^{14}C radiolabelling: a sensitive tool for studying PCB bioaccumulation in echinoderms

Bruno Danis

Olivier Cotret

Jean-Louis Teyssie

Paco Bustamante

Scott W. Fowler

Michel Warnau

Polychlorinated biphenyls (PCBs) are strictly anthropogenic chemicals that constitute one of the most problematic and widespread group of marine contaminants. These xenobiotics (represented by 209 congeners) are extremely resistant to any kind of degradation, are bioconcentrated by living organisms, and can cause various adverse effects depending on their pattern and degree of chlorine substitution (e.g., Harding & Addison, 1986; Livingstone, 1992; Metcalfe, 1994).

Being under the influence of heavy industrialisation and important urbanization, the North Sea is generally considered as a region highly contaminated by numerous contaminants, including PCBs. Therefore, there is a constant need to survey and monitor the quality status of the marine environment in the North Sea. This is particularly true for the benthic ecosystems since, due to their very low solubility, PCBs mainly accumulate in the sediments where they may become a threat to organisms and ecosystems. However, information on PCB bioaccumulation rates in marine benthic organisms is scarce and is generally of limited value, since data are mainly derived from studies using sediments experimentally contaminated with high (unrealistic) PCB concentrations (Meador *et al.*, 1995; Boese *et al.*, 1997).

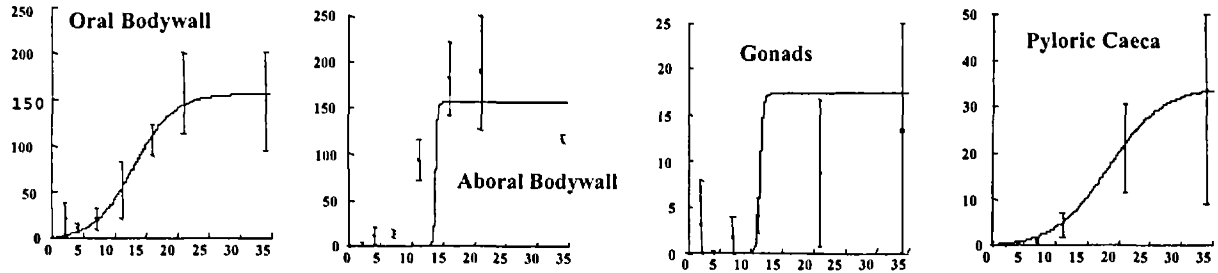
The asteroid *Asterias rubens* qualifies as a potential bioindicator species of PCB contamination in the marine environment. Widely distributed, abundant, and preying upon filter-feeders, *A. rubens* is a key species of various benthic ecosystems in the North Sea (Menge, 1982; Hostens & Hammerlynck, 1994). It is also an excellent choice for ecotoxicological studies, since it is a proven bioindicator for other contaminants (e.g. heavy metals; Temara *et al.*, 1998) and it can provide early warning signals for the presence of organic contamination (Everaarts *et al.*, 1998). This species was therefore selected as a model for an experimental study of PCB bioaccumulation.

Many studies have considered PCB bioaccumulation using commercial mixtures (e.g. Arochlor) which are not always representative of environmental contamination (Metcalfe, 1994). In the present work, bioaccumulation potential was investigated using a congener-specific approach and an extremely sensitive method (radio-analysis using β-spectrometry), which allowed us to study low (realistic) contaminant concentrations and to directly measure bioaccumulation in all the body compartments of the starfish (including very minute organs). PCB congener #153 (2,2',4,4',5,5' hexachloro-biphenyl) is the most abundant congener found in marine biota (NSTF 1993). It is therefore a good model to investigate PCB bioaccumulation and its ^{14}C-labelled form was used in the present study.

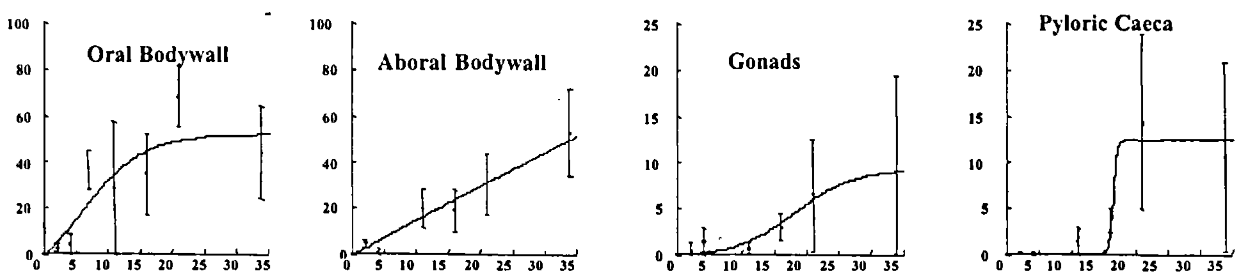
Asteroids were collected in Audresselles (Nord Pas-de-Calais, France). After being acclimatized for 1 month to laboratory conditions, starfishes were exposed for 34 days to sea water or sediments contaminated with the radio-labelled PCB congener. Contaminant concentrations were adjusted in order to correspond to an environmentally realistic level of contamination in the North Sea (Stebbing *et al.*, 1992). During the exposure period, bioaccumulation of PCB #153 was followed in eight body compartments (oral body wall, aboral body wall, pyloric caeca, central digestive system, rectal caeca, gonads, podia, and coelomic fluid) using β-spectrometry and concentrations were expressed on a lipid weight basis.

Results showed that the observed kinetics generally tended to go through an initial latency phase and then to reach a saturation concentration (steady state) after an exponential increase. The latency phase duration and the time to reach steady state were body compartment as well as exposure mode-dependent. Both body walls (oral and aboral) accumulated the PCB most efficiently (intensity and rapidity). For each body compartment, equilibrium was always reached more rapidly during seawater exposure. Most generally, uptake fitted an asymptotic sigmoid model (corrected R^2 ranged between 0.27 and 0.84), the best fit being observed for oral body wall of starfish exposed via sea water. For each body compartment, uptake was more efficient when *A. rubens* was exposed directly in seawater than via sediments, especially in the body wall compartments.

The present study constitutes a first attempt to use a radiolabelled PCB congener to examine contaminant uptake kinetics in echinoderms. This radiotracer technique is a very promising tool for the study of PCB biokinetics. It is extremely sensitive and allows directly measuring bioaccumulation of PCBs at environmentally realistic concentrations. It also allows assessing uptake into key organs which are sometimes too minute for classical analytical measurements, such as HRGC-ECD or HRGC-MS, which require large amounts of sample material (Metcalfe, 1994).



I Figure 1
Uptake kinetics in *Asterias rubens* exposed via seawater (mean concentration (ng.g^{-1} total lipids) ± SD, n=3).



I Figure 2
Uptake kinetics in *Asterias rubens* exposed via sediments (mean concentration (ng.g^{-1} total lipids) ± SD, n=3).

Bibliography

BOESE B. L., LEE H., ECHOLS S., 1997 — Evaluation of a first order model for the prediction of the bioaccumulation of PCBs and DDT from sediment into the marine deposit-feeding clam *Macoma nasuta*. *Environ. Toxicol. Chem.*, 16: 1545-1553.

EVERAARTS J. M., DEN BESTEN P. J., HILLEBRAND M. T. J., HALBROOK R. S., SHUGART L. R., 1998 — DNA strand breaks, cytochrome P450-dependant monooxygenase system activity and levels of chlorinated biphenyl congeners in the pyloric caeca of the seastar (*Asterias rubens*) from the North Sea. *Ecotoxicology*, 7: 69-79.

HARDING G. C., ADDISON R. F., 1986 — "Accumulation and effects of PCBs in marine invertebrates and vertebrates". *In*: Wood J.S. (ed): *PCBs and the environment*, CRC Press, 2: 9-30.

HOSTENS K., HAMMERLYNCK O., 1994 — The mobile epifauna of the soft bottoms in the subtidal Oosterschelde estuary: structure, function and impact of the storm-surge barrier. *Hydrobiologia*, 282/283: 479-496.

LIVINGSTONE D. R., 1992 — "Persistent pollutants in marine invertebrates". *In*: Walker C.H., Livingstone D.R. (eds). *Persistent pollutants in marine ecosystems.* Oxford, Pergamon Press: 3-34.

MENGE B. A., 1982 — "Effects of feeding on the environment: Asteroidea". *In*: Jangoux M., Lawrence J.M. (eds): *Echinoderm nutrition*. Rotterdam, Balkema: 521-551.

METCALFE C. D., 1994 — "Polychlorinated biphenyls". *In*: Kiceniuk J.W., Ray S. (eds): *Analysis of contaminants in edible aquatic resources*, VCH Press : 305-338.

MEADOR J. P., CASILLAS E., SLOAN C. A., VARANASI U., 1995 — Comparative bioaccumulation of polycyclic aromatic hydrocarbons from sediment by two infaunal invertebrates. *Mar. Ecol. Prog. Ser.*, 123: 107-124.

NSTF-North Sea Task Force, 1993 — *North Sea quality status report 1993.* Oslo & Paris Commission, ICES, London, 132 p.

STEBBING A. R. D., DETHLEFSEN V., CARR M., 1992 — Biological effects of contaminants in the North Sea. *Mar. Ecol. Prog. Ser.*, 91 (special edition).

TEMARA A., SKEI J. M., GILLAN D., WARNAU M., JANGOUX M., DUBOIS P., 1998 — Validation of the asteroid *Asterias rubens* (Echinodermata) as a bioindicator of spatial and temporal trends of Pb, Cd, and Zn contamination in the field. *Mar. Environ. Res.*, 45: 341-356.