

Data Compilation, Selection, and Derivation of PNEC Values for the Marine Aquatic Compartment

The Existing Substances Risk Assessment of Nickel was completed in 2008. The straightforward explanation of the goal of this exercise was to determine if the ongoing production and use of nickel in the European Union (EU) causes risks to humans or the environment. The European Union launched the Existing Substances regulation in 2001 to comply with Council Regulation (EEC) 793/93. “Existing” substances were defined as chemical substances in use within the European Community before September 1981 and listed in the European Inventory of Existing Commercial Chemical Substances. Council Regulation (EEC) 793/931 provides a systematic framework for the evaluation of the risks of existing substances to human health and the environment.

The conceptual approach to conducting the environment section of the EU risk assessment of nickel included the following steps (Figure 1):



Paracentrotus lividus is one of the Echinoderms represented in the marine ecotoxicity database for nickel.

- Emissions of nickel and nickel compounds to the environment were quantified for the whole life cycle, *i.e.*, from production, use, and disposal;
- Concentrations of nickel resulting from these emissions were determined in relevant environmental media (water, sediment, soil, tissue) at local and regional scales (PECs);
- Critical effects concentrations (PNECs) were determined for each of the relevant environmental media;
- Exposure concentrations were compared to critical effects concentrations for each of the relevant environmental media (risk characterization); and
- Appropriate corrective actions (also described as risk management) were identified for situations where exposure concentrations were greater than critical effects concentrations. Where exposure concentrations were below critical effects concentrations, there was no need for concern or action.

The EU Risk Assessments for Nickel and Nickel Compounds were developed over the period from 2002 to 2008. The Danish Environmental Protection Agency (DEPA) acted as the Rapporteur in this process, in close collaboration with the international nickel industry. EU Risk Assessment Reports (RARs) for the environment for nickel substances (metallic nickel, nickel carbonate, nickel chloride, nickel nitrate, and nickel sulfate) were submitted in the spring of 2008 after thorough

review by the Technical Committee on New and Existing Substances (TCNES), which was comprised of technical representatives from the EU Member States. A final peer review was provided by the Scientific Committee on Health and Environmental Risks (SCHER) (see Section 5). The European Commission’s Institute for Health and Consumer Protection published the final Risk Assessment Reports for nickel and nickel compounds in November 2009.

After the EU RARs received approval within Europe, the data sets were discussed at the international level within the Organization of Economic Cooperation and Development (OECD). The nickel ecotoxicity data sets used in the EU RARs were accepted at the OECD’s SIDS (Screening Level Information Data Set) Initial Assessment Meeting (SIAM 28, October 2008), as was the use of nickel bioavailability models to normalize the nickel ecotoxicity data.

1 INTRODUCTION

Environmental risks are typically characterized in the risk assessment framework by considering the ratio between exposure concentrations and critical effect concentrations. In OECD countries, critical effect concentrations are based on Predicted No-Effects Concentrations (PNECs), which are typically derived from long-term laboratory-based ecotoxicity tests using well-defined protocols on a limited number of species. Such information is usually retrieved from relevant literature and/or internationally recognized databases. Because the quality of the extracted data may vary considerably among individual source documents, it is important to evaluate all ecotoxicity data with regard to their adequacy for PNEC derivation and risk assessment. This fact sheet provides clear guidance on how to perform such evaluation for the marine aquatic compartment, including criteria for acceptance (or rejection) of a study in accordance with the purpose of the assessment and examples how these data were applied in the European Union Environmental Risk Assessment for Nickel and Nickel Compounds (EU RA).

In the EU RA, a stepwise approach is used for the derivation of the marine aquatic PNEC value. Figure 2 provides an overview of the

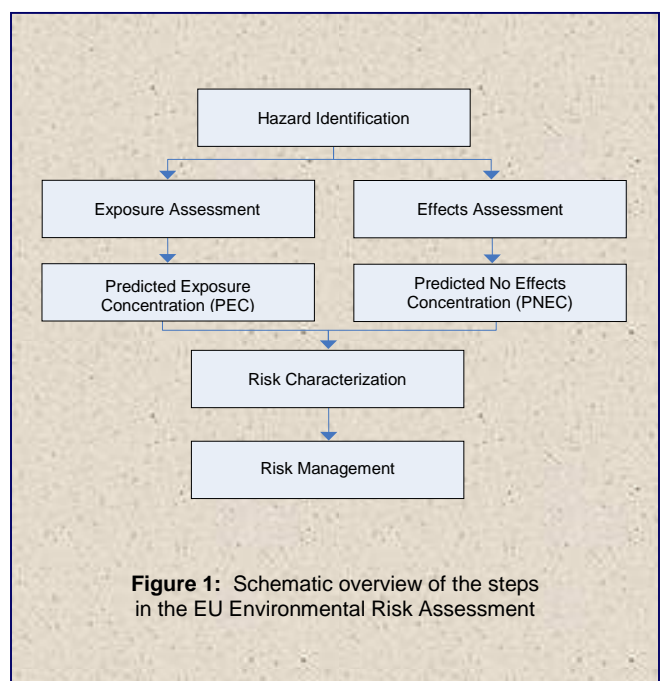


Figure 1: Schematic overview of the steps in the EU Environmental Risk Assessment

steps that need to be accomplished in order to derive the PNEC for nickel for the marine aquatic compartment.

2 GUIDANCE

2.1 DATA COMPILATION

The data on the toxicity of nickel to marine organisms were compiled from three main sources: open literature, internationally recognized databases (*e.g.*, Science Direct, Web of Science), and industry-sponsored research programs. A large dataset on the chronic ecotoxicity of nickel to marine organisms was compiled. Estuarine species were not covered in this assessment. All gathered data were further screened using the criteria as outlined in [Section 2.2](#).

2.2 DATA QUALITY SCREENING

Each individual ecotoxicity data point was screened for quality before incorporation in the nickel ecotoxicity database based on the following criteria¹:

- data were retained for the following groups of organisms: micro- and macro-algae, invertebrates, and fish;
- data covered the following relevant endpoints: survival, development, growth and/or reproduction;
- Ni-only exposure data were considered relevant (studies were rejected if indications of impurities or other substances might have an effect on the toxic properties of nickel);
- the results reported measured pH and salinity;
- the toxicity tests were performed in artificial or natural seawater at a salinity varying between 28 and 39 ppt;
- the data were from studies conducted according to approved international standard test guidelines (however, data from non-standardized tests were also assessed);
- only long-term or chronic toxicity data were used;
- the tests were performed according standard operational procedures, with a detailed description of the methods employed during toxicity testing;
- preference was clearly given on the use of measured nickel concentrations in the test concentrations;
- a clear concentration-response was observed;
- toxicity threshold values calculated as L(E)C₁₀ (the concentration that causes 10% effect during a specified time interval) values were preferred; however, NOEC values (No Observed Effect Concentration) were also seen as equivalent;
- the toxicity tests were performed with soluble nickel salts (*e.g.*, NiCl₂ and NiSO₄);
- the toxicity test results reflected dissolved nickel concentrations and were expressed as µg Ni/L; and
- ecotoxicity threshold values were derived using the proper statistical methods.

Only the identified ecotoxicity data fulfilling the above mentioned criteria were used for the marine aquatic PNEC derivation.

2.3 DATABASE DEVELOPMENT

Applying the above mentioned quality screening criteria to the identified ecotoxicity data resulted in the selection of an extensive high quality database on the ecotoxicity of nickel to marine organisms. Indeed, the database comprised 15 different “species means”

for 14 different families from 25 individual high quality L(E)C₁₀/NOEC values (9 individual NOEC for micro- and macro-algae, 14 for invertebrates, 2 for fish).

An overview of all accepted individual high quality chronic ecotoxicity data is presented in the Environmental Risk Assessment of Nickel and Nickel Compounds (see [Section 5](#)).

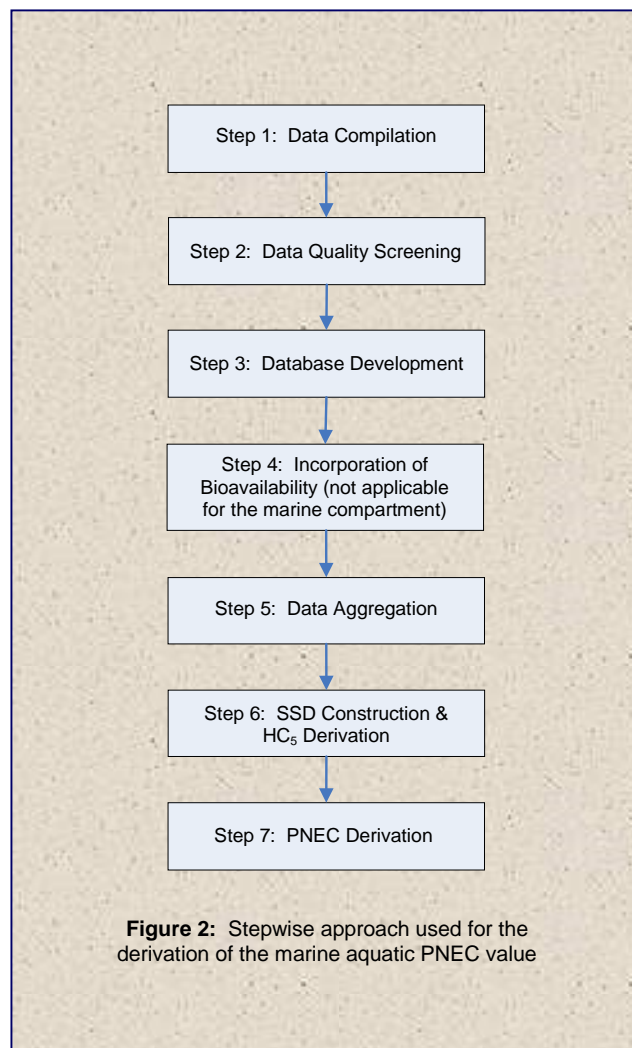


Figure 2: Stepwise approach used for the derivation of the marine aquatic PNEC value

2.4 DATA NORMALIZATION

Most of the physico-chemical characteristics known to affect nickel toxicity in the marine environment (*i.e.*, pH, cation concentration, salinity) are fairly uniform in coastal marine waters. One parameter [*i.e.*, dissolved organic carbon (DOC)] can vary substantially in marine waters. However, relationships between nickel toxicity and DOC for marine organisms are unknown. Therefore, normalization of the toxicity data has not been applied to the effect concentrations [NOEC/L(E)C₁₀] compiled in the accepted high quality ecotoxicity database. All of the marine ecotoxicity tests have been performed at low DOC, which would be expected to maximize bioavailability. Therefore, the approach followed represents a reasonable worst case PNEC value.

2.5 DATA AGGREGATION

High quality ecotoxicity data are grouped/aggregated in order to avoid over representation of ecotoxicological data from one particular species. The following major rules were used to aggregate data:

- If several chronic NOEC/L(E)C₁₀ values based on the same toxicological endpoint were available for a given species, the values were averaged by calculating the geometric mean, resulting in the “species mean” NOEC/L(E)C₁₀.
- If several (geometric mean) chronic NOEC/L(E)C₁₀ values based on different toxicological endpoints were available for a given species, the lowest (geometric value) value was selected.

After the data aggregation step, only one ecotoxicity value (*i.e.*, the geometric mean for the most sensitive endpoint) was assigned to a particular species.

2.6 CALCULATION OF PNEC USING STATISTICAL EXTRAPOLATION METHODS

Estimation of the HC₅ from the species sensitivity distribution

When a large data set for different taxonomic groups is available, the PNEC can be calculated using a statistical extrapolation method. In this approach, the ecotoxicity data are ranked from low (most sensitive species) to high (least sensitive species) and a species sensitivity distribution (SSD) is then constructed by applying an appropriate curve fitting distribution (usually a log-normal distribution) to the high quality aggregated chronic toxicity data (Aldenberg & Jaworska, 2000). However, because of the bad fit of this distribution curve, alternative distributions were used for the fitting of the marine toxicity data. From each statistically relevant SSD, an individual 5th percentile value (at the median confidence interval) is calculated and the final selected median HC₅ value is calculated as the mean value of the individual median 5th percentile.

Selection of appropriate assessment factor and derivation of the PNEC

To account for uncertainty, an assessment factor (AF) may be applied to the median HC₅. In general, such AFs vary between 1 and 5 and are determined on a case-by-case basis. The marine aquatic PNEC would therefore be calculated as follows:

$$\text{marine aquatic PNEC} = \text{median HC}_5 / \text{AF}$$

Based on the available chronic NOEC/L(E)C₁₀ data, the following points were considered when determining the AF:

- The overall quality of the database and the endpoints covered (*e.g.*, are all the compiled data representative of “true” chronic exposure?)
- The diversity of the taxonomic groups covered by the database (*e.g.*, do the databases contains all of the major groups of marine organisms?)
- The number of species (*e.g.*, does the SSD cover at least 10 different L(E)C₁₀/NOECs and preferably more than 15?)
- Statistical extrapolation (*e.g.*, how well does the SSD fit the toxicity data?)

- Comparisons between field and mesocosm studies and the PNEC (*e.g.*, is the PNEC value protective for the effects observed in mesocosm/field studies?)

In the Nickel EU RA, no marine mesocosm/field data are available that allow derivation of threshold concentrations of nickel in marine waters in the field. In addition, not all marine taxonomic groups are covered in the marine toxicity database. On the other hand, the ecotoxicity testing have been performed under conditions that tend to maximize bioavailability, and the estimated PNEC value using an AF of 2 is well below the lowest available measured toxicity value of the database. Therefore, based on weight of evidence, it was proposed to use an AF of 2.

3 EXAMPLE

3.1 DATA COMPILATION

See [Section 2.1](#)

3.2 DATA QUALITY SCREENING

The quality screening criteria as defined in [Section 2.2](#) were applied to select the high quality chronic ecotoxicity data of nickel to marine organisms.

3.3 DATABASE DEVELOPMENT

An overview of all accepted individual high quality chronic ecotoxicity data is presented in the Environmental Risk Assessment of Nickel and Nickel Compounds (see [Section 5](#)).

3.4 DATA NORMALIZATION

No bioavailability correction tools are available for the marine aquatic compartment, and therefore, no normalization of the toxicity data are performed for the marine environment.

3.5 DATA AGGREGATION

The selected individual high quality chronic ecotoxicity data of nickel to marine organisms are aggregated according to the criteria mentioned in [Section 2.5](#). An overview of the non-normalized species mean NOEC/L(E)C₁₀ value for the most sensitive endpoint is provided in [Table 1](#). Notably, marine fish (*Cyprinodon variegatus* and *Atherinops affinis*) were the least sensitive group to nickel exposure. Annelids (*Neanthes arenaceodentata*), molluscs (*Haliotis rufescens*), and crustaceans (*Mysidopsis sp.*) were among the most sensitive marine organisms.

3.6 SSD CONSTRUCTION AND MEDIAN HC₅ DERIVATION

The species mean NOEC/L(E)C₁₀ values in [Table 1](#) were further ranked from low to high. Subsequently, the conventional log-normal distribution was fitted to the ranked toxicity data using the ETx model. However, no significant fitting of the toxicity data was achieved using this model. Therefore, an alternative approach was elaborated to evaluate several other curve fitting functions for the SSD. In this “weight-of-evidence” approach, only the statistically significant parametric distribution functions for the available toxicity data set and the non-parametric “flexible kernel density estimation” were selected for the final PNEC derivation. Subsequently, the median HC₅ values were calculated from the different parametric and non-parametric distribution functions, resulting in a range of median HC₅ values between 5.3 and 25.4 µg/L (mean value of 19.9 µg/L) for the parametric distribution functions and a median HC₅ value of 14.5 for the non-parametric distribution func-

tion. From the discussions with the Member States and the Rapporteur, it was decided to use the mean value of 19.9 µg/L and 14.5 µg/L, *i.e.*, 17.2 µg/L as the final median HC₅ value for PNEC derivation. The parametric distribution functions and the mean of median HC₅ value, calculated using the @Risk software (Version 5), for the non-normalized ecotoxicity for nickel are presented in [Figure 3](#).

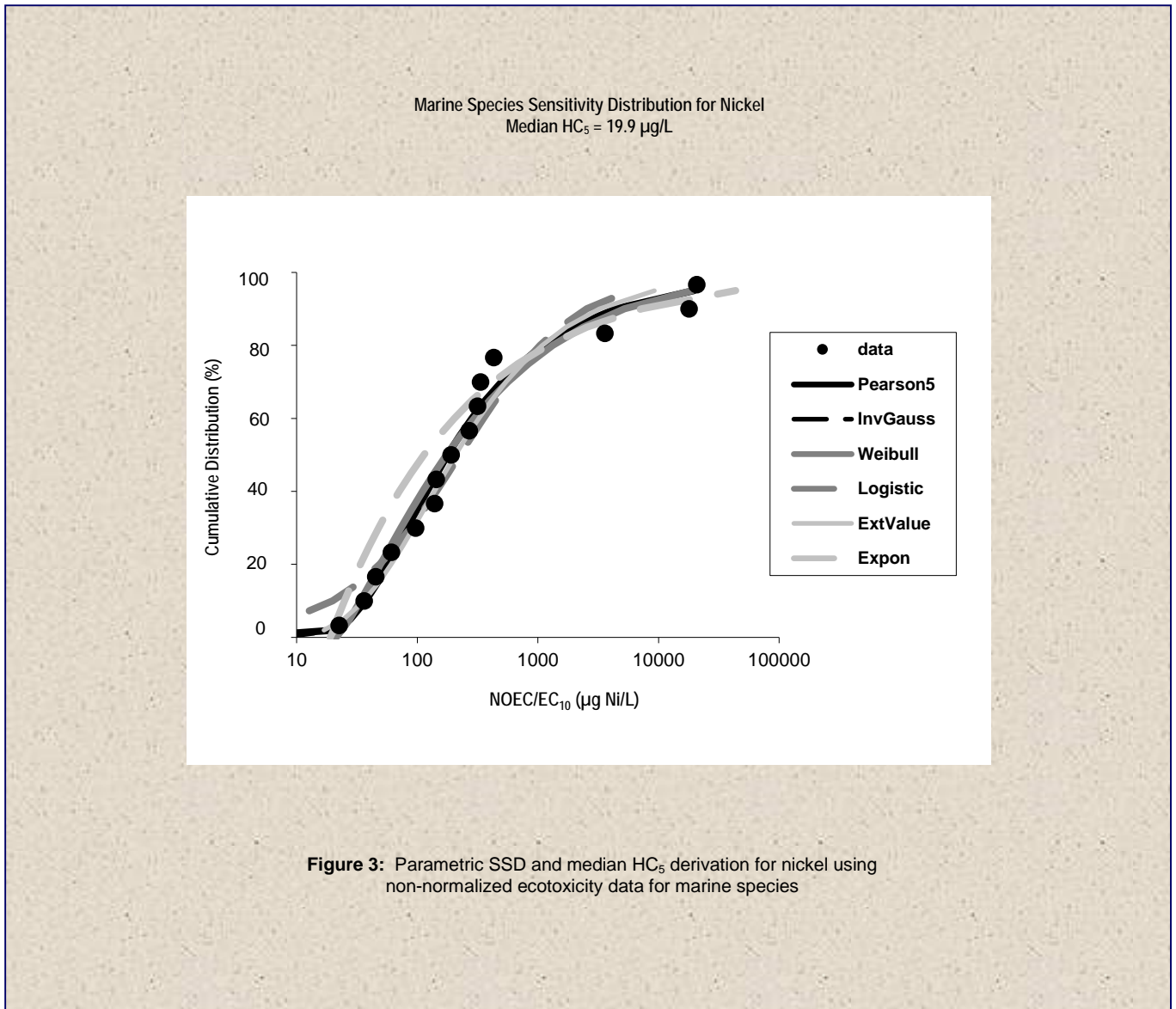
The non-parametric distribution functions and the mean of median HC₅ value for the kernel distribution function for the non-normalized ecotoxicity for nickel are presented in [Figure 4](#).

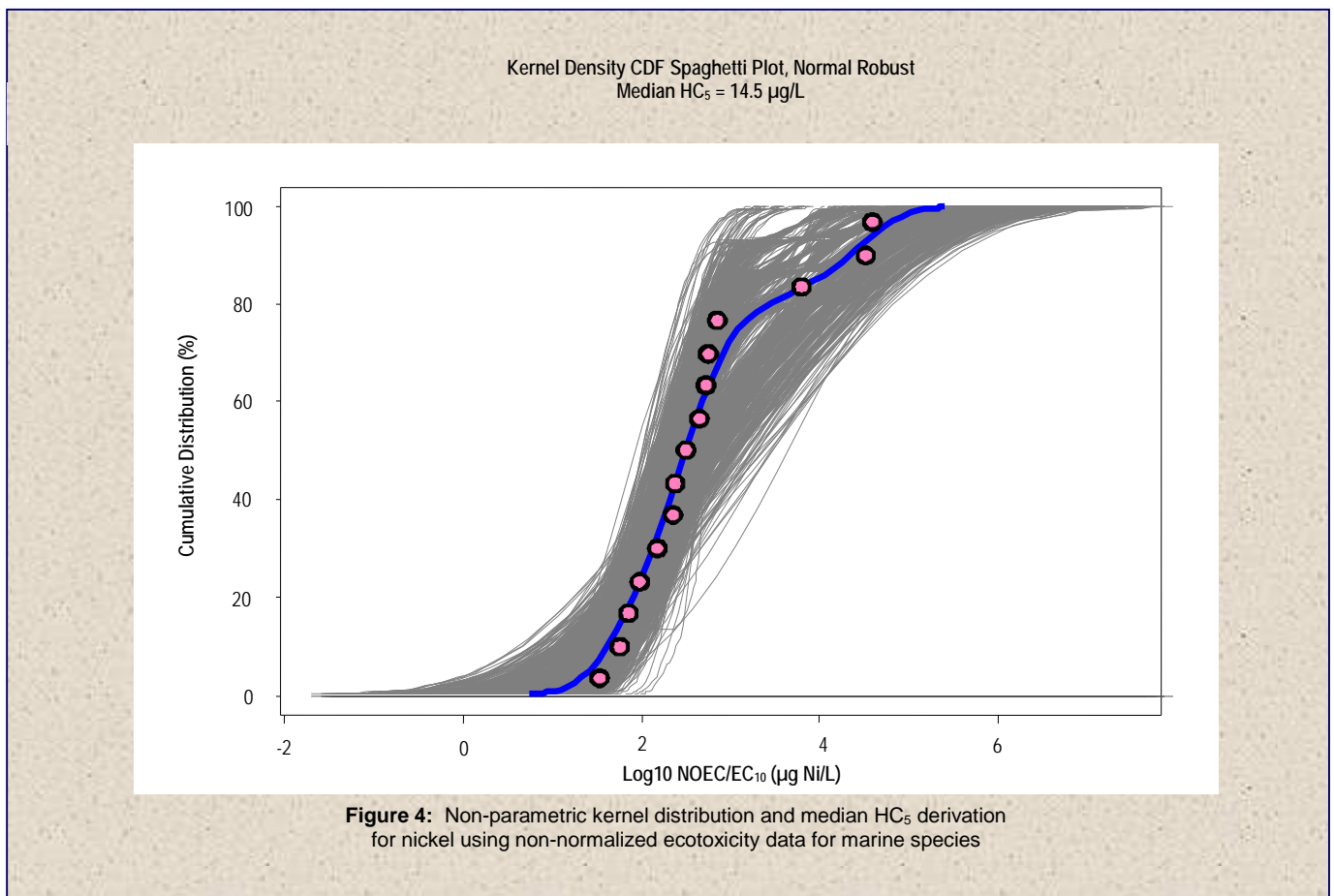
3.7 PNEC DERIVATION

An AF of 2 is applied to the mean of the median HC₅ value resulting in a marine aquatic PNEC = (mean of) median HC₅ / 2 = 17.2 µg/L / 2 = 8.6 µg/L.

Taxonomic Group	Species	Most Sensitive Endpoint	Species Mean NOEC/L(E)C ₁₀ Value (µg/L)
Micro-algae	<i>Dunaliella tertiolecta</i>	Growth rate	17,891
	<i>Skeletonema costatum</i>	Growth rate	316.5
Macro-algae	<i>Macrocystis pyrifera</i>	Growth	96.7
	<i>Champia parvula</i>	Reproduction	144.0
Annelids	<i>Neanthes arenaceodentata</i>	Reproduction	22.5
Molluscs	<i>Crassostrea gigas</i>	Development	431.0
	<i>Mytilus galloprovincialis</i>	Development	269.7
	<i>Haliotis rufescens</i>	Metamorphosis (development)	36.4
Echinoderms	<i>Paracentrotus lividus</i>	Development	139.0
	<i>Dendraster excentricus</i>	Development	191.0
	<i>Strongylocentrotus purpuratus</i>	Development	335.0
Crustaceans	<i>Mysidopsis intii</i>	Growth	45.2
	<i>Mysidopsis bahia</i>	Reproduction	61.0
Fish	<i>Cyprinodon variegates</i>	Growth	20,760.0
	<i>Atherinops affinis</i>	Mortality	3,599.0

Table 1: Selected marine species mean ecotoxicity data to nickel for the most sensitive endpoint





4 CONCLUSIONS AND NEXT STEPS IN RA

This fact sheet presents the approach for data gathering, data selection, and data aggregation to be used for the derivation of the PNEC value for the marine aquatic compartment based on the statistical extrapolation method using the SSD approach.

5 LINK TO EU RISK ASSESSMENT DOCUMENTS

The final report on the Environmental Risk Assessment of Nickel and Nickel Compounds can be retrieved from the following website:

<http://echa.europa.eu/documents/10162/cefda8bc-2952-4c11-885f-342aac769b3>

(last accessed July 2015)

The opinion of the SCHER can be found at the following address:

http://ec.europa.eu/health/ph_risk/committees/04_scher/docs/sc her_o_112.pdf

(last accessed July 2015)

6 REFERENCES

Aldenberg, T. and Jaworska, J. S. 2000. Estimation of the hazardous concentration and fraction affected for normally distributed species sensitivity distributions. *Ecotoxicology and Environmental Safety*, 46, 1-18.

SIDS (Screening Level Information Data Set) Initial Assessment Meeting (SIAM) 28. Ottawa, Ontario, Canada. October, 2008.

i The application of the quality screening criteria would also apply in case additional or new ecotoxicity data would be considered.

Fact Sheets on the European Union Environmental Risk Assessment of Nickel

This is the third in a series of fact sheets addressing issues specific to the environment section of the European Union's Existing Substances Risk Assessment of Nickel (EU RA). The fact sheets are intended to assist the reader in understanding the complex environmental issues and concepts presented in the EU RA by summarizing key technical information and providing guidance for implementation.

NiPERA welcomes questions about the concepts and approaches implemented in the EU RA. For inquiries, please contact:

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