with an average of 2550.74 ± 1191.69. The number of congeners in this species varied between 8 and 31 (Tab. 2).

Table 2: Sum PCB and number of congeners in the single samples

Mullets			**Parrotfish**		
Number	**sum PCB**	**No. of Cong.**	**Number**	**sum PCB**	**No. of Cong.**
1060	6979.60	69			
1050	8069.15	57	1051	1682.21	8
1052	7194.02	62	1053	2886.76	24
1054	5904.68	55	1055	4739.39	31
1056	5464.93	54	1057	1912.07	20
1058	4894.75	58	1059	1533.26	17
Average ±SD	6417.86 ± 1090.57	59 ± 5.08		2550.74 ± 1191.69	20 ± 7.62

The PCB pattern of the two species shows distinct differences. Concerning the pattern with respect to the degrees of chlorination, in the parrotfish 15.54 % Tri-CBs occur contrary to only 0.47 % in the mullets (Fig. 1).

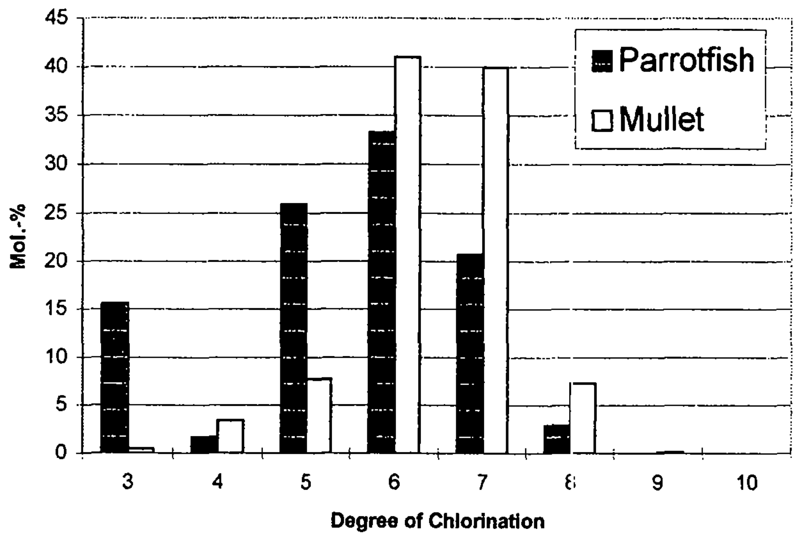

Figure 1: Molar percent parts of the single degrees of chlorination

Both species only have low parts of Tetra-CBs (parrotfish: 1.67 %, mullets 3.45 %), the Penta-CBs instead show big differences from 25.90 % in the parrotfish to 7.73 % in the mullets. Relatively low differences occur in the Hexa-CBs (parrotfish: 33.25 %, mullet: 40.98 %), big differences in the Hepta-CBs from 20.70 % for the parrotfish to 39.94 % for the mullets. The same occurs in the Octa-CBs with only 2.93 % for the parrotfish but 7.30 % for the mullets. Nona-CBs were only found in the mullets with 0.13 %, the Deca-CB was not detected.
Concerning the single CBs remarkable low numbers and molar percent (mol-%) values of the low chlorinated Tri- and Tetra-congeners occur (Fig. 2) with only seven congeners for the parrotfish and eleven for the mullets from the totally investigated 30 CBs/pairs of CBs. Only the pair CB-20/33 gets with 7.17 % a higher mol-% value in the parrotfish.

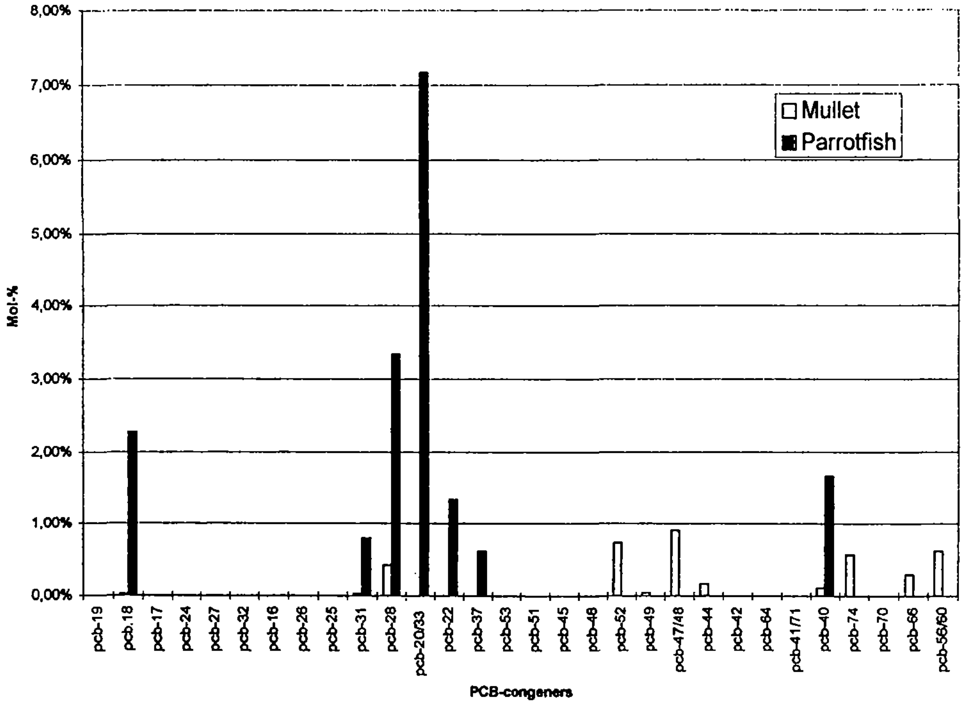

Figure 2: Molar percent parts of the Tri- and Tetra-CBs (remember the scale)

For the Penta- and Hexa-CBs further pattern differences occur between the species. In the parrotfish five CBs (95, 101, 110, 153, 156) reach mol-% values between 7.09 and 8.19 %, ten other CBs reach values up to 4.27 % (Fig. 3). Contrary to that, in the pattern of the mullets only two CBs with higher values are visible, CB-153 (15.95 %) and 138 (8.95 %), 32 other CBs reach values up to 2.61 %. In these two degrees of chlorination the total number of detectable congeners is much higher in the mullets (Penta-CBs 14, Hexa-CBs 20) than in the parrotfish (Penta-CBs 5, Hexa-CBs 10). In spite of the total number, the Penta-CBs reach a higher part in the pattern of the parrotfish than in the mullets caused by the cited high parts of CB-95, CB-101 and CB-110. Contrary to the Hexa-CBs, where the high mol-% values of CB-153 and CB-138 as well as the higher total number of congeners is the reason for the much higher part of this degree of chlorination in the pattern of the mullets.

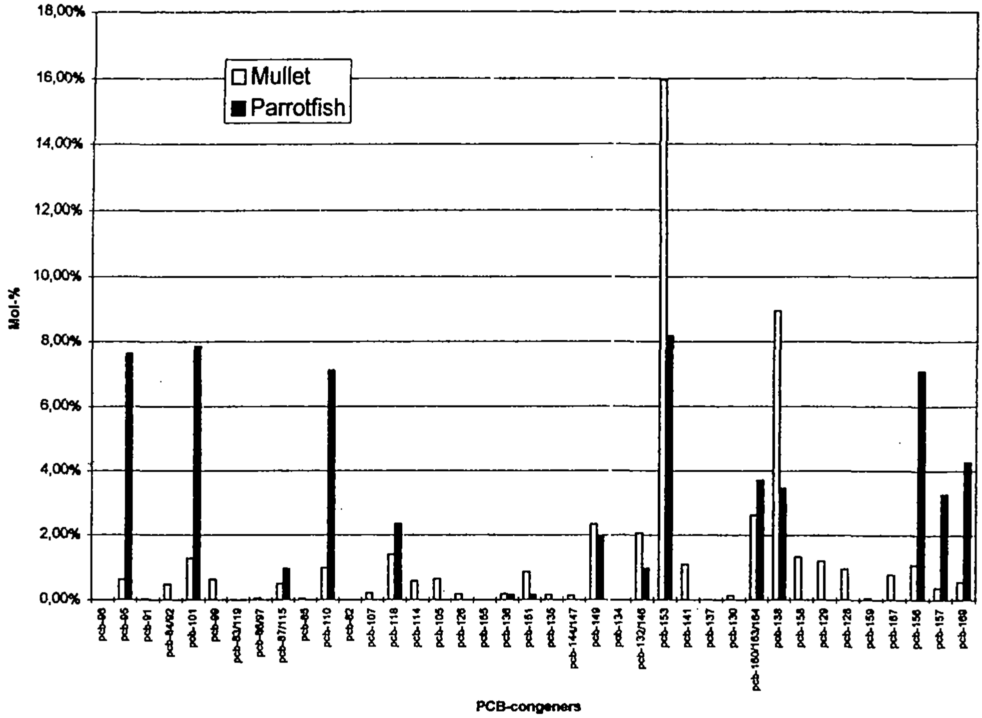

Figure 3: Molar percent parts of the Penta- and Hexa-CBs

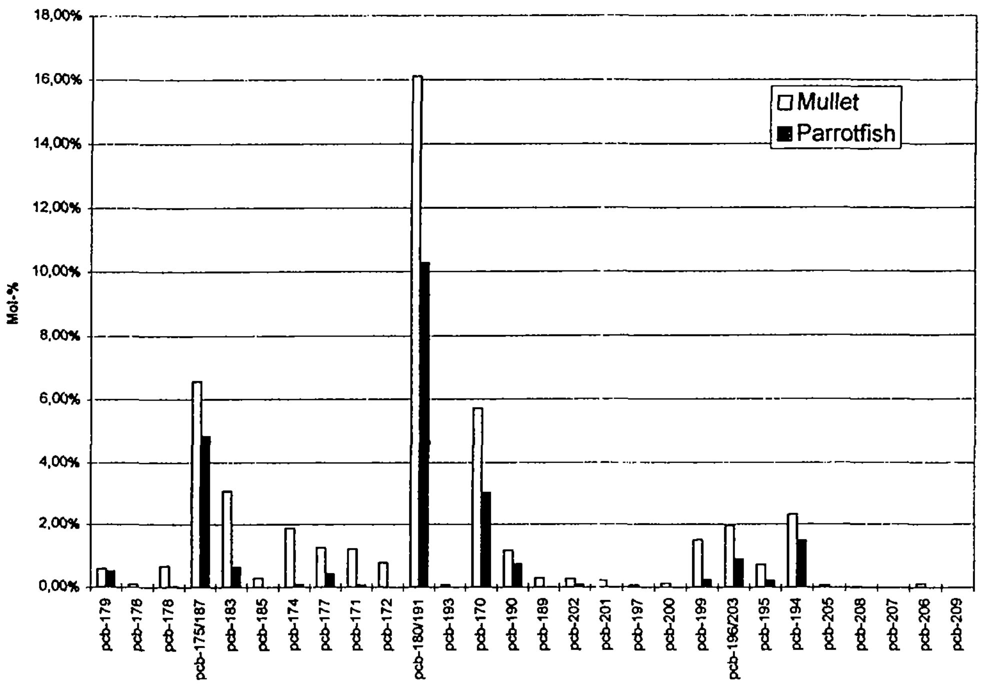

Figure 4: Molar percent parts of the Hepta- to Deca-CBs

Fig. 4 shows the mol-% values of the Hepta- to Deca-CBs. In both species CB-180/191 reaches the highest mol-% values of all CBs with 10.27 % for the parrotfish and 16.11 % for the mullets. In the mullets all investigated Hepta- and Octa-CBs and two of the three Nona-CBs were detected, indicating the very high degree of chlorination of their PCB mixture. In the pattern of the parrotfish only nine from 15 Hepta-CBs, five from nine Octa-CBs and none of the Nona-CBs were found.

Allthough the samples were collected in all four seasons of the year, only slight differences in fat content of the single fish occured. The Gulf of Akaba is a part of the Red Sea with normally relatively constant environmental conditions, so that seasonal changes should only be caused by the reproduction cycle of the fish. Over the seasons, all mullets showed a surprisingly identical PCB pattern, deviations occured only in the parrotfish, where the change of the total number of CBs caused this deviation.

The difference in the patterns of the two species seems to take its rise in their place in the food-web and their enzymatic system. The mullet is a bottom-feeding predator, so this species takes up presumably higher chlorinated PCB mixtures through its food. Higher chlorinated CBs are transported to the depth more than the lower chlorinated ones because of their higher adsorption on sinking plankton, particles etc., additionally there is a better metabolism of the lower chlorinated congeners resulting in a higher degree of chlorination in the PCB mixtures of the mullets. In a paper about sea mullets (Mugil cephalus)[9] physicochemical and steric factors are discussed in detail. As a result, high concentrations of Penta-, Hexa- and Hepta-CBs seem to be probable. Concerning the latter two, this result is in total accordance to our results.

Other investigations on fish of the family mullidae were carried out on red mullets (Mullus barbatus)[10]. In this paper seven individual CBs (28, 52, 101, 118, 138, 143, 180) were checked and a sum PCB based on a comparison with Aroclor 1254 was given. The fish were caught on several locations of the Mediterranean Sea resulting in variing PCB values, all an order of magnitude lower than our results. Concerning the individual CBs, CB-138 reaches in all samples the highest value, followed by CB-153, CB-118 and CB-180, indicating a lower degree of chlorination for the mixture of these fish compared to our results.

Mullets collected in Augusta Bay (Sicily, Italy)[11] showed also a high chlorinated PCB mixture. Of course, the value 71.5 mol-% for Octa-CBs certainly must be caused by an error in determination, so that this investigation can only be used as an indication in the direction of high chlorinated PCB mixtures of mullets. In an other paper [12] on red mullets caught in the Pagassitikos Gulf in Greece, the PCB levels were in the same order (ppb) as in our investigations, congenerspecific data unfortunately misses.

Conclusions

To our knowledge the PCB-mixture of the mullets of the Gulf of Akaba is the highest chlorinated PCB mixture ever determinated in fish, based on an efficient congenerspecific determination method. This result, deviating from all other PCB patterns of investigated fish species, shows the importance of congener specific determination. The coast regions of the Gulf of Akaba are very low industrialized, so that no direct contamination with high chlorinated PCB mixtures seems possible. Water streams, eventually originating from the Persian Gulf, streaming through the Red Sea into the Gulf of Akaba are not known, excluding a direct relationship between the Gulf War and the PCB patterns concerning the water way. On the other side, a drifting of PCB with air streams from the Persian Gulf is a real possibility of explanation for this PCB pattern.

If this point of view, or eventually a better uptake of higher chlorinated CBs by mullets compared to other fish species coupled with a better metabolism of low chlorinated CBs, is the dominating factor leading to this PCB mixture, is not explainable. Compared to the parrotfish, living in the same waters, the second reason seems to be decisive.

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