ELSEVIER

The Science of the Total Environment 257 (2000) 17–28

the Science of the Total Environment
An International Journal for Scientific Research into the Environment and its Relationship with Man

www.elsevier.com/locate/scitotenv

Distribution of polychlorinated biphenyls in marine species from French Frigate Shoals, North Pacific Ocean

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Received 10 November 1999; accepted 25 March 2000

Abstract

Polychlorinated biphenyls (PCBs) were analyzed in: sediment; coral (*Porites evermanni*); fish (*Stegastes fasciolatus*, *Neoniphon sammara*, *Acanthurus triostegus* and *Mulloidichthys vanicolensis*); crab (*Grapsus tenuicrustatus*); lobster (*Panulirus marginatus*); and eel (*Conger cinereus*, *Gymnothorax flavimarginatus*, *G. undulatus* and *G. meleagris*) samples collected from Tern Island and the corresponding reference samples from Disappearing Island. The two islands are part of French Frigate Shoals, a national wildlife refuge in the North Pacific Ocean. The dominant congeners 118, 138 and 153 represent 22–25, 32–34, 12–39, 37–46 and 30–55% of the sum of PCBs in the coral, sediment, fish, crab and eel, respectively. In general, high trophic species such as eels were found to highly bioaccumulate PCBs. The total average PCB concentrations were as high as 96 and 29 μg/g dry wt. in eels and damselfish, respectively, from Tern Island. The localized behavior and high bioaccumulation potential for PCBs suggest that damselfish are an excellent species for monitoring PCBs in small areas in the ocean. The high average concentrations of the sum of PCBs in different food chain levels suggest that pollution source(s) are around Tern Island and possibly around Disappearing Island. Aroclor 1254 and its analogs are suspected sources responsible for PCBs in the samples.

Keywords: Polychlorinated biphenyls; Marine pollution; North Pacific Ocean

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0048-9697/00/$ - see front matter
PII: S0048-9697(00)00484-8

1. Introduction

French Frigate Shoals, a part of the Hawaiian Islands National Wildlife Refuges (NWRs), is a habitat for thousands of nesting seabirds and migratory shorebirds, endangered monk seals, nesting sea turtles, and a complex community of coral reef fish and invertebrates. Tern Island is the main island in the coral reef atoll, French Frigate Shoals. It was a site of military activity during WW II and of a Long Range Navigation station from 1952 to 1979. However, since 1978, Tern Island and a large surrounding area have been a protected site with no public access under the jurisdiction of the US Fish and Wildlife Service (USFWS). Large quantities of uncharacterized debris were landfilled on the island and some was pushed directly into the ocean prior to the USFWS jurisdiction. The US Coast Guard field surveys conducted in 1997 revealed that most of the marine debris is scattered off the north shore of the island and consists of batteries, transformers, a fuel tank, and other potential contaminant sources. Elevated levels of polychlorinated biphenyls (PCBs) have also been detected in the island soils (URS Greiner Woodward Clyde, 1999). Various contaminants including PCBs may be leaching into the marine environment.

PCBs are among the most widely known class of persistent organic pollutants (POPs) because of their ubiquity, potential for magnification in the food chain, and harmful effects on humans and wildlife (Mimmi, 1994; Loomis et al., 1997; Hansen, 1998; Cheek et al., 1999). These kinds of persistent and bioaccumulative chemicals can be transported through the atmosphere and water far away from the pollution source (Blais et al., 1998). The findings reported here are part of a study to determine the concentration and distribution of PCBs in marine species in French Frigate Shoals and to identify sources of contamination around the islands.

Large proportions of PCBs that have escaped into the global environment reside in coastal sediments and open-ocean waters, suggesting the role of the marine environment as a reservoir of persistent and semivolatile organochlorines (Tatsukawa and Tanabe, 1990). Findings of the atmospheric transport of POPs supported the observations of the ubiquitous presence of PCBs worldwide, including Arctic and Antarctic ecosystems (Dobson and van Esch, 1993; Wania and Mackay, 1996). In tropical ecosystems, which are characterized by high temperatures and heavy rainfall, semivolatile organic compounds are rapidly dissipated. Volatilized residues such as organochlorines from the tropics disperse through the atmosphere, and are ultimately deposited in cold-temperature regions as a result of deposition, condensation, and accumulation (Oehme, 1991; Tanabe, 1991; Blais et al., 1998). There are very few reports describing PCB contamination in remote marine locations. Therefore, the determination of PCBs in French Frigate Shoals can present important data for understanding the transport of PCBs through the atmosphere and oceanic currents. The role of the cold water bodies in serving as a sink for semivolatile compounds such as PCBs is documented and the residues of organochlorines in Arctic waters remain constant or may even be increasing (Larsson and Okla, 1989; Bright et al., 1995a; Gregor et al., 1995). The oceanic current may also play an important role in the transport of pollutants. Tropical oceans deserve attention to investigations pertaining to POP dynamics and their impact on the environment and humans. Such investigations will elucidate the distribution and bioaccumulation of PCBs in some specific tropical marine species.

Our preliminary work suggested potential PCB pollution sources around Tern Island (Miao et al., 2000). In this study, more samples of various marine species were collected from Disappearing and Tern Islands. PCBs in the species were determined to understand the pollution source and distribution in the remote marine ecosystems.

2. Materials and methods

2.1. Sample site and collection

Coral, fish, crab, lobster and eel samples (Table 1) were collected from the waters off of the Barge site, and northeast (NE) and northwest (NW) corners of the Tern Island seawall on 5–11 May

Table 1
Marine sample information

Species	Tern-NE			Tern-NW			Tern-Barge			Disappearing		
	Length (cm)	Weight (g)	Lipid (%)	Length (cm)	Weight (g)	Lipid (%)	Length (cm)	Weight (g)	Lipid (%)	Length (cm)	Weight (g)	Lipid (%)
Conger eel (*Conger cinereus*)	92	1400	5.5	–	–	–	–	–	–	–	–	–
Undulated moray eel (*Gymnothorax undulatus*)	113	2900	4.8	96	1640	9.3	108	3000	6.0	–	–	–
Whitemouth moray eel (*Gymnothorax meleagris*)	75	1250	4.3	65	1100	2.8	–	–	–	–	–	–
Yellowmargin moray eel (*Gymnothorax flavimarginatus*)	120	2100	5.0	102	2575	19.7	–	–	–	120	3500	3.1
Convict tang (*Acanthurus triostegus*)	–	–	–	–	–	–	–	–	–	14.2	71	1.2
Damselfish (*Stegastes fasciolatus*)	8.6	24	13.4	8.4	24	7.0	7.9	20	14.1	9.8	29	2.8
Squirrelfish (*Neoniphon sammara*)	18.8	118	15.7	16.8	98	12.1	17.0	95	14.2	18.1	98	9.5
Yellowfin goatfish (*Mulloidichthys vanicolensis*)	–	–	–	–	–	–	–	–	–	21.0	137	2.3
Spiny lobster (*Panulirus marginatus*)	–	–	–	–	–	–	12.4	700	0.6	–	–	–
Crab (*Grapsus tenuicrustatus*)	4.8	50	0.9	5.1	60	1.2	–	–	–	–	–	–
Coral (*Porites evermanni*)	–	281	0.3	–	478	0.4	–	–	–	–	733	0.1
Marine sediment	–	–	–	–	–	–	–	653	0.6[a]	–	675	0.5[a]

[a] Total organic carbon of sediment sample.

1999 (Fig. 1). Sediments were also collected from Tern-Barge site and Disappearing Island on 5–11 May 1999. Sediments from Tern-NE and Tern-NW were collected on 29–31 May 1998. Tern Island is located in the Pacific Ocean, approximately 166° W longitude and 24° N latitude, and its area is approximately 35 acres. The Tern-Barge site is in the central part of the island between the NE and NW corners, which are approximately one-half mile apart. All the sampling sites are in shallow water from 0 to 10 yards out from the seawall. Reference samples were collected from around Disappearing Island, which is also located in French Frigate Shoals and approximately 16 miles from Tern Island. All sediment and tissue sample collection, preservation, and shipping were done according to the EPA Guide (US Environmental Protection Agency, 1996) and US Fish and Wildlife Service's standard operating procedures. The samples were delivered to this laboratory within 1 week of collection, and were stored at −20°C until sample preparation for analysis.

2.2. Sample preparation

Sediment and coral samples were ground and air-dried. The sediment (600–720 g) and coral (232–900 g) were then sieved through 40 (425 μm) and 60 (250 μm) mesh sieves, respectively, and stored in air-tight glass containers at ambient temperature until analysis. Three damselfish were homogenized in a blender under the protection of

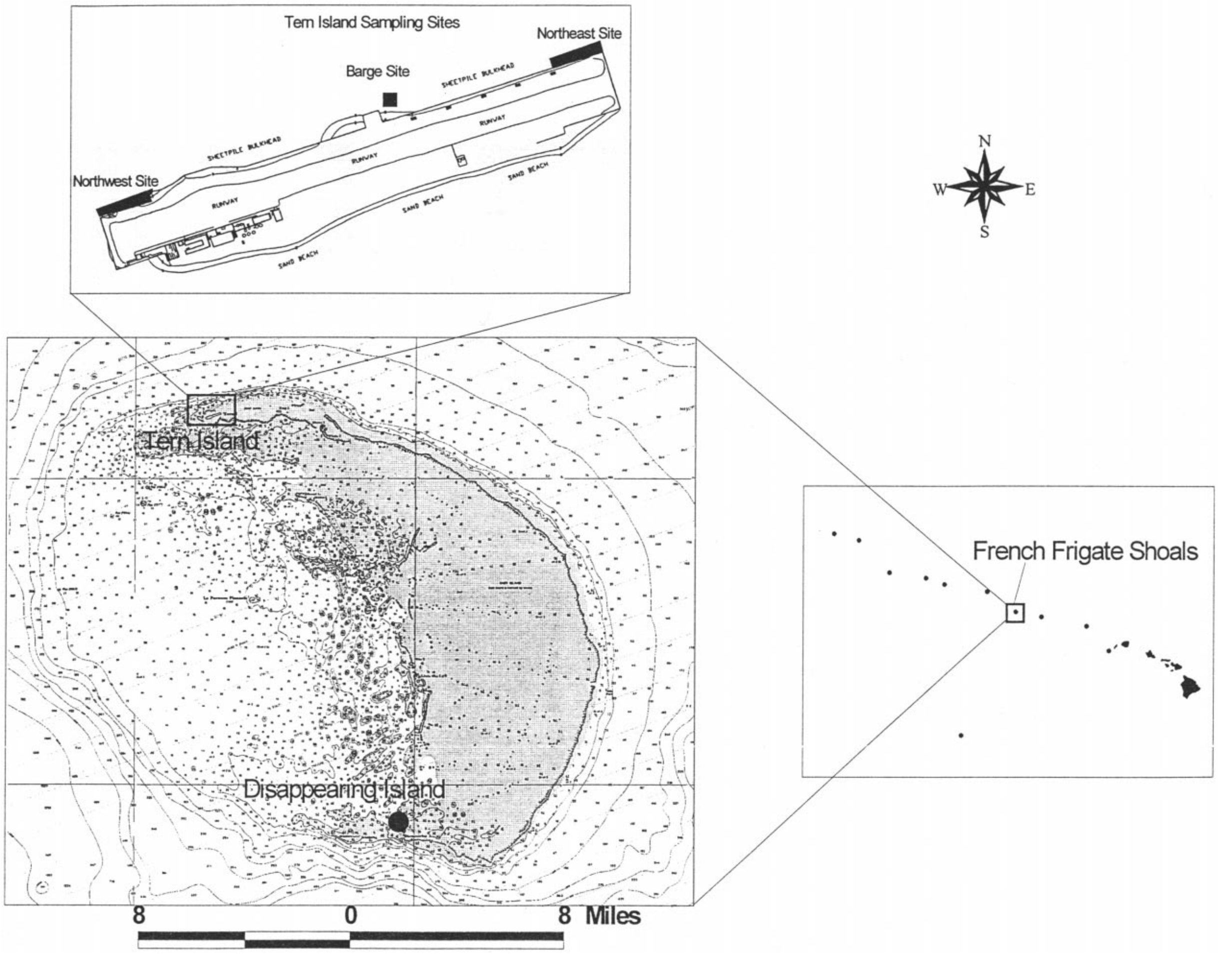

Fig. 1. Sampling locations in Tern and Disappearing Islands in French Frigate Shoals, North Pacific Ocean.

liquid nitrogen, and were then freeze-dried. Other samples were prepared individually by the same procedure as the damselfish.

2.3. Sample extraction and cleanup

PCB congeners at different chlorination levels were selected for their recovery tests from sediment, coral, crab, lobster, fish and eel samples. Each PCB congener was added in triplicate samples at a concentration of 3–7 ng/g. All extractions were performed with a supercritical fluid extractor (Isco SFX 2-10, Isco Inc.). Lyophilized coral (3.0 g), crab (1.5 g), fish (1.3–2.0 g), lobster (1.3 g) or eel (1.3 g) tissues were packed into extraction cells. Neutral alumina (3–4 g) (Aldrich Co.) was placed on the bottom of the extraction cells to retain lipids (Hale and Gaylor, 1995). Copper was used to prevent the interference from elemental sulfur contained in sediment samples as previously reported (Hartonen et al., 1997). Triplicate samples were extracted with supercritical CO_2 (SC-CO_2) at 6000 psi and 150°C. The first step was static mode extraction for 10 min followed by dynamic mode extraction with 60 ml of SC-CO_2 at 2–3 ml/min. All extracts were collected in hexane.

Extracts were subjected to column chromatographic cleanup to remove interference. Silica gel (40 μm, J.T. Backer Inc.) and alumina (60–325 mesh, Fisher Scientific Inc.) were dried for 12 h at 350 and 450°C, respectively, and then stored until use. Multilayer chromatographic columns (45 cm $\times$ 10 mm i.d.) with Teflon stopcocks were prepared by filling with 3.0 g of 3% deactivated silica gel, 2.0 g of 6% deactivated neutral alumina and 1 cm height of anhydrous Na_2SO_4 on the top. The extract (1 ml) was loaded on the top of the column, and eluted with 20 ml of hexane to recover the PCBs.

2.4. PCB determination

PCBs in the fractionated extracts were analyzed on a Hewlett-Packard (HP) 5890 series II gas chromatograph (GC)/electron capture detector (ECD) with a capillary column DB-5ms (30 m $\times$ 0.25 mm $\times$ 0.25 μm, J & W Scientific Inc.). Helium and nitrogen gases were used as carrier gas and make-up gas, respectively. Initial oven temperature was 50°C for 2 min, then increased to 290°C at 4°C/min, and remained at 290°C for 5 min. The temperatures of the injector and detector were 300 and 350°C, respectively. The injection volume was 1 μl at splitless mode with a 60-s delay.

PCB congeners were identified using retention indexes in gas chromatography (Chu et al., 1996; Miao et al., 1997), and confirmed by a HP 6890 GC/5973 mass selective detector (MSD) using a HP-5ms capillary column (30 m $\times$ 0.25 mm $\times$ 0.25 μm). The analytical performance was regularly checked against with PCB standards, such as Aroclor 1242, 1254 and 1260. The MSD was operated in the selected ion monitoring (SIM) mode. The injection mode was a pulsed splitless. The other conditions used to separate individual PCBs were the same as those of the GC-ECD analyses described above. PCB congeners were quantified with external standards (AccuStandard Inc.).

3. Results and discussion

3.1. Supercritical fluid extraction of PCB congeners

Several PCB congeners of each chlorination group were used to study the extraction efficiency of supercritical fluid extraction (SFE), because few SFE methods were found for the extraction of PCBs from some of the study species such as coral, lobster and eel. The PCB congeners were spiked in the samples, and extracted with SC-CO_2. The average recoveries ranged from 70 to 103% for different PCB groups in the sediment, coral, crab, lobster, fish and eel samples (Table 2). The recoveries were comparable with those of previous SFE and Soxhlet work (Hale and Gaylor, 1995; Bøwadt et al., 1997; Sterzenbach et al., 1997). The limit of detection (LOD) for each PCB congener in sediment, coral, crab lobster, fish and

Table 2
Recoveries of PCB congeners in marine samples[a]

Sample	Average recovery (%)						
	Cl_2-PCB	Cl_3-PCB	Cl_4-PCB	Cl_5-PCB	Cl_6-PCB	Cl_7-PCB	Cl_8-PCB
Sediment	92[b]	85[b]	89[b]	83[b]	90[b]	84[b]	79
Coral	99[b]	92[b]	89[b]	91[b]	92[b]	91[b]	88
Crab	88[b]	87[b]	97[b]	91[b]	86[b]	98[b]	81
Spiny lobster	81	83	78	74	77	76	70
Convict tang fish	85	84	92	103	88	84	72
Damselfish	96	91	80	75	80	84	83
Yellowfin goatfish	87	96	97	84	92	90	85
Squirrelfish	85	81	91	86	94	79	81
Eel	88	93	78	81	96	88	85

[a] PCB congeners 7, 10, 17, 24, 32, 41, 45, 46, 83, 103, 115, 131, 132, 164, 172, 178, 193, 196, 197 and 205. The presence of these PCBs in the samples was corrected. The recoveries of different extractions and determinations ranged from 64 to 112%.
[b] Data are from Miao et al. (2000).

eel was in a range of 10–100 pg/g for varying chlorination levels of PCBs.

3.2. Total PCB concentration and pollution source

The total PCB concentrations in the samples were determined and calculated on a dry weight basis. In general, the concentration ranges of the sum of PCBs were 85–119, 6–21, 245–28 546, 1265–19 460, 452 and 331–96 470 ng/g in the sediment, coral, fish, crab, lobster and eel samples, respectively (Table 3). High concentrations of PCBs found in different trophic levels from coral to eel from Tern NE and NW sites revealed that there are PCB pollution source(s) around the areas. Although the Barge site is only one-half miles between Tern NE and NW sites, the sum of the PCB concentration in damselfish collected from the Barge site (0.25 μg/g) was approximately 7- and 116-fold lower than those from Tern-NE (1.4 μg/g) and -NW (29 μg/g) sites, respectively. Damselfish are known as a very localized species, and thus are preferred as an indicator to locate PCB-polluted sites in this study. The elevated PCB levels in damselfish can strongly reflect a limited area of PCB pollution. Similar results were observed in squirrelfish which are less localized than damselfish. The total PCB levels varied little in fish and eels from the Barge (245–974 ng/g) and Disappearing (312–604 ng/g) sites. Therefore, it is suggested that some local sources of PCBs exist around Disappearing Island.

Most amounts of PCBs in the environment are accumulated in aquatic sediments (Tanabe and Tatsukawa, 1986). Sediment-bound PCBs strongly influence PCB concentrations in the water, and are bioavailable to marine organisms (Bremle et al., 1995; Bergen et al., 1998; Bremle and Larsson 1998a). The PCB levels in the sediments from Tern-NE and -NW (Miao et al., 2000) are much higher than those from Midway Atoll, located almost 800 miles to the northwest (Hope et al., 1997). These results further support the existence of PCB sources around Tern and Disappearing Islands.

Less chlorinated congeners such as PCBs 4, 8, 18, 22, 28 and 31 are relatively abundant in Aroclors 1016 and 1242. PCBs 44, 52 and 66 are abundant in Aroclor 1248; PCBs 87, 101, 110, 118 and 138 in Aroclor 1254; and PCBs 138, 149, 153, 170, 174 and 180 in Aroclor 1260. 'Signature' congeners in the environmental matrices are indicative of certain commercial PCB formulations (Jones, 1988). A PCB profile can be patterned by a number of factors such as a combination of commercial mixtures, degradation, physicochemical properties and weathering. However, comparing PCB profiles in sediments and corals often gives some information on pollution sources. PCB

Table 3
Average sum of PCB concentrations in marine species

Sample	Concentration (ng/g dry wt.)			
	Tern-NE	Tern-NW	Tern-Barge	Disappearing
Sediment	274[a]	273[a]	119	85
Coral	19	21	–	6
Convict tang fish	–	–	–	312
Damselfish	1397	28 546	245	388
Squirrelfish	2655	5476	556	604
Yellowfin goatfish	–	–	–	331
Crab	1265	19 460	–	–
Lobster	–	–	452	–
Conger eel	1678	–	–	–
Undulated moray eel	403	96 470	974	–
Whitemouth moray eel	552	3904	–	–
Yellowmargin moray eel	10 348	24 967	–	331

[a] Data are from Miao et al. (2000).

homologue and specific congener patterns are often used for such 'diagnostic analysis'.

The PCB homologue and dominant congener distributions in sediments from Disappearing Island are compared with those of Aroclors 1242, 1254 and 1260 (Figs. 2 and 3). The PCB homologue and congener distributions, except for trichlorobiphenyls, in the sediments are similar to those of Aroclor 1254 (Figs. 2 and 3), or possibly resemble those of a mixture of the commercial products. The less chlorinated congeners like trichlorobiphenyls are possibly from less chlorinated products such as Aroclor 1242. A recent study also found that the PCB patterns of the majority of onshore soil samples from Tern Island most closely matched the Aroclor 1254 standard pattern (URS Greiner Woodward Clyde, 1999).

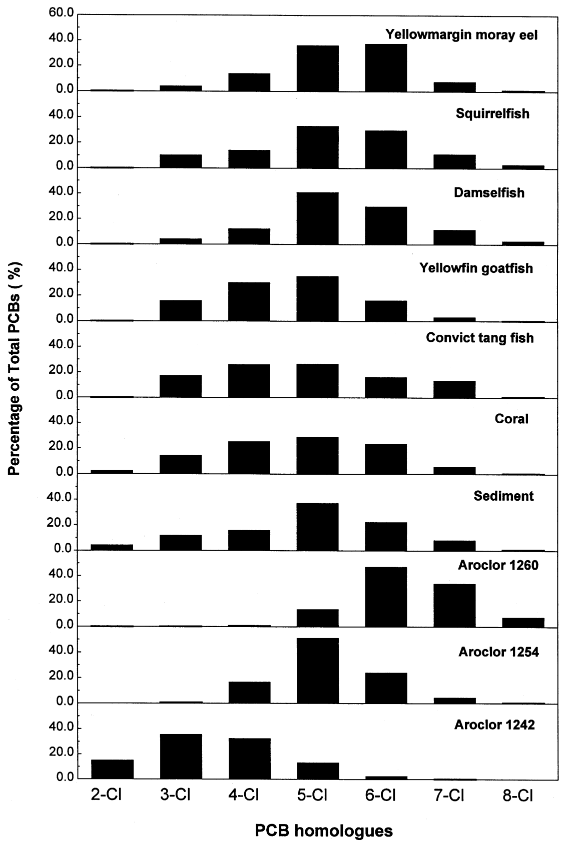

Fig. 2. PCB homologue profiles in samples from Disappearing Island. Data for Aroclors 1242, 1254 and 1260 are from Schulz et al. (1989).

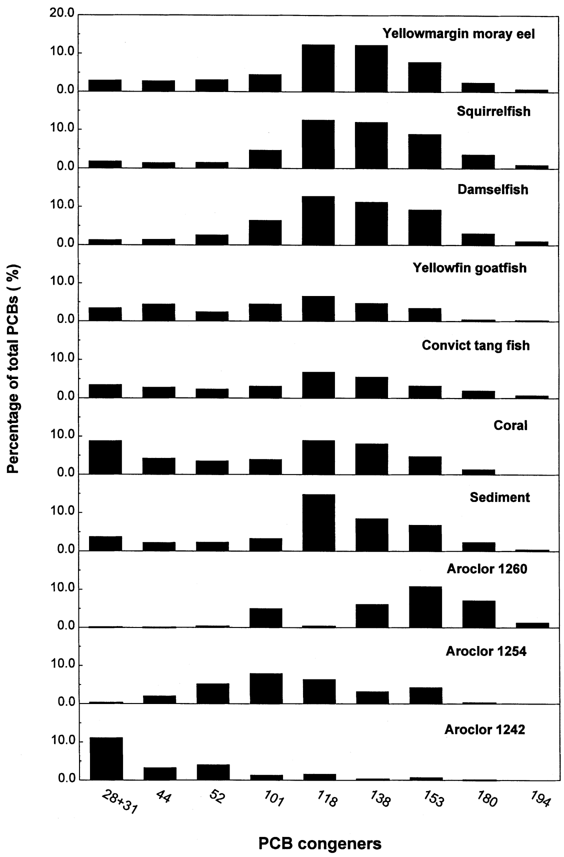

Fig. 3. PCB congener profiles in samples from Disappearing Island. Data for Aroclors 1242, 1254 and 1260 are from Schulz et al. (1989).

3.3. Distribution and bioaccumulation of PCBs in food web

The concentrations of less chlorinated PCBs (i.e. Cl_3- and Cl_4-PCBs) in the corals collected from Disappearing Island were higher than those in the sediments (Figs. 2 and 3). These results suggest preferential bioaccumulation of less chlorinated congeners by corals, which may be due to greater polarity and water solubility of less chlorinated congeners relative to highly chlorinated ones (Hawker and Connel, 1988). Low values of highly chlorinated congeners in corals are also probably attributed to the low lipid content of corals (Figs. 2 and 3, Table 1). The presence of

PCBs in the coral indicates that the PCBs are transported via oceanic currents and atmosphere possibly from local sources.

The major PCB congeners were Cl_5-PCBs in fish and crab, and Cl_6-PCBs in eels (Figs. 2–5). The results are related to species trophic levels and environmental behavior of PCBs which is influenced by a variety of factors, including physicochemical, biochemical and spatial characteristics (Loganathan and Kannan, 1991). Generally, vapor pressure, water solubility and biodegradability decrease with increasing number of chlorine atoms while lipophilicity and adsorption capacity show a reverse trend. The diet of eels is basically small fish and other living organisms; thus, they biomagnify highly chlorinated PCBs, like Cl_6-PCBs.

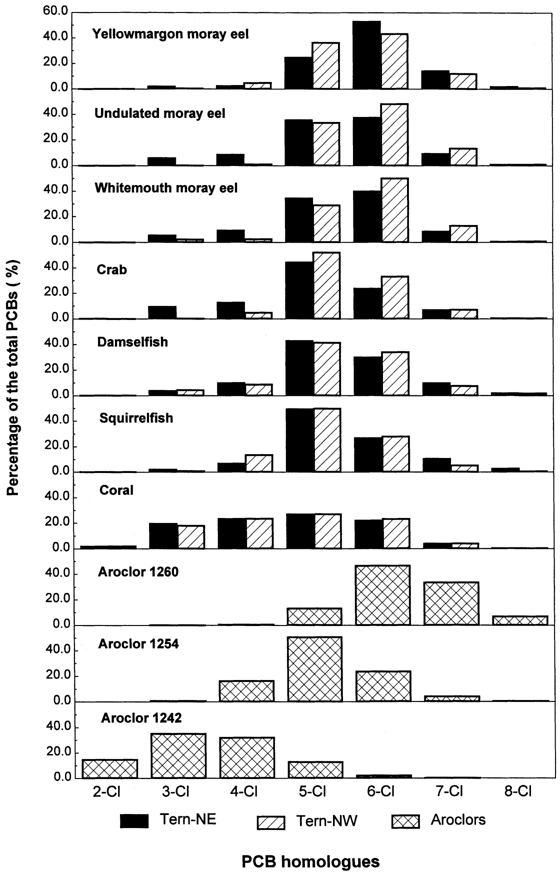

Fig. 4. PCB homologue profiles in samples from Tern Island. Data for Aroclors 1242, 1254 and 1260 are from Schulz et al. (1989).

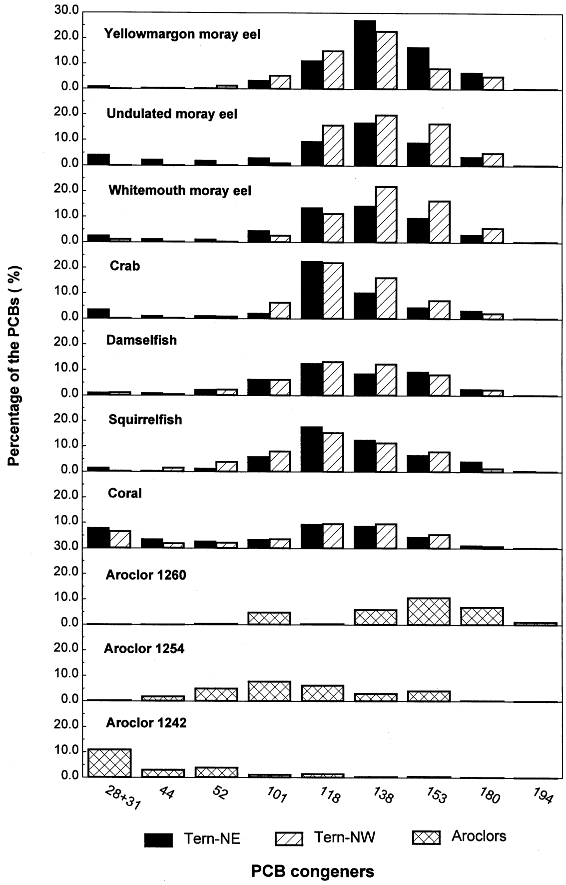

Fig. 5. PCB congener profiles in samples from Tern Island. Data for Aroclors 1242, 1254 and 1260 are from Schulz et al. (1989).

The bioaccumulation of PCBs is a complex phenomenon that involves several factors such as chemical lipophilicity, species, gender, breeding condition, tissue composition and metabolic capacity of animals (Skaare, 1996). PCBs are taken up by marine organisms by two principal routes: direct absorption and feeding on contaminated organisms. Dissolved PCBs are taken up rapidly over the gills as a result of equilibrium partitioning between water and fish lipids (Barron, 1990). The low water solubility and high lipophilicity of PCBs favor their bioconcentration, bioaccumulation and low excretion from fish. PCB persistence is attributed to slow metabolism. Damselfish and squirrelfish show more bioaccumulation than other finfish probably due to their high lipid content (Table 1). Our findings agreed very well with those of Hope et al. (1997), in which the concentrations of the sum of PCBs in convict tang, yellowfin and damselfish are 108, 526 and 625 ng/g, respectively. It is known that damselfish reside in very small areas, and feed on algae closely associated with the substrate. Several studies show that equilibrium partition governs the concentrations of organochlorines in gill-breathing animals, and thus the ambient levels in water are directly related to the residue levels in the organisms (Bremle and Larsson, 1998b). Damselfish can be an excellent indicator for PCB monitoring in a small area of the remote ocean.

Larsson et al. (1991) reported a high correlation between the concentrations of PCBs, DDE and DDD and the weight and length of eels from a clean Swedish lake. They found that accumulation of pollutants differed in age classes, and they proposed the accumulation of organochlorines be growth dependent. However, de Boer et al. (1994) found no correlation between organochlorines and the weight or length of eels. After eels from the highly contaminated river Rhine were transferred into a clean lake, the concentrations of highly chlorinated PCBs did not decrease over an 8-year period. These studies were conducted in the relatively semi-enclosed aquatic surroundings, such as lakes or rivers, where pollutants were transported slower than in open oceans. On the other hand, eels inhabit a much larger area than small fish, such as damselfish and squirrelfish; hence eels may not be suitable for locating a small PCB-contaminated area, but are a good indicator of areawide contamination.

Higher concentrations of PCBs exist in sediments than in water because of PCBs' high hydrophobicity. Aquatic animals closely associated with the water column (e.g. mussels) usually contain lower PCB concentrations than other aquatic species from the same area that live and feed in the sediment (e.g. benthic fish, crustaceans). This may explain that relatively high total PCB concentrations were found in crabs, even though they have a very low lipid content (Tables 1 and 3). This kind of non-filter-feeding organism may acquire PCBs either by direct contact or by ingesting contaminated sediment or contaminated diet (Meador et al., 1997).

The predominant environmental sources of PCBs in the human diet include contaminated aquatic or marine organisms. The US Food and Drug Administration (FDA) set a Tolerable Daily Intake (TDI) for PCBs of 1 μg/kg body wt., i.e. approximately 60–70 μg/day for a normal adult. With a PCB concentration averaging approximately 10 ppm, a daily fish consumption of only 6 g would correspond to the TDI. The US EPA also set the limit of 2 ppm for PCBs in fish and shellfish (Weihe et al., 1996). Therefore, the sum of PCBs in many samples in this study exceeds the TDI and EPA limit.

3.4. PCB congener distribution patterns

Numbers of PCB congeners detected in the sediment, *P. evermanni*, *G. tenuicrustatus*, *P. marginatus*, *S. fasciolatus*, *N. sammara*, *A. triostegus*, *M. vanicolensis*, *C. cinereus*, *G. flavimarginatus*, *G. undulatus* and *G. meleagris* were 38, 30–37, 39, 27, 38–40, 35–40, 39, 40, 34, 35–36, 34–37 and 34–37, respectively (data not shown). Cl_5- and Cl_6-PCBs, moderately chlorinated congeners, were the most abundant in the tissue samples. PCB congeners 118, 138, and 153 represent 22–25, 32–34, 18, 12–39, 37–46, and 30–55% of the sum of PCBs in the coral, sediment, lobster, fish, crab, and eel, respectively. These congeners were produced in large ratios in certain commercial mixtures (e.g. Aroclor 1254) (Schwartz et al., 1993). These PCBs are less lipophilic than higher chlorinated ones (Cl_8-, Cl_9- and Cl_{10}-PCBs), but are more readily bioavailable to organisms in the surrounding environment because they are not as tightly bound to sediments as the higher chlorinated PCBs (McFarland and Clarke, 1989). Di-*ortho* PCB congeners with chlorines at *para* and *meta* positions in both rings are non-degradable in invertebrates and vertebrates such as fish (Bright et al., 1995b; Kannan et al., 1995) and sea birds (Borlakoglu et al., 1990). The proportion of these congeners in marine species increased slightly with increasing the trophic levels (Oliver and Niimi, 1988). For example, PCBs 118, 138, 153 and 180 share the characteristic of having chlorine atoms in positions 2, 4 and 5 in one (PCBs 118 and 138) or both rings (PCBs 153 and 180). Some di-*ortho* PCBs have much longer half-lives and cannot be biotransformed if the *para* and *meta* positions are occupied (e.g. PCB 153) (Oehme et al., 1996).

PCBs 28, 31, 44, 52, 101, 118, 138, 153, 180 and 194 were selected as indicative congeners to represent different chlorination levels to study their distribution patterns in marine species (Figs. 3 and 5). Less chlorinated congeners 28 and 31 generally made larger individual contributions to the total loading in the sediment and coral than in other marine species. This is mainly due to the water solubility, low biodegradation and absorption to the sediment and coral. PCBs 118, 138 and 153 were among the major congeners in the fish and crab samples. PCB 118 was the main congener in the sediment, coral, fish and crab samples. PCB 138 predominated in the eel samples.

4. Conclusion

SC-CO_2 effectively recovered PCBs from the fortified sediment, coral, crab, lobster, fish and eel samples. There were approximately 27–40 PCB congeners detected in different samples. Results clearly showed that the biota around Tern Island was polluted with PCBs, presumably from local sources, which consist of Arcolor 1254 and (or) similar products. High PCB levels were also detected in the samples collected from the reference site, Disappearing Island. A preferential retention (profile) of PCBs was found in the species at different trophic levels. The ratios of less chlorinated PCBs to total PCBs in corals were high relative to those detected in the fish, crab, lobster and eel. Damselfish can be used as an indicator for PCB monitoring in a small site of the remote ocean because of their bioaccumulative potential for PCBs, and localized behavior.

Acknowledgements

The work was funded by the US Fish and Wildlife Service (USFWS). We thank K. Foster in USFWS-Honolulu for specimen collection, D. Palawski in USFWS-Honolulu for helpful discussion and project support. We also thank M. Park, D. Miyahira and C. Tomas in this laboratory for their assistance on some sample extraction and cleanup.

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