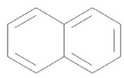
NAPHTHALENE

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: Where possible, the concentrations (i.e. whether nominal or measured) used in the cited studies have been indicated. Further explanation has been added regarding the non-use of a SSD approach to determine the AA-QS, and regarding the application of an additional assessment factor for the marine sediment EQS.

This dossier is a revision of the 2005 EQS fact sheet for naphthalene, 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 version of the European Union Risk Assessment Report (E.C., 2003) made available in the context of the assessment of existing chemicals (Regulation 793/93/EEC). The present fact sheet reviews the EQS for naphthalene based on this new document and on a report in preparation provided by RIVM (Verbruggen, in prep.) which was made available to the assessor.

1 CHEMICAL IDENTITY

Common name	Naphthalene
Chemical name (IUPAC)	Naphthalene
Synonym(s)	-
Chemical class (when available/relevant)	Polyaromatic hydrocarbons (PAH)
CAS number	91-20-3
EC number	202-049-5
Molecular formula	$C_{10}H_8$
Molecular structure	
Molecular weight (g.mol^{-1})	128.2

2 EXISTING EVALUATIONS AND REGULATORY INFORMATION

Legislation	
Annex III EQS Dir. (2008/105/EC)	No (existing priority substance included in Annex I EQS Dir.)
Existing Substances Reg. (793/93/EC)	Priority List #1. Substance #020. Rapporteur: UK EU-RAR finalised 2003
Pesticides(91/414/EEC)	No
Biocides (98/8/EC)	Product Type #19 (Repellents and attractants) – To be phased out by 21/08/2009 Decision Reference: Commission Decision 2008/681/EC
PBT substances	Not investigated by EU-PBT Working Group
Substances of Very High Concern (1907/2006/EC)	Not investigated

POPs (Stockholm convention)	Not investigated
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_{water_eco} for protection of pelagic organisms is 2 µg.l^{-1} for both freshwater and marine waters, and is deemed the "critical QS" for derivation of an Environmental Quality Standard.

Data are available on 3 trophic levels for both acute and chronic ecotoxicity. Many acute data are available, including 7 and 6 taxonomic groups of freshwater and marine organisms, respectively. Many chronic data are also available, including 5 and 6 taxonomic groups of freshwater and marine organisms, respectively. Significant differences between freshwater and marine species cannot be demonstrated from the information available. An assessment factor of 10 was applied to derive the $AA\text{-}QS_{water\ eco}$ (using the assessment factor method) and no additional assessment factor was applied to derive the marine EQS in view of the substantial marine dataset and the presence of specific taxonomic groups (echinoderms). An assessment factor of 5 was applied to the chronic-HC_5 for derivation of the MAC-QS for both freshwater and marine water.

	Value	Comments
Proposed AA-EQS for [freshwater] [µg.l^{-1}]	**2**	**Critical QS is $QS_{water\ eco}$**
Proposed AA-EQS in [marine water] [µg.l^{-1}]	**2**	**See section 7**
Proposed MAC-EQS for [freshwater] [µg.l^{-1}]	**130**	**See section 7.1**
Proposed MAC-EQS for [marine water] [µg.l^{-1}]	**130**	

3.2 SPECIFIC QUALITY STANDARD (QS)

Protection objective[2]	Unit	Value	Comments
Pelagic community (freshwater)	[µg.l^{-1}]	2	See section 7.1
Pelagic community (marine water)	[µg.l^{-1}]	2	
Benthic community (freshwater)	[µg.kg^{-1} $_{dw}$]	138	See section 7.1
Benthic community (marine)	[µg.kg^{-1} $_{dw}$]	138	
Predators (secondary poisoning)	[µg.kg$^{-1}_{biota\ ww}$]	12 266	See section 7.2
	[µg.l^{-1}]	23.8 (fresh water) 23.8 (marine water)	
Human health via consumption of fishery products	[µg.kg$^{-1}_{biota\ ww}$]	2 435	See section 7.3
	[µg.l^{-1}]	4.7 (fresh water) 4.7 (marine water)	
Human health via consumption of water	[µg.l^{-1}]	140	

[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

All data hereunder are extracted from Naphthalene EU-RAR (E.C., 2003).

4.1 USES AND QUANTITIES

There are two sources for the manufacture of naphthalene in the EU. These are coal tar (which accounts for the majority of the production) and petroleum. For the purposes of the assessment the total annual production of naphthalene in the EU has been taken to be 200,000 tonnes based on site-specific information. This figure includes a production tonnage of 20,000 tonnes per annum of “naphthalene oil” which is understood to be at least 90% pure. Lower grade naphthalene oil, containing about 60% naphthalene, has a separate CAS number and has not been considered in the assessment. Companies producing naphthalene are located in the UK, Belgium, France, Italy, Netherlands, Denmark, Germany, Austria and Spain. Production figures from individual producers ranged from 4,000 to 70,000 tonnes per annum.

Figures for the amount of naphthalene used within the EU vary. For the purposes of the assessment a value of approximately 140 000 tonnes per annum has been taken in the EU-RAR, with the remaining tonnage being exported. This value was derived from the most recent information available for the specific uses summarised in the table below.

Approximate tonnages of naphthalene assumed in the assessment

Process	**Approximate annual continental tonnages used in assessment**
Phthalic anhydride production	40 000
Manufacture of dyestuffs	46 000
Naphthalene sulphonic acid manufacture	24 000
Alkylated naphthalene solvent production	15 000
2-naphthol production	12 000
Pyrotechnics manufacture	15
Mothballs manufacture	1 000
Grinding wheels manufacture	350

4.2 ESTIMATED ENVIRONMENTAL EMISSIONS

The EU-RAR (E.C., 2003) considers the release of naphthalene to the environment from its production, its use as a chemical intermediate, the formulation and use of pyrotechnics, the formulation and use of mothballs and the production of grinding wheels. Releases of naphthalene to the environment also arise from indirect sources, particularly from vehicle emissions. Releases from these sources have been estimated and included in calculating PECs at the regional and continental levels. The vast majority (~99.5%) of emissions occur initially to air. Emissions from traffic are estimated to account for 87% of the total emissions to air.

5 ENVIRONMENTAL BEHAVIOUR

5.1 ENVIRONMENTAL DISTRIBUTION

			Master reference
Water solubility ($mg.l^{-1}$)		31.9	Mackay *et al.*, 1992 *in* E.C., 2003; E.C., 2008b
Volatilisation		Naphthalene is readily volatilised from surface water. Its half-life for volatilisation from water up to 1m deep is approx. 7 hours.	
Vapour pressure (Pa)		11.2 at 25°C	Mackay *et al.*, 1992 *in* E.C., 2003; E.C., 2008b
Henry's Law constant ($Pa.m^3.mol^{-1}$)		50 at 25°C	Mackay *et al.*, 1992 *in* E.C., 2003; E.C., 2008b
Adsorption		Naphthalene is expected to adsorb to sediments to a moderate extent. **The value 1 349 is used as K_{OC} for derivation of QS.**	
Organic carbon – water partition coefficient (K_{OC})		log K_{OC} = 3.13 (*calculated from K_{OW}*) K_{OC} = 1 349	Karickhoff *et al.*, 1979
Sediment – water partition coefficient($K_{sed\ -water}$)		35 (*calculated from K_{OC}*)	E.C., 2011
Bioaccumulation		**The BCF value of 515 is used for derivation of $QS_{biota\ secpois}$. Thus, BMF_1 = BMF_2 = 1 (Bleeker, 2009; E.C., 2011).**	
Octanol-water partition coefficient (Log Kow)		3.34	Mackay *et al.*, 1992 *in* E.C., 2003; E.C., 2008b
BCF	Annelids	*Arenicola marina* (marine worms): 160 (oesophageal glands), 300 (stomach wall)	Lyes, 1979[3]
	Molluscs	*Mytilus edulis* (marine bivalve): 27 – 38	Hansen *et al.*, 1978[3]
	Crustaceans	*Daphnia magna*: 50 *Daphnia pulex*: 131 *Diporeia spp.*: 311, 459, 736	Eastmond *et al.*, 1984[3] Southworth *et al.*, 1978[3] Landrum *et al.*, 2003
	Fish	*Pimephales promelas*: 427 *Cyprinodon variegatus*: 895, 999 *Cyprinus carpio*: 66, 76 *Lepomis macrochirus*: 300	Call & Brook (1977)[3, 4] Jonsson *et al.*, 2004 RIITI, 1979 McCarthy and Jimenez, 1985
	If normalised to 5% lipid weight, values from Jonsson et al. (2004) result in a worst case BCF for fish of 515. This latter value is chosen for back calculation of QS_{biota} into water as well as default BMF values of 1 according to Draft Technical Guidance Document on EQS derivation (E.C., 2011).		

[3] As cited *in* Veith *et al.*, 1979, cited itself *in* E.C., 2003.

[4] Note that this reference can not be traced back. Therefore, it can not be used with confidence.

5.2 ABIOTIC AND BIOTIC DEGRADATIONS

		Master reference
Photodecomposition, oxidation and hydrolysis are not considered to be significant pathways for polynuclear aromatic hydrocarbon degradation in the soil environment (Sims and Overcash, 1983 *as cited in* E.C., 2003).		
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 anthracene (Howard *et al.*, 1991).	E.C., 2008b
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. The degradation 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. It was shown by Zepp and Schlotzhauer that for PAHs in true solution in "pure" water or seawater, direct photolysis is considerably more significant than photooxidation by means of singlet oxygen. There are great differences in photochemical reactivity between the various PAHs.	E.C., 2008b
	The half-life for photolysis in water lies in the range 25 – 550 hours depending on the experimental conditions used.	E.C., 2003
Biodegradation	The results of the only standardised screening test for inherent biodegradability for naphthalene suggest that naphthalene is not inherently biodegradable (2% degradation after 4 weeks). However, numerous other 'non-standard' biodegradation tests suggest that it is easily degraded under aerobic and denitrifying conditions, particularly where acclimated microorganisms are used, with naphthalene falling below measurable levels within 8-12 days in a number of tests. Naphthalene has therefore been considered to be inherently biodegradable in the Final EU-RAR (E.C., 2003).	E.C., 2003

6 AQUATIC ENVIRONMENTAL CONCENTRATIONS

6.1 ESTIMATED CONCENTRATIONS

Compartment		**Predicted environmental concentration (PEC)**	**Master reference**
Freshwater ($\mu g.l^{-1}$)	$PEC_{continental}$	0.0025	E.C., 2003
	$PEC_{regional}$	0.03	
	$PEC_{local – production (worst case)}$	0.31	
	$PEC_{local – use as intermediate (site-sp.)}$	0.031	
	$PEC_{local – use as intermediate}$	0.042	

	$PEC_{local – pyrotechnics manufacture}$	2.35	
	$PEC_{local – mothballsmanufacture}$	0.03	
	$PEC_{local - grinding wheels manufacture}$	294	
Marine waters (µg.l^{-1})	-	No data available	E.C., 2003
Freshwater sediment (µg.kg^{-1} dw)	$PEC_{continental}$	0.075	E.C., 2003
	$PEC_{regional}$	1	
	$PEC_{local – production (worst case)}$	8.7	
	$PEC_{local – use as intermediate (site-sp.)}$	0.87	
	$PEC_{local – use as intermediate}$	1.2	
	$PEC_{local – pyrotechnics manufacture}$	66	
	$PEC_{local – mothballsmanufacture}$	0.83	
	$PEC_{local - grinding wheels manufacture}$	8 232	
Marine sediment (µg.kg^{-1} dw)	-	No data available	E.C., 2003
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: 0.12 PEC 2: 1.17	James *et al.*, 2009*(1)*
		0.005 – 2.24	E.C., 2003
Marine waters (coastal and/or transitional) (µg.l^{-1})		0.3	E.C., 2003
WWTP effluent (µg.l^{-1})		No data available	
Sediment (µg.kg^{-1} dw)	Sed < 2 mm	PEC 1: 117 PEC 2: 97	James *et al.*, 2009*(1)*
	Sed 20 µm	PEC 1: 766 PEC 2: 655	
	Sed 63 µm	PEC 1: 54 PEC 2: 41	
	Freshwaters	Up to 750	E.C., 2003
	Estuarine and coastal	Up to 91	
	Urban areas	Up to 7 720	
Biota (µg.kg^{-1} ww)	Invertebrates	PEC 1: 6 PEC 2: 6	James *et al.*, 2009*(1)*
	Fish	PEC 1: 79 PEC 2: 19	

Compartment		**Measured environmental concentration (MEC)**	**Master reference**
	Marine predators	No data available	

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

7 EFFECTS AND QUALITY STANDARDS

Final Coal Tar Pitch High Temperature EU-RAR (E.C., 2008b) states that “PAHs can be toxic via different modes of action, 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.*, 2006). 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. According to some authors (Weinstein and Oris, 1999) 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. 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. Clements *et al.*, 1994; Kukkonen and Landrum, 1994), followed by subsequent solar ultraviolet radiation exposures closer to the surface. 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 in this dossierand 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 EU-RAR (E.C., 2008b) and a RIVM report in preparation (Verbruggen, in prep.) which was made available to the assessor.

Final naphthalene EU-RAR (E.C., 2003) indicates that care must be taken when interpreting data from tests based on nominal concentrations because naphthalene can rapidly volatilise from solution in case of e.g. poorly sealed test beakers. Therefore, whenever it was possible, for each species, endpoints were 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 was given on the type of exposure, i.e.: static (s), static closed (sc), renewal (r), renewal closed (rc), or continuous flow (cf).

Given that many PAH chemicals are phototoxic, information on the absence/presence of light as well as the type of light was reported in the tables as much as possible.

In the tables below, all data reported were considered valid for effects assessment purposes when they 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 RIVM report in preparation (Verbruggen, in prep.). Information on reliability was not available in the finalised version of EU-RAR (E.C., 2008b) but no data extracted only from the RAR that were not also evaluated by RIVM are key data for QS derivation. Finally, it is to be noted that naphthalene is highly volatile and that many toxicity studies were therefore rejected by RIVM "*due to high uncertainty in exposure concentrations, either because analysis showed that the concentrations in static systems dropped very quick or because exposure concentrations were not analytically verified*" (Verbruggen, in prep.). Still, there are many valid toxicity data available for this substance.

7.1.1 Organisms living in the water column

ACUTE EFFECTS			Klimisch code	Master reference
Micro-organisms **Bacteria** **(µg.l^{-1})**	**Freshwater**	*Nitrosomonas* / unknown duration $IC_{50 – inhibition ammonia consumption}$ = 29 (n, sc)	Assessed by E.C., 2003 4 acc^{ing} to RIVM	Blum and Speece, 1991
		Tetrahymena pyriformis / 60h $IC_{50 – growth}$ = 188.85	Assessed by E.C., 2003	Schultz *et al.*, 1983
		Anabaena flos-aqua / 2h $EC_{50 – nitrogen fixation – continuous light}$ = 24 (m, s)	2 acc^{ing} to RIVM	Bastian and Toetz, 1985
	Marine	*Vibrio fischeri* / 15mn $EC_{50 – bioluminescence – dark}$ = 0.72 (n, s) $EC_{50 – bioluminescence – visible light}$ = 0.7 (n, s)	2 acc^{ing} to RIVM	El-Alawi *et al.*, 2001
		Vibrio fischeri / 30mn / Lumistox test $EC_{50 – bioluminescence – dark}$ = 1.89 (m, s)	2 acc^{ing} to RIVM	Loibner *et al.*, 2004
Algae & aquatic plants **(mg.l^{-1})**	**Freshwater**	*Pseudokirchneriella subcapitata* / 4h $EC_{50 – growth (photosynthesis)}$ =2.96 (m, s)	Assessed by E.C., 2003 2 acc^{ing} to RIVM	Millemann *et al.*, 1984
		Nitzschia palae / 4h $EC_{50 – growth (photosynthesis)}$ = 2.82 (m, s)	Assessed by E.C., 2003 2 acc^{ing} to RIVM	Millemann *et al.*, 1984
		Scenedesmus vacuolatus / 24h EC50 – growth (cell number) = 3.8 (m, sc)	2 acc^{ing} to RIVM	Walter *et al.*, 2002
	Marine	*Skeletonema costatum* / unknow duration $EC_{30 to 50 – growth}$ = 0.4	Assessed by E.C., 2003	Østgaard *et al.*, 1984
		Champia parvula / 14d / female $EC_{50 – growth – light:dark=16:8h}$ = 2.2 (n, rc) *Champia parvula* / 14d / tetrasporophyte $EC_{50 – growth – light:dark=16:8h}$ = 1.378 (n, rc, geo. mean)	2 acc^{ing} to RIVM	Thursby *et al.*, 1985
Invertebrates **(mg.l^{-1})**	**Freshwater** Molluscs	*Physa gyrina* / 48h LC_{50} = 5.02 (m, rc)	Assessed by E.C., 2003 2 acc^{ing} to RIVM	Millemann *et al.*, 1984
	Crustaceans	*Daphnia magna* / 48h $LC_{50 – light:dark=16:8h}$ = 3.4 or 4.1[5] (m, s)	Assessed by E.C., 2003 2/3 acc^{ing} to RIVM	Crider *et al.*, 1982
		Daphnia magna / 48h $EC_{50 - immobility}$ = 2.16 (m, sc)	Assessed by E.C., 2003 2 acc^{ing} to RIVM	Millemann *et al.*, 1984
		Daphnia magna / 48h $EC_{50 – immobility – dark}$ = 1.664 (m, s)	2 acc^{ing} to RIVM	Bisson *et al.*, 2000
		Daphnia pulex / 96h $LC_{50– light:dark=12:12h}$ =1 (m, sc)	Assessed by E.C., 2003 2 acc^{ing} to RIVM	Trucco *et al.*, 1983
		Diporeia spp. / 5d $EC_{50 – immobility}$ = 1.587 (m, r)	2 acc^{ing} to RIVM	Landrum *et al.*, 2003

[5] Value depending on data treatment (3.4 applying linear regression versus 4.1 applying probit analysis)

ACUTE EFFECTS			Klimisch code	Master reference
		Gammarus minus / 48h LC_{50} = 3.93 (m, sc)	Assessed by E.C., 2003 2 acc[ing] to RIVM	Millemann *et al.*, 1984
	Marine Annelids	*Neanthes arenaceodentata* / 96h LC50 = 1.069 (m, s)	2 acc[ing] to RIVM	Rossi and Neff, 1978
	Molluscs	*Mytilus edulis* / 48h $EC_{50 – \text{feeding filtration}}$ = 0.922 (m, r)	2 acc[ing] to RIVM	Donkin *et al.*, 1991; Donkin *et al.*, 1989
	Crustaceans	*Artemia salina* / larvae *nauplii* / 24h $EC_{50 – \text{immobility – constant illumination}}$ = 3.19 (m, s)	Assessed by E.C., 2003 2 acc[ing] to RIVM	Foster and Tullis, 1984
		Callinectes sapidus / adult / 48h $LC_{50 – \text{constant artificial illumination}}$ = 2.3 (m, cf, geo. mean)	Assessed by E.C., 2003 2 acc[ing] to RIVM	Sabourin, 1982
		Cancer magister / 1st instar larvae / 96h $LC_{50 – \text{light:dark=13:11h}}$ > 2 (m, r)	Assessed by E.C., 2003 2 acc[ing] to RIVM	Caldwell *et al.*, 1977
		Calanus finmarchicus / 96h LC50 = 2.4 (m, sc)	2 acc[ing] to RIVM	Falk-Petersen *et al.*, 1982
		Elasmopus pectenicrus / 96h LC_{50} = 2.68 (n, rc)	2/3 acc[ing] to RIVM	Lee and Nicol, 1978a
		Eualis suckleyi / 96h LC_{50} = 1.39 (m, cf)	Assessed by E.C., 2003 2 acc[ing] to RIVM	Rice and Thomas, 1989
		Eurytemora affinis / adult / 24h LC_{50} = 3.8 (m, sc)	Assessed by E.C., 2003 2 acc[ing] to RIVM	Ott *et al.*, 1978
		Hemigrapsus nudus / 8d LC_{50} = 1.863 (n, cf, geo. mean) $EC_{50 – \text{locomotory dysfunction}}$ = 1.648 (n, cf, geo. mean)	2 acc[ing] to RIVM	Gharrett and Rice, 1987
		Neomysis Americana / 96h LC_{50} = 1.043 (m, cf, geo. mean)	Assessed by E.C., 2003 2 acc[ing] to RIVM	Smith and Hargreaves, 1983
		Neomysis Americana / 96h LC_{50} = 1.066 (m, r, geo. mean)	Assessed by E.C., 2003 2 acc[ing] to RIVM	Hargreaves *et al.*, 1982
		Oithona davisae / 48h LC_{50} = 7.19 (m, s) $EC_{50 – \text{immobility}}$ = 4.48 (m, s)	2 acc[ing] to RIVM	Barata *et al.*, 2005
		Palaemonetes pugio / adult / 24h LC_{50} = 2.6 (s)	4 acc[ing] to RIVM	Anderson *et al.*, 1974
		Palaemonetes pugio / adult / 24 – 96h LC_{50} = 2.35 (n, s)	4 acc[ing] to RIVM	Tatem, 1975
		Palaemonetes pugio / 48h $LC_{50 – \text{fluorescent constant light}}$ = 2.111 (m, r)	2 acc[ing] to RIVM	Unger *et al.*, 2008

ACUTE EFFECTS			Klimisch code	Master reference
		Paracartia grani / 48h $LC_{50 – light:dark=12:12h}$ = 2.517 (m, s, geo. mean) $EC_{50 – immobility – light:dark=12:12h}$ = 2.467 (m, s)	2 acc[ing] to RIVM	Calbet *et al.*, 2007
		Parhyale hawaiensis / 24h LC_{50} = 6 (n, sc)	2 acc[ing] to RIVM	Lee and Nicol, 1978b
		Penaeus aztecus / 24 – 96h LC_{50} = 2.5 (s)	4 acc[ing] to RIVM	Anderson *et al.*, 1974
		Scylla serrata / intermoult juvenile / 96h LC_{50} = 17 (n)	Assessed by E.C., 2003	Kulkarni and Masurekar, 1983
	Sediment Insects	*Chironomus tentans* / 4th instar larvae / 48h $EC_{50 – immobility – dark}$ = 2.81 (m, sc)	Assessed by E.C., 2003 2 acc[ing] to RIVM	Millemann *et al.*, 1984
		Chironomus riparius / 96h / 1st instar, <24h $LC_{50 – mercury light}$ = 0.6 (m, s) $LC_{50 – UV light}$ = 0.65 (m, s)	2 acc[ing] to RIVM	Bleeker *et al.*, 2003
		Somatochlora cingulata / 96h LC_{50} = 1 – 2.5 (n)	4 acc[ing] to RIVM	Correa and Coler, 1983
Fish **($mg.l^{-1}$)**	**Freshwater**	*Oncorhynchus kisutch* / 96h / fry, 1g LC_{50}= 2.1 (m, cf)	Assessed by E.C., 2003 2 acc[ing] to RIVM	Moles *et al.*, 1981
		Oncorhynchus kisutch / 96h / fry, 0.3g, 7d LC_{50}= 3.22 (m, cf)	2 acc[ing] to RIVM	Moles, 1980
		Oncorhynchus mykiss / 96h $LC_{50 – light:dark=16:8h}$ = 1.6 (m, cf))	Assessed by E.C., 2003 2 acc[ing] to RIVM	DeGraeve *et al.*, 1982
		Oreochromis mossambicus / 96h LC_{50} = 7.9 (n, r)	4 acc[ing] to RIVM	Dangé, 1986
		Pimephales promelas / 96h / 31 – 35d LC_{50} =6.08 (m, cf)	2 acc[ing] to RIVM	Holcombe *et al.*, 1984
		Pimephales promelas / 96h / 1-2 mo, 0.27g $LC_{50 – light:dark=16:8h}$ =1.99 (m, sc)	2 acc[ing] to RIVM	Millemann *et al.*, 1984
		Pimephales promelas / 96h / 0.9g, 46mm $LC_{50 – light:dark=16:8h}$ =7.8 (m, cf)	Assessed by E.C., 2003 2 acc[ing] to RIVM	DeGraeve *et al.*, 1982
	Marine	*Cyprinodon variegatus* / 24 – 96h LC_{50} = 2.4 (s)	4 acc[ing] to RIVM	Anderson *et al.*, 1974
		Fundulus heteroclitus / 96h / 8.2±2cm $LC_{50 – light:dark=14:10h}$ =5.3 (m, r)	2 acc[ing] to RIVM	DiMichele and Taylor, 1978
		Onchorhynchus gorbuscha / 96h / 325mg, 32mm LC_{50} = 1.2 (m, cf)	Assessed by E.C., 2003 2 acc[ing] to RIVM	Moles and Rice, 1983

ACUTE EFFECTS			Klimisch code	Master reference
		Onchorhynchus gorbuscha / 48h / fry LC_{50} = 0.961 (m, cf)	Assessed by E.C., 2003 2 acc^{ing} to RIVM	Rice and Thomas, 1989
	Sediment	No information available		
Amphibians ($mg.l^{-1}$)	**Freshwater**	*Xenopus laevis* / 96h / larvae, 3w $LC_{50\ –\ light:dark=12:12h}$ = 2.1 (m, cf)	Assessed by E.C., 2003 2/3 acc^{ing} to RIVM	Edmisten and Bantle, 1982
		Xenopus laevis / 96h Frog Embryo Teratogenesis Assay-Xenopus (FETAX). No effects at saturated concentrations.	Assessed by E.C., 2003	Schultz and Dawson, 1995

CHRONIC EFFECTS			Valid according to	Master reference
Algae & aquatic plants (mg.l^{-1})	**Freshwater** Algae	*Pseudokirchneriella subcapitata* / 72h $EC_{10 - growth}$ > 4 270 (m, s)	2 acc^{ing} to RIVM	Bisson *et al.*, 2000
		Scenedesmus vacuolatus / 24h $NOEC_{growth (cell number) - fluorescent light}$ = 1.2 (m, sc)	2 acc^{ing} to RIVM	Walter *et al.*, 2002
	Macrophytes	*Lemna gibba* / 8d $EC_{10 - growth rate - partial UV light}$ = 32 (m, r)	2 acc^{ing} to RIVM	Ren *et al.*, 1994
	Marine Macrophytes	*Champia parvula* / 14d / female $EC_{10 - growth - light:dark=16:8h}$ = 0.85 (n, rc) *Champia parvula* / 14d / tetrasporophyte $EC_{10 - growth - light:dark=16:8h}$ = 0.47 (n, rc)	2 acc^{ing} to RIVM	Thursby *et al.*, 1985
Invertebrates (mg.l^{-1})	**Freshwater** Crustaceans	*Daphnia magna* / 28d NOEC = 3	4 acc^{ing} to E.C., 2003	Parkhurst, 1982
		Ceriodaphnia dubia / 7d / ind<24h $EC_{10 - reproduction light:dark=16:8h}$ = 0.514 (m, r)	2 acc^{ing} to RIVM	Bisson *et al.*, 2000
		Hyalella azteca / 10d / org.=2-3w, 0.5-1mm $NOEC_{mortality}$ = 1.161 (m, r)	2 acc^{ing} to RIVM	Lee *et al.*, 2002
	Marine Molluscs	*Mytilus edulis* / 48h / fertilized eggs $EC_{10 - larval development - dark}$ = 4.037 (m, sc, average) $EC_{10 - larval development - light:dark=14:10h}$ = 8.241 (m, sc, average)	2 acc^{ing} to RIVM	Bellas *et al.*, 2008
	Crustaceans	*Cancer magister* / 40d / Alaska larvae $NOEC_{larval development - ligh:dark=13:11h}$ = 0.021 (m, cf) *Cancer magister* / 60d / Oregon larvae $NOEC_{larval development - ligh:dark=13:11h}$ ≥ 0.17 (m, cf)	2 acc^{ing} to RIVM	Caldwell *et al.*, 1977
		Eurytemora affinis / 10d $NOEC_{feeding rate, egg production}$ ≥ 0.05 (m, r)	2 acc^{ing} to RIVM	Berdugo *et al.*, 1977
		Eurytemora affinis / lifetime, 15d $NOEC_{repro}$ < 0.014 (m, sc, one concentration tested)	2 acc^{ing} to RIVM	Ott *et al.*, 1978
	Echinoderms	*Paracartia grani* / 48h / eggs 1.3 < $NOEC_{egg hatching - light:dark=12:12h}$ < 6.4 (m, r, one concentration tested)	2 acc^{ing} to RIVM	Calbet *et al.*, 2007
		Paracentrotus lividus / 48h / fertilized eggs $EC_{10 - larval development - dark}$ = 0.649 (m, sc, average) $EC_{10 - larval development - light:dark=14:10h}$ = 0.741 (m, sc, average)	2 acc^{ing} to RIVM	Bellas *et al.*, 2008

CHRONIC EFFECTS			Valid according to	Master reference
		Psammechinus miliaris / 48h / fertilized eggs, 2-8 cells, <4 h $NOEC_{larval\ development\ –\ light:dark=16:8h} \geq$ 0.355 (m, sc)	2 acc[ing] to RIVM	AquaSense, 2005
		Strongylocentrus droebachiensis / eggs / ELS / 96h LC_{10} = 0.94 (m, s)	2 acc[ing] to RIVM	Falk-Petersen *et al.*, 1982
		Strongylocentrus droebachiensis / eggs / ELS / 96h LC_{10} = 0.58 (m, s)	2 acc[ing] to RIVM	Saethre *et al.*, 1984
	Sediment Insects (freshwater)	*Tanytarsus dissimilis* / life-cycle / spiked water, no sediment $NOEC_{egg\ hatching,\ adult\ emergence\ –\ light:dark=16:8h}$ < 0.5 (m, cf)	2-3 acc[ing] to RIVM 3 acc[ing] to the assessor (see text hereunder)	Darville and Wilhm, 1984
Fish **(mg.l^{-1})**	**Freshwater**	*Danio rerio* / 96h / larvae $NOEC_{malformations} \geq$ 0.388 (m, r, one concentration tested)	2 acc[ing] to RIVM	Petersen and Kristensen, 1998
		Micropterus salmoides / 7 d incl. 4 post-hatch / eggs 2-4 d post spawning LC_{10} = 0.037 (m, cf)	2 acc[ing] to RIVM	Black *et al.*, 1983
		Oncorhynchus kisutch / 40d / fry, 1g $NOEC_{growth}$ = 0.37 (m, cf)	2 acc[ing] to RIVM	Moles *et al.*, 1981
		Oncorhynchus mykiss / 27 d incl. 4 post-hatch / eggs 20 min post fertilization LC_{10} = 0.02 (m, cf)	2 acc[ing] to RIVM	Black *et al.*, 1983
		Pimephales promelas / 30d / embryo-larvae $NOEC_{growth\ –\ light\ :dark=16:8h}$ = 0.45 (m, cf)	2 acc[ing] to RIVM	DeGraeve *et al.*, 1982
	Marine	*Gadus morhua* / 4d / eggs / ELS LC_{10} = 1 (m, s, geo. mean)	2 acc[ing] to RIVM	Falk-Petersen *et al.*, 1982
		Gadus morhua / 4d / eggs / ELS LC_{10} > 0.7 (m, s, weighted average)	2 acc[ing] to RIVM	Saethre *et al.*, 1984
		Oncorhynchus gorbuscha / 40d / 325 mg, 32 mm $NOEC_{growth}$ = 0.12 (m, cf)	2acc[ing] to RIVM	Moles and Rice, 1983
	Sediment	No information available		
Tunicates	**Marine** Ascidians	*Ciona intestinalis* / 20h / fertilized eggs $EC_{10\ –\ larval\ development\ –\ dark}$ = 0.61 (m, sc, average) $EC_{10\ –\ larval\ development\ –\ light:dark=14:10h}$ =3.025 (m, sc, average)	2 acc[ing] to RIVM	Bellas *et al.*, 2008

	Available ecotoxicological information for organisms living in water column	
	Fresh water species	**Marine species**
Acute	7 taxonomic groups - algae, crustaceans, and fish - micro-organisms, molluscs, insects, amphibians	6 taxonomic groups - algae, crustaceans and fish - micro-organisms, annelids, molluscs
Chronic	5 taxonomic groups - algae, crustaceans, and fish - macrophytes and insects	6 taxonomic groups - algae, crustaceans and fish - cnidarians, 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 naphthalene in fact, there are enough data to perform a "*meaningful statistical comparison*" and the statistical analysis made showed no evidence of "*a difference in sensitivity between freshwater vs saltwater organisms*" (F-test 0.19; t-test 0.99; 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 data sets may be combined for QS derivation according to the Technical Guidance Document on EQS derivation (E.C., 2011).

Determination of the MAC

- ### Assessment Factor Method

The majority of the results from short-term tests lie in the range 1-10 mg.l^{-1}, except for some data on prokaryotes (bacteria and cyanophyta). All of the organisms tested appear to show similar sensitivity in the short-term tests, which is characteristic of narcotic effects. The predicted values were 7.8 mg.l^{-1} (LC_{50} for fish), 6.1 mg.l^{-1} (LC_{50} for daphnia) and 3.8 mg.l^{-1} (EC_{50} for algae), all of which fit closely the range of measured values whilst being towards the high end. Therefore, assessment factors of 10 and 100 applied to the lowest acute data seem conservative enough for derivation of $MAC\text{-}QS_{freshwater,\ eco}$ and $MAC\text{-}QS_{marine\ water,\ eco}$, respectively. The effect concentration of 0.4 mg.l^{-1} for *Skeletonema costatum* is the lowest value of the dataset. However, exposure duration is unknown and the percentage of affected organisms is unclear (30 to 50%). Therefore, the value obtained on *Chironomus riparius* with a 96h exposure *via* water – which is of the same order of magnitude as for the diatom *Skeletonema* – is preferred for derivation of the $MAC_{water,\ eco}$. Applying the above cited assessment factors results in a $MAC_{freshwater,\ eco}$ of 60 µg.l^{-1} and a $MAC_{marine\ water,\ eco}$ of 6 µg.l^{-1}.

- ### SSD Method

If the acute data sets for freshwater and marine species are combined, the combined data set appears sufficient to apply a statistical derivation approach to derive the $MAC\text{-}QS_{water,\ eco}$ values. Indeed, data appropriate for the derivation of a Species Sensitivity Distribution (SSD) include 7 taxonomic groups (algae, annelids, bacteria, crustaceans, molluscs, fish and amphibians) but it is not deemed necessary to include macrophytes as sensitive species to naphthalene given the high EC_{10} obtained for *Lemna gibba* after a chronic exposure of 8d, i.e. 32 mg.l^{-1}.

In its report in preparation (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 are reported hereunder for acute ecotoxicity.

Selected acute toxicity data of naphthalene to freshwater species (Verbruggen, in prep.)

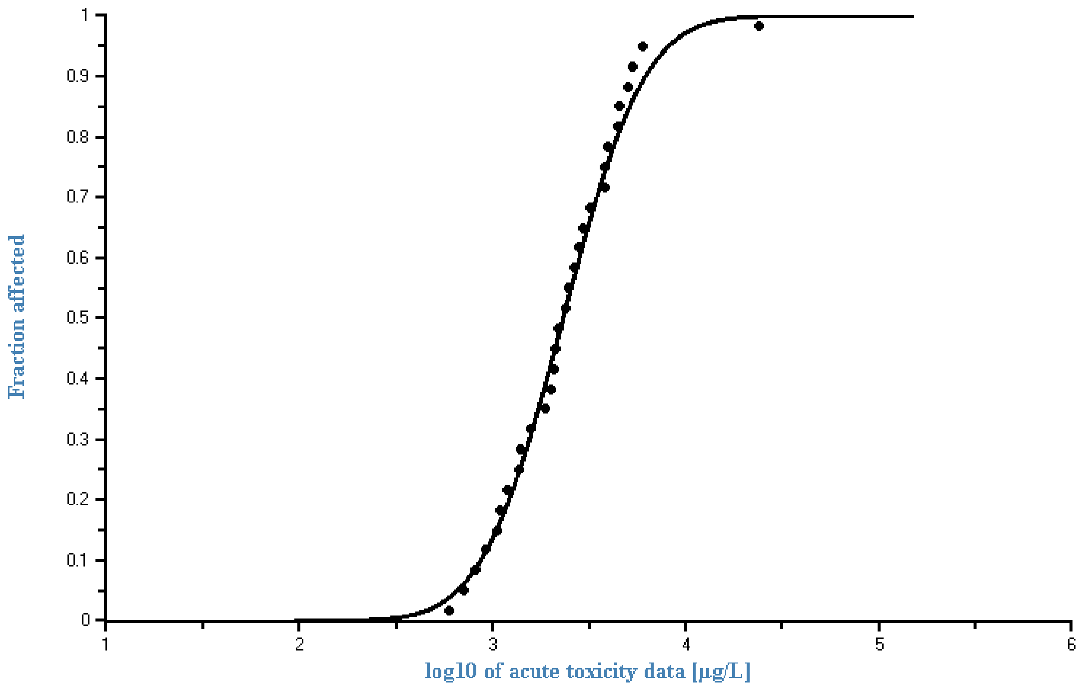
Taxon	Species	LC50 or EC50 [µg.l^{-1}]
Algae	Nitzschia palea	2820
Algae	Pseudokirchneriella subcapitata	2960
Algae	Scenedesmus vacuolatus	3800
Amphibia	Xenopus laevis	2100
Crustacea	Daphnia magna	1896 a
Crustacea	Diporeia spp.	1587
Crustacea	Gammarus minus	3930
Cyanophyta	Anabaena flos-aqua	24000
Insecta	Chironomus riparius	600 b
Mollusca	Physa gyrina	5020
Pisces	Oncorhynchus mykiss	2212 c
Pisces	Pimephales promelas	4572 d

[a] Geometric mean of 2160 and 1664 µg/L for the most sensitive parameter (immobility) at a standard exposure time of 48 h
[b] Most sensitive lifestage exposed under light conditions including some UV-A
[c] Geometric mean of 2100, 3220, and 1600 µg.l^{-1}
[d] Geometric mean of 1680, 1990, and 7900 µg.l^{-1}

Selected acute toxicity data of naphthalene to marine species (Verbruggen, in prep.)

Taxon	Species	LC50 or EC50 [µg.l^{-1}]
Algae	*Champia parvula*	1378 [a]
Annelida	*Neanthes arenaceodentata*	1069
Bacteria	*Vibrio fischeri*	710 [b]
Crustacea	*Artemia salina*	3190
Crustacea	*Calanus finmarchicus*	2400
Crustacea	*Elasmopus pectenicrus*	2680
Crustacea	*Eualis suckleyi*	1390
Crustacea	*Eurytemora affinis*	3800
Crustacea	*Hemigrapsus nudus*	1100 [c]
Crustacea	*Neomysis Americana*	825 [d]
Crustacea	*Oithona davisae*	4480 [e]
Crustacea	*Palaemonetes pugio*	2111
Crustacea	*Paracartia grani*	2467 [e]
Crustacea	*Parhyale hawaiensis*	6000
Mollusca	*Callinectus sapidus*	2301 [f]
Mollusca	*Mytilus edulis*	922
Pisces	*Fundulus heteroclitus*	5300
Pisces	*Oncorhynchus gorbuscha*	1200 [g]

[a] Geometric mean of 1000 and 1900 µg.l^{-1} for the most sensitive lifestage (tetrasporophyte)
[b] Geometric mean of 700 and 720 µg.l^{-1} at standard exposure time (15 min)
[c] Lowest value obtained with continuous exposure instead of intermittent exposure
[d] Geometric mean of 800 and 850 µg.l^{-1} at highest test temperature of 25 ºC
[e] Most sensitive parameter (immobility)
[f] Lowest value at highest salinity of 30‰
[g] Most relevant exposure time (96 h) and probably also most relevant life-stage for acute toxicity testing



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

The HC_5 of this SSD is 650 µg.l^{-1}, the HC_{50} is 2324 µg.l^{-1}. The $MAC_{water, eco}$ is by default derived applying an assessment factor of 10 to the HC_5. However, in their report in preparation, the RIVM states that "*the number of toxicity data and the taxonomic diversity is high and the differences in species sensitivity are low, which is characteristic of narcotic effects.*"

The RIVM proposes the above direct comparison for nine species from five taxonomic groups of the no-effect level and the 50% effect levels. The values are different by a factor of 5 or less.

Acute no effect levels (10% cut-off by means of EC10) versus 50% effect levels (EC50) for naphthalene

Taxon	Species	EC50/EC10 or LC50/LC10 (mg.l^{-1})
Amphibia	*Xenopus laevis*	1.6
Algae	*Scenedesmus vacuolatus*	2.2
Algae	*Champia parvula*	1.4 – 2.1
Bacteria	*Vibrio fischeri*	4.8
Crustacea	*Calanus finmarchicus*	1.1
Crustacea	*Oithona davisae*	1.8
Crustacea	*Paracartia grani*	1.6
Crustacea	*Parhyale hawaiensis*	1.6
Cyanophyta	*Anabaena flos-aqua*	2.5

Given that the $MAC_{water, eco}$ has to be protective of any acute toxicity effects but that the values used in the SSD are 50% effective concentrations and given the little difference between 50% effect levels and no effect levels, RIVM considered an assessment factor of 5 as sufficient to apply to the HC5 to derive the $MAC_{freshwater, eco}$. Given the large number of marine data in the dataset and the presence of non standard species such as seaweed, annelids and molluscs, an extra assessment factor for the $MAC_{marine\ water, eco}$ was not deemed necessary. Thus, both $MAC_{freshwater, eco}$ and $MAC_{marine\ water, eco}$ could be set to 130 $\mu g.l^{-1}$.

There are no acute data below these proposed values of 130 $\mu g.l^{-1}$. Therefore, this value seems sufficiently conservative and is proposed as $MAC_{freshwater, eco}$ and $MAC_{marine\ water, eco}$ rather than the values obtained by the assessment factor method.

Determination of the $AA\text{-}QS_{water, eco}$

- **Assessment Factor Method**

Longer-term studies are also available to derive $AA\text{-}QS_{water, eco}$. Species sensitivities are again rather comparable between taxa but less than for acute data as fish and daphnia appear to be more sensitive than algae. The RIVM report (Verbruggen, in prep.) justifies the use of the two results on fish reported by Black et al. (1983) data – while it was disregarded by naphthalene RAR – as follows: The data reported for Black et al. (1983) show a clear dose-response relationship.

"*The LC_{10} for survival after 4 days post-hatching is 20 µg/L. Clearly, this is the lowest usable effect concentration for naphthalene in freshwater species. In the RAR of naphthalene the study of Black et al., was disregarded because the method could not be repeated with toluene and it generally gives much lower results than standard studies. After reconsideration, it was concluded in the RAR of coal tar pitch that the value could be used.*

There are some differences between the studies with toluene and naphthalene. First, for toluene the difference with the other toxicity data is several orders of magnitude, while for naphthalene, there are several studies which show the onset of chronic effects or effects on sensitive life stages around the value of 20 µg/L. For the most sensitive strain of Dungeness crabs a NOEC of 21 µg/L was found in a 40-d study (Caldwell et al., 1977). In this study only two exposure concentrations are used. Although well-performed, the statistical power of this test is limited. For the marine herbivorous copepod Eurytemora affinis one concentration of 14 µg/L tested in a 15-d study resulted in significant effects (Ott et al., 1978). However, a 10-d study with the same species resulted in no significant effects up to 50 µg/L (Berdugo et al., 1977).

Second, the EC10 for toluene is also an order of magnitude lower than that for naphthalene, while naphthalene is a compound with a log K_{ow} that is 0.6 unit higher than that of toluene. For this reason, the EC10 for naphthalene would be expected to be lower than the EC10 for toluene, which is apparently not the case.

Further, both EC10s do not originate from the same publication, or at least toluene has been omitted from the publication. If a read-across is performed with the data for phenanthrene instead of toluene with data from the same study (Black et al., 1983), the data are very well in line with another study with the same species and with data for other species tested with phenanthrene. Therefore, the EC10 is considered to be useful in this case. "

The available data cover 5 freshwater taxonomic groups as well as 6 marine taxonomic groups, including echinoderms. Hence an assessment factor of 10 applied to the lowest chronic value of 0.02 $mg.l^{-1}$ obtained from a 27d-study on salmonid *Oncorhynchus mykiss* is deemed relevant to derive both $AA\text{-}QS_{freshwater, eco}$ and $AA\text{-}QS_{marine\ water, eco}$.

- **SSD Method**

Valid chronic toxicity data are available for more than 10 species originating from seven taxonomic groups. Usable value for an additional eighth taxa representing the insects is missing. Indeed, in a full life-cycle study with the midge *Tanytarsus dissimilis*, it was concluded that concentrations below 500 $\mu g.l^{-1}$ resulted in minimal effects (Darville and Wilhm, 1984) but details on the dose-response relationship for this species are missing and some results are ambiguous (deletion of results of one control and one treatment subunits for the reason that no hatching was observed). With this value missing on insects, a species sensitivity distribution can in principle not be applied. For comparative purposes the SSD was tentatively realised by RIVM in their report (resulting in a HC_5 of 25 $\mu g.l^{-1}$) but the data did not fit well to a log-normal distribution and effects for one species that were observed in one study were not always observed in the other or differences existed even between different strains for the same species. Moreover, there were some effects observed even below the lowest EC_{10}. The wide range of NOEC or EC_{10} values for different species, also raised some question whether there were “more specific modes of toxic action involved besides the baseline toxicity caused by narcosis”. RIVM considered that “part of the differences might also be explained from the difficulties in maintaining constant exposure concentration in toxicity”.

Because of all these uncertainties, a species sensitivity distribution can in principle not be applied and assessment factor method is applied exclusively to derive AA-$QS_{water,\ eco}$.

Tentative QS_{water} **Assessment factor method**	**Relevant study for derivation of QS**	**AF**	**Tentative QS**
$MAC_{freshwater,\ eco}$	SSD-HC_5 = 0.65 mg.l^{-1}	5	130 µg.l^{-1}
$MAC_{marine\ water,\ eco}$		5	130 µg.l^{-1}
AA-$QS_{freshwater,\ eco}$	*Oncorhynchus mykiss* / 27 d incl. 4 post-hatch / eggs 20 min post fertilization LC_{10} = 0.02 mg.l^{-1}	10	2 µg.l^{-1}
AA-$QS_{marine\ water,\ eco}$		10	2 µg.l^{-1}

7.1.2 Sediment-dwelling organisms

The toxicity of naphthalene was studied exposing the sediment-dwelling crustacean *Rhepoxynius abronius* during 10d *via* spiking of muddy sand (2.58% organic matter) (Boese *et al.*, 1998). The endpoints were mortality and reburial and irradiation of the crustaceans with UV light had little effect on these parameters. The EC_{50} for reburial of *Rhepoxynius abronius* after 10 days of exposure is 227 µmol.g^{-1} for an OC content of 2.58%. This value corresponds to a concentration of 29 101 mg.kg^{-1} for the same OC content and to a value of 56 397 mg.kg^{-1} when normalized to an OC content of 5% as recommended by the Draft Technical Guidance Document on EQS derivation (E.C., 2011).

RIVM notes in its report that although this value is an EC_{50}, the exposure time (10-d) as well as the endpoint (reburial) are rather chronic than acute. Nevertheless, the difference with the LC_{50} is negligible (LC_{50} normalised to 5% OC content is 57 889 mg.kg^{-1}_{dw}).The long-term test on the freshwater sediment species *Tanytarsus* cited here before (see section 7.1.1., SSD method) can not be used for the above cited reasons, and in particular because the test was carried out in the absence of sediment.

Because of the dataset available (one acute test but no true long-term sediment test available and no saltwater sediment test representing different living and feeding conditions), assessment factors of 1000 and 10 000 should be applied to derive $QS_{freshwater,\ sed}$ and $QS_{marine\ water,\ sed}$ of 56 397 µg.$kg^{-1}_{dw,}$ respectively 56 397 µg.kg^{-1}_{dw} as recommended by the TGD on EQS derivation (E.C., 2011).

Tentative $QS_{water,\ sed}$ **Assessment factor method**	**Relevant study for derivation of QS**	**AF**	**Tentative QS**
AA-$QS_{freshwater,\ sed.}$	*Rhepoxynius abronius* / 10d LC_{50} of 57 889 mg.kg^{-1}_{dw} EC_{50} of 56 397 mg.kg^{-1}_{dw}	1 000	56 397 µg.kg^{-1}_{dw}
AA-$QS_{marine\ water,\ sed.}$		10 000	5 639 µg.kg^{-1}_{ww}
AA-$QS_{freshwater,\ sed.}$	*Oncorhynchus mykiss* / 27 d incl. 4 post-hatch / eggs 20 min post fertilization LC_{10} = 0.02 mg.l^{-1}	EqP	53 µg.kg^{-1}_{ww} 138 µg.kg^{-1}_{dw}
AA-$QS_{marine\ water,\ sed.}$		EqP	53 µg.kg^{-1}_{ww} 138 µg.kg^{-1}_{dw}

The values derived *via* the equilibrium partitioning approach are more conservative and therefore proposed as the $QS_{water,\ sed}$ values.

As a matter of comparison, provisional ecotoxicological assessment criteria for naphthalene in seawater and sediment were agreed in November 1993 (Oslo and Paris Commissions, 1994). For seawater, the ecotoxicological assessment criteria was provisionally set as 1-10 $\mu g.l^{-1}$, based on a NOEC of 40 $\mu g.l^{-1}$ and an assessment factor of 10. Concentrations in sediment were calculated by applying the equilibrium partitioning approach and the provisional assessment criteria for sediment is 10-100 $\mu g.kg^{-1}{}_{dw}$.

7.2 SECONDARY POISONING

Based on the Technical Guidance Document on EQS derivation (E.C., 2011), this substance does trigger the bioaccumulation criteria (e.g. log K_{OW} = 3.34) although the toxicological data available do not seem to demonstrate a high toxicological potential (NOEC > 1 000 $mg.kg^{-1}{}_{feed\ ww}$).

Secondary poisoning of top predators		**Master reference**
Mammalian oral toxicity	Mouse / Oral / 90d / absolute brain, liver and spleen weights for females NOAEL = 133 $mg.kg^{-1}{}_{bw}.d^{-1}$ NOEC = 1 104 $mg.kg^{-1}{}_{feed\ ww}$ (CF=8.3)	Shopp et al (1984) *in* E.C., 2003
	Dog / Oral / 7d / Haemolytic anaemia LOAEL = 220 $mg.kg^{-1}{}_{bw}.d^{-1}$ LOEC = 8 800 $mg.kg^{-1}{}_{feed\ ww}$ (CF=40) *Poorly conducted study with no control* (as cited in E.C., 2003)	Zuelzer and apt (1949) *in* E.C., 2003
	Reprotoxicity: Overall naphthalene only produces fetotoxicity at maternally toxic doses in animals, and does not produce developmental toxicity at maternally subtoxic doses.	E.C., 2003
Avian oral toxicity	No information available	

For the back calculation of $QS_{biota,\ hh}$ into water, the BCF value of 515 is used as well as BMF_1 = BMF_2 = 1 (cf. section 5.1).

Tentative $QS_{biota\ secpois}$	**Relevant study for derivation of QS**	**AF**	**Tentative QS**
Biota	NOEC = 1 104 $mg.kg^{-1}{}_{feed\ ww}$	90	12 266 $\mu g.kg^{-1}{}_{biota\ ww}$ corresponding to 23.8 $\mu g.l^{-1}$ (freshwater) 23.8 $\mu g.l^{-1}$ (marine water)

7.3 HUMAN HEALTH

Based on the Technical Guidance Document on EQS derivation (E.C., 2011), this substance does trigger the criteria defined on the basis of the hazardous properties of the chemical of interest. Specific triggers include classification criteria according to the Regulation on classification, labelling and packaging of substances and mixtures (E.C., 2008a), which are H302 (Harmful if swallowed) and H351 (Suspected of causing cancer). Based on this information, a $QS_{biota,\ hh}$ should be derived.

Human health via consumption of fishery products		**Master reference**
Mammalian oral toxicity	Mouse / Oral / 90d / absolute brain, liver and spleen weights for females NOAEL = 133 $mg.kg^{-1}_{bw}.d^{-1}$ NOEC = 1 104 $mg.kg^{-1}_{feed\ ww}$ (CF=8.3)	Shopp et al (1984) *in* E.C., 2003
	If naphthalene is considered to be not carcinogenic, due to its negative genotoxicity as suggested in an RIVM report (Baars *et al.*, 2001), then it is deemed acceptable to use the proposed TDI of 0.04 $mg.kg^{-1}_{bw}.d^{-1}$ as the Threshold Level.	Baars *et al.*, 2001
CMR	Not classified as mutagenic nor reprotoxic. Classified as Carcinogenic category 2: suspected carcinogenic substance	E.C., 2008a
	No oral threshold values are available in the EU-RAR.	E.C., 2008b
	Potential of naphthalene for carcinogenicity is questioned and discussed by ATSDR, RIVM, and U.S. EPA. Conclusions are controversial: - EPA classifies this compound as C, a possible human carcinogen, using criteria of the 1986 cancer guidelines (US-EPA, 1986). Using the 1996 Proposed Guidelines for Carcinogen Risk Assessment (US-EPA, 1996), the human carcinogenic potential of naphthalene via the oral or inhalation routes "cannot be determined" at this time based on human and animal data; however, there is suggestive evidence [observations of benign respiratory tumors and one carcinoma in female mice only exposed to naphthalene by inhalation (NTP, 1992]. Additional support includes increase in respiratory tumors associated with exposure to 1-methylnaphthalene. An oral slope factor for naphthalene was not derived because of a lack of chronic oral naphthalene studies. - RIVM questioned the potential for carcinogenicity of naphthalene but concluded that it is not carcinogenic due to its negative genotoxicity, therefore basing their risk estimate on the threshold approach (Baars *et al.*, 2001). - ATSDR has published a Toxicological Profile for Naphthalene (ATSDR, 2005). Although ATSDR discusses the carcinogenicity data in its evaluation, it does not currently assess cancer potency or perform cancer risk assessments.	US-EPA, 1998

According to the evaluations reported above, a clear conclusion cannot be drawn on the carcinogenic potential of naphthalene. There is no evidence of naphthalene being a genotoxic substance; therefore, it is considered acceptable to base the $QS_{biota,\ hh}$ on a Tolerable Daily Intake of 40 $µg.kg^{-1}_{bw}.d^{-1}$ as the Threshold Level.

For the back calculation of $QS_{biota,\ hh}$ into water, the BCF value of 515 is used as well as BMF_1 = BMF_2 = 1 (cf. section 5.1).

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	TPH fraction specific RfD of the TPHCWG method (TPHCWG, 1997) [(1)]		0.04	2 435 $\mu g.kg^{-1}_{biota\ ww}$ corresponding to 4.7 $\mu g.l^{-1}$ (fresh and marine waters)

[(1)] TPH = Total Petroleum Hydrocarbons; TPHCWG = Total Petroleum Hydrocarbons Criteria Working Group, Toxicology Technical Action Group

Human health via consumption of drinking water		**Master reference**
Existing drinking water standard(s)	No existing regulatory standard	Directive 98/83/EC
Provisional calculated drinking water standard	140 $\mu g.l^{-1}$	Baars *et al.*, 2001 and E.C., 2011

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