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ONEMA
MEETINGS

Lessons from the national PCB action plan

A symposium held on 31 May 2012 in Bordeaux.

Polychlorinated biphenyls (PCB) have been forbidden for 25 years, but are still present at the bottom of many French rivers and... in the flesh of the animals living there. A spotlight was thrown on this long-standing pollution in 2006 when the EU adopted new health standards concerning the consumption of freshwater fish. France subsequently launched an action plan that produced, thanks to three years of research, considerable progress in our understanding of PCB transfers from sediment to fish and of the degree to which humans are exposed. The goals of the plan were met, notably concerning the establishment of thresholds for PCB contamination of sediment, above which fish are no longer suitable for consumption. These results raise the question of the lessons to be drawn from this situation for «emerging» contaminants. That was one of the main topics of the feedback symposium for the action plan, organised by Onema, the Ecology ministry and the University of Bordeaux 1, in a partnership with the Agriculture and Health ministries, and held on 31 May in Bordeaux. This document reports on that meeting.

From 2008 to 2010, 2300 samples of freshwater fish were collected by Onema territorial units on 300 sites throughout France *(Figure 1)* and analysed to determine the concentrations of 18 PCB congeners [1], among other priority substances listed by the Water framework directive (WFD). This inventory, the most complete to date in France, confirmed the high degree of contamination of freshwater fish by PCBs, various levels of which were detected in every batch analysed [2]. The contamination profiles revealed significant variability between sites, different types of PCB and species *(M. Barbut, Irstea)*. For example, distinctions could be made between species with high potential for bioaccumulation (eels, giant catfish, barbels, bream, etc.) and those with low potential (zander, pike-perch, roach, chubs, etc.).

The chub *(S. cephalus)* is one of the freshwater-fish species studied in the Irstea research project on PCB transfer from sediment to fish.

[1] Plus 17 dioxin and furan congeners that are the involuntary by-products of many industrial processes and of combustion.
[2] The data analysed by ANSES may be consulted at www.eaufrance.fr.

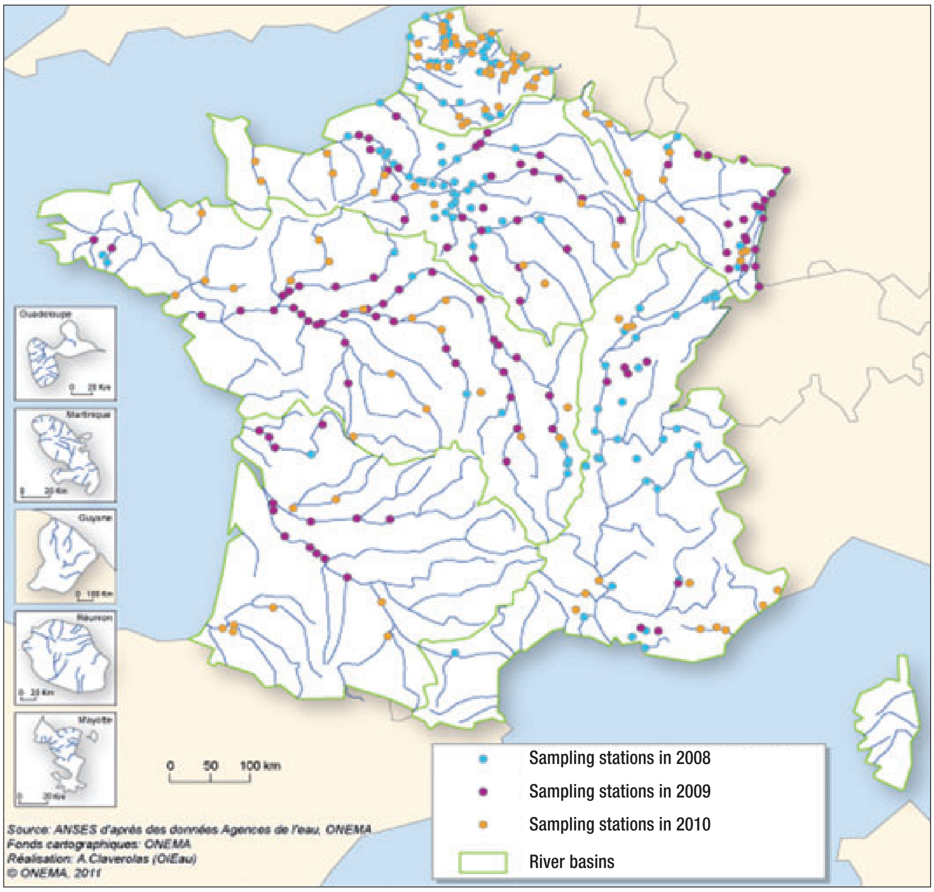

Figure 1. Sampling sites for fish and sediment selected by Onema and the Water agencies in 2008, 2009 and 2010, in the framework of the national PCB action plan.

Convincing progress in modelling transfers to living organisms

A central component in the PCB plan was to improve our understanding of the relations between contamination of the biota (fish muscles) and that of the sediment in the environment of the fish. That was the goal of a research project carried out at three stations on the Rhône river, with funding by Onema, the RMC Water agency and the Rhône-Alpes and Provence-Alpes-Côte d'Azur regions. The study *(C. Lopez, Irstea)* analysed the contamination of 135 fish of three species (bream, barbel, chub) and sediment samples from the three sites. Two complementary approaches were developed. The first, statistical approach linked the observed contamination in the fish to a set of explanatory variables. It showed that three variables (size of the animal, percentage of organic carbon of detrital origin in its food and the maximum PCB content in the sediment to which the animal was exposed during its life) were sufficient to explain 78% of the variability in fish contamination. The second approach, which included the development of a PCB-accumulation model based on fish physiology, integrated variability in the individual behaviour of fish, notably by examining their stomach contents, to explain why, on a given site, two comparable individuals have different contamination levels. Via this double approach, the research teams were in a position to propose consistent sets of sediment-contamination thresholds (2.6 to 14 ng/g of PCBs in sediment, dry weight) above which fish would no longer be considered suitable for consumption according to current standards. The approaches remain nonetheless perfectible in that they must be tested with other data sets and expanded to include other species. Further work on the consistency of the sediment-contamination thresholds, taking into account targeted protection objectives and the vulnerability of environments would also be worthwhile. Approaches similar to those developed by Irstea for the PCB plan could be used to revise the thresholds proposed by the Géode group [3] for dredging mud and sediment in ports and disposing of it in the ocean *(J. Duchemin, Seine-Normandy water agency)*.

The national PCB action plan

Following analyses which detected PCB levels exceeding health-standard thresholds in the flesh of certain freshwater fish, on 6 February 2008 the Ecology, Health and Agriculture&Fisheries ministers adopted a PCB action plan organised around six goals.

1. Increase efforts to reduce release of PCBs to the environment.
2. Improve scientific knowledge on the fate of PCBs in aquatic environments and manage the pollution.
3. Reinforce inspections on fish intended for human consumption and adopt any necessary risk-management measures.
4. Improve knowledge on health risks and their prevention.
5. Accompany commercial and recreational fishermen affected by the risk-management measures.
6. Evaluate and report on plan results and progress.

Onema participates in four parts of the national plan. It contributes to improving scientific knowledge on the fate of PCBs in aquatic environments (Goal 2). It manages the national network to monitor contamination of fish (Goal 3). It supports State agencies and services in accompanying fishermen affected by the risk-management measures (Goal 5) and it participates in the national steering and monitoring committee (Goal 6).

[3] Study and observation group on dredging and the environment, founded in France in 1990.

Limited health impact from consumption of freshwater fish?

Only 3.6% of French women of childbearing age and less than 1% of all other adults have PCB levels higher than the thresholds set by ANSES (Agency for food, environmental and occupational health & safety), i.e. 700 and 1 800 ng/g of lipids [4] respectively. That is one of the results of the ENNS (national nutrition and health) study carried out in 2006 and 2007 by the national institute for health monitoring (InVS) on a representative sample of the adult French population, on the basis of questionnaires and biological analyses quantifying various substances, including six PCB congeners in various body tissues (blood, urine, hair) used as biomarkers. Though higher than the European average, the serous levels of PCB measured in the French population have fallen sharply. Compared to a similar study carried out in 1986, the results in 2007 were three times lower. The ENNS study showed that among the factors studied in the adult population (18 to 74), the age of the person and the consumption of animal and fish products had the greatest influence on PCB levels in the body, whereas geographic and socio-economic factors contributed to a lesser extent *(N. Fréry, InVS)*.

For the PCB plan, an ANSES-InVS study attempted to evaluate the incidence of the consumption of freshwater fish on human exposure to PCBs. On the basis of household surveys and blood analyses, it determined the dietary habits and the exposure level of over 600 recreational and 16 commercial fishermen, and of their families. The results showed generally low consumption levels of the fish caught. Consumption is even lower for the highly bioaccumulative species that only 13% of the panel (essentially older participants) eat more than twice per year. Concerning PCB levels in the body, they were comparable to that of the general population. Only older participants, living in highly contaminated zones and regularly consuming highly bioaccumulative fish showed PCB levels greater than the thresholds set by ANSES *(M. Merlo and G. Rivière, ANSES)*.

Cover of the ANSES-InVS report on PCB levels in regular consumers of freshwater fish.

These results indicate that contamination of freshwater fish by PCBs is more of an ecological issue than a health issue. They will also assist in orienting scientific research on PCBs, notably the study of transfers in food chains and our understanding of the environmental impacts linked to chronic exposure of ecosystems to low doses, as well as current work to set guidelines for sediment dredging.

Significant impact on coastal areas and seafood

PCB contamination is not limited to continental waters. Rivers disperse suspended matter containing these chemical substances in coastal zones. In 2007, analyses on oysters and mussels along all French coasts (data provided by the national network for the observation of marine environments) showed significant total PCB concentrations near the major estuaries (C. Munschy, Ifremer) of approximately 70 ng of the CB-153 congener per gram of dry weight at the mouths of the Loire, Gironde and Rhône rivers, and up to 250 ng/g in the Bay of the Seine (Figure 2).

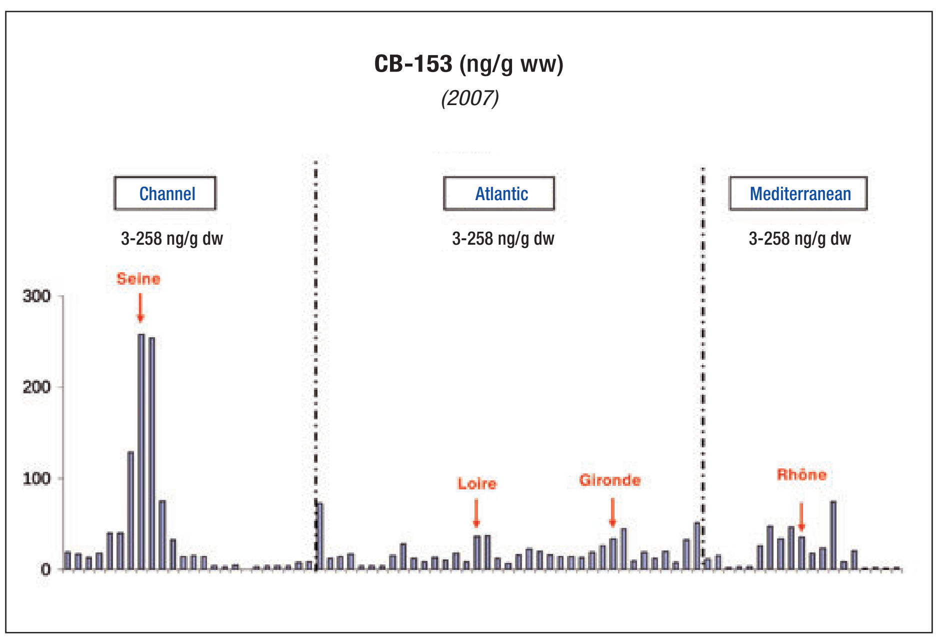

Figure 2. Geographic distribution of the CB-153 congener (in nanograms per gram dry weight) in marine bivalve molluscs along French coasts (RNO-ROCCH data) showing the significant quantities of PCBs transported by rivers to the marine environment.

[4] Total for the six NDL PCBs monitored by the study, i.e. the 28, 52, 101, 138, 153 and 180 congeners.

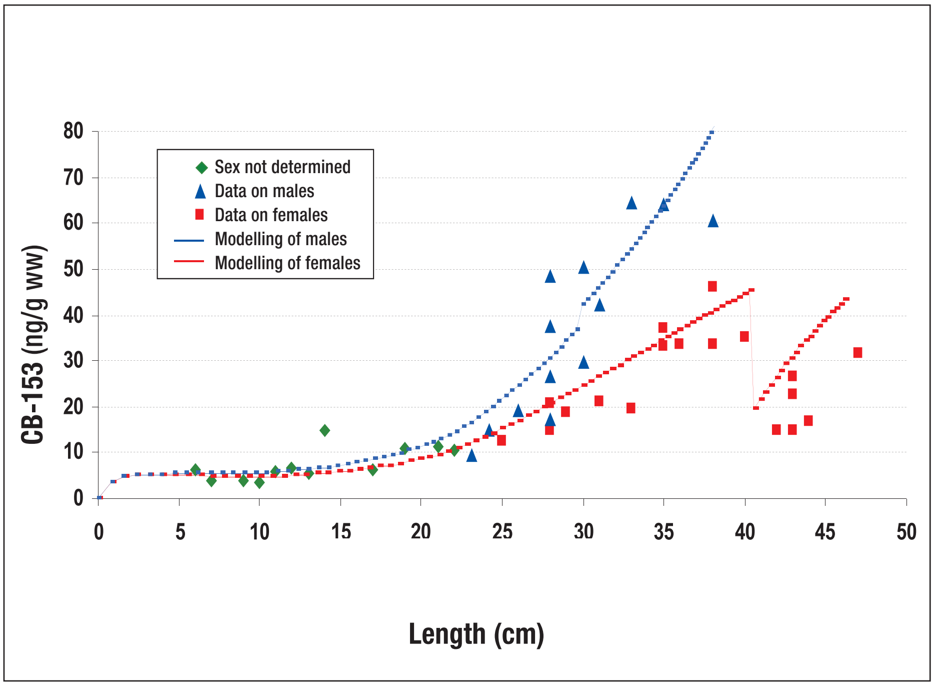

Figure 3. Congener CB-153 in male and female hakes. Comparison of field data and modelling data (Bodiguel et al. 2009).

A number of studies run by Ifremer addressed the fate of these contaminants in marine food chains in the Gulf of Lions. The Merlumed project (V. Loizeau, Ifremer) focussed on contamination in hakes, a species high up in the food chain and of major commercial value, in which high PCB concentrations have been measured locally. On the basis of samples drawn at different levels in the food chain, the research teams proposed a PCB-bioaccumulation model for the species, which combines a dynamic energy budget (DEB) model model (nutrition, growth and reproduction of individual fish) with a model on contaminant kinetics. The resulting model correctly simulates changes in PCB contamination over the life of hakes (Figure 3).

On the heels of this study, the Costas project (V. Loizeau, Ifremer) will now attempt to understand and model the entry and fate of chemical contaminants in the food chain, ranging from plankton up to small pelagic fish in the Golf of Lions (Figure 4). It looks in particular at the bioaccumulation of contaminants in sardines and anchovies, two species that are important in the ecosystem and often eaten by humans.

This recent work, among other projects, indicates enhanced awareness of the PCB issue for marine environments. This greater awareness must be expanded even further given the environmental and health issues involved. Seafood, particularly molluscs and crustaceans from contaminated bays and estuaries, represent one of the major dietary channels of exposure to PCBs for the French population, as was shown by the total diet study (EAT2) carried out by ANSES from 2006 to 2010, by analysing over 400 substances in representative food products in France (S. Denys, ANSES) (Figure 5).

Promising bio-analytical tools to detect contaminants

Since 2008, Ineris and Onema have developed new bio-detection methods for dioxin-like compounds, including dioxin-like PCBs (DL PCB), in complex samples such as river sediment (S. Aït-Aïssa, Ineris). At the crossroads between chemical analysis (detection and quantification of a sub-set of contaminants) and biological tests (integrated toxicity assessment of a mixture of contaminants), these innovative approaches measure early biological activity specific to a given mode of action of toxicants and thus make it possible to link exposure and effects. The work at Ineris resulted in the development of two in vitro tests on microplates. Satisfactory test results in the surveillance-monitoring network of the Artois-Picardie basin confirmed their suitability for routine use, e.g. to select samples prior to chemical analysis. They represent a promising way forward at a time when water managers stress the need for integrated biological tools to monitor environmental quality.

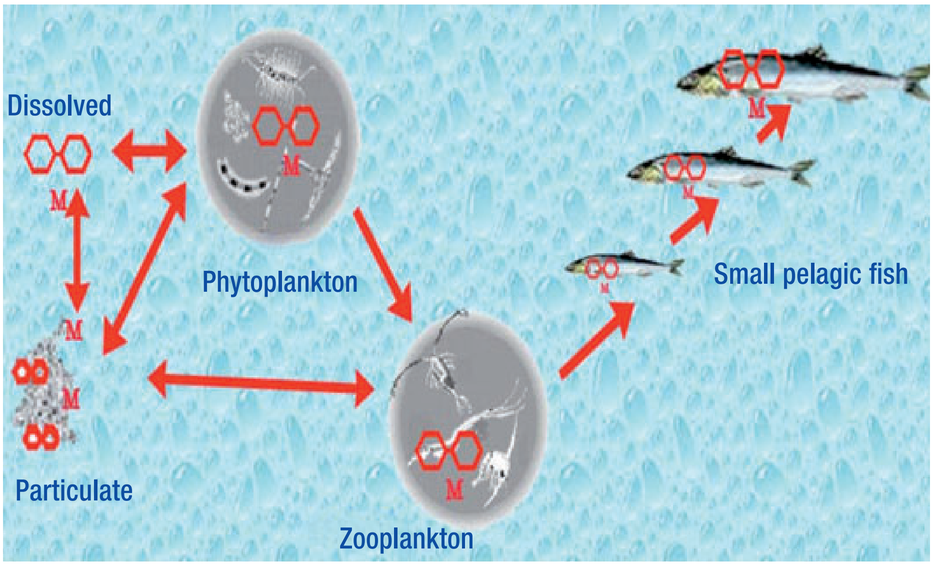

Figure 4. Simplified food chain of small pelagic fish in the Golf of Lions (J. Tronczynski, Ifremer, Onema meeting on aquatic micropollutants).

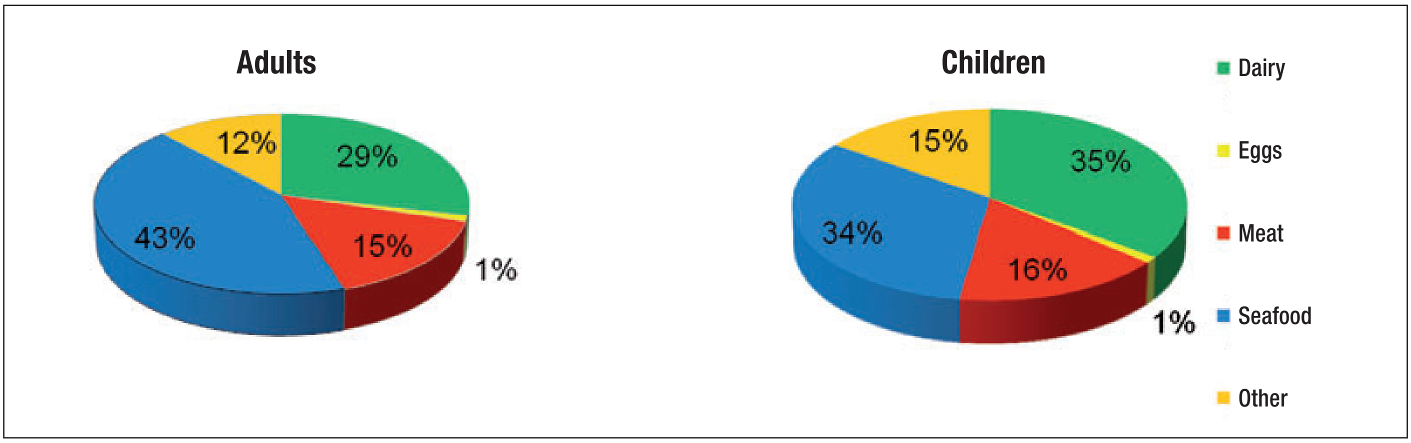

Figure 5. Relative contribution of various foodstuffs to exposure of the adult and child population in France to six NDL PCBs via food (ANSES).

Knowledge transfers : for emerging pollutants?

«To what extent can the knowledge concerning PCBs be transferred to emerging pollutants?» The question was put to the speakers of the final roundtable at the symposium in Bordeaux, but had already been raised a number of times that day during the debates. All participants agreed that it was indispensable to use all the knowledge gained over a number of decades to «save time» in managing other contaminants. However, the notion of «emerging contaminants» elicited debate. It may mean recently developed compounds or existing substances for which no durable monitoring systems have yet been set up. For some participants, the attention paid to polybrominated flame retardants, a long-standing source of pollution, must not mask the environmental and health risks represented by other contaminants such as organotins, phthalates, perfluorinated compounds and chlorinated biocides. Generally speaking, knowledge transfers are conditioned by progress in monitoring techniques and should take into account similarities in the action and the effects produced by substances in the environment.

The family of compounds most commonly mentioned for such transfers is PBDEs (polybrominated diphenyl ethers) that have been used since the 1980s as flame retardants for textiles and plastics. To a certain degree, these hydrophobic contaminants share with PCBs their persistent, toxic and bioaccumulative nature. Some have been forbidden in the EU since 2004 and listed as priority substances by the Water framework directive (e.g. penta-BDE). The Ifremer LBCO lab has monitored them for a number of years in marine bivalve molluscs along French coasts and in its report (C. Munschy, Ifremer), it stressed the need to reinforce monitoring and maintain it over the long term. Generally speaking, Ifremer argues in favour of setting up long-term and upgradable monitoring of contaminants. In conjunction with the work to set risk priorities for chemical substances by the European Norman network [5], it also wants to add to the list of monitored contaminants the HBCDs (hexabromocyclododecanes), a flame retardant used in polystyrene isolation in buildings, brominated flame retardants used to replace PBDEs, and synthetic musks. In parallel with the monitoring work, research programmes are required to improve knowledge on the environmental effects of these substances, e.g. transfers within eco-systems, degradation, bioaccumulation and biological impacts.

Jean Duchemin,
Seine-Normandy water agency

«An ounce of pollution prevention is worth a pound of cure, that is the major lesson to be drawn from PCBs. That is why work today should address the «real» emerging pollutants, i.e. those whose use is still growing. I find perfluorinated compounds the most worrisome. These contaminants are widely produced, for everything from pizza boxes to frying-pan surface coatings, and they are bioaccumulative, reprotoxic and endocrine disruptors. They are also found everywhere, in aquifers and in the flesh of polar bears. Other substances include the organotins that are used in antifouling paints for boats and certain biocides. For all these pollutants, now is the time to act in order to better understand how they react in the environment and regulate their use.»

Hélène Budzinski,
President of the PCB-plan scientific advisory committee

«The issue of knowledge transfer from PCBs to emerging contaminants remains a difficult one. Many worrisome chemical substances today are very different than PCBs. The lessons to be drawn from PCBs concern above all how we work, the sustained dialogue between scientists and managers, and the need for change in how we approach the risks raised by chemical substances. That approach is still largely corrective today, however, notably following the European REACH regulation, it will have to evolve toward a more preventive approach.»

[5] European network of reference labs, research institutes and associated organisations for monitoring of emerging substances in the environment.

Issues and gaps in knowledge, the roadmap for the future

Thanks to the three years of work invested in the national PCB plan, significant progress has been made. Contaminant transfers from river sediment to the flesh of fish have been successfully described by the models which now provide valuable information on the fate of PCBs in freshwater environments and supply water managers with tools, i.e. the threshold values, to avoid health risks. New knowledge has been gained in our understanding and for the management of contaminant impacts on estuarial and coastal environments. Finally, work is now underway on the national level to encourage the transfer of the knowledge gained on PCBs to other, more recent contaminants in view of a more preventive approach.

However, a great deal remains to be done to understand and reduce the impact of these pollutants in ecosystems. To identify current gaps in our environmental knowledge on PCBs, in terms of the main issues for pollution management of the PCB family of substances in aquatic environments, Onema met individually with over 30 water stakeholders and scientific experts active in environmental research on PCBs, on behalf of the PCB-plan scientific advisory committee. The survey results, filled out with bibliographical data and summarised in a detailed report, were presented during the symposium in Bordeaux. The report lists a set of recommendations for scientific policy, taking into account the expected management tools, ranging from the identification and quantification of pollution sources to good practices for the management of dredging sediment, and including the recording of long data series on contamination levels in predators at the top of marine food chains, that are particularly sensitive to these contaminants. The document is accessible on the Onema site.


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Pollution des milieux aquatiques par les polychlorobiphényles (PCB) en France : principaux enjeux de gestion et lacunes identifiées dans les connaissances environnementales

Rapport final

Nathalie HUBAUX,
Olivier PERCEVAL,
les membres du comité de suivi scientifique du plan national d'actions sur les PCB

Décembre 2011

Cover of the report by the PCB-plan scientific advisory committee.

Fishing for PCB analysis in the Vaucouleurs river (Yvelines department).

For more information…

The presentations and datasheets are available at http://www.onema.fr/PCB-seminaire-mai2012

The report of the PCB-plan scientific advisory committee on current PCB environmental knowledge is available at www.onema.fr/IMG/pdf/PCB-milieux-aquatiques.pdf

Meeting organisation:

For Onema, Olivier Perceval, scientific officer for ecotoxicology at the R&D department.

For the Ecology ministry, Nathalie Tchilian, policy officer at the Office for household and industrial pollution.

For the University of Bordeaux 1, Jean-François Narbonne, professor of toxicology.

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