The Swedish Dioxin Survey: Summary of Results From PCDD/F and Coplanar PCB Analyses in Biota

C.A. de Wit[A], U.G. Järnberg[A], L.T. Asplund[A], B. Jansson[A], M. Olsson[B], T. Odsjö[B], I.L. Lindstedt[C], Ö. Andersson[D], S. Bergek[E], M. Hjelt[E], C. Rappe[E], A. Jansson[F], M. Nygren[F]
[A]Institute of Applied Environmental Research, Stockholm University, S-171 85 Solna, Sweden
[B]Swedish Museum of Natural History, Box 50007, S-104 05 Stockholm, Sweden
[C]Department of Zoology, Section of Morphology and Systematics, University of Göteborg, Box 25059, S-400 31 Göteborg, Sweden
[D]National Food Administration, Box 622, S-751 26 Uppsala, Sweden
[E]Institute of Environmental Chemistry, Umeå University, S-901 87 Umeå, Sweden
[F]National Defense Research Establishment, S-901 82 Umeå, Sweden

INTRODUCTION

The Swedish Environmental Protection Agency has conducted a survey from 1988 to 1993 to determine the levels and sources of polychlorinated dioxins and furans and related substances into the Swedish environment[1]. Within the survey, numerous samples from biota have been analyzed for PCDD/F as well as for several coplanar PCB. These samples were analyzed to study geographical distribution, time trends, bioaccumulation, biomagnification as well as the effect of age, size and sex on body concentrations. Some of these results are summarized below. No attempts have been made to compare these to results from similar studies.

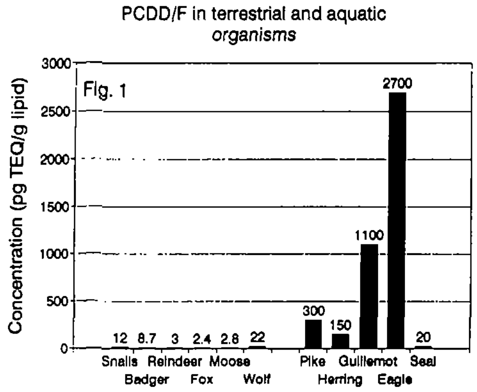
MATERIALS AND METHODS

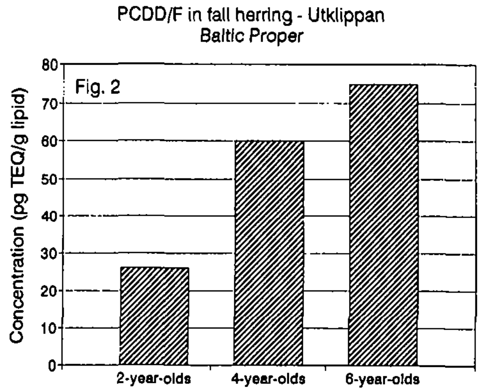
For PCDD/F, TCDD equivalents have been calculated according to the Nordic model (NTEQ)[2]. The PCB congeners analyzed were 3,3',4,4'-tetrachlorobiphenyl (CB 77), 3,3',4,4',5-pentachlorobiphenyl (CB 126), 3,3',4,4',5,5'-hexachlorobiphenyl (CB 169), 2,3,3',4,4'-pentachlorobiphenyl (CB 105) and 2,3',4,4',5-pentachlorobiphenyl (CB 118). PCB-TEQ values have been calculated using the WHO-IPCS TEF model[3].

Samples were collected from terrestrial and aquatic ecosystems in and around Sweden. The samples analyzed include numerous fish and shellfish species such as herring, pike, burbot, whitefish, Arctic char, salmon, trout, plaice, mackerel, cod, crab, lobster and mussels. The following fish-eating birds have been studied: guillemot, white-tailed sea eagle and osprey. Terrestrial animals studied included wolf, fox, moose, reindeer, badger, otter, rabbit and snails. The marine mammals studied included grey, common, harp and ringed seal and common porpoise. Crabeater seal from Antarctica were also studied. The collection sites represent hot spots, areas with diffuse pollution, less industrialized areas and remote areas.

RESULTS AND DISCUSSION

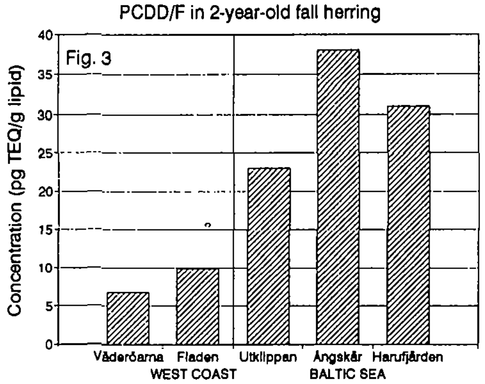
Generally speaking, PCDD/F and coplanar PCB concentrations are much lower in terrestrial animals than in animals from aquatic ecosystems (Fig. 1). Organisms from the Baltic Sea have some of the highest concentrations, however, remarkably low levels were found in seals.

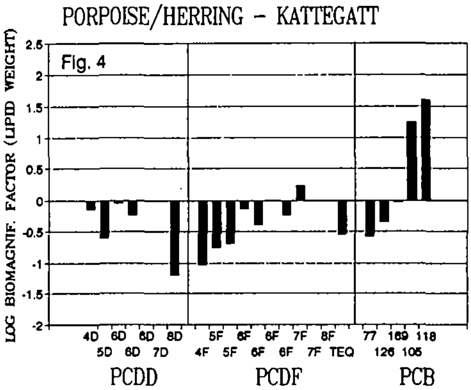




Herring collected in the spring have a lower fat content than those collected in the fall leading to higher lipid weight PCDD/F and coplanar PCB concentrations in the spring herring. Younger and smaller herring have lower PCDD/F and coplanar PCB concentrations than older and larger herring (Fig. 2).

Herring homogenates (mixed age classes) from different collection sites along the Swedish coast of the Baltic Sea and the west coast have been analyzed for PCDD/F and coplanar PCBs. The majority of these samples were taken close to the coasts. PCDD/F and coplanar PCB concentrations in Baltic herring are both fairly similar from north to south. Mean PCDD/F and coplanar PCB concentrations were the same, 150 pg NTEQ and PCB-TEQ/g lipid. Herring samples collected near the Bothnian sea coast often contain higher relative levels of 2,3,7,8-TeCDF and 2,3,7,8-TeCDD, two specific PCDD/F that are associated with effluents from paper bleaching. Numerous kraft pulp mills are located along this stretch of the Swedish coast. Herring collected from Kattegat and Skagerrak on the Swedish west coast have lower mean PCDD/F and coplanar PCB concentrations, 24 pg NTEQ/g lipid and 11 pg PCB-TEQ/g lipid, respectively.





To better study geographical trends, homogenates of 2-year-old fall herring from five environmental monitoring stations were also analyzed for PCDD/F. These stations represent background stations in the Baltic Sea and the west coast and are as far from local sources as possible. The stations are at Harufjärden (Bothnian Bay), Ängskär (Bothnian Sea), Utklippan (Baltic Proper), Fladen (Kattegat) and Väderöarna (Skagerrak). These results confirm that PCDD/F concentrations are higher in the Baltic Sea than in Kattegatt/Skagerak (Fig. 3).

Pike are stationary fish and thus representative of the sampling area. A good correlation was found between concentrations of PCDD/F and coplanar PCB in pike and in surficial sediments collected from the same site. Pike collected from remote areas had the lowest PCDD/F concentrations (36-90 pg NTEQ/g lipid). In lakes and rivers with many diffuse sources, PCDD/F concentrations were higher (150-400 pg NTEQ/g lipid). The highest concentrations of PCDDs and especially PCDFs were found in pike collected just outside chloralkali industries (400-1400 pg NTEQ/g lipid). The levels of coplanar PCB-TEQs were much the same as levels of PCDD/F TEQs except where PCB pollution was known to have occurred. Samples of muscle and liver from the same individuals had similar concentrations of PCDD/F on a lipid weight basis.

Pike and burbot were studied from the mouths of 3 rivers (Råne älv, Kalix älv, Torne älv) along the northern coast of Bothnian Bay, two of which have been polluted by industrial discharges. Reduced fertility in burbot has been reported from one of these polluted rivers. PCDD/F concentrations were found to not differ in burbot and pike from all three sites.

Seal blubber homogenates were analyzed from common seal (Baltic Proper, Kattegatt), ringed seal (Bothnian Bay, Arctic), grey seal (Baltic Proper) and crabeater seal (Antarctic). Ringed seal from the Arctic and crabeater seal from Antarctica included samples from each sex and different age groups. Ringed seal from Bothnian Bay included samples from yearlings and adult females. Most other samples were taken from yearlings. PCDD/F concentrations in the Antarctic seals were less than 1 pg NTEQ/g lipid. PCDD/F concentrations in seals from the northern hemisphere are similar independent of sampling site, sex or age, about 15-25 pg NTEQ/g lipid[4,5]. These PCDD/F levels are fairly low and indicate that seals do not biomagnify these substances. These levels can be compared to the higher levels found in herring, a major part of the diet of many seal species (Fig. 1). Herring from the Baltic Proper have average PCDD/F levels around 150 pg NTEQ/g lipid. The coplanar PCB (CBs 77, 126 and 169) also do not biomagnify in seals. This indicates lower uptake or that seals are able to metabolize PCDD/F and coplanar PCB and eliminate them.

PCDD/F do not biomagnify in the common porpoise, similar to the finding for seals (Fig. 4). The PCDD/F concentrations are 1-4 pg NTEQ/g lipid in porpoise blubber from Kattegat/Skagerrak and 6-7 pg NTEQ/g lipid in individuals from the Baltic Proper. No obvious relationship was seen between PCDD/F concentrations and age or sex. The non-*ortho* coplanar PCBs (PCB 77, 126 and 169) also do not biomagnify, whereas the mono-*ortho* PCBs 105 and 118 do.

Fish-eating birds do seem to biomagnify PCDD/F and coplanar PCB however. The levels in guillemot (Fig. 5), osprey and white-tailed sea eagle are much higher than in the fish species they feed on. Guillemot eggs collected in 1990 from the island of Stora Karlsö in the Baltic Proper have PCDD/F concentrations of 1100 pg NTEQ/g lipid and the coplanar PCB-TEQ is 5100 pg/g lipid.

Mean PCDD/F concentrations in white-tailed sea eagle eggs from the Baltic Proper are 2700 pg NTEQ/g lipid and coplanar PCB-TEQ is 8900 pg/g lipid. For comparison purposes, white-tailed sea eagle eggs from Lapland, which is a background area receiving PCDD/F primarily via atmospheric input, contain much lower PCDD/F concentrations, 210 pg NTEQ/g lipid. Coplanar PCB concentrations were 580 pg PCB-TEQ/g lipid in the Lapland eagle eggs. The PCDD/F and coplanar PCB concentration in ospreys is dependent on age (adults, fledglings) and geographical location (northern, middle or southern Sweden). The highest concentrations are found in adults from southern Sweden, especially for the coplanar PCBs. Thus, piscivorous birds may be at more risk than seals for effects related to high concentrations of PCDD/F and coplanar PCB.

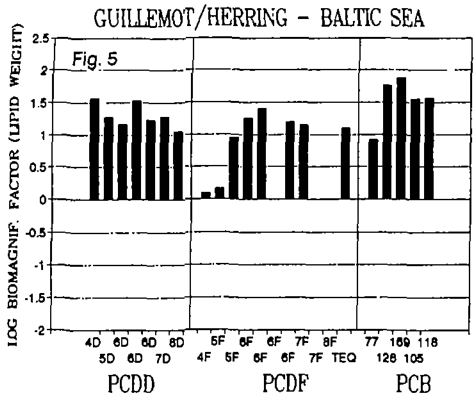
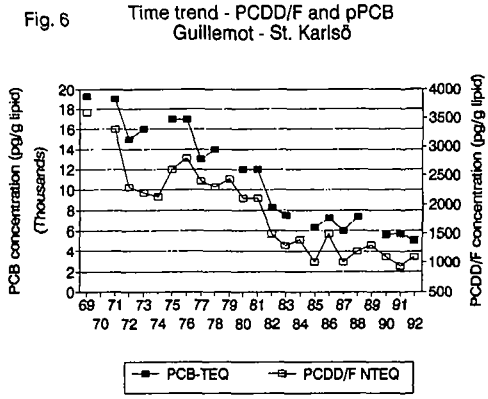


Fig. 6



PCDD/F and coplanar PCB were analyzed in homogenates of guillemot eggs (Fig. 6) collected from St. Karlsö in the Baltic Proper from 1969 to 1992 and in homogenates of pike from Lake Storvindeln in Lapland collected from 1968 to 1992. The concentrations have decreased in both species during this time period. This indicates that actions taken in numerous countries in the 1970s such as banning PCB, pentachlorophenol and 2,4,5-T has led to reduced inputs of PCDD/F and coplanar PCB to the environment.

REFERENCES

1. de Wit, C.A., Jansson, B. and Strandell, M. (1989) Swedish dioxin survey. Chemosphere 19: 497-500.
2. Ahlborg, U.G. (1989) Nordic risk assessment of PCDDs and PCDFs. Chemosphere 19: 603-608.
3. Ahlborg, U.G., Becking, G.C., Birnbaum, L.S., Brouwer, A., Derks, H.J.G.M., Feeley, M., Golor, G., Hanberg, A., Larsen, J.C., Liem, A.K.D., Safe, S.H., Schlatter, C., Wærn, F., Younes, M. and Yrjänheikki, E. (1994) Toxic equivalency factors for dioxin-like PCBs: Report on a WHO-ECEH and IPCS consultation, December 1993. Chemosphere 28: 1049-1067.
4. Bignert, A., Olsson, M., Bergqvist, P-A., Bergek, S., Rappe, C., de Wit, C. and Jansson, B. (1989) Polychlorinated dibenzo-p-dioxins (PCDD) and dibenzofurans (PCDF) in seal blubber. Chemosphere 19: 551-556.
5. Bergek, S., Bergqvist, P-A., Hjelt, M., Olsson, M., Rappe, C., Roos, A. and Zook, D. (1992) Concentrations of PCDDs and PCDFs in seals from Swedish waters. Ambio 21: 553-556.