

HISTORY OF MAMPEC

Carol Mackie
RCL

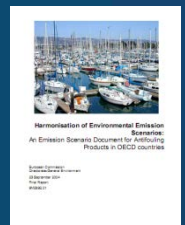
- MAMPEC – short history
- Processes addressed
- New features version 3.0
- Ballast water scenario
- Status and future work

Use of MAMPEC by Regulatory Authorities

- US- EPA
- EU
- Japan
- China
- New Zealand
- IMO – Ballast water substances

Brief History of MAMPEC

- 1996-1999 commissioned by **CEPE Antifouling Working Group** as part of EU project “Utilisation of more environmental friendly antifouling products” (96/559/3040/DEB/E2)
- Steering committee: EC, MS, Industry, IMO
- Model upgrades commissioned by CEPE: 2002 (v 1.4) and 2005 (v 1.6), 2006 (v.1.6.03), 2008 (v2.0/2.5), **2010 (v3.0)**
- Model referenced in the EU-OECD Emission Scenario Document for A/F paints PT-21 (2004)
- Reviewed in EU for the BPD 2004 – to date
- MAMPEC-BW (2010) for ballast water exp. assessment



OECD Exposure assessment

- Emissions: ESD Document
- Service life
 - Application, maint. & repair, removal
- Estimation of leaching rate
 - ASTM / ISO
 - *In-situ* Dome method
 - ISO mass balance
 - ...
- Exposure modelling (PEC):
 - MAMPEC
 - REMA (HSE UK)

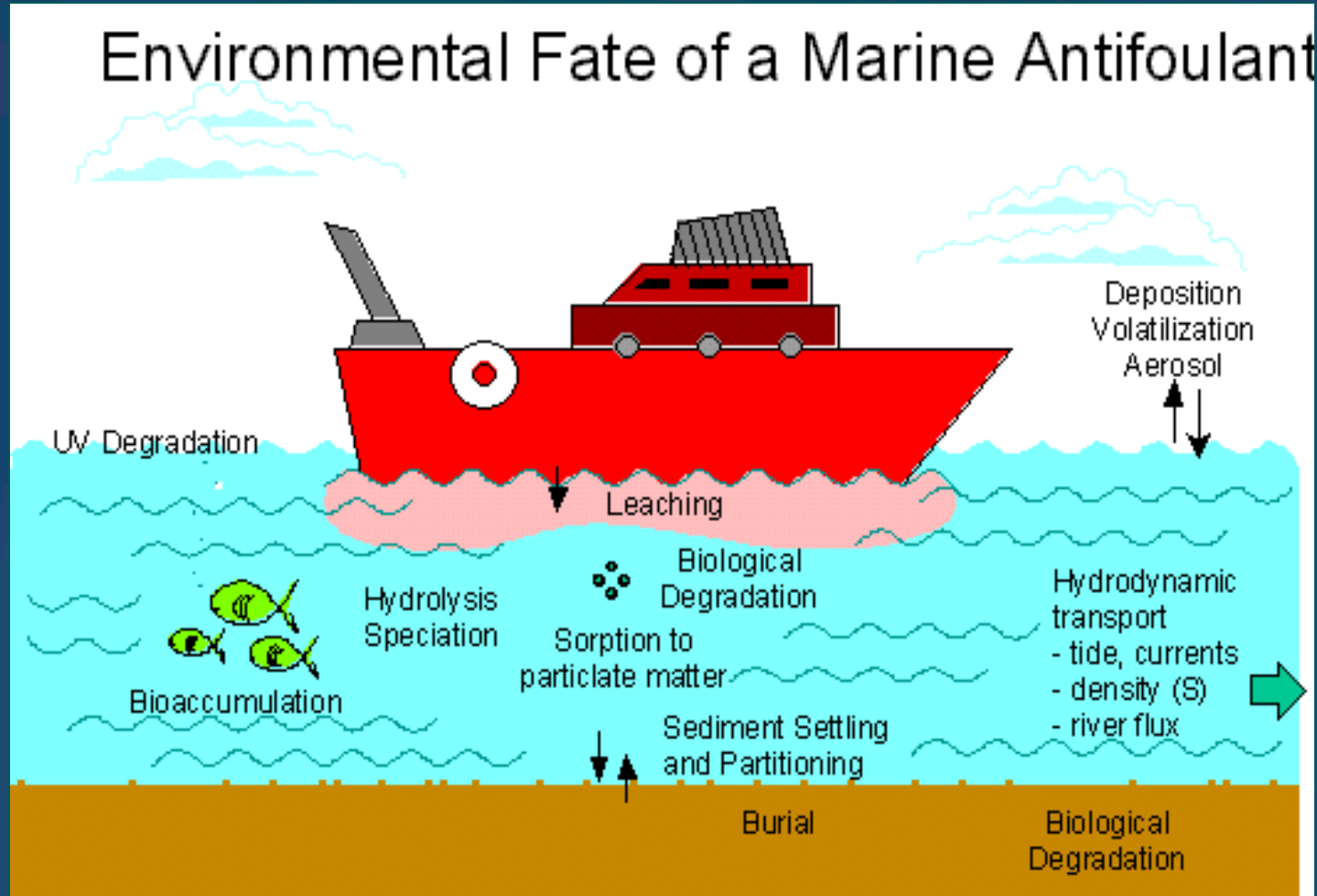


Harmonisation of Environmental Emission Scenarios:
An Emission Scenario Document for Antifouling Products in OECD countries

European Commission
Directorate-General Environment
23 September 2004
Final Report
9M/28/92/01



MAMPEC - fate and exposure / main factors



General structure of MAMPEC – workflow v1.0-2.5

The screenshot shows the MAMPEC 2.0 Release Candidate software interface. The main window is titled 'MAMPEC - Run definition and calculation'. It features a menu bar with 'File', 'Settings', and 'Help'. Below the menu bar is a 'Run' section with a 'Filter' input field, a 'Refresh list' button, and a dropdown menu showing 'OECD-EU Commercial harbour TBT (default) OECD-EU Commercial Harbour'. A 'Delete run' button is also present. The 'Information' section displays the following details:

Information	
Environment	OECD-EU Commercial harbour
Compound	TBT (default)
Emission	OECD-EU Commercial Harbour
Load	2495.06775 g/d
Background conc.	0.00E+00 ug/l

Below the information section is a 'Memo' text area. The 'Harbour' tab is selected, and the 'Surroundings' tab is also visible. The 'Results' section displays a table of concentrations for different parameters:

Results	Total conc.	Dissolved	Suspended matter	Sediment after 10 y
Maximum concentration	1.94E-01 ug/l	1.84E-01 ug/l	2.10E-01 ug/g dw	2.44E-02 ug/g dw
95 % concentration	1.90E-01 ug/l	1.80E-01 ug/l	2.05E-01 ug/g dw	2.39E-02 ug/g dw
Average concentration	6.87E-02 ug/l	6.53E-02 ug/l	7.43E-02 ug/g dw	8.64E-03 ug/g dw
Median concentration	1.93E-02 ug/l	1.84E-02 ug/l	2.09E-02 ug/g dw	2.43E-03 ug/g dw
Minimum concentration	2.77E-03 ug/l	2.64E-03 ug/l	3.00E-03 ug/g dw	3.49E-04 ug/g dw

Buttons for 'Save as ..', 'Cancel', and 'Print ...' are located at the bottom of the window.

Main input:

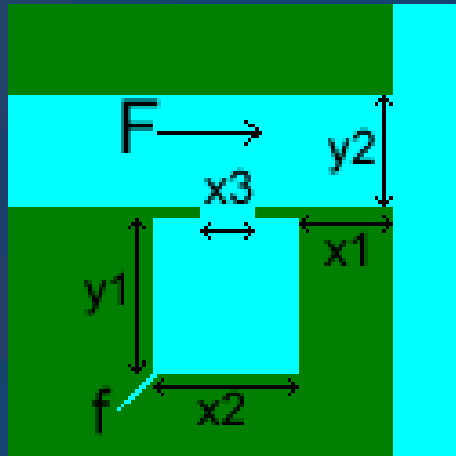
- Environmental settings
- Biocide properties
- Emission estimation module

Output:

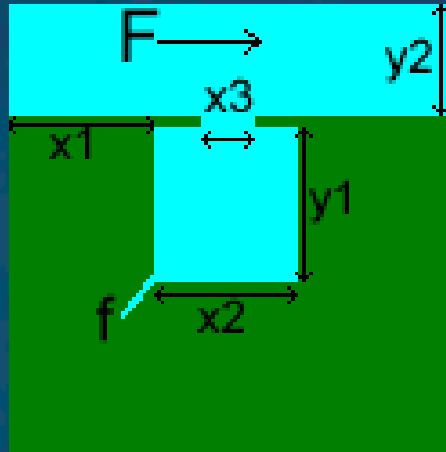
- PECs water and sediment

- **Main input data:**
- Environmental settings
 - Marinas
 - Harbours
 - Shipping lanes
- Biocide properties
 - Phys-chem data
 - Environmental fate
- Emission estimation module
 - Number of boats – size, submerged surface area
 - Leaching rate

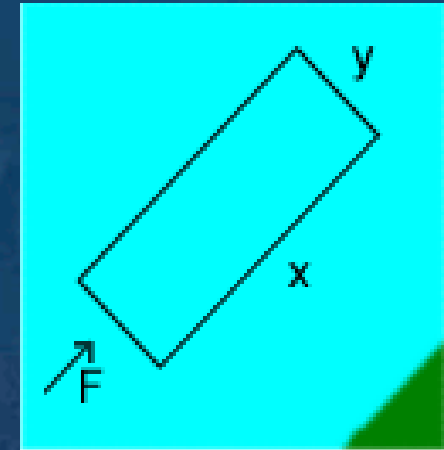
Examples of prototype environmental scenarios



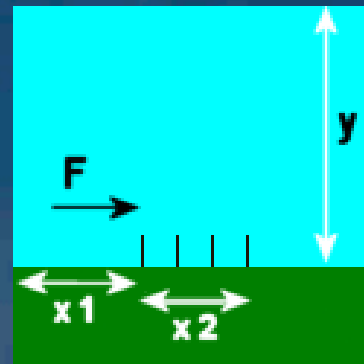
1 Commercial harbour
Estuarine harbour



3 Marina



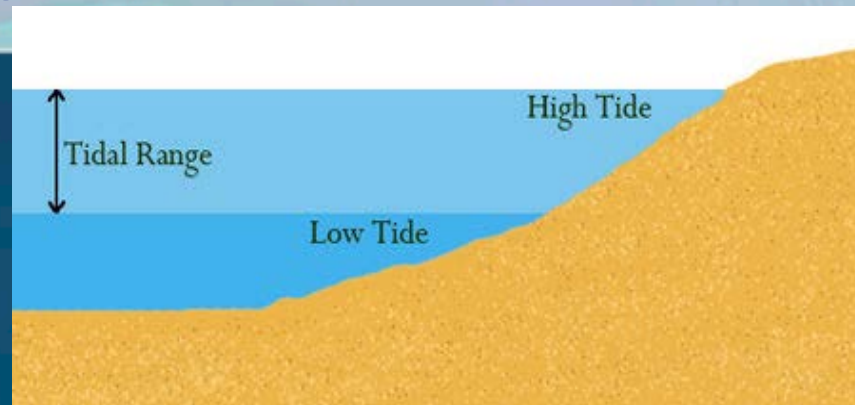
4 Shipping lane
Open sea



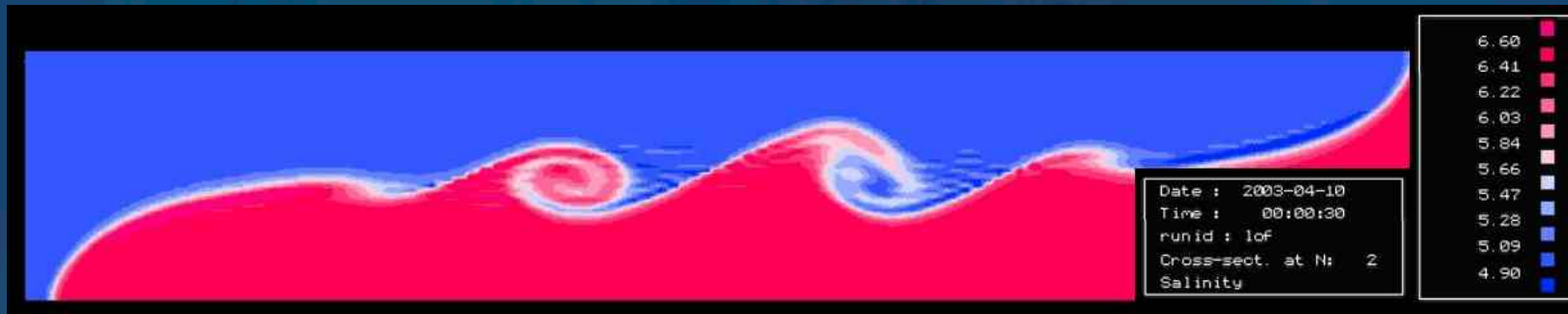
5 Open harbour

Hydrodynamic exchange in MAMPEC

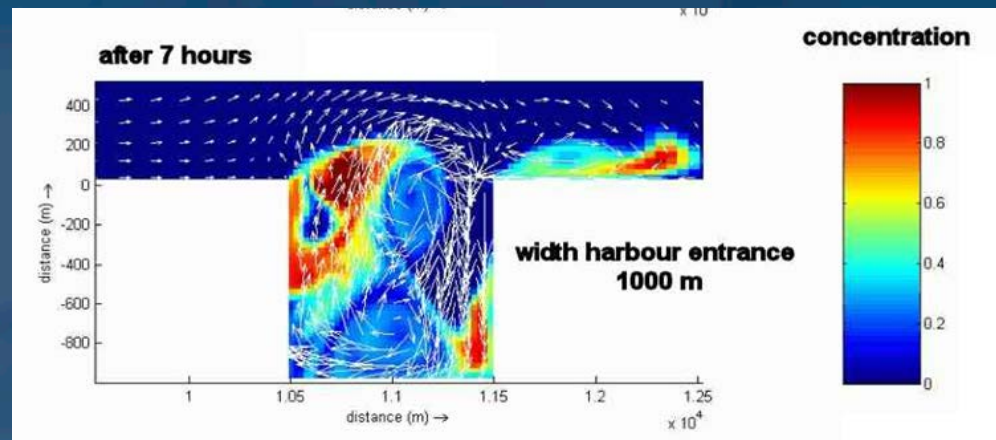
1. Tide



2. Salinity difference



3. Horizontal flow in relation to dimensions (harbour layout)



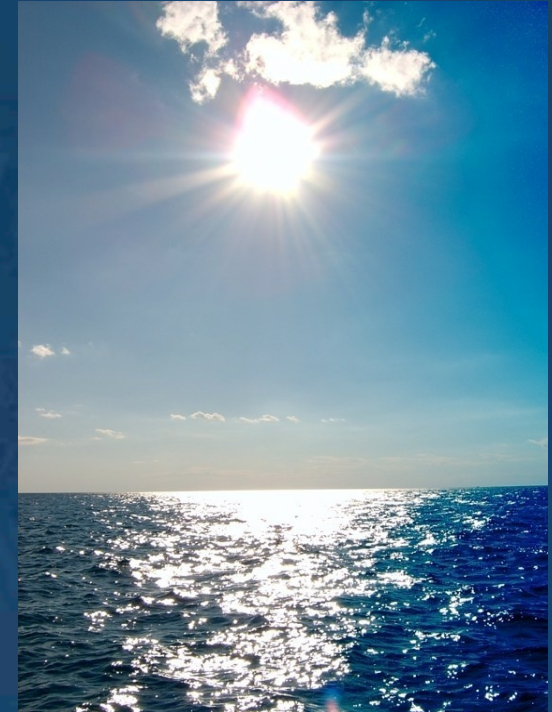
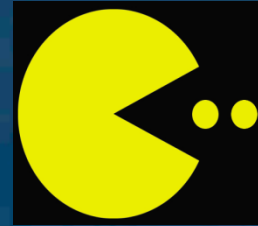
Hydrodynamic exchange

- 4. additional exchange due to wind driven currents
- 5. other non tidal water level changes (important in absence of previous exchange mechanisms)



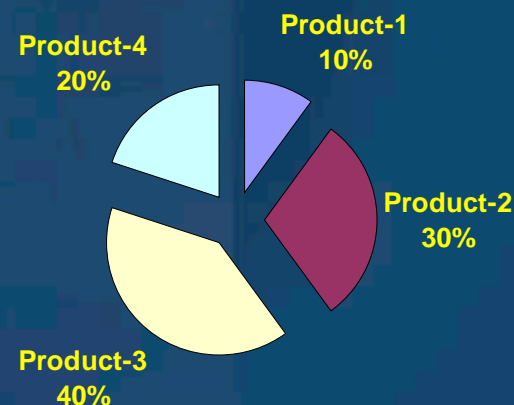
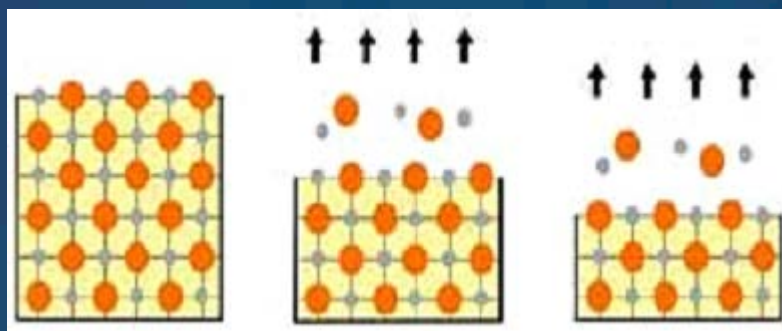
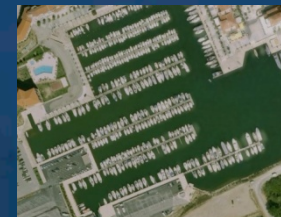
MAMPEC degradation processes

- Degradation
 - Water
 - Sediment
- Abiotic
 - hydrolysis
 - photolysis (2 options)
 - Speciation (e.g. copper)
- Biotic
 - Biodegradation (aerobic+anaerobic)



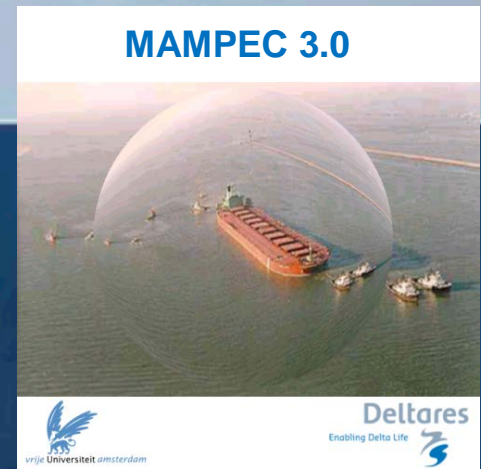
Emissions

- number of boats
- size, wet surface area of boats
- residence time
- leaching rate (paint matrix, Temp, velocity,..)
- application factor (market share)



Objectives Version 3.0

- Compatability with Windows Vista / 7
- New emission scenarios for new-build and docking activities - full assessment according to ESD
- Multi-lingual support (Japanese in v2.5, Chinese)
- Analysis of fate and most important fluxes
- Plot of PEC-profile downstream harbour
- Copper speciation according to WHAM and BLM
- In response to comments: extension of sediment module (org-C handling and degradation; concentration basis already in v2.5)



Environment in v3.0 – Example: OECD Comm. Harbour

Mampec 3.0

File Language Help

Model

Environment
OECD-EU Commercial harbour

Compound
TBT

Emission
OECD-EU Commercial Harbour

Run

Run model & view results
Default commercial harbour 1 TBT...

Multiple runs

Import / export

Import

Export

Load

Description: OECD-EU Commercial harbour

Harbour type: Commercial harbour

Reference: ESD-PT21 Table 0.5

Hydrodynamics

Tidal period: 12.41 hour

Tidal difference: 1.5 m

Max. density difference tide: 0.4 kg/m³

Non tidal daily water level change: 0 m

Flow velocity (F): 1 m/s

Layout

Length: x1 1000 m, x2 5000 m

Width: y1 1000 m, y2 500 m

Depth: 15 m

Mouth width: x3 2500 m

Water characteristics

TPM concentration: 35 mg/l

POC concentration: 1 mg/l

DOC concentration: 2 mg/l

Chlorophyll: 3 µg/l

Salinity: 34 s.e.

Temperature: 15 °C

pH: 7.5

General

Latitude: 50 ° (dec) NH

Sediment

Depth mixed sediment layer: 0.2 m

Sediment density: 1000 kg/m³

Degr. organic carbon in sediment: 0 1/d

Nett sedimentation velocity: 1 m/d

Fraction organic carbon in sediment: 0.02852

Wind

Average wind speed: 0 m/s

Fraction of time wind perpendicular: 0 -

Flush

Flush (f): 0 m³/s

Max. density difference flush: 0 kg/m³

Harbour lay-out data, used for density flow exchange

Height of submerged dam: 0 m

Width of submerged dam: 0 m

Depth-MSL in harbour entrance: h0 10 m

Exchange area harbour mouth (below mean sea level): 37500 m²

Calculated exchange volumes (m³/tide)

Category	Value	Percentage
Tidal	7.500E+006	14.65 %
Horizontal	9.166E+006	17.91 %
Density induced	3.452E+007	67.44 %
Wind driven	0.000E+000	0.00 %
Non tidal	0.000E+000	0.00 %
Total	5.119E+007	m3 / tide
	68.25	% / tide

Work flow

Compounds in v3.0

Mampec 3.0 File Language Help

Model

- Environment
OECD-EU Commercial harbour
- Compound
TBT**
- Emission
OECD-EU Commercial Harbour

Run

New Save Save as new Delete Load

Compound description: TBT CAS number:

Compound name: TBT EINECS number:

Molecular mass: 290.04 (g/mol) Reference:

Saturated vapour pressure at 20 °C: 8.5E-05 (Pa)

Solubility at 20 °C: 1.9 (g/m³)

Depth and 24 h averaged degradation rates

	Water (diss.)		Sediment/SPM	
	Rate Constant (day ⁻¹)	Half-life (day)	Rate Constant (day ⁻¹)	Half-life (day)
Degradation rate - abiotic - at 20 °C	0.00E+000	Infinity	0.00E+000	Infinity
Degradation rate - photolytic - at 20 °C	0.00E+000	Infinity	0.00E+000	Infinity
Degradation rate - biological - at 20 °C	4.10E-002	1.68E+001	1.40E-003	4.93E+002

☐ Use advanced photolytic

Advanced photolytic degradation

Octanol-water partition coefficient K_{ow}: 3.80E+000 (10 log K_{ow})

Partition coefficient K_{oc}: 4.60E+000 (10 log K_{oc} (1/kgOC))

Henry's constant at 20 °C: 2.00E-002 (Pa.m³/mol)

Estimate missing values

Melting temperature: 0 °C

Acid dissociation constant pK_a: 0 (-)

V3.0 Emission

FileLanguageHelp

Model

Environment
OECD-EU Commercial harbour

Compound
Advanced Photolysis (Test)

Emission
OECD-EU Commercial Harbour

Run

Run model & view results
Default commercial harbour 1 TBT ...

Multiple runs

Import / export

Import

Export

NewSaveSave as newDeleteLoad

DescriptionOECD-EU Commercial Harbour

Reference

Emissions from ships at berth2303.145g/d

Emissions from moving ships191.92275g/d

Other emissions0g/d

Total emission2495.06775g/d

Calculate emission

Service lifeApplication / removal

Length class (m)	Surface area (m2)	# Ships at berth (/d)	# Ships moving (/d)	Application factor (%)
50-100	1163	11	1.8	90
100-150	3231	5	0.4	90
150-200	6333	5	0.4	90
200-250	10469	1	0.1	90
250-300	15640	2	0.1	90
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0

Leaching rate (at berth)2.5µg/cm²/d

Leaching rate (moving)2.5µg/cm²/d

Service life

☒ Ships at berth2.30E+003g/d

☒ Ships moving1.92E+002g/d

Application professional

☒ New building0.00E+000g/d

☒ Maintenance0.00E+000g/d

☒ Removal0.00E+000g/d

Application non professional

☐ Maintenance0.00E+000g/d

☐ Removal0.00E+000g/d

Totals

Total service life2.50E+003g/d

Total new building0.00E+000g/d

Total maintenance0.00E+000g/d

Total removal0.00E+000g/d

Total2.50E+003g/d

Use calculated values

Emission – non service life

Service life Application / removal

Service life Application / removal

☒ Commercial ships ☐ Pleasure crafts

New building Maintenance & repair Removal

The removal period

The number of days for the treatment of one boat

Number of ships treated per period

The fraction of the paint that is to be removed from the hull by HPW

The fraction of the paint that is to be removed from the hull by abrasion

The concentration of active ingredient in the paint

Fraction of a.i. remained in exhausted paint removed by HPW

Fraction of a.i. remained in exhausted paint removed by abrasion

The amount of paint applied per boat

Average hull surface of a ship

Theoretical coverage of the paint

Number of coats applied on the hull

Fraction excess paint applied

Ratio reblasting/ spot blasting

Fraction to surface water

Service life

☒ Ships at berth 2.30E+003 g/d

☒ Ships moving 1.92E+002 g/d

Application professional

☒ New building 0.00E+000 g/d

☒ Maintenance 0.00E+000 g/d

☒ Removal 0.00E+000 g/d

Application non professional

☐ Maintenance 0.00E+000 g/d

☐ Removal 0.00E+000 g/d

Totals

Total service life 2.50E+003 g/d

Total new building 0.00E+000 g/d

Total maintenance 0.00E+000 g/d

Total removal 0.00E+000 g/d

Total 2.50E+003 g/d

Use calculated values

V3.0 View results

Mampec 3.0

File Language Help

Model

- Environment
OECD-EU Commercial harbour
- Compound
TBT
- Emission
OECD-EU Commercial Harbour

Run

- Run model & view results
OECD-EU Commercial harbour TB...
- Multiple runs

Import / export

- Import
- Export

New Save

Run name

Environment

Compound

Emission

Load

Background conc.

Run date 7/13/2010 3:58 PM

Distribution of antifoulant at steady state Analysis of fate and fluxes of antifoulant at steady state Surrounding pollution

Harbour

	Total conc.	Dissolved	DOC	Suspended matter	Sediment after 1 Years	Sediment after 2 Years	Sed
Maximum concentration	2.01 E-001 ug/l	1.91 E-001 ug/l	2.28 E-003 ug/l	7.60 E-003 µg/g oc	3.70 E-004 µg/g oc	5.78 E-004 µg/g oc	7.98
95 % concentration	1.96 E-001 ug/l	1.87 E-001 ug/l	2.23 E-003 ug/l	7.43 E-003 µg/g oc	3.61 E-004 µg/g oc	5.66 E-004 µg/g oc	7.80
Average concentration	7.29 E-002 ug/l	6.93 E-002 ug/l	8.28 E-004 ug/l	2.76 E-003 µg/g oc	1.34 E-004 µg/g oc	2.10 E-004 µg/g oc	2.90
Median concentration	2.53 E-002 ug/l	2.41 E-002 ug/l	2.88 E-004 ug/l	9.59 E-004 µg/g oc	4.67 E-005 µg/g oc	7.29 E-005 µg/g oc	1.01
Minimum concentration	3.21 E-003 ug/l	3.05 E-003 ug/l	3.64 E-005 ug/l	1.21 E-004 µg/g oc	5.91 E-006 µg/g oc	9.24 E-006 µg/g oc	1.28

Surroundings

	Total conc.	Dissolved	DOC	Suspended matter	Sediment after 1 Years	Sediment after 2 Years	Sed
Maximum concentration	1.00 E-002 ug/l	9.53 E-003 ug/l	1.14 E-004 ug/l	3.80 E-004 µg/g oc	1.85 E-005 µg/g oc	2.89 E-005 µg/g oc	3.99
95 % concentration	6.21 E-003 ug/l	5.91 E-003 ug/l	7.05 E-005 ug/l	2.35 E-004 µg/g oc	1.14 E-005 µg/g oc	1.79 E-005 µg/g oc	2.47
Average concentration	2.24 E-003 ug/l	2.13 E-003 ug/l	2.54 E-005 ug/l	8.46 E-005 µg/g oc	4.12 E-006 µg/g oc	6.44 E-006 µg/g oc	8.89
Median concentration	1.57 E-003 ug/l	1.50 E-003 ug/l	1.79 E-005 ug/l	5.96 E-005 µg/g oc	2.90 E-006 µg/g oc	4.53 E-006 µg/g oc	6.26
Minimum concentration	5.98 E-009 ug/l	5.70 E-009 ug/l	6.80 E-011 ug/l	2.27 E-010 µg/g oc	1.10 E-011 µg/g oc	1.72 E-011 µg/g oc	2.38

Diagram illustrating the spatial distribution of antifoulant at steady state. The Harbour is represented by a yellow grid with dimensions X1, X2, and Y1. The Surroundings are represented by a green grid with dimensions X3 and Y2. A small inset diagram shows the spatial coordinates x1, x2, x3, y1, y2 and fluxes F and f.

Cu Speciation: WHAM / BLM, 3L-Model

CopperSpeciationDialog

Cu speciation 3-Ligand model Cu-speciation WHAM Model

Cu - Ligand equilibrium constants

Equilibrium constant
Cu+Li(1)=CuLi Range 1-1000 E11

Equilibrium constant
Cu+Li(2)=CuLi Range 1-100 E8

Equilibrium constant
Cu+Li(3)=CuLi Range 1-100 E6

Organic ligand concentration

Organic ligand L1 - strong
complex Range 2 - 20 E-8

Organic ligand L2 - medium
complex Range 5 - 50 E-8 M

Organic ligand L3 - weak complex
Range 5 -50 E-6 M

Environmental conditions

Salinity

pH

Copper speciation - Results

Total dissolved Cu	<input type="text" value="1.21E-009"/>	M	
Cu++ free	<input type="text" value="1.50E-013"/>	M	0.01 %
CuLi(1)	<input type="text" value="1.21E-009"/>	M	99.94 %
CuLi(2)	<input type="text" value="2.09E-013"/>	M	0.02 %
CuLi(3)	<input type="text" value="3.22E-013"/>	M	0.03 %
CuCO3	<input type="text" value="2.52E-014"/>	M	0.00 %
CuOH	<input type="text" value="1.27E-014"/>	M	0.00 %
CuCl	<input type="text" value="5.65E-015"/>	M	0.00 %
CuSO4	<input type="text" value="3.82E-015"/>	M	0.00 %

V3.0 Export settings and results

Mampec 3.0

File Language Help

Model

- Environment
OECD-EU Commercial harbour2
- Compound
TBT
- Emission
OECD-EU Commercial Harbour

Run

- Run model & view results
Default commercial harbour 1 TBT ...
- Multiple runs

Import / export

- Import
- Export

Export items

Environments	Emissions	Compounds
Default commercial harbour	Default Commercial Harbour Biocide 100%	Advanced Photolysis (Test)
Default commercial harbour 1	Default Commercial Harbour Cu 100%	Copper (total)
Default estuarine harbour	Default Commercial Harbour TBT 100%	Copper Omadine (default)
Default marina	Default Estuarine Harbour TBT 100%	Dichlofluanid (default)
Default marina 400m poorly flushed	Default Marina biocide 100 %	Diuron (default)
Default open sea	Default Marina biocide 20 %	Irgarol (default)
Default shipping lane	Default Marina Cu 100%	Seanine (default)

Export to database

Export runs

Default commercial harbour Test
Default commercial harbour 1 Copper (total) Def...
Default commercial harbour 1 TBT OECD-EU C...

— Mampec 3 – Result Sheet —

Run name	Default commercial harbour 1 TBT OECD-EU Commercial Harbour		
Version	3.0.0.0		
Date	Tuesday, July 13, 2010 4:01 PM		
Memo			

— Input —

Environment	OECD-EU Commercial harbour2	
Emission	OECD-EU Commercial Harbour	
Compound	TBT (default)	
Background conc.	0.00E+000	g/d

— Harbour —

— Total conc. —

Maximum concentration	2.01 E-001	ug/l		
95 % concentration	1.96 E-001	ug/l		
Average concentration	7.29 E-002	ug/l		
Median concentration	2.53 E-002	ug/l		
Minimum concentration	3.21 E-003	ug/l		

To text to RTF file

New Developments

- Currently the US Copper Task Force are developing a freshwater inland marina scenario for the US
- Looking to conduct copper monitoring data during this summer along with usage surveys to determine how antifouling paints are used in freshwater
- Will include existing monitoring data in the US and GIS data for water quality characteristics and water exchange data

Concluding remarks

- MAMPEC result of proactive role of industry in risk assessment of antifoulants.
- Model is constantly being adapted to need of users (applicants, authorities, water managers, students), software developments, and state of the art in ERA.
- Recognized by regulatory authorities in EU, Switzerland, USA, Australia, Japan, China, and other OECD countries
- Version 3.0 meets modern software standards, has a number of useful new extensions, bug fixes, and works much easier and faster
- Multi-run option: useful for sensitivity analysis and risk assessment of mixtures

Thank you for your attention

- Websites:
 - delftsoftware.wldelft.nl (official download & support)
 - www.antifoulingpaint.com
 - www.cepe.org