by John Noble and Harry Rothman

In September last year the corpses of over 8,000 sea birds were washed up on our coasts from Northern Ireland, Ayrshire, Cumberland, Lancashire to North Wales. We may never fully understand how this disaster came about for only eight of the dead birds were properly examined for toxic chemicals etc. However, they all contained larger than usual amounts of one particular compound, polychlorinated biphenyl or PCB. To most naturalists the name PCB meant nothing. For this reason we feel that it is worthwhile summarising the current state of knowledge of environmntal pollution by PCB.

PCB is not a single compound but a general name for a whole family c compounds with a common basic structure. Mixtures of PCB compounds have interesting properties enabling them to be used in diverse technical areas. Our awareness of the ecological implications of PCB is comparatively recent and so it comes as a surprise to many people that commercial manufacture of PCB was begun as far back as 1929 by the Monsanto Chemical Company of America.

It was noted recently that the effects of exposure to PCB are not limited only to the immediate location of its use.

Since then PCB production has spread to most major industrial countries, including Britain. Monsanto are still the major manufacturer here and market PCB mixtures under the trade name Arochlor.

PCB is made by adding chlorine to biphenyls, terphenyls and other more complex poly-phenyls. Chlorination is done in special cylindrical steel towers three feet in diameter and eighteen feet high using special catalysts and heat.

The technical uses of PCB depend on their great chemical stability and special physical properties, which may be varied to suit specific applications. PCB has a number of uses in the electrical industry, in paints and varnishes where they have a similar role to oil except that they do not oxidise and lose their flexibility with age. Resinous products of PCB are an integral part of synthetic adhesives. Lubricants for use under extreme conditions often contain PCB.

The national and international production figures for PCB have never been published but we can see from the list of its applications that PCB is used on a large scale.

For such a widely used compound, toxicological data were pretty sparse, yet it was noticed recently that the effects of exposure to PCB are not limited only to the immediate location of its use.

Affects skin and liver

In the standard text on industrial toxicology, *Dangerous properties of industrial chemicals* by Sax, PCB is reported to "have two distinct actions on the body, namely a skin effect and a toxic action on the liver. The lesion produced in the liver is an acute yellow atrophy... The higher the chlorine content of the diphenyl (= biphenyl) compound, the more toxic it is liable to be... The skin lesion is known as chlorache, and consists of small pimples and dark pigmentation of the exposed areas initially. Later comedones and pustules develop. In persons who have suffered from systemic intoxication the usual signs and symptoms are nausea, vomiting and loss of weight, jaundice, edema and abdominal pain. Where the liver damage is severe the patient may pass into a coma and die. PCB is also recognised as a disaster hazard, for highly toxic fumes are given off when it is heated to decomposition. Of course these are acute effects resulting from exposure to very high concentrations. Such a danger could only arise in the event of an industrial accident."

A very disturbing finding about the biological effects of PCB is that they can have an insidious effect on the hormonal system of birds. Hormones are vital in co-ordinating the complex biochemical reactions of living organisms. Any interference with the normal body-regulating effects of hormones could have a profound effect on an organism, for they control rates of growth, ultimate body size and shape, masculinity or femininity, mental and physical alertness.

Effect on birds

The way in which PCB interferes with the hormonal systems of birds, is complex and not yet fully understood. Only a small quantity of PCB can speed up the production of certain enzymes produced by small bodies in the liver, a process called enzyme induction. As a result, the calcium metabolism so vital in egg production, is disturbed.

This information becomes crucial when it is realised that PCB has been found throughout much of the global environment, even in measurable amounts (0.06 parts per million) in mother's milk samples in California. Environmental scientists are becoming increasingly concerned about any chemicals which can persist in the environment and be accumulated along food chains. How do they get into the environment and what long term toxic hazard do they present even in very

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minute doses? In many ways PCB resembles DDT and related organochlorine insecticides. They are both fat-soluble, persistent and able to induce liver microsomal enzymes. They are fairly close chemical relatives and their ecological properties are literally interwoven.

History of PCB pollution

The tragic post-war decline of certain species of birds of prey and sea birds in many parts of the world is now well known. The story of the discovery of PCB pollution is intimately related to the unravelling of the mystery of this decline.

In the late 1950s, Derek Ratcliffe of the Nature Conservancy sounded the first warnings about the mysterious decline of the British peregrine population. When other birds of prey were similarly studied it was found that the golden eagle was declining in Western Scotland. Much circumstantial evidence pointed to organochlorine insecticide residues as the guilty agent and appropriate changes in the use of these compounds prevented a complete disaster. Ratcliffe also noted behavioural changes in the peregrine, birds eating their eggs, increased incidence of broken eggs. He also showed that the thickness of egg shells had decreased during the period since the introduction of organochlorine insecticides. This was the first evidence that the resulting widespread change in the chemical environment had in some way affected the calcium metabolism of the birds.

These events initiated routine analyses of wild-life cadavers in Britain. It was during these analyses for organochlorine pesticide residues that several workers noticed the presence of strange organochlorine compounds which they could not identify. These unidentified compounds were so similar to DDT etc., that they actually interfered with DDT measurements causing a certain amount of confusion. The unknown compounds occurred most frequently and in the largest proportions in the livers, fat and eggs of birds, particularly terrestrial predators such as sparrow hawks and kestrels, and in marine feeders like guillemots and kittiwakes. They were also found in fresh water fish. Small amounts were detected in human fat samples, though in much smaller proportions than in the birds. In 1966 workers in Scotland found the same compounds in fish and seals in Scottish waters, the levels were low in the fish, whereas in the seals they corresponded to the larger levels found in birds.

The solution to the mystery of the identity of the compounds was provided by a Swedish scientist, Soren Jensen. At the end of 1966, the *New Scientist* reported that Jensen had found PCB in pike, and also in the hair of his whole family, including a five month old baby. Jensen looked for PCB in eagle feathers in a museum and only found it in specimens caught after 1944. This is probably indicative of how long PCB has been an environmental contaminant. A little later, the British workers, Holmes, Simmons and Tatton, announced that the previously unidentified compounds associated with analyses for organochlorine insecticides were PCB. Their findings were repeated in the Netherlands and North America and soon PCB was found to be distributed throughout living creatures in the Northern Hemisphere.

More PCB in industrial areas

Riseborough and his American col-

Monsanto takes a big step

The chemicals implicated in the massive slaughter of seabirds off the north-west coast last autumn may soon be the subject of a voluntary ban. Monsanto Chemicals, one of the principal manufacturers of the industrial chemicals polychlorinated biphenyls—known as PCBs—is trying to get other manufacturers to limit the application of the product. Monsanto want PCBs to be confined to closed-system uses, like its application in electrical insulations. This would mean a ban on the use of PCBs in paints and varnishes and coatings.

It is this second type of usage that causes the pollution. Factory waste pipes leak PCBs while manufacturing or using paints and surface coatings. The chemicals are carried in effluent into the sea where it is believed that unusual weather conditions can cause local concentrations. The amount of PCBs in these concentrations is still very low, but it can be lethal.

Without a doubt the source of the pollution does not exist in the PCB manufacture stage. The only place in Britain where PCBs are produced—under the market name of Arachlor 1254—is at Monsanto's Newport, Monmouthshire plant. But the production process is dry and no PCB waste goes down the plant's pipeline into the Bristol Channel.

Monsanto will have to work hard to get co-operation, if only because rival manufacturers are of different nationality. But the value of a voluntary ban is highlighted by the recent disclosure of the Government Chemist. In his annual report, he reveals that the highest ever concentration of PCBs has been found in wildlife by his laboratory. The Chemist gives the results of an analysis of PCB levels in herons. Levels more than twice the previously recorded "highs" in seabirds were found. This is very disturbing, given the effects of PCBs on calcium metabolism.

Jeremy Bugler

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PCB possesses great chemical stability and is therefore highly persistent once it escapes into the environment. It is likely that a steady build-up is occurring.

leagues have reported that the highest levels of PCB are found in wild life from industrialised areas. In the few land birds and fresh water species examined by American scientists PCB was found, and it is quite likely that the compound is now distributed in the continental ecosystems of the United States.

Exactly how PCB gets into wild life is not yet known, for unlike organochlorine insecticides, PCB is not deliberately sprayed into ecosystems. There are however several possibilities. The fact that PCB residues are generally highest in creatures living near to industrial areas, leads us to suspect that PCB might escape from the factories manufacturing or using it. It could be released in effluent or PCB-containing hydraulic oils into the rivers, eventually reaching the sea. Another potential PCB source is air pollution. It has been suggested that transport by air currents explains the presence of PCB in remote regions like Alaska. As far as we know no one has recorded and measured the presence of PCB in the air. It might escape into the atmosphere during its manufacture at a point when high temperatures are reached. Alternatively, the burning of waste containing PCB may lead to atmospheric pollution. The Ministry of Housing and Local Government has started a research project to examine the sources of PCB pollution which will no doubt throw more light on this problem.

Long term effects?

PCB possesses great chemical stability and is therefore highly persistent once it escapes into the environment. It is likely that a steady build-up is occurring. Small amounts of PCB have been shown experimentally to have sublethal physiological effects on birds, and small amounts are now found in people. Will they have any long term toxic effect? Nobody knows, but do we have to wait? The best move might be to suspend further use of PCB in industrial processes until one has established its effects on ecosystems and human health. Such firm action would also act as a spur to industry to work more seriously in the future on the ecological implications of their action.

The almost accidental manner in which PCB pollution was discovered does not give us great confidence in the present environmental monitoring effort. Wild-life populations are as someone once said "our miner's canary", but only very rarely is there the necessary information about population dynamics to say with any accuracy whether a particular population is behaving in a peculiar fashion. It is necessary to finance, on a world scale, studies of a carefully selected range of species so that we can biologically monitor environmental changes. Any change in the numbers, behaviour or chemical composition of an indicator population would be noted and its cause searched for. It is a priority task, and the scale of activity in such monitoring ought at least to be tied to the increasing rate of industrial activity. The cost of such a "doomwatch" activity may be high, but if it helps mankind to avoid large scale ecological disasters, it is a price that has to be paid.

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