PCB's

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POLYCHLORINATED BIPHENYLS (PCB)

Polychlorinated biphenyls (PCB) consist of a mixture of compounds only slightly soluble in water; highly soluble in fats, oils, and nonpolar liquids; and highly resistant to both heat and biological degradation. PCB have a wide variety of industrial uses, primarily as insulating fluid in electrical and heat transfer equipment (Interdepartmental Task Force 1972).[311]

Exposure to PCB is known to cause skin lesions (Schwartz and Peck (1943)[320] and to increase liver enzyme activity that may have a secondary effect on reproductive processes (Risebrough et al. 1968,[317] Street et al. 1969,[321] Wassermann et al. 1970[323]). It is not clear at this time whether the effects are due to PCB or its contaminants, the chlorinated dibenzofurans that are highly toxic (Bauer et al. 1961,[307] Schulz 1968,[319] Verrett 1970[324]). It is also not known whether the chlorinated dibenzofurans are produced by degradation of PCB as well as during its manufacture.

The occurrence of PCB in our waters has been documented [illegible] (Mon. Science 1966,[313] Holmes et al. 1967,[310] Risebrough et al. 1968,[317] Jensen et al. 1969,[312] Koeman et al. 1969,[313] Schmidt et al. 1971,[318] Veith and Lee 1971[322]). They have been associated with sewage effluents (Holden 1970,[309] Schmidt et al. 1971[318]) and rainwater (Turrant and Tatton 1963),[322] as well as releases and leakage. Failures of closed systems using PCB have caused some of the more well known releases (Kuratsune et al. 1969,[314] Duke et al. 1970[308]). It has been reported that the defined treatment process does little or nothing to remove PCB (Ahling and Jensen 1970).[306]

An epidemiological study on severe poisoning by rice oil contaminated with polychlorinated biphenyls in 1968 indicated that about 0.5 grams ingested over a period of approximately one month was sufficient to cause the *Yusho* disease. Many of those affected showed no signs of relief after about three years (Kuratsune et al. 1969).[314] Price and Welch (1971)[318] have estimated on the basis of 194 samples that 41 to 45 per cent of the general population of the U.S. may have PCB levels of 1.0 mg/kg or higher (wet weight) in adipose tissue. Therefore, it appears that PCB may accumulate in the body. On this basis it can be calculated that a daily intake of 0.02 mg would require about 70 years to be toxic. Applying a factor of safety of 10 would permit a daily intake of 0.002 mg, and assuming a two liter per day intake, suggests a permissible concentration in water to be 0.001 mg/l.

However, evaluation of the retention and accumulation of PCB from water instead of oil in humans is highly desirable. A study on rats with a single oral dose of 170 mg/kg showed urinary excretion of PCB to be limited, while 70 per cent of the dose was found in the feces during an eight week period (Yoshimura et al. 1971).[326] Information on PCB in the diet would also be helpful.

Conclusion

Because too little is known about the levels in waters, the retention and accumulation in humans, and the effects of very low rates of ingestion, no defensible recommendation can be made at this time.

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Polychlorinated Biphenyls (PCB) Polychlorinated biphenyls are chlorinated hydrocarbons which are highly resistant to chemical or biological degradation. They have been widespread environmental contaminants (Jensen et al. 1969,[196] Risebrough et al. 1968[390]). Their biological effects at present environmental concentrations are not known. PCB's can elevate microsomal enzyme activity (Risebrough et al. 1968.[390] Street et al. 1968[394]), but the environmental significance of that finding is not clear. The toxicity of PCB is influenced by the presence of small amounts of contaminated chlorinated dibenzofurans (Vos and Koeman 1970,[396] Vos et al. 1970[397]) which are highly toxic to developing embryos.

Recommendation

Because of the persistence of PCB and their susceptibility to biological magnification, it is recommended that the body burdens of PCB in birds and mammals not be permitted to increase and that monitoring programs be instituted (see Section IV).

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TABLE III-14—Acute Toxicity of Di-n-butyl Phthalate to Four Species of Fish and Daphnia Magna.

Species	Temperature	LCM in µg/l 24 hr	48 hr	96 hr
Fathead minnow (Pimephales promelas)		.....	1196	1300 (Stalling)[illegible]
Bluegill (Lepomis macrochirus)		1230	731	731 (Stalling)[illegible]
Channel catfish (Ictalurus punctatus)		3230	2910	2910 (Stalling)[illegible]
Rainbow trout (Salmo gairdneri)		.....	.....	6470 (Sanders)[illegible]
Daphnia magna		.....	.....	>5000 (Sanders)[illegible]

POLYCHLORINATED BIPHENYLS

Polychlorinated biphenyls (PCB) have been found in fish and wildlife in many parts of the world and at levels that may adversely affect aquatic organisms (Jensen et al. 1969;[374] Holmes et al. 1967;[375] Koeman et al. 1969;[378] Risebrough et al. 1968).[386] The environmental occurrence, uses, and present toxicological aspects of PCB were recently reviewed by Peakall and Lincer (1970),[394] Gustafson (1970),[372] Risebrough (1970),[387] and Reynolds (1971).[393]

Biphenyls may have 1 to 10 attached chlorine atoms, making possible over 200 compounds (Gustafson 1970).[372] PCB occur as residues in fish, and presumably also in water, as mixtures of chlorinated biphenyl isomers as shown in Table III-15 (Stalling and Johnson, *unpublished data* 1970,[374] Stalling *in press*[392]).

Analysis of PCB has been accomplished by gas chromatography after separation of PCB from pesticides. A separation method has been described by Armour and Burke (1970)[392] and modified by Stalling and Huckins (1971).[391] A method using separation on a charcoal column has shown good reproducibility (Frank and Rees, *personal communication*).[395] No standardized gas-liquid chromatography method has been proposed for the analysis of mixtures of PCB in environmental samples. The solubility of these formulations in water has not been precisely determined, but it is in the range of 100 to 1,000 µg/l (Papageorge 1970).[393] Since PCB have gas chromatographic characteristics similar to many organochlorine pesticides, they can cause serious interference in the gas chromatographic determination of chlorinated insecticides (Risebrough et al. 1968).[386]

The Monsanto Company, the sole manufacturer of PCB

TABLE III-15—Composition of PCB Residues in Selected Fish Samples from the 1970 National Pesticide Residue Monitoring Program

River	Location	Species	PCB Residue as Aroclor® type (µg/g whole body) 1232	1240	1254	1260	Total
Ohio	Cincinnati, O.	Carp Cyprinus carpio	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Ohio	Cincinnati, O.	White crappie Pomoxis annularis	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Ohio	Marietta, O.	Channel catfish Ictalurus punctatus	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Ohio	Marietta, O.	Channel catfish	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Tarbe	Edwards, Miss.	Smallmouth buffalo Ictiobus bubalus	[illegible]	.....	[illegible]	.....	[illegible]
Hudson	Poughkeepsie, N.Y.	Goldfish Carassius auratus	[illegible]	[illegible]	[illegible]	.....	[illegible]
Allegheny	Natrona, Pa.	Walleye Stizostedion vitreum n.	.....	[illegible]	[illegible]	[illegible]	[illegible]
Delaware	Camden, N.J.	White perch Roccus americanus	.....	[illegible]	[illegible]	[illegible]	[illegible]
Cape Fear	Elizabeth Town, N.C.	Gizzard shad Porosomus cepedianum	[illegible]	.....	[illegible]	[illegible]	[illegible]
Lake Ontario	Port Ontario, N.Y.	White perch	[illegible]	.....	[illegible]	[illegible]	[illegible]
Mississippi	Memphis, Tenn.	Drum Aplodinotus grunniens	[illegible]	.....	[illegible]	[illegible]	[illegible]
Merrimac	Lowell, Mass.	Drum	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

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[illegible] Aroclor® 1242 [illegible] They are [illegible] [illegible] Aroclor® 1242 [illegible] and [illegible] 1248 [illegible] are [illegible] under the trademark [illegible] and a mixture of bi- and terphenyl [illegible] 4465. The isomer composition and chromatographic characteristics of each formulation have been described by Stalling and Huckins (1971)[371] and Bagley et al. (1970).[370] A contaminant of some PCB, especially those manufactured in Europe, are chlorinated dibenzofurans (*Brunge personal communication* 1972).[373] Although these byproducts would appear to be extremely toxic, no data are available on their toxicity to aquatic life.

Direct Lethal Toxicity

Studies of toxicity of PCB to aquatic organisms are limited. They show considerable variation of toxicity to different species, as well as variation with the chlorine content of the PCB. Nevertheless, some trends in the toxic characteristics have become apparent, principally from the work of Mayer as described below:

- The higher the per cent chlorine, the lower the apparent toxicity of PCB to fish (Mayer, *in press*).[379] This was found in 15-day intermittent-flow bioassays using bluegills (*Lepomis macrochirus*) and channel catfish (*Ictalurus punctatus*) with Aroclor® 1242, 1248, 1254. All LC50 values were in the range 10 to 300 μg/l.
- The bluegill/channel catfish experiments also illustrated that all LC50 values decreased significantly when exposures continued from 15 to 20 days. The 96-hour LC50 of a PCB to fish cannot adequately measure its lethal toxicity.
- The same tests showed that the toxicity of Aroclor® 1248 doubled when the temperature was raised from 20 C to 27 C.

To invertebrates, Aroclor® 1242 has about the same acute toxicity that it has to fish. In 4- and 7-day tests (Saunders, *in press*),[380] it killed *Gammarus* at 42 μg/l and crayfish (*Cambarus*) at 30 μg/l, with values that were similar to the 15-day LC50 reported for bluegills. However, there [illegible] an extreme range in the reported short-term lethal levels [illegible] Aroclor® 1254 for invertebrates. Saunders (*in press*)[379] [illegible]ported a 96-hour LC50 as 80 μg/l for crayfish and only [illegible] μg/l for glass shrimp (*Paleomonetes*) in 7-day tests; and [illegible] al. (1970)[371] reported that as little as 0.94 μg/l [illegible] mature pink shrimp (*Panaeus duorarum*). Part of this [illegible] related to exposure periods in the tests; part [illegible]

[illegible] water ones ([illegible] section IV). [illegible] and *Leiostomus* [illegible] were [illegible] for [illegible] days to Aroclor® 1254, mortalities were [illegible] [illegible] μg/l (Hansen, et al. 1971).[illegible] This indicates [illegible] toxicity about five times greater than summarized [illegible] for [illegible] fish but [illegible] at the same as the toxicity for the marine crustaceans mentioned above.

Feeding Studies

Dietary exposure to PCB seems to be less of a direct hazard to fish than exposure in water. Coho salmon (*Oncorhynchus kisutch*) fed Aroclor® 1254 in varying amounts up to 14,500 μg/kg body weight per day accumulated whole body residues which were only 0.9 to 0.5 of the level in the food after 240 days of dietary exposure. Growth rates were not affected. However, all fish exposed to the highest treatment died after 240 days exposure; and thyroid activity was stimulated in all except the group treated at the lowest concentration (Mehrle and Grant *unpublished data* 1971).[374]

At present, evaluation of data from laboratory experiments indicates that exposures to PCB in water represents a greater hazard to fish than dietary exposures. However, in the environment, residue accumulation from dietary sources could be more important, because PCB have a high affinity for sediments, and therefore, they readily enter food chains (Duke et al. 1970;[371] Nimmo, et al. 1971).[385]

Residues in Tissue

It is clear that widespread pollution of major waterways has occurred, and that appreciable PCB residues exist in fish. When analyses of 40 fish from the 1970 National Pesticide Monitoring Program were made, only one of the fish was found to contain less than 1 μg/g PCB (Stalling and Mayer 1972).[380] The 10 highest residue levels in the 40 selected fish ranged from 19 μg/g to 213 μg/g whole body weight.

By contrast, residues measured in ocean fish have been generally below 1 μg/g (Risebrough 1970;[387] Jensen, et al. 1969).[376] Between the ranges in freshwater fish and those in marine fish are the levels of PCB found in seals (Jensen et al. 1969;[378] Holden 1970),[374] and in the eggs of fish-eating birds in North America (Anderson et al. 1969;[382] Mulhern et al. 1971;[380] Reynolds 1971).[385]

In laboratory experiments, crustacea exposed to varying levels of Aroclor® 1254 in the water concentrated the PCB within their bodies more than 20,000 times. The tissue residues may sometimes reach an equilibrium, and in *Gammarus fasciatus* PCB did not concentrate beyond 27,000 times despite an additional 3-week exposure to 1.6 μg/l Aroclor® (Saunders 1972).[388] In contrast, PCB residues in crayfish did not reach equilibrium after a 28-day exposure.

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[illegible] by two [illegible] and [illegible] *xanthurus*, [illegible] [illegible] exposure levels in water [illegible] [illegible] to [illegible] that these [illegible] at water concentrations of PCB that killed the [illegible] to [illegible] days.

Also similar were the accumulation ratios of 20,[illegible] to 56,000 for bluegills (*Lepomis macrochirus*) chronically exposed to 2 to 15 µg/l of Aroclor® 1248 and 1254. Fathead minnows (*Pimephales promelas*) chronically exposed to Aroclor® 1242 and 1254 for 8 weeks concentrated PCB 100,000 and 200,000 times the exposure levels, respectively. Residues of 50 µg/l (whole body) resulted from exposure for 8 weeks to 0.3 µg/l Aroclor® 1254 (Nebeker et al. 1972).[381] These experiments with bluegills also indicated that the maximum levels of PCB were generally related to the concentration of PCB in the water (50,000–200,000 times higher) to which they were exposed (Stalling and Huckins *unpublished data* 1971).[397]

Effects on Reproduction

PCB residues in salmon eggs are apparently related to mortality of eggs. In preliminary investigations in Sweden, Jensen and his associates (1970)[377] reported that when residues in groups of eggs ranged from 0.4 to 1.9 µg/g on a whole-weight basis (7.7 to 84 µg/g on a fat basis), related mortalities ranged from 10 per cent up to 100 per cent.

PCB concentrations in the range of 0.5 to 10 µg/l in water interfered with reproduction of several aquatic animals according to recent work of Nebeker et al. (1971).[381] About 5 µg/l of Aroclor® 1248 was the highest concentration that did not affect reproduction of *Daphnia magna* and *Gammarus pseudolimnaeus*. In tests of reproduction by fathead minnows (*Pimephales promelas*) all died when exposed chronically to greater than 8.3 µg/l of either Aroclor® 1242 or Aroclor® 1254. Reproduction occurred at and below 5.4 µg/l Aroclor® 1242, and at and below 1.8 µg/l of Aroclor® 1254.

The association between residue levels and biological effects in aquatic animals is scarcely known, but the work of Jensen et al. (1970)[377] suggested that about 0.5 µg/g of PCB in whole salmon eggs might be the threshold for egg mortality. Such a level in eggs would be associated with levels in general body tissue (e.g., muscle) of 2.5 to 5.0 µg/g. The residue in muscle corresponded to the present Food and Drug Administration level for allowable levels of PCB in fish used as human food. Residues measured in the survey by the 1970 National Pesticide Monitoring Program were generally above 5 µg/g.

Applying a minimal safety factor of 10 for protection of the affected population, and for protection of other species higher in the food chain, would yield a maximum permissible tissue concentration of 0.5 µg/g in any aquatic organism in any habitat affected by PCB.

General Considerations and Further Needs

Another means of control would be justified in view of the [illegible] of PCB, the lack of [illegible] about how it first [illegible] natural ecosystems as a pollutant, and its apparent distribution [illegible] concentrations in freshwater fish in the United States. This method would be to regulate the manufacture of PCB and maintain close control of its uses to avoid situations where PCB is lost to the environment. The Monsanto Company recently restricted the sale of PCB for uses in which disposal of the end products could not be controlled, as with plasticizers (Gustafson 1970).[377]

Basis for Recommendations

For PCB levels in water, the most sensitive reaction shown by aquatic organisms is to the lethal effects of low concentrations continually present in water for long periods (weeks or months). Concentrations in the range of 1 to 8 µg/l have been shown to be lethal to several animals.

The work of Hansen, et al. (1971)[373] and Stallings and Huckins (*unpublished data* 1971)[391] indicates that concentrations of 0.01 µg/l of PCB in water over periods of up to 36 weeks could lead to dangerous levels of PCB in the tissues of aquatic organisms. Accumulation by factors of 75,000 to 200,000 times is indicated by their work. If the higher ratio is taken, 0.01 µg/l in water might result in 2.0 µg/g in flesh on whole fish basis. This is comparable to the residue level in salmon eggs associated with complete mortality of embryos. Therefore, a concentration is recommended that is reduced by a factor of 5, or 0.002 µg/l. In addition, a control based on residue levels is required, as well as one based on PCB in the water.

Recommendations

Aquatic life should be protected where the maximum concentration of total PCB in unfiltered water does not exceed 0.002 µg/l at any time or place, and the residues in the general body tissues of any aquatic organism do not exceed 0.5 µg/g.

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TOXIC ORGANICS

The toxic organics constitute a considerable variety of chemical compounds, almost all of which are synthetic. The total production of synthetic organic chemicals in the U.S. in 1968 was 120,000 million pounds, a 15 per cent increase over 1967; 135,000 million pounds were produced in 1969, a 12 per cent increase over 1968 (United States Tariff Commission 1970).[477] This figure, in the order of 5×10^{14} grams, may be compared with the total productivity of the sea, which is in the order of 2×10^{18} grams of carbon incorporated into phytoplankton per year (Ryther 1969).[373] When considered in a global and future context, the production of synthetic chemicals by man cannot be considered an insignificant fraction of nature's productivity.

The majority of the synthetic organic chemicals, including those considered toxic, are readily degradable to elementary materials which reenter the chemical cycles in the biosphere. These pose no long-term hazard if applied or released into the environment in quantities sufficiently small to meet the recommendations for mixing zones (see p. 51).

[illegible] pounds that enter the environment, whether they are introduced incidentally as waste materials or deliberately through their use. The toxicity, chemical stability, and resistance to biological degradation of such chemicals are factors that must be considered in assessing their potential effects on ecosystems. Moreover, because of the partitioning of nonpolar compounds among the components of marine ecosystems, relatively high concentrations of these, including halogenated hydrocarbons, are frequently found in organisms.

Only recently it was discovered that polychlorinated biphenyls (PCB), a class of chlorinated hydrocarbons used in a variety of industrial applications, were widespread contaminants in marine ecosystems (Duke et al.).[illegible] Concentrations up to or higher than 10.0 ppm in the body fat of estuarine birds have been recorded in both Europe and North America (Risebrough et al. 1968,[371] Jensen et al. 1969[illegible]). Moreover, both DDT and PCB have been found in organisms from depths of 3200 meters in the open North Atlantic Ocean (Harvey et al. 1972).[illegible]

The discovery of a man-made contaminant such as PCB, unknown in the environment a few years ago, in such unexpectedly high concentrations in marine organisms raises several questions. Are the concentrations of these compounds still increasing in the marine environment and at what rate, and what are the long-term effects upon the marine communities? Is it possible that other pollutants, undetected by the methodology that measures the chlorinated hydrocarbons, are present in comparable [illegible]?

Criteria employed in the past to protect free-water ecosystems were based on data now seen to be inadequate and on an approach that looked at pollutant concentrations in waste water effluents rather than in the receiving system. Evidently it is necessary to attempt to relate the amounts of input into the ecosystem to the levels in the various components of the ecosystem, including indicator organisms. The concentrations of a persistent pollutant in an indicator organism are considered the best way of following accumulation trends in an aqueous ecosystem that serves as a sink for the pollutant, once the capacity of the ecosystem to absorb the pollutant has been determined. If the concentrations in the indicator organisms exceed those considered safe for the ecosystem, input should then be reduced, restricted, or eliminated until environmental levels are acceptable on the basis of established criteria. Inputs of persistent pollutants into the marine environment, however, are in many cases indirect and not immediately controllable, e.g. river runoffs, atmospheric fallout, and dumping by foreign and domestic ships. The sources of the chemicals in atmospheric fallout may be located anywhere in the world.

Different recommendations must therefore be developed to protect the marine environment from increasing amounts and varieties of organic pollutants that might be anticipated over the next century. The same recommendations may be applied to estuaries, but these must also be protected from a variety of chemicals that are less persistent and pose no long-term hazard, but that may, because of toxic effects upon organisms, cause unacceptable amounts of damage. These include many of the pesticides, components of sewage, biological wastes from slaughter houses, and other organic wastes from industry.

Acute toxicity values and subacute effects of pesticides on marine life are listed in Appendix III–Table 6, and in Table IV–7, p. 163. Table IV–6 is a summary of the "most sensitive" organisms taken from Appendix III–Table 6 and includes a list of chemicals that are considered to have potential environmental importance in estuarine or marine ecosystems. The list includes many of the pesticides that are readily degradable in the environment but because of their high toxicity are potentially dangerous to estuarine ecosystems. The list, which should be revised as new data become available, proposes a minimum number of such chemicals. Appendix III–Table 6 includes the following information relative to the potential importance of each material as coastal and marine contaminants. (a) Production figures, which are taken from the 1969 Tariff Commission reports, are listed in the second column. The production figures provide a useful clue to the compounds that are of potential importance as marine pollutants. The order of the chemicals generally follows that of the Tariff Commission reports and is not intended to be a ranking in order of importance. (b) The third column of the table indicates

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[illegible] has been detected in [illegible] water or in marine organisms. Compounds which have been detected are of greater immediate concern than those which have not. [redacted] their low solubility in water, [redacted] compounds which are biologically [redacted] in an organism but not in the water [redacted] (c) The fourth column, trophic accumulation, indicates whether the compound has been shown to pass through the food web from prey species to predator. Compounds that are so accumulated are of greater concern than compounds of comparable toxicity which are not. Finally, the species thought to be most sensitive to the compound are indicated in the final columns with reference to original studies in the scientific literature. These data are useful as a guide only and are not sufficient in themselves for definitive evaluation of the environmental significance of each compound.

The report, "The Effects of Chemicals on Aquatic Life, vol. 3, Environmental Protection Agency, Water Quality Office, 1971," has been useful as a guide to the available toxicity data of industrial chemicals on marine organisms. Appendix III–Table 6 is a compendium of data on toxicity of pesticides to marine organisms. These sources are incomplete and should be continually revised.

Bases for Recommendations

1. In order to provide an adequate level of protection for commercially important marine species and for species [redacted] Section III, p. 40.) It assumes that a concentration of one one-hundredth (0.01) of that causing harm to the most sensitive species to be protected will not damage this species or the ecosystem. Future studies may show that the application factor must be decreased or increased in magnitude.

2. The application factor may also be used for the compounds that are trophically accumulated in food webs in order to protect fish and invertebrates to which these compounds are toxic. It cannot be used, however, to protect fish-eating birds and mammals which may trophically accumulate these compounds from their prey species, in part because sublethal effects [redacted] hormone imbalance may adversely affect reproductive capacity and therefore the long term survival of populations. Levels that would protect fish-eating birds and mammals against the effects of compounds that are trophically accumulated from prey species are given in the discussion of Marine Wildlife (see pp. 31–43).

The recommendations below apply to all organics of both proved and potential toxicity.

Recommendations

In general, marine life with the exception of fish-eating birds and mammals should be protected with [illegible] maximum concentration of the chemical in [illegible] does not exceed one one-hundredth (0.01) of the LC50 values listed in Column 7, Table IV-7, p. 158. If new data indicate that an ecosystem can adequately degrade a particular pollutant, a higher application factor for this pollutant may be used.

In order to maintain the integrity of the ecosystem to the fullest possible extent, it is essential to consider effects on all non-target organisms when applying pesticides to estuarine habitats in order to control one or more of the noxious species. For those occasions when chemicals must be used, the following guidelines are offered:

- a compound which is the most specific for the intended purpose should be preferred over a compound that has broad spectrum effects;
- a compound of low persistence should be used in preference to a compound of greater persistence;
- a compound of lower toxicity to non-target organisms should be used in preference to one of higher toxicity;
- water samples to be analyzed should include all suspended particulate and solid material: residues associated with these should therefore be considered as present in the water;
- when a derivative such as p,p'-DDE or 1-napthol is measured with or instead of the parent compound, the toxicity of the derivative should be considered separately: if the toxicity of a derivative such as an ionic species of a pesticide is considered equivalent to that of the original parent compound, concentrations should be expressed as equivalents of the parent compound.

It is recommended that the chemicals listed in Table IV-7 and all chemicals subsequently added to this list be considered as toxic organic compounds potentially harmful to the marine environment. It is emphasized that the data in Table IV-7 are not sufficient in themselves for final evaluation of the environmental significance of each compound.

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Section [illegible] Tables IV-1 and IV-2

TABLE IV-[illegible] [illegible] Aquatic Species [illegible]

Chemical (1)	Bioconcentration factor (2)	Concentration measured (3)	Duration (4)	Species (5)	Life stage (6)	Test type (7)	Effect (8)	Test conditions (9)	Reference (10)
Cyclic compounds, cont.									
				Invertebrate crustacean (Mysidopsis bahia)	[illegible]	S	LC-50	[illegible]	[illegible]
[illegible]	Not available	Unlikely	Unlikely	Crustacean (Daphnia magna)	[illegible]	U	LC-50	[illegible]	[illegible]
[illegible]	Not available	Unlikely	Unlikely	Trichoplax adhaerens (Reichert)	[illegible]	U	LC-50	[illegible]	[illegible]
[illegible]	Not available	Unlikely	Unlikely	Invertebrate data					
[illegible]	Not available	Unlikely	Unlikely	Cyprinodon variegatus (Lowefish)	.....	S	Acetylcholinesterase activity in brain, muscle, gonads, liver	[illegible]	[illegible]
[illegible]	Not available	Unlikely	Unlikely	Crassostrea virginica (Eastern oyster)	.....	4	LC-50	[illegible]	[illegible]
[illegible]	Not available	Unlikely	Unlikely	Crassostrea virginica (Eastern oyster)	.....	1,300	TLM	[illegible]	[illegible]
[illegible]	Not available	Unlikely	Unlikely	Crassostrea virginica	.....	>1x10^6	TLM	[illegible]	[illegible]
Dyestuff synthesis									
[illegible]	4.8x10^6	Unknown	Unknown	Marinogorgia dichotoma (Horny coral)	.....	100	TLM	[illegible]	[illegible]
[illegible]	3.6x10^6	Unknown	Unknown	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Fuel and fuel additives									
Benzene	1.7x10^1 est.	Unknown	Unknown	Insufficient data					
Toluene	3.8x10^1 est.	Unknown	Unknown	Insufficient data					
Xylene	3.8x10^1 est.	Unknown	Unknown	Insufficient data					
Naphthalene	6.7x10^1 est.	Unknown	Unknown	Insufficient data					
Plasticizers									
Phthalic acid di-n-octyl ester, total	6.4x10^4	Expected	Unknown	Insufficient data					
Adipic acid ester, total	6.8x10^2	Unknown	Unknown	Insufficient data					
Surface-active agents									
Dialkyldimethylammonium, total	3.7x10^4 (1980)	Unknown	Unlikely	Insufficient data					
Linear alkylbenzene, total	4.6x10^2 est.	Unknown	Unknown	Insufficient data					
Nitrilotriacetic acid	Not available	Unknown	Unlikely	Cyprinodon variegatus (Sheepshead minnow)	Embryo-larval	3.4x10^4	28% growth reduction	72 hr static bioassay	Eriksen et al. (1980)
				Mysidopsis bahia (Mysid shrimp)	Juvenile	1.0x10^4	100% mortality	7 day static bioassay	Nimmo et al. (1977)
Miscellaneous Manufactures									
Carbon tetrachloride	7.8x10^1 (1980)	Unknown	Unlikely	Insufficient data					
Dichlorodifluoromethane	3.2x10^1 (1980)	Unknown	Unlikely	Insufficient data					
Ethylene dichloride	4.8x10^1 (1980)	Unknown	Unlikely	Insufficient data					
Ethylene vinyl acetate polymer (ethylene content of vinyl chloride polymers)	2x10^4 (calculated on basis of 1 part vinyl acetate polymerized)	Surface waters and marine organisms of Puget Sound, Washington	Unknown	Galaxias maculatus (Jenyns)	Adult	10,000	LC-50	96 hr static bioassay	Jensen et al. (1980)
Polyvinyl alcohol	Not available	Isomers et al. (1980), Mississippi et al. (1980)	.....	Pimephales promelas (Fathead minnow)	Adult 1.5%	0.01	50% mortality	10 day static renewal bioassay	Warne et al. (1979)
Polyvinyl acetate polymer	Not available	Expected	Expected	Insufficient data					
Diethylhexyl phosphate	Not available	Unknown	Unlikely	Insufficient data					
Organic Intermediates									
Monochlorobenzene	6.8x10^1	Expected	Unlikely	Insufficient data					
Phenol	1.7x10^1	Expected	Unlikely	Mytilus edulis (Blue mussel)	.....	6.3x10^4	TLM	48 hr static bioassay	Portmann et al. (1980)
Miscellaneous chemicals									
Trichloroethylene	6.7x10^1	Unknown	Unlikely	Insufficient data					

[illegible]

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[illegible] 25

[illegible] D. C., R. [illegible] and [illegible] insecticide [illegible] crab *Cancer* [illegible]

[illegible] J. E. Bidleman and T. A. [illegible] fresh [illegible] Texas. *Pesticides Monitoring J.* [illegible]

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54.

Polychlorinated Biphenyls (PCB)

Evidence is accumulating that PCB [illegible] to the shell thinning that has been a [illegible] reproductive failures and population [illegible] and fish-eating birds. Dietary PCB [illegible] ning of eggs of Mallard Ducks (*Anas* [illegible]) ([illegible] et al. *in press* 1972),[43] nor did PCB have any effect on [illegible] Ring Doves (*Streptopelia risoria*) (Peakall 1971).[44] A PCB effect could not be associated with the thinning of Brown Pelican (*Pelecanus occidentalis*) eggshells (Risebrough *in press* 1972).[45] PCB may increase susceptibility to infectious agents such as virus diseases (Friend and Trainer 1970).[46] Like other chlorinated hydrocarbons, PCB increases the activity of liver enzymes that degrade steroids, including the sex hormones (Risebrough et al. 1968;[44] Street et al. 1968).[47] The ecological significance of this phenomenon is not clear.

Because laboratory studies have indicated that PCB, with its derivatives or metabolites, causes embryonic death of birds (Vos et al. 1970;[74] Vos and Koeman 1970;[74] Vos *in press* 1972;[72] Peakal et al. *in press* 1972[19]) and because exceptionally high concentrations are occasionally found in fish-eating and raptorial species (Risebrough et al. 1968;[64] Jensen et al. 1969[48]), it is highly probable that PCB has had an adverse effect on the reproductive capacity of some species of birds that have shown population declines.

Median PCB concentrations in whole fish of eight species from Long Island Sound, obtained in 1970, were in the order of one milligram per kilogram (mg/kg) (Hays and Risebrough 1972),[47] and comparable concentrations have been reported from southern California (Risebrough 1969).[51] On the basis of the high probability that PCB in the environment has contributed to the reproductive failures of fish-eating birds, it is desirable to decrease these levels by at least a factor of two (see Section III on Freshwater Aquatic Life and Wildlife pp. 203–213).

Recommendation

It is recommended that PCB concentrations in any sample consisting of a homogenate of 25 or more whole fish of any species that is consumed by fish-eating birds and mammals, within the same size range as the fish consumed by any bird or [redacted]

In the absence of a standardized methodology for the determination of PCB in environmental samples, it is recommended that estimates of PCB concentrations be based on the commercial Aroclor® preparation which it most closely resembles in chlorine composition. If the PCB composition should resemble a mixture of more than one Aroclor®, it should be considered a mixture for the basis of quantitation, and the PCB concentration reported should be the sum of the component Aroclor® equivalents.

[illegible]

[illegible] in [illegible] *Auk.* [illegible]

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Appendix [illegible]

Pesticides Recommended for Monitoring in the Environment

Common or trade name	Chemical name
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]

APPENDIX B-F

[1] Schechter, M. S. (1971), Revised chemicals monitoring guide for the National Pesticide Monitoring Program Journal. Vol. 5, No. 1, p. 68-71.

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