Note: This is presentation material only

In-feed modelling methodology

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Overview

- DEPOMOD review
- assumptions
- modelling methodology
- summary

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DEPOMOD summary

- DEPOMOD is a Lagrangian particle-tracking model
- predicts deposition of solids to the sea-bed from fish-farms
- predicts benthic faunal response
- comprises five functional modules
- NOT hydrodynamic

Cromey, C.J., Nickell, T.D. and Black, K.D. (2000) DEPOMOD A model for predicting the effects of solids deposition from mariculture to the benthos, Scottish Association for Marine Science, Oban (ISBN 0-9529089-1-3) 120 pp.

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DEPOMOD modules

- GRIDGEN - details of bathymetry, cage and reference station positions
- PARTRACK - settling and advection of particles through the water column
- RESUS - calculation of solids, carbon or particle-bound compound deposition/flux with resuspension
- BENTHIC - benthic response to solids accumulation
- GaBoM - a sub-module to determine fish growth and biomass

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Assumptions I

- Constant biomass - average feed load
- feed and quantity of chemical are proportional to biomass
- SEPA can't prescribe at what point in the growth cycle fish are treated

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Assumptions II

- A single current meter mooring is representative of 1km^2
- not true where there are obstructions, e.g. islands, headlands, reefs, or other complex bathymetries
- very large sites may extend for more than 1km
- SEPA's hydrographic data requirements specify quiescent wind conditions during collection
- periodic major resuspension events are not captured
- sediment density is constant
- 'intangibles' are discounted

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method I: Chemical characteristics

- Teflubenzuron (TFBZ) - ‘Calicide’
  - chitinase inhibitor
  - $T_{½}$= 115 days
  - Only 10% of treatment mass acts on parasites
- Emamectin benzoate (EmBZ) - ‘Slice’
  - disruption of physiological processes by increased membrane permeability to chloride ions
  - $T_{½}$= 250 days (including breakdown products)
  - 90% of treatment mass acts on parasites

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method II-1: Consent Strategy

TFBZ

- maximum treatment quantity
- unlimited retreatments controlled by $T_{½}$ table

EmBZ

- maximum treatment quantity (MTQ)
- total allowable quantity (TAQ) - up to 5x biomass
- site residual curve (SRC) of chemical mass on sea bed
- retreatments controlled by table to calculate superposition of scaled SRCs extended by $T_{½}$ info

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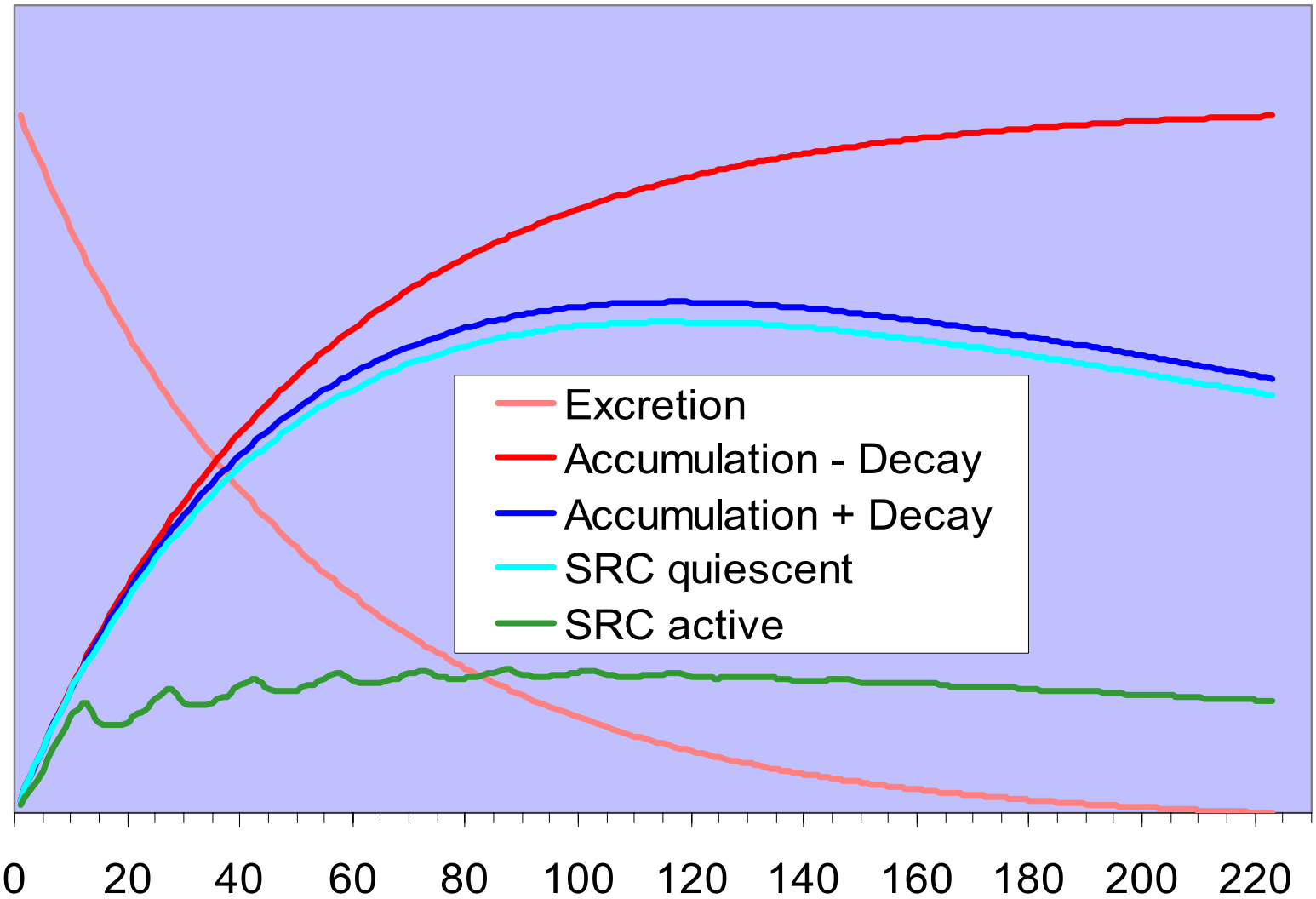
method II-2: Site Residual Curves



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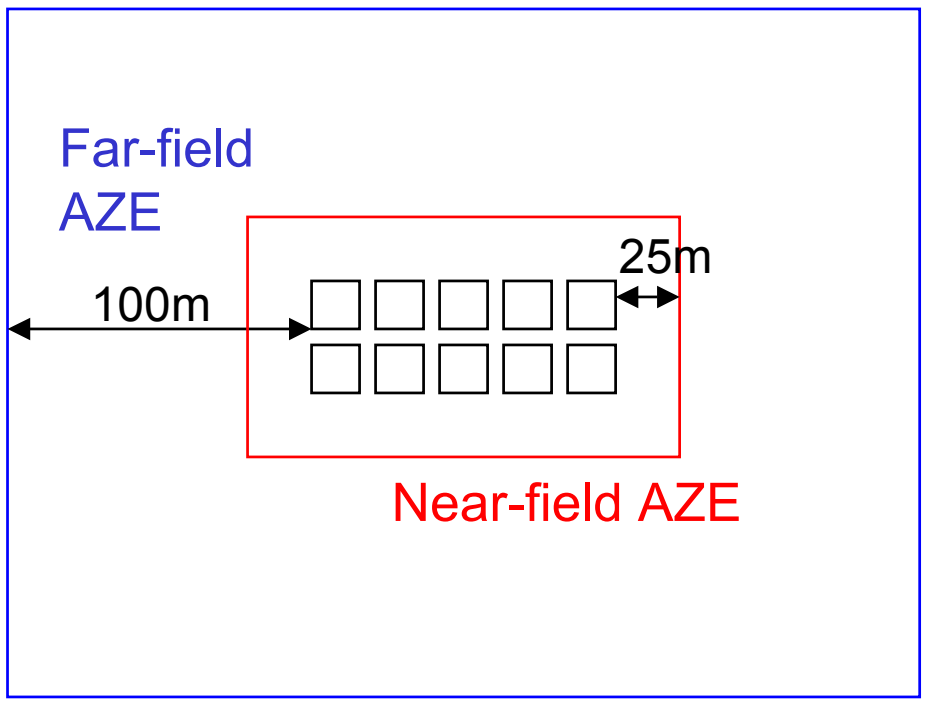
method III: EQS & AZE

- EQS development – ecotoxicological study of critical sensitive species; PNEC/safety factor
- Allowable Zone of Effect (AZE)

EQS	EmBZ µg/kg	TFBZ mg/kg
near	7.63	10
far	0.763	0.002



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method IV: Data Preparation Tools

- standard method, model domain, grid resolution, time-step *&c.* and consistent structure of input data
- templates and macros
  - vector-average and format current data
  - extract and format bathymetry
  - calculate cage centres and reduce to DEPOMOD coordinates
  - calculate AZE
- facilitate file-naming conventions and maintenance of audit trail for QC

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method V: Set-up & scenario testing

- model application procedure
  - GRIDGEN - cage positions & bathymetry
    - PARTRACK - cage sizes, current data & discharge load
    - RESUS - resuspension (and decay)
    - areal analysis - SURFER contouring & EQS tests
    - refinement of applied load until compliance
  - (produce SRC for EmBZ)
- report MTQ (+ TAQ & SRC for EmBZ) and mass balance

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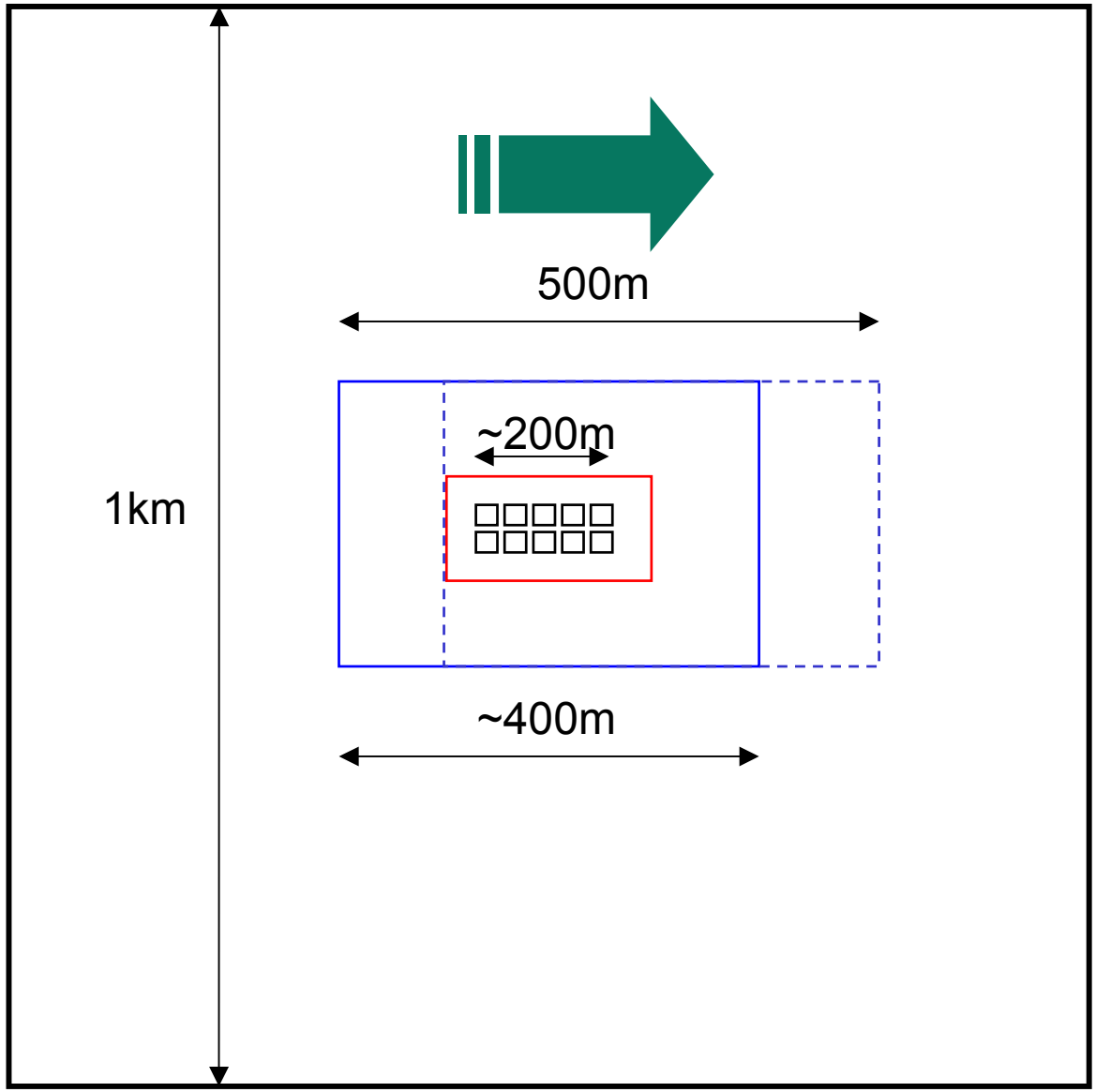
method VI: Model Domain



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method VII: Model Resolution

- resolution: required accuracy and computing power
- DEPOMOD calculates at $^{1}/_{10}^{th}$ 'minor grid' resolution
- 25m 'minor grid' composed of 100 x 6.25m^2 elements
- example: single 15m square cage
  - near-field AZE = 4225m^2 (0.0015%)
  - far-field AZE = 46,225m^2 (0.00014%)

- conclusion: use of 25m grid does not introduce significant error into calculations

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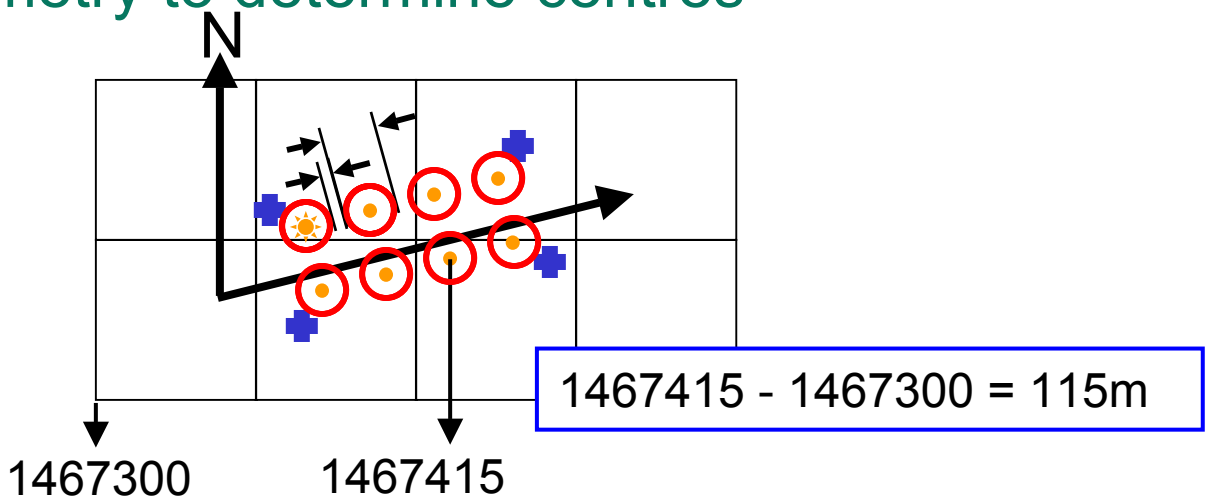
method VIII: Cage Positions

- require cage centres as distance from model origin
  - cages are typically in regular pattern
    - group corner positions from survey
    - cage size, separation and group orientation
    - location of single cage (lat/long or NGR)
    - trigonometry to determine centres



- reduce centre NGRs by origin NGR

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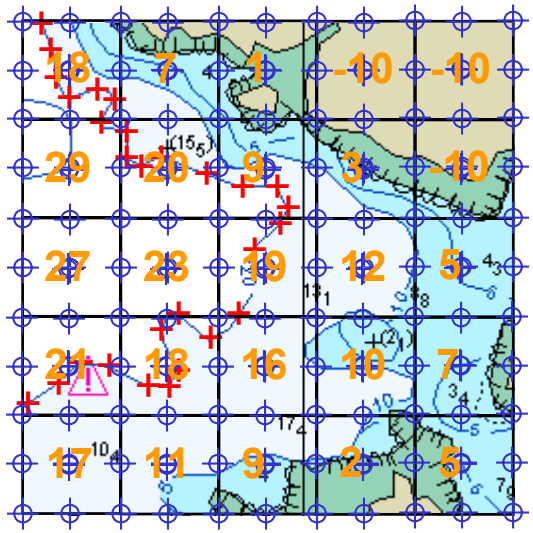
method IX: Bathymetry

- require mean depth of 25m grid cells
- C-MAP digital chart : lat/long & depth m (CD)
- extract x-y-z and land boundary as NGR and depth m (CD)
- grid at 12.5m in SURFER
- extract at 25m, to ASCII text file
- reformat with EXCEL macro to DEPOMOD major grid file



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method X: Hydrographic Data

- 15 days data at hourly intervals
- vector-average higher resolution data
- identify intermediate tide records:
  - neap-spring-neap
  - spring-neap-spring
- file header includes:
  - depth of mooring
  - height of data retrieval above sea-bed
  - local MSL (m CD)
  - local magnetic variation
  - data source file

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method XI: Chemical Loads

- 3% waste
- Decay rates: TFBZ = 115 days; EmBZ = 250 days
- Excretion rates
  - TFBZ: 90% in 7 days
    - treatment load discharged at constant rate
    - ⇒ method insensitive to pulse at flood/slack/ebb
  - EmBZ: $T_{½}$= 36 days
    - 10% during treatment - constant discharge
    - 90% x 98% over following 216 days
    - peak mass ‘in environment’ on day 118 (day of test)
    - total discharge over 223 days

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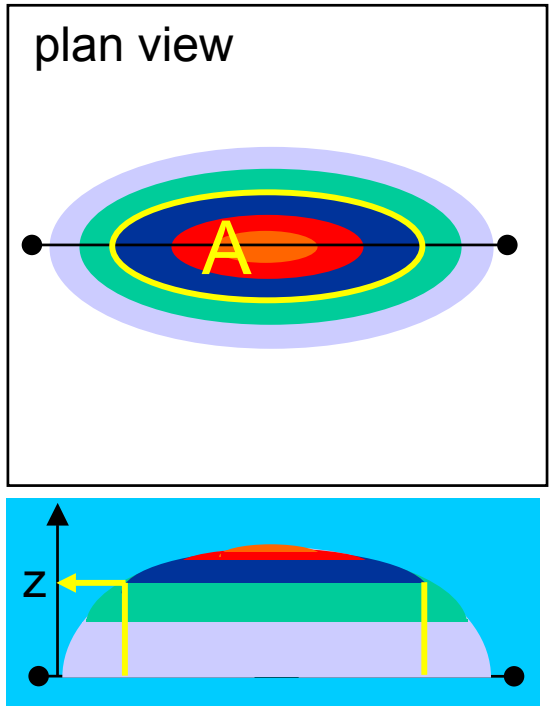
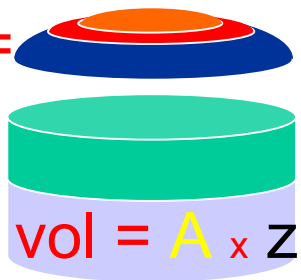
method XII: Compliance Testing

- perform near & far-field tests
  - area within far-field EQS contour
  - mean conc. within near-field AZE
- SURFER 'volume' tool calculates area within specified contour (z) value and integrates volume under 'surface'
- mean conc. (c) in near-field AZE

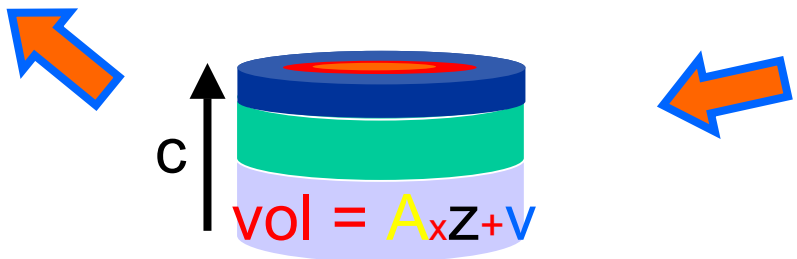


$$c = \frac{(A \times z) + v}{A}$$

vol under surface, v =



vol = A x z



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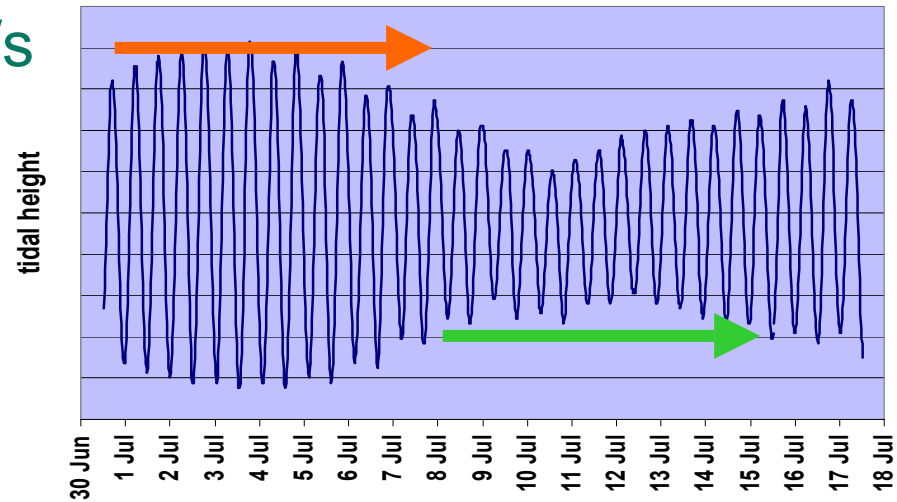
method XIII: Tidal 'worst case'

- TFBZ release sensitive to tide: SP-NP or NP-SP
- resus threshold = 9.5cm/s
- 4 day consolidation
- comparative runs for both conditions
- 1º: compare near-field concentration



- 2º: compare area at far-field EQS - if difference between near-field concentrations is insignificant

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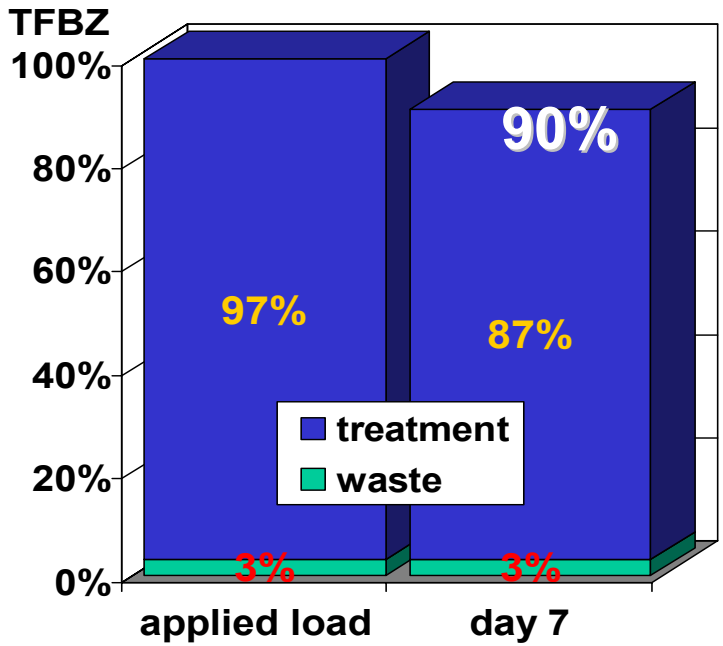
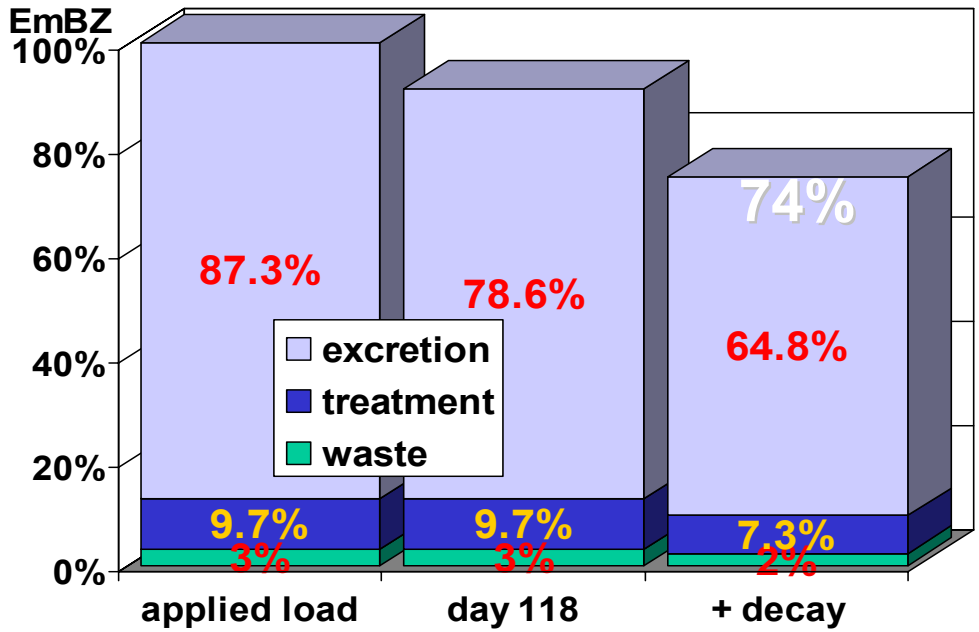
method XIV: Mass Balance

- mass of chemical exported from model?
- DEPOMOD: mass in model on seabed at end of each day
- calculate ‘no resuspension’ mass (% of applied load)





- if more than 20% exported: assess fate
  - have regard for area of available receiving water

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summary: Required Information

- 15 days hourly current data
- depth of current meter deployment site and heights of meters above seabed
- magnetic variation
- number, shape, size (depth and diameter or width), separation and layout of cages
- site survey positions
- bathymetry for 1km square, centred on groups
- mean sea level
- maximum biomass
- annual feed load

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