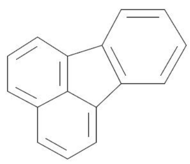
FLUORANTHENE

This EQS dossier was prepared by the Sub-Group on Review of the Priority Substances List (under Working Group E of the Common Implementation Strategy for the Water Framework Directive).

The dossier was reviewed by the Scientific Committee on Health and Environmental Risks (SCHER), whose comments have been addressed as follows. In section 7.1.2 the endpoint used to calculate the marine sediment EQS has been normalised to 5% organic carbon; the additional assessment factor of 5 has been removed and explanation added (see section 7.1.2). For the human health standard, the linear extrapolation of animal tumour incidences has been maintained as in other EQS dossiers identifying a virtually safe dose for carcinogenic substances.

This dossier is a revision of the 2005 EQS fact sheet for fluoranthene, which was not totally consistent with the revised Technical Guidance for deriving EQS (E.C., 2011) and did not include the latest ecotoxicological and toxicological data contained in the Final draft Coal Tar Pitch High Temperature European Union Risk Assessment Report (E.C., 2008a) made available in the context of assessment of existing chemicals (Regulation 793/93/EEC) and which addresses the so-called 16 Polycyclic Aromatic Hydrocarbons (PAHs) of which fluoranthene is one. Besides, although fluoranthene has not been classified as CMR in the CLP regulation, several authors consider fluoranthene as a suspected carcinogen (Baars *et al.*, 2001; Doornaert and Pichard, 2003) and that a non-threshold approach is warranted for human risk assessment. The present document reviews the EQS for fluoranthene based on these new documents and on a report in preparation provided by RIVM (Verbruggen, in prep.) which was made available to the assessor.

1 CHEMICAL IDENTITY

Common name	Fluoranthene
Chemical name (IUPAC)	Fluoranthene
Synonym(s)	-
Chemical class (when available/relevant)	Polyaromatic hydrocarbons (PAH)
CAS number	206-44-0
EC number	205-912-4
Molecular formula	$C_{13}H_{10}$
Molecular structure	
Molecular weight ($g.mol^{-1}$)	202.3

2 EXISTING EVALUATIONS AND REGULATORY INFORMATION

Legislation	
Annex III EQS Dir. (2008/105/EC)	No (existing priority substance including in Annex I EQS Dir.)
Existing Substances Reg. (793/93/EC)	Not individually listed. Included in the Coal Tar Pitch High Temperature assessment.
Pesticides(91/414/EEC)	No

Biocides (98/8/EC)	Not notified
PBT substances	Not investigated
Substances of Very High Concern (1907/2006/EC)	Not investigated
POPs (Stockholm convention)	No
Other relevant chemical regulation (veterinary products, medicament, ...)	No
Endocrine disrupter **(**E.C., 2004 and E.C., 2007[1])	Not investigated

1 Commission staff working document on implementation of the Community Strategy for Endocrine Disrupters.

3 PROPOSED QUALITY STANDARDS (QS)

3.1 ENVIRONMENTAL QUALITY STANDARD (EQS)

QS_{biota_hh} for protection of human health *via* consumption of fishery product is deemed the "critical QS" for derivation of an Environmental Quality Standard. The value is 30 µg.kg^{-1}$_{biota\ ww}$ and corresponds to values of 6.3 10^{-3} µg.l^{-1} for both fresh and marine waters.

Original data on which QS_{biota_hh} is based on are linked to a virtually safe dose and expressed for an oral cancer risk of 10^{-6} based on the read-across between benzo[a]pyrene and fluoranthene.

	Value	Comments
Proposed AA-EQS for [biota] [µg.kg^{-1}$_{biota\ ww}$]	**30**	**Critical QS is $QS_{biota,\ hh}$**
Corresponding AA-EQS for [freshwater] [µg.l^{-1}]	6.3 10^{-3}	**See section 7**
Corresponding AA-EQS in [marine water] [µg.l^{-1}]	6.3 10^{-3}	
Proposed MAC-EQS for [freshwater] [µg.l^{-1}]	**0.12**	**See section 7.1**
Proposed MAC-EQS for [marine water] [µg.l^{-1}]	**0.12**	

3.2 SPECIFIC QUALITY STANDARD (QS)

Protection objective[2]	**Unit**	**Value**	**Comments**
Pelagic community (freshwater)	[µg.l^{-1}]	0.12	See section 7.1
Pelagic community (marine water)	[µg.l^{-1}]	0.12	
Benthic community (freshwater)	[µg.kg^{-1} $_{dw}$]	2 000	See section 7.1
	[µg.l^{-1}]	4	
Benthic community (marine)	[µg.kg^{-1} $_{dw}$]	2 000	
	[µg.l^{-1}]	4	
Predators (secondary poisoning)	[µg.kg^{-1}$_{biota\ ww}$]	11 522	See section 7.2
	[µg.l^{-1}]	2.4 (fresh and marine water)	
Human health via consumption of fishery products	[µg.kg^{-1}$_{biota\ ww}$]	30	See section 7.3
	[µg.l^{-1}]	6.3 10^{-3} (fresh and marine water)	
Human health via consumption of water	[µg.l^{-1}]	1.8	

[2] Please note that as recommended in the Technical Guidance for deriving EQS (E.C., 2011), "EQSs […] are not reported for 'transitional and marine waters', but either for freshwater or marine waters". If justified by substance properties or data available, QS for the different protection objectives are given independently for transitional waters or coastal and territorial waters.

4 MAJOR USES AND ENVIRONMENTAL EMISSIONS

4.1 USES AND QUANTITIES

Data reported hereunder are extracted from Final Coal Tar Pitch HT EU-RAR (E.C., 2008a) which includes information on fluoranthene.

4.1.1 Production

Final CTPHT EU-RAR (E.C., 2008a) states that within the European Union, high temperature coal tar pitch, containing fluoranthene is produced "by ten companies at eleven sites in nine countries. The total European Union production capacity in 2004 was 1 127 000 tonnes. The actual production output of coal tar pitch in that year was about 817 800 tonnes. Import from outside the EU was reported to be about 91 600 tonnes per year and export was about 355,600 tonnes per year. The total consumption of coal tar pitch in the EU from these figures is estimated to be about 554 000 tonnes per year."

4.1.2 Uses

Coal tar pitch is mainly used as a binding agent in the production of carbon electrodes, anodes and Søderberg electrodes for instance for the aluminium industry. It is also used as a binding agent for refractories, clay pigeons, active carbon, coal briquetting, road construction and roofing. Furthermore small quantities are used for heavy duty corrosion protection.

4.2 ESTIMATED ENVIRONMENTAL EMISSIONS

4.2.1 Sources of PAH emissions (E.C., 2008a)

Industrial sources

"The most important industrial emission sources include coke production, primary aluminium production and creosote and wood preservation. CTPHT is produced at coke plants as such and as a by-product of primary steel production. The main source of PAH emissions in the iron and steel industry is the coke ovens, used to make coke for the steel production. (…) The coke industries improved their PAH emissions markedly by applying modern technology. Nevertheless, old installations still have high PAH emissions, leading to local high ambient air concentrations (E.C., 2001). PAH emissions at steel production using electric arc furnaces originate from the presence of tar in the used refractory material."

"Creosote is a distillation product of coal tar, a by-product of bituminous coal coking. Emissions of PAH take place at all stages of the wood preservation process: impregnation, storage, transport and use. In the creosote and wood preservation industry, wood is mainly impregnated under pressure in vessels, but can also be sprayed or dipped. Since 2003 creosoted wood is only to be used for certain applications by professionals when treated in vacuum/pressure installations. Creosoted wood, which is treated through spraying, brushing or dipping is banned in the European Union. Creosoted wood is completely banned for certain applications like playgrounds, garden and garden furniture according to the EU Directive 2001/90/EC. Consequently wood preservation through spraying and dipping has been phased out in the European Union. Therefore emission from this source is expected to reduce considerably. PAH emissions to air from solvent use, which includes wood impregnation, in the United Kingdom clearly decreased over the period 1990 till 2002 from 104 tonnes to 69 tonnes with no clear decrease in the period 2000 till 2002. From this information it might be concluded that there is not clear direct effect on emissions from PAH resulting from the enforcement of the EU Directive at least in the United Kingdom. Other industrial sources include petrochemical and related industries (refineries), bitumen and asphalt industries (production and use), waste incineration, power plants, rubber tyre production, cement production (combustion of fossil fuels) and motor test rigs."

Domestic sources

"PAH-emissions from domestic sources are predominantly associated with the combustion of solid fuels as wood and coal for heating and cooking purposes. These sources contribute significantly to the total PAH emission. In Europe there is a large geographic variation in these domestic emissions due to climatic differences and to the heating systems in use. In addition to heating purposes, wood, coal or peat are also burned for the decorative effect in open fireplaces."

Mobile sources

"Mobile sources include all modes of transport using a combustion engine. PAH emissions from these sources depend on engine type, fuel type, emission control, outdoor temperature, load of vehicle, age of the car/engine and driving habits. Diesel fuelled vehicles have higher particulate emissions and the emission control equipment is less developed than gasoline vehicles. Therefore, diesel fuelled vehicles are responsible for more PAH emissions on the road. The wear and tear of tyres is also an important source of PAH emissions. Due to the extensive use of catalytic converters and improved diesel quality, the PAH emissions from tyres could even be larger than those from the exhaust of vehicles (Edlund, 2001). Non road transport includes all PAH emissions from combustion engines used by shipping activities, railways and aircrafts."

Agricultural sources

"Agricultural sources involve the burning of organic materials under less optimum combustion activities and therefore produce significant amounts of PAH. These activities include stubble burning, open burning of land for regeneration purposes or the open burning of brushwood, trimmings, straw etc. In some EU countries there are regulations in place regulating these emissions (E.C., 2001)."

4.2.2 Fluoranthene emissions to water

Fluoranthene can be emitted to surface water directly or indirectly via a STP by (industrial) point sources and via atmospheric deposition. Information on Fluoranthene emission to surface water for the EU is limited to the E-PRTR database. The European Pollutant Release and Transfer Register (E-PRTR, 2010) reports Fluoranthene emission of the different point sources for 2008 (see Table below).

Fluoranthene emissions to water in the EU for 2008 (The European Pollutant Release and Transfer Register (E-PRTR, 2010)) All values are yearly releases.

Pollutant: Fluoranthene
Year: 2008
Area: All Reporting States for E-PRTR
Facilities: 44

Releases per industrial activity		Facilities	Water
1 Energy sector	**Total**	**17**	**134 kg**
	Accidental	**0**	**0**
1.(a) Mineral oil and gas refineries	Total	1	1.91 kg
	Accidental	0	0
1.(b) Gasification and liquefaction	Total	1	1.91 kg
	Accidental	0	0
1.(c) Thermal power stations and other combustion installations	Total	13	119 kg
	Accidental	0	0
2 Production and processing of metals	**Total**	**6**	**8.31 t**
	Accidental	**0**	**0**
2.(a) Metal ore (including sulphide ore) roasting or sintering installations	Total	1	3.10 kg
	Accidental	0	0
2.(b) Production of pig iron or steel including continuous casting	Total	2	21.3 kg
	Accidental	0	0

Releases per industrial activity		**Facilities**	**Water**
2.(c) Processing of ferrous metals	Total Accidental	1 0	20.2 kg 0
2.(d) Ferrous metal foundries	Total Accidental	1 0	2.50 kg 0
2.(e) Production of non-ferrous crude metals from ore, concentrates or secondary raw materials	Total Accidental	1 0	8.26 t 0
2.(e).(i) Metallurgical, chemical or electrolytic production of non ferrous metals	Total Accidental	*1* *0*	*8.26 t* *0*
4 Chemical industry	**Total** **Accidental**	**2** **0**	**17.6 kg** **0**
4.(a) Industrial scale production of basic organic chemicals	Total Accidental	2 0	17.6 kg 0
4.(a).(iv) Nitrogenous hydrocarbons	*Total* *Accidental*	*1* *0*	*4.10 kg* *0*
Unspecified (Not reported on this level)	*Total* *Accidental*	*1* *0*	*13.5 kg* *0*
5 Waste and waste water management	**Total** **Accidental**	**17** **1**	**51.6 kg** **156 g**
5.(f) Urban waste-water treatment plants	Total Accidental	15 1	47.6 kg 156 g
5.(g) Independently operated industrial waste-water treatment plants serving a listed activity	Total Accidental	2 0	18.0 kg 0
9 Other activities	**Total** **Accidental**	**2** **0**	**18.0 kg** **0**
9.(a) Pretreatment or dyeing of fibres or textiles	Total Accidental	1 0	9.00 kg 0
9.(d) Production of carbon or electro-graphite through incineration or graphitization	Total Accidental	1 0	9.00 kg 0
Total **Accidental**	**Total** **Accidental**	**44** **1**	**8.53 t** **156 g**

5 ENVIRONMENTAL BEHAVIOUR

5.1 ENVIRONMENTAL DISTRIBUTION

		Master reference
Water solubility ($mg.l^{-1}$)	0.2	Mackay *et al.*, 1992 *in* E.C., 2008a
Volatilisation	**Fluoranthene is not likely to volatilise from surface water.**	
Vapour pressure (Pa)	$1.2\ 10^{-3}$ at 25°C	Mackay *et al.*, 1992 *in* E.C., 2008a
Henry's Law constant ($Pa.m^3.mol^{-1}$)	1.1 at 25°C	Mackay *et al.*, 1992 *in* E.C., 2008a
Adsorption	**The value 97 724 is used for derivation of QS**	
Organic carbon – water partition coefficient (K_{OC})	log K_{OC} = 4.99 (*calculated from K_{OW}*) K_{OC} = 97 724	Karickhoff *et al.*, 1979
Sediment – water partition coefficient ($K_{sed\ -water}$)	2 444 (*calculated from K_{OC}*)	E.C., 2011
Bioaccumulation	**The BCF value of 4 800 is used for derivation of QSbiota secpois. and BMF1 = BMF2 = 1 given the absence of biomagnification (Bleeker, 2009).**	
Octanol-water partition coefficient (Log Kow)	5.2	Mackay *et al.*, 1992 *in* E.C., 2008a
BCF	1 179 (*calculated from exp. K_{OW}*)	US-EPA, 2008
	Geometric means per taxa based on data reported in the BCF dedicated table hereafter: - BCF polychaetes = 720 - BCF molluscs = 3 932 - BCF crustaceans ≅ 4 800 - BCF insects = 1 496 - BCF fish = 2 439 - BCF amphibians = 1 007 BCF is set to the highest geometric mean, that is to say 4 000. Moreover, these data demonstrate an absence of biomagnification given that higher trophic levels (fish and amphibians) present lower BCF values than lower trophic levels such as molluscs. Therefore, trophic dilution seems more likely than biomagnification and BMF values should be set to 1 by default.	Bleeker, 2009
BSAF fish	2 – 6 (*Ictalurus nebulosus*)	van der Oost *et al.*,

	0.0005–0.001 (*Fundulus heteroclitus*) 0.00016 (*Salvelinus namaycush*)	1994 *in* E.C., 2008a

Table summarising BCF values for fluoranthene in several aquatic species (Bleeker, 2009)

Taxa	Species	Test system (a)	Chem. Analysis (b)	BCF ($l.kg^{-1}$)	Type (c)	Reliability (d)	Reference
Pisces	*Pimephales promelas*	FT	HPLC	2439	Equi.	2	Carlson *et al.*, 1979
Mollusca	*Mya arenaria*	FT	HPLC	4120	Kin.	1	McLeese and Burridge, 1987
	Mytilus edulis	FT	HPLC	5920	Kin.	1	McLeese and Burridge, 1987
	Perna viridis	SR	GC	12250[1]	Equi.	2	Richardson *et al.*, 2005
	Utterbackia imbecillis (glochidia)	FT	HPLC	1735, 1813	Equi	2	Weinstein, 2001
Crustacea	*Crangon septemspinosa*	FT	HPLC	180	Kin.	1	McLeese and Burridge, 1987
	Daphnia magna	SR	HPLC	1742	Equi.	2	Newsted and Giesy, 1987
	Diporeia spp.	SR	14C	15136 – 58884[2]	Kin.	2	Schuler *et al.*, 2004
	Hyalella azteca	SR	14C	1202 – 5370[4]	Kin.	2	Schuler *et al.*, 2004
Insecta	*Chironomus tentans* (3rd instar larvae)	SR	14C	891 – 2512[4]	Kin.	2	Schuler *et al.*, 2004
Polychaeta	*Nereis virens*	FT	HPLC	720	Kin.	1	McLeese and Burridge, 1987
Amphibia	*Rana pipiens*	FT	HPLC	611 – 1659[4]	Equi.	1	Monson *et al.*, 1999

a) FT: flow-through system; S: static; SR: static renewal. b) 14C: radioactive carbon in the parent compound; GC: Gas chromatography; GCMS: Gas chromatography with mass spectrometry; Flu.Spec.: fluorescence spectrometry; 3H: radioactive hydrogen in the parent compound; HPLC: high pressure liquid chromatography. c) Kin.: Kinetic BCF, i.e. $k1/k2$; Equi.: BCF at (assumed) equilibrium, i.e. Corganism/Cwater. d) Reliability; 1: valid without restrictions; 2: valid with restrictions.

[1] In this study BCF values are based on lipid weight, values given in this table are normalized to 5% lipid content.

[2] Values represent (a range of) BCF values from (a range of) different exposure concentrations.

5.2 ABIOTIC AND BIOTIC DEGRADATIONS

All information reported hereunder are extracted from Final CTPHT EU-RAR (E.C., 2008a).

Hydrolysis	PAH are chemically stable, with no functional groups that results in hydrolysis. Under environmental conditions, therefore, hydrolysis does not contribute to the degradation of PAH (Howard *et al.*, 1991).
Photolysis	The main abiotic transformation is photochemical decomposition, which in natural water takes place only in the upper few centimetres of the aqueous phase. PAHs are photodegraded by two processes, direct photolysis by light with a wavelength < 290 nm and indirect photolysis by least one oxidizing agent (Volkering and Breure, 2003). Singlet oxygen usually plays the main role in this process and the degradation process is related to the content of oxygen dissolved (Moore and Ranamoorthy, 1984). When PAHs are absorbed on particles, the accessibility for photochemical reactions may change, depending on the nature of the particles. There are great differences in photochemical reactivity between the various PAHs.
Biodegradation	The results from standard test for biodegradation in water show that PAH with up to four aromatic rings are biodegradable under aerobic conditions but that the biodegradation rate of PAH with more aromatic rings is very low (EHC, 1998). Although some evidence for anaerobic transformation of PAHs has been obtained (Coates *et al.*, 1997; Thierrin *et al.*, 1993), PAHs are usually considered to be persistent under anaerobic conditions (Neff, 1979; Volkering and Breure, 2003). Because marine sediments are often anaerobic, degradation of PAHs in this compartment is expected to be very slow. The biochemical pathway for the aerobic biodegradation of PAHs has extensively been investigated. It is understood that the initial step in the aerobic catabolism of a PAH molecule by bacteria occurs via oxidation of the PAH to a dihydrodiol by a multicomponent enzyme system. These dihydroxylated intermediates may then be processed through either an ortho cleavage type of pathway, in which ring fission occurs between the two hydroxylated carbon atoms, or a meta cleavage type of pathway, which involves cleavage of the bond adjacent to the hydroxyl groups, leading to central intermediates such as protocatechates and catechols. These compounds are further converted to tricarboxylic acid cycle intermediates (van der Meer *et al.*, 1992). Although the biodegradation pathway of the different PAHs is very similar their biodegradation rates differ considerably. In general the biodegradation rate decreases with increasing number of aromatic rings. For example, for degradation by bacteria from estuary half lives for B[a]P of more than 1750 days was found (Gerlach, 1981). According to Volkering and Breure (2003), two factors are considered responsible for the difference in degradation rate. First, the bacterial uptake rates of the compounds with higher molecular weight have been shown to be lower than the uptake rates of the low molecular weight PAHs. The second and most important factor is the bioavailability of PAHs, due to sorption on suspended organic matter and sediment. Since the Kow and the Koc are strongly correlated, high molecular weight PAHs will degrade slower than low molecular weight PAHs. This is illustrated by Durant *et al.*, 1995 who found that the half-life of PAHs in estuarine sediment was reversely related to the Kow. Biodegradation rates also are extremely dependent on the (a)biotics conditions both in the lab and in the field. Important influencing factors are (1) the substrate concentration; with low PAH concentrations leading to longer half-lives; (2) temperature, which reversely relates to the half-live and (3) the presence or absence of a lag-phase (De Maagd, 1996b). In addition, the desorption rate of PAH appears to decrease with increase of the residence time of PAHs due to slow sorption into micropores and organic matter, and polymerization or covalent binding to the organic fraction. The consequence of this aging process is a decreased biodegradability and a decreased toxicity (Volkering and Breure, 2003).

6 AQUATIC ENVIRONMENTAL CONCENTRATIONS

6.1 ESTIMATED CONCENTRATIONS

As sufficient monitoring data are available no separate calculation of the regional PECs had been performed. Therefore, only C_{local} values are presented hereunder.

Compartment		**Predicted environmental concentration (PEC)**	**Master reference**
Freshwater (µg.l^{-1})	$C_{\text{local – production}}$	$3.4\ 10^{-7}$ – $5\ 10^{-3}$	E.C., 2008a
	$C_{\text{local – primary Al production}}$	0.021 – 210	
Marine waters (µg.l^{-1})	$C_{\text{local – production}}$	$2\ 10^{-5}$	E.C., 2008a
	$C_{\text{local – ferro-alloy producing ind.}}$	0.0275	
	$C_{\text{local – primary Al production}}$	$5.5\ 10^{-4}$ – 17	
Freshwater sediment (µg.kg^{-1} dw)	$C_{\text{local – production}}$	$3.4\ 10^{-3}$ – 55	E.C., 2008a
	$C_{\text{local – primary Al production}}$	210 – 210 000	
Marine sediment (µg.kg^{-1} dw)	$C_{\text{local – production}}$	0.26	E.C., 2008a
	$C_{\text{local – ferro-alloy producing ind.}}$	266.5	
	$C_{\text{local – primary Al production}}$	0.1 – 160 000	
Biota (freshwater)		No data available	
Biota (marine)		No data available	
Biota (marine predators)		No data available	

6.2 MEASURED CONCENTRATIONS

Compartment		**Measured environmental concentration (MEC)**	**Master reference**
Freshwater (µg.l^{-1})		PEC 1: 0.059 PEC 2: 0.05	James *et al.*, 2009$^{(1)}$
Marine waters (coastal and/or transitional) (µg.l^{-1})		No data available	
WWTP effluent (µg.l^{-1})		No data available	
Sediment(µg.kg^{-1} dw)	Sed < 2 mm	PEC 1: 439.5 PEC 2: 373	James *et al.*, 2009$^{(1)}$
	Sed 20 µm	PEC 1: 2 388 PEC 2: 2 388	
	Sed 63µm	PEC 1: 66 PEC 2: 60	
Biota(µg.kg^{-1} ww)	Invertebrates	PEC 1: 0.004 PEC 2: 0.004	James *et al.*, 2009$^{(1)}$

	Fish	PEC 1:	35.6	
		PEC 2:	33.8	
	Marine predators	No data available		

[(1)] *data originated from EU monitoring data collection*

7 EFFECTS AND QUALITY STANDARDS

Final CTPht EU-RAR (E.C., 2008a) states that "PAHs can be toxic via different mode of actions, such as non-polar narcosis and phototoxicity. The last is caused by the ability of PAHs to absorb ultraviolet A (UVA) radiation (320–400 nm), ultraviolet B (UVB) radiation (290–320 nm), and in some instances, visible light (400–700 nm). This toxicity may occur through two mechanisms: photosensitization, and photomodification. Photosensitization generally leads to the production of singlet oxygen, a reactive oxygen species that is highly damaging to biological material. Photomodification of PAHs, usually via oxidation, results in the formation of new compounds and can occur under environmentally relevant levels of actinic radiation (Lampi et al., 2005). The photo[induced]toxic effects can be observed after a short period of exposure, which explains why for PAHs like anthracene, fluoranthene and pyrene, where photo[induced]toxicity is most evident, the acute toxicity values are even lower than the chronic toxicity values. there is a growing body of evidence which suggests that photo[induced]toxic PAHs may be degrading aquatic habitats, particularly those in highly contaminated areas with shallow or clear water (Weinstein and Oris, 1999). For example, the photoinduced chronic effects of anthracene have been reported at those UV intensities occurring at depths of 10 to 12 m in Lake Michigan (Holst and Giesy, 1989). In addition to direct uptake of PAHs from the water column, another potential route of exposure for aquatic organisms is their accumulation from sediments (see e.g. Clemens *et al.*, 1994; Kukkonen and Landrum, 1994), followed by subsequent solar ultraviolet radiation exposures closer to the surface. Other authors (Ankley et al., 2004) also concluded in their peer review that PAHs are present at concentrations in aquatic systems such that animals can achieve tissue concentrations sufficient to cause photoactivated toxicity. Although UV penetration can vary dramatically among PAH-contaminated sites, in their view it is likely that at least some portion of the aquatic community will be exposed to UV radiation at levels sufficient to initiate photoactivated toxicity. They do recognize that at present time, the ability to conduct PAH photoactivated risk assessment of acceptable uncertainty is limited by comprehensive information on species exposure to PAH and UV radiation during all life stages. PAH exposure and uptake, as well as UV exposure, are likely to vary considerably among species and life stages as they migrate into and out of contaminated locations and areas of high and low UV penetration. For all but sessile species, these patterns of movements are the greatest determinant of the risk for photoactivated toxicity."

Despite these uncertainties, it is thought that the photo[induced]toxic effects cannot be ignored in the effects assessment and EQS derivation processes. Therefore these effects are also considered and it should be noted that the UV exposure levels of the selected studies did not exceed the UV levels under natural sun light conditions.

7.1 ACUTE AND CHRONIC AQUATIC ECOTOXICITY

Ecotoxicity data reported in the tables hereunder were extracted exclusively from the finalised version of CTPHT EU-RAR (E.C., 2008a) and a RIVM report in preparation (Verbruggen, in prep.) which was made available to the assessor.

Many ecotoxicity data are available to assess fluoranthene effects. Almost all data were reported in the tables below but preference was given to L(E)Cx > EC10 > NOEC for acute data as well as to NOEC > EC10 > L(E)Cx for chronic data. In the same vein, preference was always given to sublethal effects compared to mortality whenever both endpoints were available. When EC10 and NOEC were available but EC10 was lower, the EC10 value was preferred to the NOEC value.

Fluoranthene being very phototoxic, information on the absence/presence of light as well as the type was reported in the tables as much as possible.

Whenever it was possible, for each species, endpoints are reported for tests for which results were based on measured concentrations (reported as (m) in the tables hereunder) rather than nominal concentrations (reported as (n) in the tables hereunder). Also, when available, information is given on the type of exposure, i.e.: static (s), static closed (sc), renewal (r), renewal closed (rc), continuous flow (cf), or intermittent flow system (if).

In the table below, all data reported were considered valid for effects assessment purposes, i.e. could be given a reliability index (Klimisch code) of 1 or 2, or were considered useful as supporting information for effects assessment purposes, i.e. could be given a reliability index (Klimisch code) of 2/3. Information on reliability was retrieved from the finalised version of CTPHT EU-RAR (E.C., 2008a) and a RIVM report in preparation (Verbruggen, in prep.).

7.1.1 Organisms living in the water column

ACUTE EFFECTS			**Klimisch code**	**Master reference**
Bacteria $(mg.l^{-1})$	**Freshwater**	No information available		
	Marine	*Vibrio fischeri* / 30mn / Lumistox test $EC_{10\text{ – bioluminescence}}$ > water solubility (m, s)	2 acc^{ing} to RIVM	Loibner *et al.*, 2004
Algae & aquatic plants $(mg.l^{-1})$	**Freshwater** Algae	*Scenedesmus vacuolatus* / 24h $EC_{50\text{, cell number}}$ = 0.036 (m, sc)		Walter *et al.*, 2002
		Scenedesmus vacuolatus / 24h $EC_{50\text{, cell number}}$ = 0.034 (m, sc)		Altenburger *et al.*, 2004
		Anabaena flos-aqua / 2h $EC_{10\text{ – nitrogen fixation}}$ = 0.210 (m, s)		Bastian and Toetz, 1985
	Macrophytes	*Lemna minor* / 96h $EC_{50\text{ – growth – fluorescent light}}$ > 0.166 (m) $EC_{50\text{ – growth – UV light}}$ > 0.159 (m)	2 acc^{ing} to EU-RAR	Spehar *et al.*, 1999
	Marine	No information available		

ACUTE EFFECTS			Klimisch code	Master reference
Invertebrates ($mg.l^{-1}$)	**Freshwater** Coelenterates	*Hydra Americana* / 96h $LC_{50 \text{ – fluorescent light}}$ = 0.070 (m, cf) $LC_{50 \text{ – UV light}}$ = 2.2 10^{-3} (m, cf)	2 acc[ing] to EU-RAR	Spehar *et al.*, 1999
	Annelids	*Lumbriculus variegatus* / 96h $LC_{50 \text{ – fluorescent light}}$ > 0.178 (m, cf) $LC_{50 \text{ – UV light}}$ = 1.2 10^{-3} (m, cf)		Spehar *et al.*, 1999
		Lumbriculus variegatus / 96h $LC_{50 \text{ – fluorescent light}}$ > 0.143 (m, cf) $LC_{50 \text{ – UV light}}$ = 0.072 (m, cf)		Ankley *et al.*, 1995
	Molluscs	*Physella virgata* / 96h / adult $LC_{50 \text{ – fluorescent light}}$ > 0.178 (m, cf) $LC_{50 \text{ – UV light}}$ = 0.082 (m, cf)		Spehar *et al.*, 1999
		Utterbackia imbecilis / 4+24h / larvae $LC_{50 \text{ – ambient laboratory light}}$ > 0.110 (m, r) $LC_{50 \text{ – UV light}}$ = 2 10^{-3} – 2.9 10^{-3} (m, r)	2 acc[ing] to RIVM	Weinstein and Polk, 2001
	Crustaceans	*Ceriodaphnia dubia* / 48h / larvae $LC_{50 \text{ – fluorescent light}}$ = 0.045 (m, r)	2 acc[ing] to EU-RAR	Oris *et al.*, 1991
		Daphnia magna / 72-96h / larvae (m, s) $EC_{50 \text{ – mortality – artificial light, low UV}}$ = 0.058 $EC_{50 \text{ – feeding – artificial light, low UV}}$ = 0.037 $EC_{50 \text{ – reproduction – artificial light, low UV}}$ = 0.043 $EC_{50 \text{ – growth – artificial light, low UV}}$ = 0.104		Barata and Baird, 2000
		Daphnia magna / 48h / larvae $EC_{50 \text{ – dark}}$ = 0.087 (m, s)	2 acc[ing] to RIVM	Barata and Baird, 2000
		Daphnia magna / 48h / larvae $EC_{50 \text{ – dark}}$ > 0.112 (m, s)	2 acc[ing] to EU-RAR	Barata and Baird, 2000
		Daphnia magna / 48h / larvae $LC_{50 \text{ – fluorescent light}}$ = 0.117 (m, r) $LC_{50 \text{ – UV light}}$ = 1.6 10^{-3} (m, r)		Spehar *et al.*, 1999
		Daphnia magna / 48h LC_{50} = 0.105 (m, s)		Suedel and Rodgers, 1996
		Gammarus pseudolimnaeus / 96h / adult $LC_{50 \text{ – fluorescent light}}$ = 0.108 (m, cf)		Spehar *et al.*, 1999
		Hyalella azteca / 5d / juvenile LC_{50} = 0.177 (m, r)	2 acc[ing] to RIVM	Schuler *et al.*, 2004
		Hyalella azteca / 96h $LC_{50 \text{ – fluorescent light}}$ = 0.044 (m, r)	2 acc[ing] to EU-RAR	Spehar *et al.*, 1999
		Hyalella azteca / 48h LC_{50} = 0.092 (m, s)		Suedel and Rodgers, 1996

ACUTE EFFECTS			**Klimisch code**	**Master reference**
Invertebrates ($mg.l^{-1}$)	**Marine** Annelids	*Neanthes arenaceodentata* / 96h / immature young LC_{50} = 0.258 (m, s)	2 acc[ing] to EU-RAR	Rossi and Neff, 1978
		Neanthes arenaceodentata / 96h / adult $LC_{50\,–\,fluorescent\,light}$ > 0.127 (m, r)		Spehar *et al.*, 1999
	Molluscs	*Mulinea lateralis* / 96h / juvenile $LC_{50\,–\,UV\,light}$ = 1.8 10^{-3} (m, s) $EC_{50\,–\,growth\,–\,UV\,light}$ > 0.81 10^{-3} (m, s)		Pelletier *et al.*, 1997
		Mulinea lateralis / 96h / embryo-larval $LC_{50\,–\,fluorescent\,light}$ > 0.127 (m, s)		Spehar *et al.*, 1999
		Mytilus edulis / 48h $EC_{50\,–\,feeding\,f\,filtration}$ = 0.08 (m, r)		Donkin *et al.*, 1989 Donkin *et al.*, 1991
	Crustaceans	*Acartia tonsa* / 48h / fertilized female LC_{50} = 0.12 (n, rc)		Bellas and Thor, 2007
		Ampelisca abdita / 96h / juvenile $LC_{50\,–\,fluorescent\,light}$ = 0.067 (m, r)		Spehar *et al.*, 1999
		Callinectes sapidus / 1h / 1d-larvae $LC_{50\,–\,sunlight}$ = 0.025 (m, s) $LC_{50\,–\,UV\,light}$ = 0.0.17 (m, s)	2 acc[ing] to RIVM	Peachey, 2005
		Corophium insidiosum / 96h $LC_{50\,–\,UV\,light}$ = 0.085 (m, r) $LC_{50\,–\,1h\,UV\,(after\,reburial,\,expo>\,96h)}$ = 0.02 – 0.054 (m, r)	2 acc[ing] to EU-RAR	Boese *et al.*, 1997
		Emerita analoga / 96h $LC_{50\,–\,UV\,light}$ = 0.074 (m, r) $LC_{50\,–\,1h\,UV\,(after\,reburial,\,expo>\,96h)}$ = 0.073-0.074 (m, r)		Boese *et al.*, 1997
		Eohaustorius estuaries / 96h (m, r) $LC_{50\,–\,UV\,light}$ > 0.07 $LC_{50\,–\,1h\,UV\,(after\,reburial,\,expo>\,96h)}$ = 0.066 $EC_{50\,–\,reburial\,(after\,1h\,UV,\,expo>\,96h)}$ = 0.007		Boese *et al.*, 1997
		Excirolana vancouverensis / 96h (m, r) $LC_{50\,–\,UV\,light}$ > 0.07 $LC_{50\,–\,1h\,UV\,(after\,reburial,\,expo>\,96h)}$ > 0.07 $EC_{50\,–\,reburial\,(after\,1h\,UV,\,expo>\,96h)}$ > 0.07		Boese *et al.*, 1997
		Grandidierella japonica / 96h (m, r) $LC_{50\,–\,UV\,light}$ = 0.036 $LC_{50\,–\,1h\,UV\,(after\,reburial,\,expo>\,96h)}$ = 0.026 $EC_{50\,–\,reburial\,(after\,1h\,UV,\,expo>\,96h)}$ = 0.019-0.027		Boese *et al.*, 1997

ACUTE EFFECTS			Klimisch code	Master reference
		Homarus americanus / 96h / larvae $LC_{50 \text{ – fluorescent light}}$ = 0.317 (m, r)		Spehar *et al.*, 1999
	(Marine Crustaceans Continued)	*Leptocheirus plumulosus* / 96h (m, r) $LC_{50 \text{ – UV light}}$ > 0.098 $LC_{50 \text{ – 1h UV (after reburial, expo> 96h)}}$ = 0.069 $EC_{50 \text{ – reburial (after 1h UV, expo> 96h)}}$ = 0.020-0.051	2 acc^{ing} to EU-RAR	Boese *et al.*, 1997
		Libinia dubia / 1h / 1d-larvae $LC_{50 \text{ – UV light}}$ = 0.017 (m, s)	2 acc^{ing} to RIVM	Peachey, 2005
		Menippe adina / 1h / 1d-larvae $LC_{50 \text{ – UV light}}$ = 0.039 (m, s)		Peachey, 2005
		Mysidopsis bahia / 48h / juvenile $LC_{50 \text{ – fluorescent light}}$ = 0.063 (m, s) $LC_{50 \text{ – UV light}}$ = 0.005 (m, s)	2 acc^{ing} to EU-RAR	Pelletier *et al.*, 1997
		Mysidopsis bahia / 96h (m, cf) $LC_{50 \text{ – fluorescent light}}$ = 0.031 $LC_{50 \text{ – UV light (intensity 7 µW/cm2 UV-A)}}$ = 0.058 $LC_{50 \text{ – outdoor natural UV light}}$ = 1.7 10^{-3} $LC_{50 \text{ – UV light (intensity 1788 µW/cm2 UV-A)}}$ = 1.4 10^{-3}		Spehar *et al.*, 1999
		Oithona davisae / 48h / adult $EC_{50 \text{ – immobility}}$ = 0.133 (m, s)	2 acc^{ing} to RIVM	Barata *et al.*, 2005
		Palaemonetes sp. / 96h $LC_{50 \text{ – fluorescent light}}$ = 0.142 (m, r)	2 acc^{ing} to EU-RAR	Spehar *et al.*, 1999
		Panopeus herbstii / 1h / 1d-larvae $LC_{50 \text{ – UV light}}$ = 0.025 (m, s)	2 acc^{ing} to RIVM	Peachey, 2005
	Echinoderms	*Arbacia punctulata* / 96h / embryo-larval $LC_{50 \text{ – fluorescent light}}$ > 0.127 (m, s)	2 acc^{ing} to EU-RAR	Spehar *et al.*, 1999
	Sediment Freshwater	*Chironomus tentans* / 48h LC_{50} = 0.140 (m, r)	2 acc^{ing} to RIVM	Schuler *et al.*, 2004
		Chironomus tentans / 48h LC_{50} > 0.250 (m, s)	2 acc^{ing} to EU-RAR	Suedel and Rodgers, 1996
		Ophiogemphus sp. / 96h / nymph $LC_{50 \text{ – fluorescent light}}$ > 0.178 (m, cf) $LC_{50 \text{ – UV light}}$ > 0.110 (m, cf)		Spehar *et al.*, 1999
		Stylaria lacustris / 48h LC_{50} > 0.220 (m, s)		Suedel and Rodgers, 1996

ACUTE EFFECTS			Klimisch code	Master reference
	Marine	*Rhepoxynius abronius* / 96h (m, r) $LC_{50 – UV\ light}$ > 0.07 $LC_{50 – 1h\ UV\ (after\ reburial,\ expo>\ 96h)}$ = 0.014 $EC_{50 – reburial\ (after\ 1h\ UV,\ expo>\ 96h)}$ < 5-0.063		Boese *et al.*, 1997
Fish (mg.l^{-1})	**Freshwater**	*Lepomis macrochirus* / 96h / juvenile $LC_{50 – fluorescent\ light}$ > 0.117 (m, cf) $LC_{50 – UV\ light}$ = 0.012 (m, cf)	2 acc^{ing} to EU-RAR	Spehar *et al.*, 1999
		Oncorhynchus mykiss / 96h $LC_{50 – fluorescent\ light}$ > 0.091 (m, cf) $LC_{50 – UV\ light}$ = 7.7 10^{-3} (m, cf)		Spehar *et al.*, 1999
		Pimephales promelas / 96h $LC_{50 – fluorescent\ light}$ > 0.212 (m, cf) $LC_{50 – UV\ light}$ = 0.012 (m, cf)		Spehar *et al.*, 1999
		Pimephales promelas / 96h / larvae $LC_{50 – fluo.\ light\ +\ UV\ radiation}$ = 6.8 10^{-3} – 9.4 10^{-3} (m, cf)		Diamond *et al.*, 1995
	Marine	*Cyprinodon variegatus* / 96h $LC_{50 – fluorescent\ light}$ > 0.127 (m, r)		Spehar *et al.*, 1999
		Pleuronectus americanus / 96h $LC_{50 – fluorescent\ light}$ > 0.188 (m, s) $LC_{50 – UV\ light}$ = 1 10^{-4} (m, s)		Spehar *et al.*, 1999
	Sediment	No information available		
Amphibians (mg.l^{-1})	**Freshwater**	*Rana catesbeiana* / 96h / embryo LC_{50} = 0.111 (m, s)	2 acc^{ing} to RIVM	Walker *et al.*, 1998
		Rana pipiens / 48h / embryo $LC_{50 – without\ UV\ light}$ > 30.6 10^{-3} (m, cf) $LC_{50 – UV\ light}$ = 2 10^{-3} – 7.3 10^{-3} (m, cf)	2 acc^{ing} to EU-RAR	Monson *et al.*, 1999
		Rana pipiens / 48h / embryo LC_{50} = 0.193 (m, r)		Hatch and Burton, 1998
	Marine	No information available		

CHRONIC EFFECTS			**Klimisch code**	**Master reference**
Algae & aquatic plants (**mg.l^{-1}**)	**Freshwater** Algae	*Pseudokirchneriella subcapitata* / 72h $EC_{10\text{ – growth – 6000-8000 lux}}$ = 8.6 10^{-3} (m, sc)	2 acc^{ing} to EU-RAR	Bisson *et al.*, 2000
		Scenedesmus vacuolatus / 24h $NOEC_{50,\text{ cell number}}$ = 0.013 (m, sc)	2 acc^{ing} to RIVM	Walter *et al.*, 2002
		Scenedesmus vacuolatus / 24h $EC_{10,\text{ cell number}}$ = 0.014 (m, sc)		Altenburger *et al.*, 2004
	Macrophytes	*Lemna gibba* / 8d $EC_{10\text{ – growth rate}}$ = 0.130 (m, r)	2 acc^{ing} to EU-RAR	Ren *et al.*, 1994
	Marine	No information available		

CHRONIC EFFECTS			Klimisch code	Master reference
Invertebrates ($mg.l^{-1}$)	**Freshwater** Crustaceans	*Ceriodaphnia dubia* / 7d $EC_{10 \text{ – reproduction}} = 1.2\ 10^{-3}$ (m, r)	2 acc[ing] to EU-RAR	Bisson *et al.*, 2000
		Ceriodaphnia dubia / 7d $NOEC_{reproduction} = 0.032$ (m, r)		Oris *et al.*, 1991
		Daphnia magna / 21d $NOEC_{\text{growth – fluorescent light}} = 0.017$ (m, r) $NOEC_{\text{growth – UV light}} = 1.4\ 10^{-3}$ (m, r)		Spehar *et al.*, 1999
		Daphnia magna / 10d $NOEC_{mortality} = 0.090$ (m, s)		Suedel and Rodgers, 1996
		Diporeia sp. / 10d $NOEC_{\text{mortality – yellow light}} < 0.063$ (m, r)		Kane Driscoll *et al.*, 1997
		Diporeia sp. / 28d $LC_{10} = 6.5\ 10^{-3}$ (m, r)	2 acc[ing] to RIVM	Schuler *et al.*, 2004
		Hyalella azteca / 10d $NOEC_{mortality} = 0.018$ (m, s)	2 acc[ing] to EU-RAR	Suedel and Rodgers, 1996
		Hyalella azteca / 10d $NOEC_{\text{mortality – yellow light}} = 0.014$ (m, r)		Kane Driscoll *et al.*, 1997
		Hyalella azteca / 10d (m, r) $LC_{\text{10 – mortality – gold light}} = 0.056$ $LC_{\text{10 – mortality – fluorescent light}} = 0.008$ $LC_{\text{10 – mortality – UV light}} = 0.001$		Wilcoxen *et al.*, 2003
		Hyalella azteca / 10d (m, r) $LC_{\text{50 – mortality – without UV light}} = 0.071$ $LC_{\text{50 – mortality – simulated sunlight}} = 7.3\ 10^{-3}$		Hatch and Burton, 1999
		Hyalella azteca / 10d / juvenile $LC_{\text{10 – mortality – gold light}} = 0.026$ (m, r)	2 acc[ing] to RIVM	Schuler *et al.*, 2004
		Hyalella azteca / 10d $EC_{\text{50 – immobility – 1000 lux}} = 0.044$ (m, s)	2 acc[ing] to EU-RAR	Suedel *et al.*, 1993
	Marine Molluscs	*Mulinea lateralis* / 48h / embryo-larval (m, s) $EC_{\text{50 –development – fluorescent light}} = 0.058$ $EC_{\text{50 –development – UV light}} = 1.09\ 10^{-3}$	2 acc[ing] to EU-RAR	Pelletier *et al.*, 1997
		Mytilus galloprovincialis / 48h / fertilized eggs (m, sc) $EC_{\text{10 – larval development – cool daylight}} = 0.0.34$	2 acc[ing] to RIVM	Bellas *et al.*, 2008
	Crustaceans	*Acartia tonsa* / 48-72h / fertilised female $EC_{\text{10 – reproduction}} = 0.041$ (n, rc)	2 acc[ing] to EU-RAR	Bellas and Thor, 2007
		Mysidopsis bahia / 31d $NOEC_{\text{reproduction – fluorescent light}} = 6\ 10^{-4}$ (m, cf)		Spehar *et al.*, 1999

		Mysidopsis bahia / 31d $NOEC_{reproduction – UV light}$ = 0.011 (m, cf)		Spehar *et al.*, 1999
	Echinoderms	*Paracentrotus lividus* / 48h / fertilized eggs $EC_{10 – larval development}$ = 0.021 (m, sc)	2 acc^{ing} to RIVM	Bellas *et al.*, 2008
Tunicates	**Marine** Ascidiaceans	*Ciona intestinalis* / 20h / fertilized eggs (m, sc) $EC_{10 – larval development – cool daylight}$ = 0.242	2 acc^{ing} to RIVM	Bellas *et al.*, 2008

CHRONIC EFFECTS			**Klimisch code**	**Master reference**
Invertebrates ($mg.l^{-1}$) continued	**Sediment**	*Chironomus tentans* / 10d $LC_{50 – artificial light}$ = 0.012 (m, r)	2 acc^{ing} to EU-RAR	Hatch and Burton, 1999
		Chironomus tentans / 10d / 3rd instar $LC_{10 – gold light}$ = 0.013 (m, r)	2 acc^{ing} to RIVM	Schuler *et al.*, 2004
		Chironomus tentans / 10d $EC_{50 – growth}$ = 0.031 (m, s)	2 acc^{ing} to EU-RAR	Suedel *et al.*, 1993
		Chironomus tentans / 10d $NOEC_{mortality}$ = 0.030 (m, s) (m, r)		Suedel and Rodgers, 1996
Fish ($mg.l^{-1}$)	**Freshwater**	*Danio rerio* / 41d / ELS $NOEC_{mortality}$ = 0.047 (m, if) $NOEC_{length}$ = 4.4 10^{-3} (m, if) $NOEC_{weigth}$ = 0.016 (m, if)		Hooftman and Evers-de Ruiter, 1992
		Pimephales promelas / 11w / full-life $NOEC_{survival of hatchlings – fluorescent light}$ < 6.2 (m, cf)		Diamond *et al.*, 1995
		Pimephales promelas / 32d / ELS $NOEC_{growth – fluorescent light}$ = 10.4 (m, cf) $NOEC_{growth – UV light}$ = 1.4 (m, cf)		Spehar *et al.*, 1999
	Marine	No information available		
	Sediment	No information available		
Amphibians ($mg.l^{-1}$)	**Freshwater**	*Ambystoma maculatum* / 12d / embryo $NOEC_{mortality – visible light}$ = 0.125 (m, r)	2 acc^{ing} to EU-RAR	Hatch and Burton, 1998
		Rana pipiens / 96h / embryo $NOEC_{mortality, malformation – visible light}$ = 0.125 (m, r)		Hatch and Burton, 1998
		Rana pipiens / 2d post hatch / embryo $NOEC_{hatching – sunlight}$ = 0.025 (m, r)		Hatch and Burton, 1998
		Xenopus laevis / 96h / embryo $NOEC_{malformation – visible light}$ = 0.025 (m, r)		Hatch and Burton, 1998
	Marine	No information available		
	Sediment	No information available		

	Available ecotoxicological information for organisms living in water column	
	Fresh water species	**Marine species**
Acute	9 taxonomic groups - algae, crustaceans, and fish - macrophytes, coelenterates, annelids, molluscs, insects and amphibians	5 taxonomic groups - crustaceans and fish - annelids, molluscs and echinoderms
Chronic	6 taxonomic groups - algae, crustaceans, and fish - macrophytes, insects and amphibians	4 taxonomic groups - crustaceans, - ascidiaceans, molluscs and echinoderms

The Technical Guidance Document on EQS derivation (E.C., 2011) states that "*in principle, ecotoxicity data for freshwater and saltwater organisms should be pooled for organic compounds, if certain criteria are met*" and that "*the presumption that for organic compounds saltwater and freshwater data may be pooled must be tested, except where a lack of data makes a statistical analysis unworkable*."

For fluoranthene in fact, there are enough data to perform a "*meaningful statistical comparison*" and the statistical analysis made showed no further indications of "*a difference in sensitivity between freshwater vs saltwater organisms*" (Verbruggen, in prep.). Moreover, the mode of action (cf. reference to narcosis above) is an additional piece of information allowing no differentiation between the two media.

Therefore, in this case, the data sets may be combined for QS derivation according to the Technical Guidance Document on EQS derivation (E.C., 2011).

Fluoranthene appears to be extremely phototoxic when some organisms are exposed in combination with ultraviolet radiation, such as sunlight. The lowest chronic NOECs or EC10 are in between 1.0 and 8.6 $\mu g.l^{-1}$. The acute $L(E)C_{50}$ values for fluoranthene with exposure under laboratory lighting are comparable to or even lower than the chronic NOEC values, like the outlier LC_{50} of 0.1 $\mu g.l^{-1}$ reported for the marine fish *Pleuronectes americanus* (Spehar et al., 1999). The 96h-LC_{50} for the freshwater oligochaete *Lumbriculus variegatus* and *Hydra americana* were 1.2 $\mu g.l^{-1}$ and 2.2 $\mu g.l^{-1}$, respectively, with ultraviolet light at 359-587 µW/cm² UV-A and 63-80 µW/cm² UV-B and a photoperiod of 12:12 h light:dark. The 48h-LC_{50} for *Daphnia magna* was 1.6 $\mu g.l^{-1}$, with ultraviolet light at 783- 850 µW/cm² UV-A and 104 µW/cm² UV-B and a photoperiod of 12:12 h light:dark (Spehar et al., 1999).
Based on the dataset available and the recommendation of the Technical Guidance Document on EQS derivation (E.C., 2011), assessment factors of 10 and 100 should be used to derive $QS_{freshwater}$ and the $QS_{marine\ water}$, respectively. It should be noted that the additional marine assessment factor (AF) 10 is applicable for both the MAC-QS_{water} and the AA-QS_{water} values. In fact, this AF addresses the higher uncertainty in derivation of marine QS compared to freshwater QS because of the higher biodiversity of marine ecosystems and the fact that marine ecosystems include specific taxonomic groups not represented in the dataset (e.g. echinoderms).

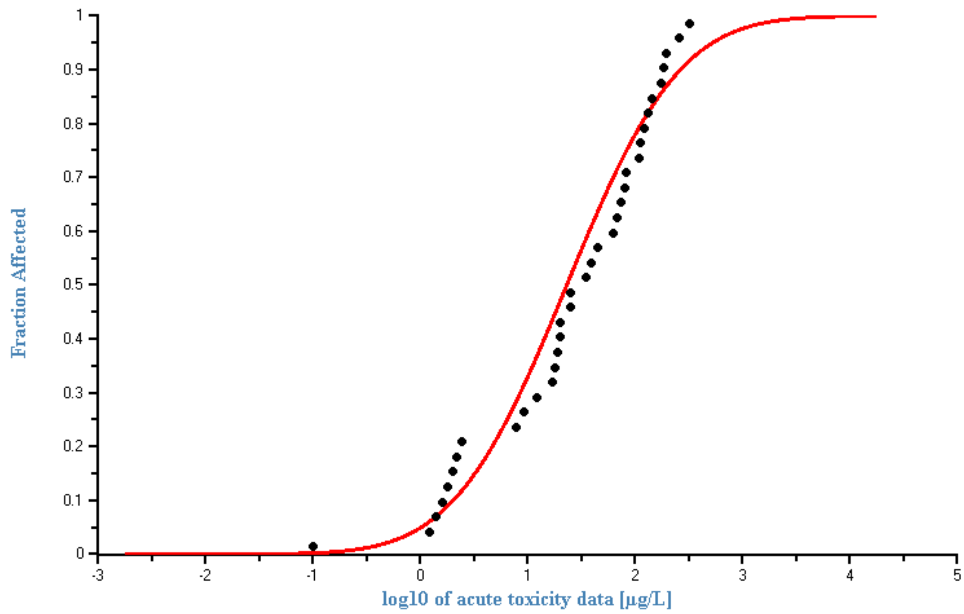
Tentative QS_{water} **Assessment factor method**	**Relevant study for derivation of QS**	**AF**	**Tentative QS**
$MAC_{freshwater,\ eco}$	*Pleuronectus americanus* / 96h	10	0.01 $\mu g.l^{-1}$
$MAC_{marine\ water,\ eco}$	$LC_{50 - UV\ light}$ = 1 10^{-4} $mg.l^{-1}$	100	0.001 $\mu g.l^{-1}$
AA-$QS_{freshwater,\ eco}$	*Hyalella azteca* / 10d	10	0.1 $\mu g.l^{-1}$
AA-$QS_{marine\ water,\ eco}$	$LC_{10 - mortality - UV\ light}$ = 0.001 $mg.l^{-1}$ *Mulinea lateralis* / 48h / embryo-larval $EC_{50\ -development - UV\ light}$ = 1.1 10^{-3} $mg.l^{-1}$	100	0.01 $\mu g.l^{-1}$

These $MAC_{water,\ eco}$ and AA-$QS_{water,\ eco}$ assessments are not satisfactory as the MAC values are lower than the chronic AA-QS by a factor of 10 for both freshwater and marine species.

The Technical Guidance Document on EQS derivation (E.C., 2011) indicates that "*Whilst derivation of the AA-QS typically employs chronic toxicity data, the MAC-QS always relies on acute data. When […] the ratio between acute effects and chronic no-effects is narrow, the estimated MAC-QS can sometimes be more stringent than the AA-QS. It is also possible that the effects observed in chronic studies are due to the initial contact with the test substance, rather than to prolonged exposure. In that case it is also reasonable that the MAC-QS and AA-QS are similar. […] Since effects of chronic exposure normally occur at lower concentrations than those of acute exposure, MAC-QS values below the AA-QS make little toxicological sense.* ***Therefore, where the derivation of the MAC-QS leads to a lower value than the AA-QS, the MAC-QS is set equal to the AA-QS***."

As a result of combining freshwater and marine species, it appears that both acute and chronic dataset are sufficient (10 and 8 taxonomic groups, respectively) to apply a statistical derivation approach to derive the AA-QS$_{water, eco}$ and MAC-QS$_{water, eco}$ values in addition to the assessment factor method.

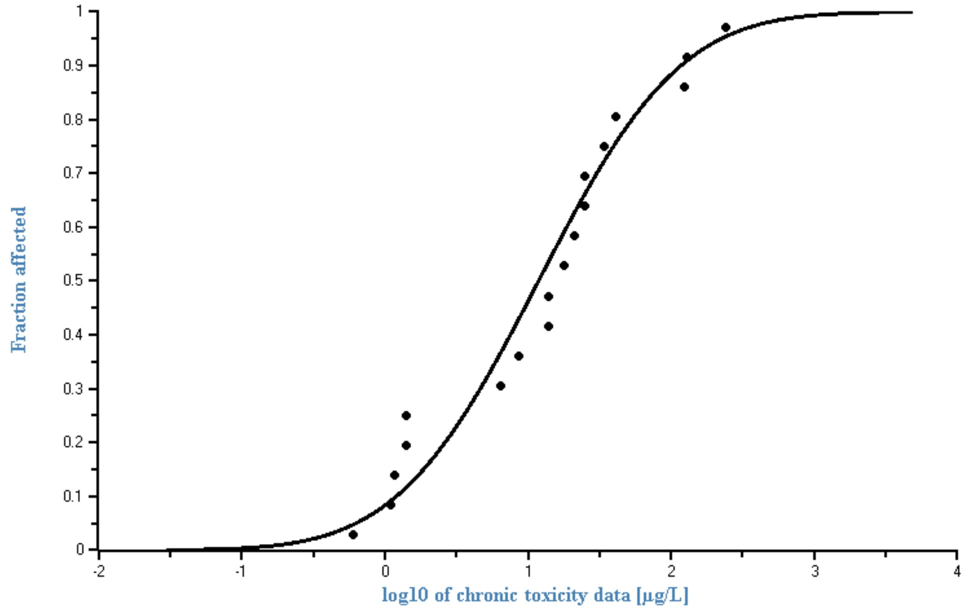
In its report made available to the assessor (Verbruggen, in prep.), RIVM proposes such an assessment based on the combined freshwater and marine datasets. The Species Sensitivity Distribution (SSD) curves after the goodness of fit has been tested (Kolmogorov-Smirnov test) are reported hereunder for acute as well as chronic ecotoxicity.



Species sensitivity distribution for the acute toxicity of fluoranthene to freshwater and marine species (Verbruggen, in prep.).

The RIVM report in preparation (Verbruggen, in prep.) indicates that "*value of 0.1 µg.l^{-1} for the marine fish species winter flounder (Pleuronectes americanus) can be considered a bit of an outlier.*" It is the only value that is below the acute distribution HC$_5$ of 0.99 µg.l^{-1}.

Chronic toxicity data are represented in the figure below.



Species sensitivity distribution for the chronic toxicity of fluoranthene to freshwater and marine species (Verbruggen, in prep.).

The RIVM report (Verbruggen, in prep.) indicates that as for acute data, "*the lowest NOEC or EC_{10} values were obtained in the presence of UV light, although the UV intensity is less harsh in most of these studies*". There are no NOECs or EC_{10} values below the SSD HC_5 of 0.6 µg.l^{-1}.

The species sensitivity distributions for chronic and acute data are very similar, with HC_5 of 0.6 and 0.99 µg.l^{-1}, respectively. According to the Technical Guidance Document on EQS derivation (E.C., 2011), the MAC-$QS_{water,\ eco}$ would be derived from the HC_5 for acute L(E)C_{50} values by applying an assessment factor of 10 for freshwater and an assessment factor of 100 for marine waters, which would result in values of 0.099 µg.l^{-1} and 9.9 10^{-3} µg.l^{-1}. In parallel, the AA-$QS_{water,\ eco}$ would be derived by applying an assessment factor of 1 to 5 to the HC_5 for chronic NOEC or EC_{10} values for freshwater. However, the uncertainty linked to the very low acute values of the phototoxic effects is high. Except for the LC_{50} for the winter flounder and the NOEC for the crustacean *Mysidopsis bahia* (Spehar et al., 1999), no studies validated (Klimisch codes 1 or 2) report effect concentrations below 1 µg.l^{-1} under natural conditions not exposed to UV light.

To take into account the uncertainties surrounding phototoxicity, the RIVM report (Verbruggen, in prep.) concludes that the maximum assessment factor of 5 should be applied to the HC_5 for chronic data, which results in a value of 0.12 µg.l^{-1}, close to the lowest datum reported of 0.1 µg.l^{-1} (96h-LC_{50} reported for the marine flounder *Pleuronectes americanus*).

For this reason, it is proposed that the MAC-$QS_{eco,\ water}$ and AA-$QS_{eco,\ water}$ are set to 0.12 µg.l^{-1} for both freshwater and marine waters.

7.1.2 Sediment-dwelling organisms

It is to be noted that all concentrations reported in the tables hereunder are expressed as normalised to 10% organic carbon.

ACUTE EFFECTS			**Klimisch code**	**Master reference**
Freshwater Invertebrates ($mg.kg^{-1}{}_{dw}$)	Crustaceans	*Diporeia sp.* / 30d NOEC ≥ 2 979 (m)	2 acc[ing] to EU-RAR and RIVM	Kane Driscoll and Landrum, 1997
		Hyalella azteca / 14d / 2-3 weeks org. LC_{50} = 15 (m)		Verrhiest *et al.*, 2001
		Hyalella azteca / 10d / 2-3 weeks org. LC_{50} = 29 – 87 (m)		Suedel *et al.*, 1993
		Hyalella azteca / 10d / 7-14d org. LC_{50} = 49 (m)		Hatch and Burton, 1999
		Hyalella azteca / 10d LC_{50} = 799 – 1 908 (m)		Wilcoxen *et al.*, 2003
		Hyalella azteca / 16d / 2-3 weeks org. LC_{50} = 3 779 (m)		Kane Driscoll and Landrum, 1997
	Insects	*Chironomus tentans* / 10d / 10-12d org. $EC_{50\text{ – immobility}}$ = 40 – 102 (m)		Suedel *et al.*, 1993
		Chironomus riparius / 11d / larvae, 24h post-hatch LC_{50} = 330 – 461 (m)		Stewart and Thompson, 1995
		Chironomus riparius / 28d / larvae, 24h post-hatch $EC_{50\text{ – emergence}}$ = 497 (m)		Stewart and Thompson, 1995
		Chironomus riparius / 10d / larvae, 48h LC_{50} = 43 (m)		Verrhiest *et al.*, 2001

ACUTE EFFECTS			Klimisch code	Master reference
Marine Invertebrates ($mg.kg^{-1}_{dw}$)	Annelids	*Arenicola marina* / 10d / adult LC_{50} > 161 765	2 acc[ing] to EU-RAR and RIVM	Bowmer, 1994
		Monopylephorus rubroniveus / 10d / adult LC_{50} > 11 280 (m)		Weinstein *et al.*, 2003
		Streblospio benedicti / 10d / adult LC_{50} = 115 – 189 (m)	2 acc[ing] to RIVM	Weinstein and Sanger, 2003
	Molluscs	*Mercenaria mercenaria* / 10d / juvenile LC_{50} = 18 (m)	2 acc[ing] to RIVM	Chung *et al.*, 2007
	Crustaceans	*Corophium volutator* / 10d LC_{50} = 220 (geometric mean)	2 acc[ing] to EU-RAR and RIVM	Bowmer, 1994
		Corophium spinicorne / 10d LC_{50} = 163 – 258 (m)		Swartz *et al.*, 1990
		Coullana sp. / 10d / non-ovigerous female 10d-$EC_{50 – mortality}$ = 518 (m) 10d-$EC_{50 – reproduction}$ =192 (m) 27h- $EC_{50 – grazing\ rate}$ =137 (m)		Lotufo, 1998
		Rhepoxynius abronius / 10d LC_{50} = 270 (m, geometric mean)		Boese *et al.*, 1998 Cole *et al.*, 2000 DeWitt *et al.*, 1992 Swartz *et al.*, 1988 Swartz *et al.*, 1990 Swartz *et al.*, 1997
		Rhepoxynius abronius / 10d $EC_{50 – reburial}$ < 39 [1] (m)		Boese *et al.*, 1998
		Schizopera knabeni 4d-LC_{50} > 8235, up to 13 257 (m) 10d-LC_{50} = 819 (m)		Lotufo, 1997 Lotufo, 1998
		Schizopera knabeni 10d-$EC_{50 - reproduction}$ = 212 (m) 14d-$EC_{50 - reproduction}$ = 128 ; 149 (m)		Lotufo, 1998 Lotufo, 1997
		Schizopera knabeni 6h-$EC_{50 – grazing\ rate}$ = 332 ; 369 (m) 27h-$EC_{50 – grazing\ rate}$= 131 (m)		Lotufo, 1997 Lotufo, 1998
	Echinoderms	*Echinocardium cordata* / 14d LC_{50} = 1053 ; 1667		Bowmer, 1994

[1] Low environmental relevancy because the organisms were tested in the presence of UV radiation while in contrast to several other crustaceans, *Rhepoxynius abronius* is a subsurface burrower that typically does not extend body parts in overlying water (Boese *et al.*, 1998; Swartz *et al.*, 1997 as cited *in* Verbruggen, in prep.).

CHRONIC EFFECTS			Klimisch code	Master reference
Freshwater Invertebrates ($mg.kg^{-1}_{dw}$)	Annelids	*Stylaria lacustris* / 10d $NOEC_{mortality}$ = 112 (m)	2 acc[ing] to EU-RAR and RIVM	Suedel and Rodgers, 1996
	Crustaceans	*Hyalella azteca* / 14d / 2-3 weeks org. $NOEC_{mortality}$ = 9 (m)	2 acc[ing] to EU-RAR and RIVM	Verrhiest *et al.*, 2001
		Hyalella azteca / 10d $NOEC_{mortality}$ < 54 (m)		Suedel and Rodgers, 1996
		Hyalella azteca / 16d / 2-3 weeks org. $NOEC_{mortality}$ = 600 (m)		Kane Driscoll and Landrum, 1997
	Insects	*Chironomus tentans* / 10d $NOEC_{mortality}$ = 58 (m)		Suedel and Rodgers, 1996
		Chironomus riparius / 10d / larvae, 48h Fluoranthene exposure: $NOEC_{mortality\ and\ growth}$ < 15 (m) Mixture exposure (30%fluorant. + 30%phenant. + 30%benzo[k]fluorant.): LOEC = 9.6 (as fluoranthene) (m) $NOEC_{mortality\ and\ growth}$ < 8.8 (m)		Verrhiest *et al.*, 2001
		Chironomus riparius / 28d / larvae, 24h post-hatch $NOEC_{emergence}$ = 166 (m) $EC_{10-emergence}$ = 352 (m)		Stewart and Thompson, 1995
Marine Invertebrates ($mg.kg^{-1}_{dw}$)	Crustaceans	*Corophium spinicorne* / 10d $LC_{10-mortality}$ = 108 (m)	2 acc[ing] to EU-RAR	Swartz *et al.*, 1990
		Coullana sp. / 10d / non-ovigerous female 10d-$LC_{10-mortality}$ = 157 (m) 10d-$EC_{10-reproduction}$ = 173 (m) 27h- $EC_{10-grazing\ rate}$ = 39 (m)		Lotufo, 1998
		Rhepoxynius abronius / 10d LC_{10} = 135 (m, geometric mean)		DeWitt *et al.*, 1992 Swartz *et al.*, 1988 Swartz *et al.*, 1990 Swartz *et al.*, 1997
		Schizopera knabeni 4d-LC_{10} = 512 (m) 10d-LC_{10} = 615 (m)		Lotufo, 1997 Lotufo, 1998
		Schizopera knabeni 10d-$EC_{10-reproduction}$ = 58 (m) 14d-$EC_{10-reproduction}$ = 41 (m)		Lotufo, 1998 Lotufo, 1997

		Schizopera knabeni 6h-$EC_{10 \text{ – grazing rate}}$ = 189 (m) 27h-$EC_{10 \text{ – grazing rate}}$= 9 (m)		 Lotufo, 1997 Lotufo, 1998

	Available ecotoxicological information for sediment-dwelling organisms	
	Benthic fresh water species	**Benthic marine species**
Acute	2 invertebrates taxonomic groups - crustaceans - insects	4 invertebrates taxonomic groups - annelids - molluscs - crustaceans - echinoderms
Chronic	3 invertebrates taxonomic groups - annelids - crustaceans - insects	1 invertebrates taxonomic groups - crustaceans

The Technical Guidance Document on EQS derivation (E.C., 2011) states that "*in principle, ecotoxicity data for freshwater and saltwater organisms should be pooled for organic compounds, if certain criteria are met*" and that "*the presumption that for organic compounds saltwater and freshwater data may be pooled must be tested, except where a lack of data makes a statistical analysis unworkable*."

For fluoranthene in fact, there are enough data to perform a "*meaningful statistical comparison*" and the statistical analysis made showed "*the tested marine species are equally sensitive as freshwater species*" (Verbruggen, in prep.). Moreover, the mode of action (cf. reference to narcosis above) is an additional information allowing no to differentiate between the two media.

Therefore, in this case, the freshwater and marine data sets may be combined for QS derivation according to the Technical Guidance Document on EQS derivation (E.C., 2011).

The lowest effect concentration for fluoranthene in sediment is found for mortality and growth of *Chironomus riparius* (Verrhiest *et al.*, 2001) but the available value is a LOEC and results for the same species vary widely (see NOEC of 166 $mg.kg^{-1}{}_{dw}$ from Stewart and Thompson, 1995). The lowest relevant value is therefore chosen as the 14d-EC_{10} for reproduction of the marine crustacean *Schizopera knabeni* (Lotufo, 1997). This value of 41 $mg.kg^{-1}{}_{dw}$ corresponds to organic carbon content of 10% and should be normalised to 5% organic carbon as recommended by the Technical Guidance Document on EQS derivation (E.C., 2011), becoming a value of ca. 20 $mg.kg^{-1}{}_{dw}$. For this species a more sensitive endpoint (grazing after one day exposure) was also found but this did not apparently affect reproduction in longer exposure duration of 14 d. Therefore, reproduction is chosen as the most sensitive and environmentally relevant parameter for derivation of $AA\text{-}QS_{water,\ sed}$.

Because freshwater data are available for annelids, crustaceans, and insects, an assessment factor of 10 can be applied to this value for derivation of $AA\text{-}QS_{freshwater,\ sed}$.

The marine studies with benthic annelids, crustaceans and echinoderms appear chronic rather than acute; exposure duration being 10 or 14 days. The AF of 10 covers all observed effects, i.e. resulting in an $AA\text{-}QS_{marine\ water,\ sed}$ of 2 $mg.kg^{-1}{}_{dw}$. With 8 species with a reliable NOEC or EC_{10} of which 4 are marine crustacean species, and additional information in the form of (sub)chronic $E(L)C_{50}$s for marine species from additional taxonomic groups, an AF of 10 is deemed sufficiently conservative. This is confirmed by the water data for which there are many marine data available, but they do not show an increased sensitivity compared to freshwater species.

Against this argument, the point could be made that the acute LC_{50} of 18 mg.kg$^{-1}_{dw}$ for the mollusc *Mercenaria mercenaria* is at the low end of the range of data in the chronic dataset (lowest value of 9 mg.kg$^{-1}_{dw}$ among NOECs or LC_{10} values), suggesting that the chronic dataset may not cover the most sensitive species. However, there are evidences from other PAHs (e.g. fluoranthene and naphthalene), that molluscs do not apparently show an increased sensitivity compared to other taxa.

Therefore, an assessment factor of 10 is applied to the lowest value of 20 mg.kg$^{-1}_{dw}$ for derivation of AA-$QS_{marine\ water,\ sed}$.

If the equilibrium partitioning method were applied to AA-$QS_{water,\ eco}$, then corresponding values in sediments would be more stringent, i.e. 103.8 µg.kg$^{-1}_{dw}$. However, given the rather substantial sediment dataset, it does not seem relevant to apply this estimation method to derive the AA-$QS_{water,\ sed.}$ values.

Tentative QS_{water} **Assessment factor method**	**Relevant study for derivation of QS**	**AF**	**Tentative QS**
AA-$QS_{freshwater,\ sed.}$	*Schizopera knabeni* / 14d / normalised 5% organic carbon $EC_{10\ -\ reproduction}$ = 20 mg.kg$^{-1}_{dw}$	10	2 000 µg.kg$^{-1}_{dw}$ corresponding to 4.09 µg.l^{-1} *via* the EqP method
AA-$QS_{marine\ water,\ sed.}$		10	2 000 µg.kg$^{-1}_{dw}$ corresponding to 4.09 µg.l^{-1} *via* the EqP method

7.2 SECONDARY POISONING

Based on the Technical Guidance Document on EQS derivation (E.C., 2011), this substance does trigger the bioaccumulation criteria given the high values of log KOW (5.2) and the high value of BCF (7 692).

Data on the PAH toxicity to birds are scarce (Albers and Laoughlin, 2003; Patton and Dieter, 1980) and Final CTPHT EU-RAR (E.C., 2008a) states that "*from these data it is not possible to derive a NOAEL for birds for either of the PAHs*".

The toxicity dataset for mammals is also rather limited, almost all of the long term studies being designed to assess carcinogenic potency of PAH (i.e. "*not considered appropriate for secondary poisoning assessment*"). A $QS_{biota\ secpois}$ is however tentatively derived hereunder.

Secondary poisoning of top predators		**Master reference**
Mammalian oral toxicity	Mice / Gavage / 90d / Nephropathy, increased liver weight, hematological alterations and clinical effects NOAEL = 125 $mg.kg^{-1}_{bw}.d^{-1}$ NOEC = 1037 $mg.kg^{-1}_{food}$	US-EPA, 1988 as cited *in* US-EPA, 1990
Avian oral toxicity	No information available	

Tentative $QS_{biota\ secpois}$	**Relevant data for derivation of QS**	**AF**	**Tentative $QS_{biota,\ sec\ pois}$**
Biota	NOEC = 1037 $mg.kg^{-1}_{food}$	90	11 522 $\mu g.kg^{-1}_{biota\ ww}$ corresponding to 2.4 $\mu g.l^{-1}$ (freshwater) 2.4 $\mu g.l^{-1}$ (saltwater)

7.3 HUMAN HEALTH

Based on the Technical Guidance Document on EQS derivation (E.C., 2011), this substance does trigger the bioaccumulation criteria given the high values of log KOW (5.2) and the high value of BCF (7 692). Hence, protection of human health from consumption of fishery products is relevant.

Human health via consumption of fishery products		**Master reference**
Mammalian oral toxicity	Mice / Gavage / 90d NOAEL = 125 $mg.kg^{-1}_{bw}.d^{-1}$	US-EPA, 1988 as cited *in* US-EPA, 1990
CMR	Not classified as carcinogenic, mutagenic or reprotoxic	E.C., 2008b
	Test on benzo[a]pyrene Rat / Gavage / 2years / Hepatic and rumen cancer Virtually Safe Dose = 5 10^{-6} mg B[a]P.$kg^{-1}_{bw}.d^{-1}$	Kroese *et al.*, 2001
	Fluoranthene is a suspected carcinogen and the potency of fluoranthene relative to the potency of benzo[a]pyrene is 0.01.	Kalberlah *et al.*, 1995 as cited *in* IPCS, 1998 Baars *et al.*, 2001
	Fluoranthene is a suspected carcinogen and the potency	Nisbet and Lagoy,

	of fluoranthene relative to the potency of benzo[a]pyrene is 0.001.	1992 Doornaert and Pichard, 2003

According to the weight of evidence and a read-across approach on PAH compounds, Baars *et al.*, 2001 and Doornaert and Pichard, 2003 concluded that fluoranthene is a suspected carcinogen and that a non-threshold approach is warranted for risk estimation. The two institutes used a carcinogenic potency approach to estimate the potency of PAHs relative to the potency of benzo[a]pyrene, defined as 1. Baars *et al.*, 2001 and Doornaert and Pichard, 2003 used the same original toxicological value of 0.2 $mg.kg^{-1}.d^{-1}$, based on tumor development in a variety of organs and tissues observed in a chronic oral (gavage) rat study (Kroese *et al.*, 2001) to calculate a virtually safe dose (VSD). Baars *et al.*, 2001adopted a relative potency value for fluoranthene of 0.01 (Kalberlah *et al.*, 1995 as cited *in* IPCS, 1998) while Doornaert and Pichard, 2003 considered a relative potency value for fluoranthene of 0.001 (Nisbet and Lagoy, 1992). Therefore, the virtually safe doses estimated for fluoranthene are $5\ 10^{-4}$ $mg.kg^{-1}.d^{-1}$ and $5\ 10^{-3}$ $mg.kg^{-1}.d^{-1}$ for Baars *et al.*, 2001 and Doornaert and Pichard, 2003, respectively. These values represent the oral exposure that is associated with a 10^{-6} excess lifetime cancer risk and are reported in the table hereunder for the derivation of $QS_{biota\ hh}$.

Tentative $QS_{biota\ hh}$	**Relevant data for derivation of QS**	**AF**	**Threshold Level** ($mg.kg^{-1}{}_{bw}.d^{-1}$)	**Tentative $QS_{biota,\ hh}$**
Human health	NOAEL = 125 $mg.kg^{-1}{}_{bw}.d^{-1}$	3000	US-EPA RfD = $4.167\ 10^{-2}$ (1)	2536 $\mu g.kg^{-1}{}_{biota\ ww}$ corresponding to 0.528 $\mu g.l^{-1}$ (fresh and marine waters)
	Cf. above paragraph		Doornaert and Pichard, 2003 VSD = $5\ 10^{-3}$	304 $\mu g.kg^{-1}{}_{biota\ ww}$ corresponding to 0.063 $\mu g.l^{-1}$ (fresh and marine waters)
			Baars *et al.*, 2001 VSD = $5\ 10^{-4}$	30 $\mu g.kg^{-1}{}_{biota\ ww}$ corresponding to $6.3\ 10^{-3}$ $\mu g.l^{-1}$ (fresh and marine waters)

(1) Value endorsed by US-EPA, 1990

Although fluoranthene is not classified as carcinogenic by E.C. (E.C., 2008b), for purpose of effects assessment, a conservative choice is made that is to use the value derived by Baars *et al.*, 2001 to assess protection of human health from consumption of fishery products.

Human health via consumption of drinking water		**Master reference**
Existing drinking water standard(s)	No existing regulatory standard	Directive 98/83/EC
Drinking water standard (*calculated*)	1.8 $\mu g.l^{-1}$ (based on the above cited threshold level of $5\ 10^{-4}$ $mg.kg^{-1}{}_{bw}.d^{-1}$)	E.C., 2011

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