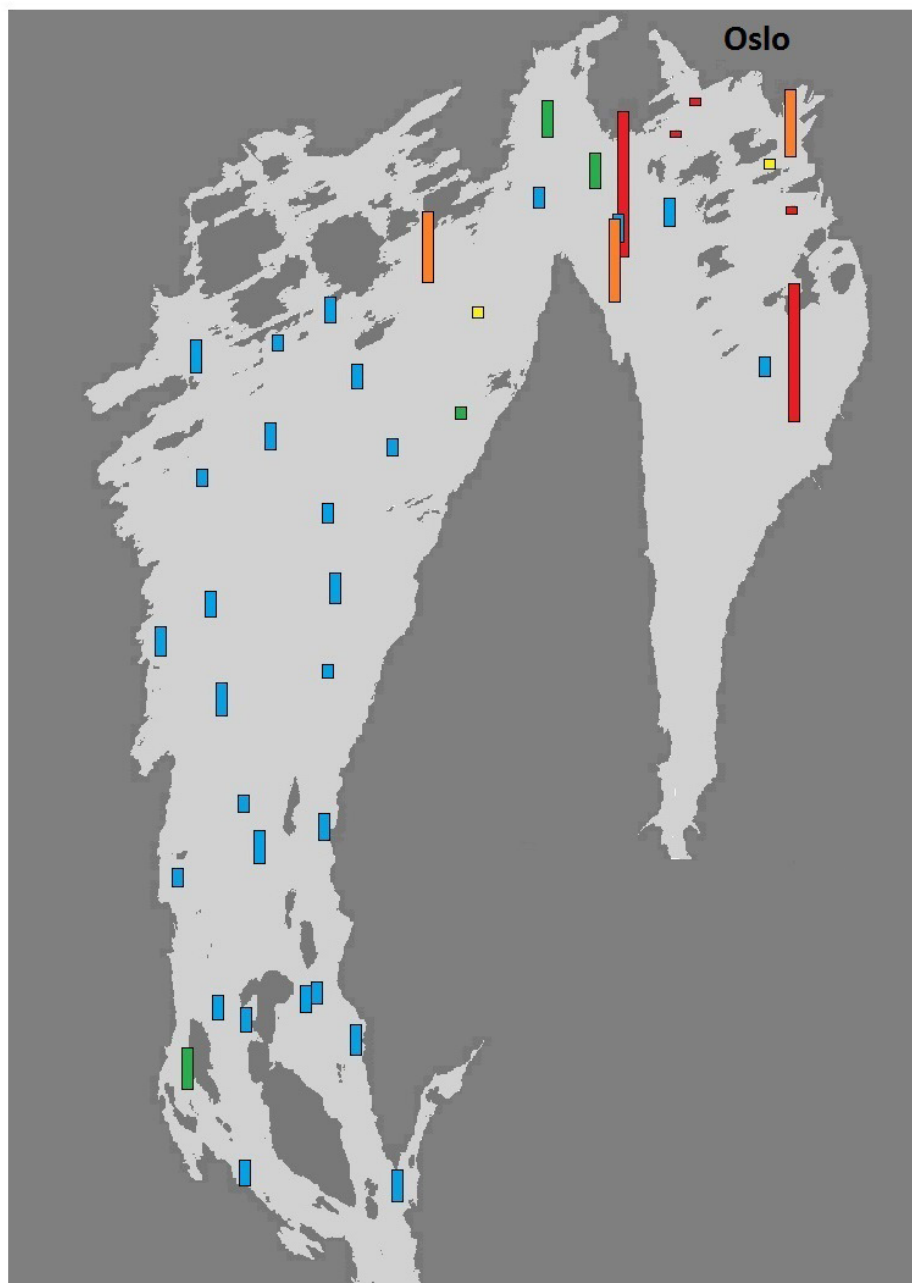


DI (density index). Density of marine macroinvertebrates as indicator of environmental status



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Title DI (density index). Density of marine macroinvertebrates as indicator of environmental status	Report No. 6654-2014	Date 2014.03.29
	Project No. Q-8221	Pages Price 14
Author(s) Brage Rygg	Topic group	Distribution
	Geographical area Norway	Printed NIVA

Client(s) Norsk institutt for vannforskning, NIVA	Client ref.
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Abstract <p>DI (density index) is a new index for fauna density. DI was specially developed for classifying status of low-density faunas. Indices for diversity and sensitivity in those cases may function poorly, due to accidental fauna composition implied by scarcity of data. Low-density faunas especially occur at sites with depleted oxygen, or strong industrial pollution. Abnormally high densities of tolerant species indicate influence from organic pollution, common near municipal or aquaculture plants. DI signalizes abnormally high as well as abnormally low densities. Border values between status classes for DI are defined. DI is included in the revised Norwegian classification system 02:2013.</p>

4 keywords, Norwegian <ol style="list-style-type: none"> 1. Bløtbunnsfauna 2. Tilstandsklassifisering 3. Indeks for individtetthet 4. DI 	4 keywords, English <ol style="list-style-type: none"> 1. Marine macroinvertebrates 2. Status classification 3. Index for density 4. DI
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**DI (density index). Density of marine
macroinvertebrates as indicator of environmental
status**

Preface

During the revision of the Norwegian environmental quality classification system (Veileder 01:2009 into Veileder 02:2013) the need for an index indicating status, based on density of individuals of macroinvertebrates, was pointed out. The new index (DI) is described in the present report and is included in the revised classification system.

Oslo, 29 March 2014

Brage Rygg

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Summary

Title: DI (density index). Density of marine macroinvertebrates as indicator of environmental status.

Year: 2014

Author: Brage Rygg

Source: Norwegian Institute for Water Research, ISBN No.: ISBN 978-82-577-6389-3

DI (density index) is a new index for fauna density. DI is specially developed for classifying status of low-density faunas. Indices for diversity and sensitivity in those cases may function poorly, due to accidental fauna composition implied by scarcity of data. Low-density faunas especially occur at sites with depleted oxygen, or strong industrial pollution. Abnormally high densities of tolerant species indicate influence from organic pollution, common near municipal or aquaculture plants. DI signalizes abnormally high as well as abnormally low densities. Border values between status classes for DI are defined. DI is included in the revised Norwegian classification system (Veileder 02:2013).

Sammendrag

Tittel: DI (density index). Individtetthet hos marin bløtbunnsfauna som indikator på miljøtilstand.

År: 2014

Forfatter: Brage Rygg

Kilde: Norsk Institutt for Vannforskning, ISBN No.: ISBN 978-82-577-6389-3

DI (density index) er en ny indeks for individtetthet. DI er spesielt utviklet med tanke på tilstandsklassifisering av individfattig fauna. Indeksene for artsmangfold og ømfintlighet fungerer da av og til dårlig, fordi de kan styres av tilfeldigheter i de små datasettene. Fattig fauna finnes særlig ved dårlige oksygenforhold, eller ved svært kraftig industriforurensning. Ekstremt høye individtettheter av tolerante arter tyder på påvirkning av organisk belastning, vanlig nær renseanlegg og matfiskanlegg. DI signaliserer også dette. Det er fastsatt grenseverdier for DI mellom de enkelte tilstandsklassene. DI inngår i den reviderte veilederen for tilstandsklassifisering (Veileder 02:2013).

1. Introduction

Status classification of soft-bottom fauna (marine macroinvertebrates) requires an index which shows low status at both abnormally low and abnormally high fauna densities.

The Pearson-Rosenberg model predicts medium fauna densities at no or slight disturbances from pollution. Fauna densities tend to get abnormally high or abnormally low at increasing pressures of disturbance (Pearson and Rosenberg 1978, **Figure 1**).

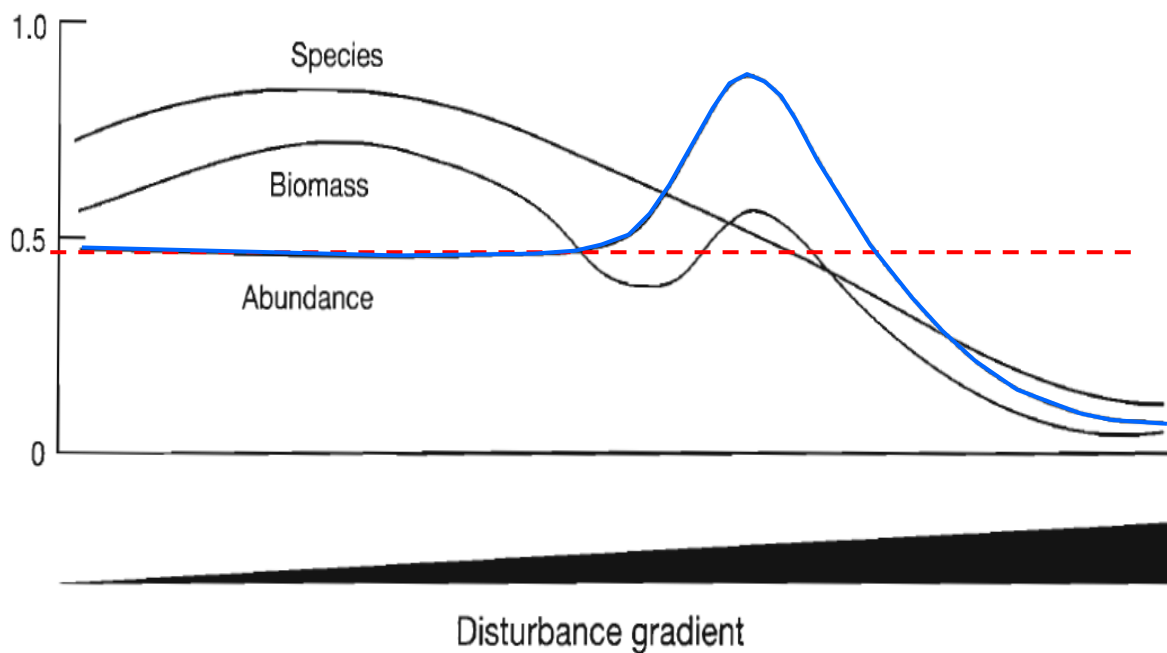


Figure 1. Pearson-Rosenberg model for changes in fauna parameters along a disturbance gradient. Red line: Level of normal fauna density. Blue curve: Fauna density (abundance) along the disturbance gradient.

2. Results

Samples from a large number of macrofauna stations ($n=3922$, the NIVA database) show that fauna densities are approximately log-normally distributed (**Figure 2**).

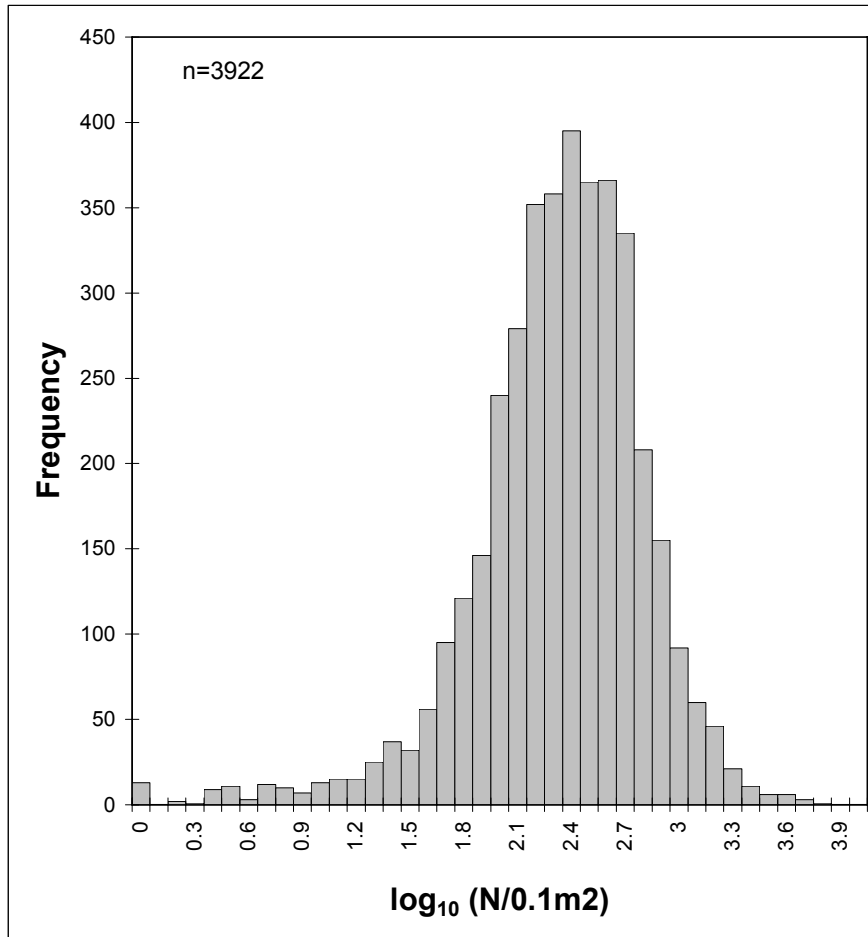


Figure 2. Frequency distribution of \log_{10} [individuals per $0.1m^2$]

Analyses of data from the NIVA base indicated a correlation between fauna densities (log densities) with the other classification indices already in use in the classification system (**Figur 3-7**). Descriptions of the different indices can be found in Veileder 02:2013 (Direktoratsgruppen, 2013).

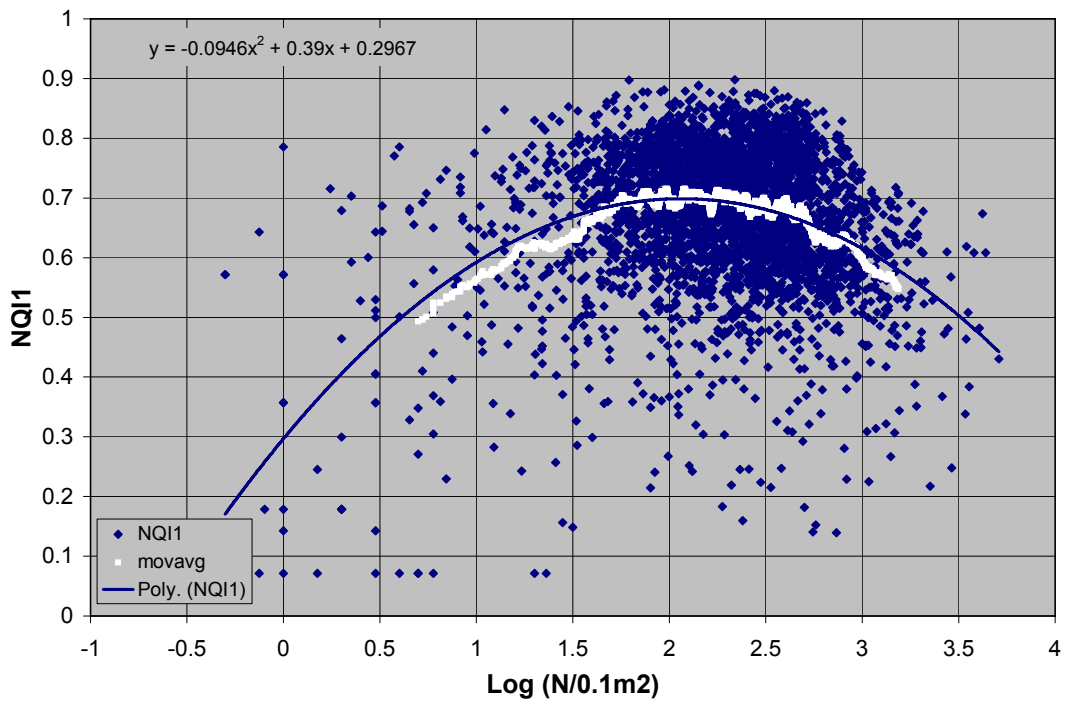


Figure 3. The Norwegian quality index NQI1 plotted vs \log_{10} fauna density. Moving average (white) and fitted 2nd degree polynomial.

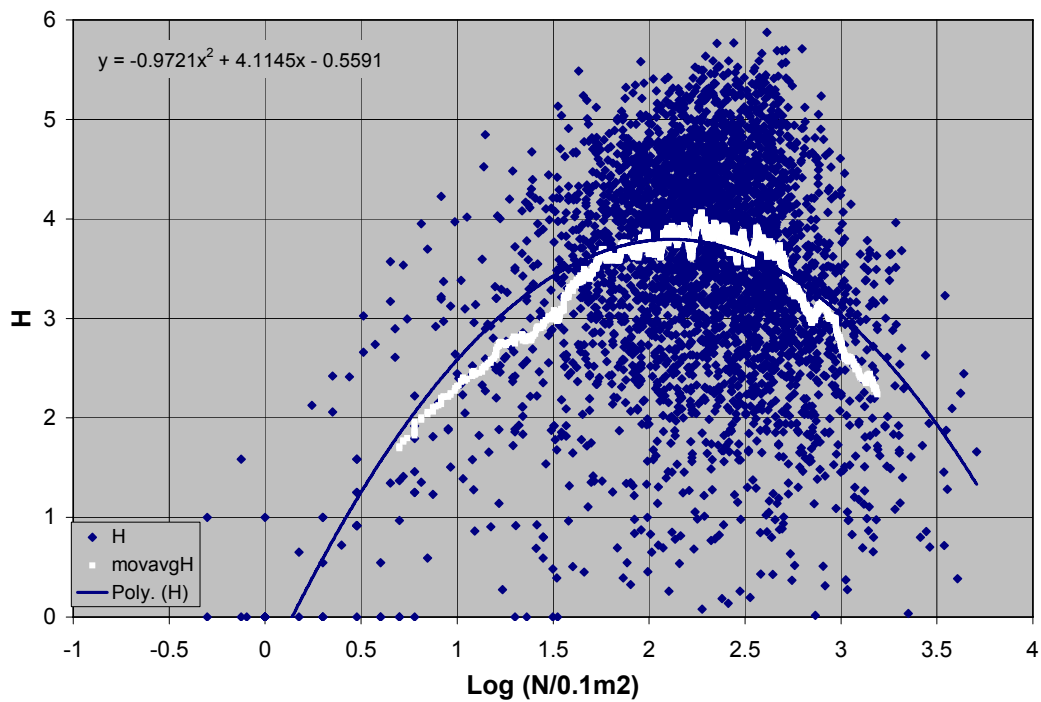


Figure 4. Shannon H plotted vs \log_{10} fauna density. Moving average (white) and fitted 2nd degree polynomial.

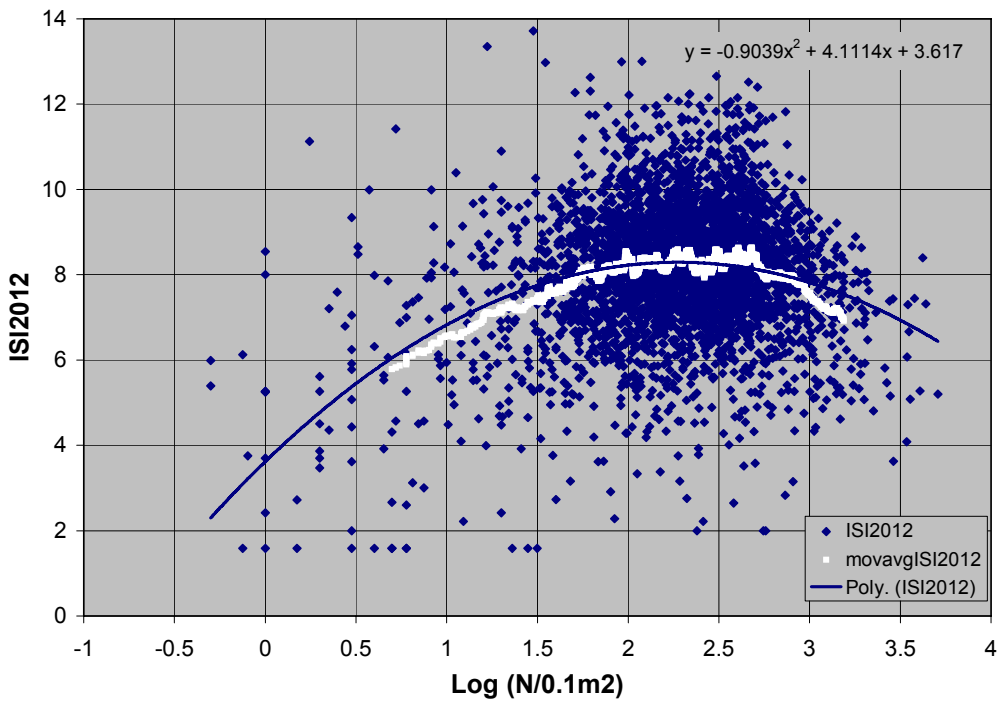


Figure 5. ISI₂₀₁₂ plotted vs log₁₀ fauna density. Moving average (white) and fitted 2nd degree polynomial.

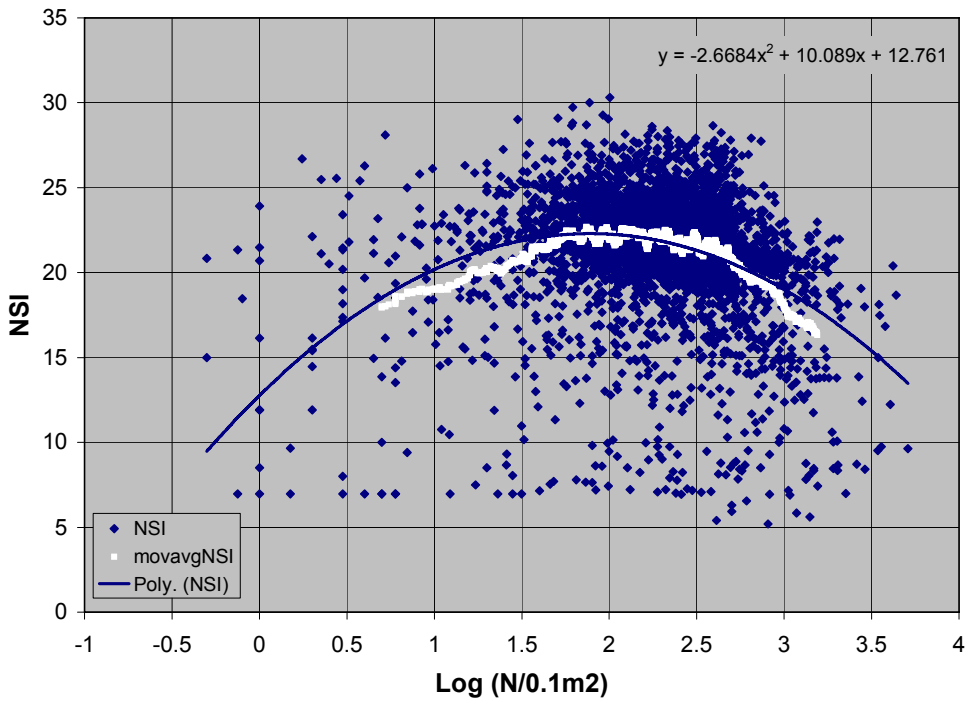


Figure 6. Norwegian sensitivity index NSI plotted vs log₁₀ fauna density. Moving average (white) and fitted 2nd degree polynomial.

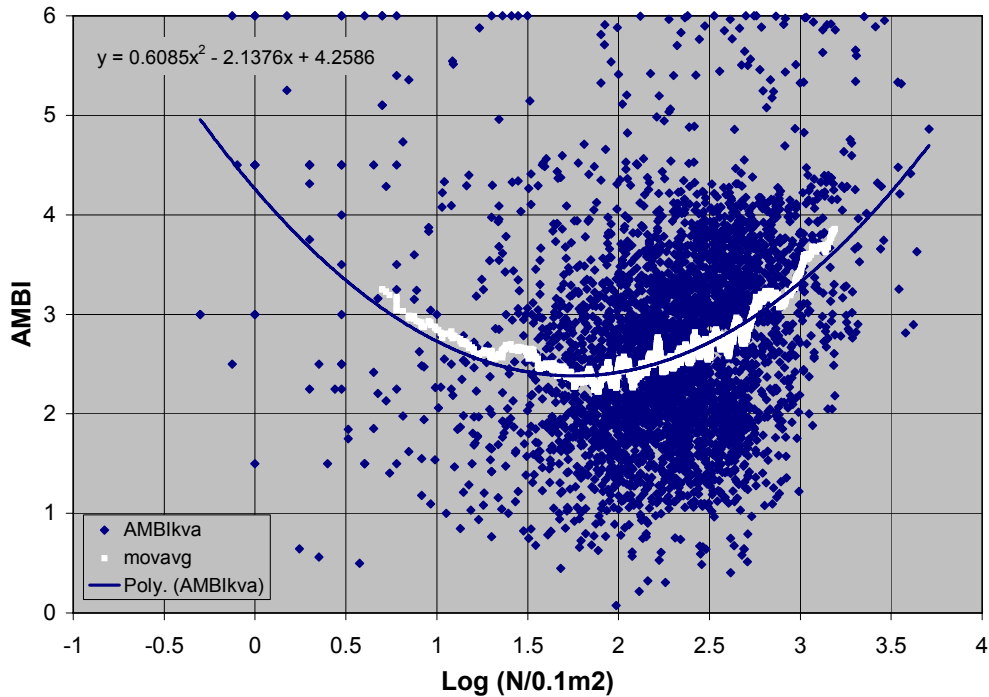


Figure 7. The AMBI index plotted vs \log_{10} fauna density. Moving average (white) and fitted 2nd degree polynomial.

Fauna density values were found to correlate with values of already established indices. A symmetrical model (2nd degree polynom) based on log densities shows a good fit. This is evident when also the moving average is presented. The established indices are based on diversity or on species sensitivities. Medium fauna density values and high (good) values of the other indices are correlated. Abnormally low or high fauna densities and low (poor) values of the other indices are correlated. Thus, fauna density indicates environmental status as well, and provides a supplementary tool to assess status. Indices for diversity and sensitivity may function poorly in situations when fauna density is low, due to accidental species composition implied by scarcity of animals. Low-density faunas especially occur at sites with depleted oxygen, or strong industrial pollution. Abnormally high densities of tolerant species indicate influence from organic pollution, common near municipal or aquaculture plants. DI signalizes abnormally high as well as abnormally low densities. The DI index indicates best environmental status at medium fauna densities, poorest status at low or high fauna densities, thus supporting the Pearson-Rosenberg model.

Central \log_{10} values for fauna densities vary between 1.77 and 2.27, depending on which index is chosen for the ordinate axis (**Figure 3 - Figure 7**). So, the best status is indicated when fauna densities are within the range of 50-200 individuals per 0.1 m².

In principle, the density index (DI) is defined as follows: Status (DI index value) is equivalent to \log_{10} distance from the central value, as the model (the 2nd degree polynom) is symmetrical. Increasing distance (one way or the other) shows an increasingly poor status.

For defining DI the absolute distance (absolute value) from the central value (= 2.05) in the correlation with NQI1 (**Figure 3**) was applied. NQI1 was chosen because this index is intercalibrated within the NEAGIG. NQI1 also acts as the reference index for calibrating class border values of the other indices in the Norwegian classification system.

Thus, index value for DI = $\text{abs} \left| \log_{10}(N/0.1\text{m}^2) - 2.05 \right|$, where N = number of individuals

DI index values were intercalibrated with NQI1 values to establish class intervals for DI (**Figure 8**).

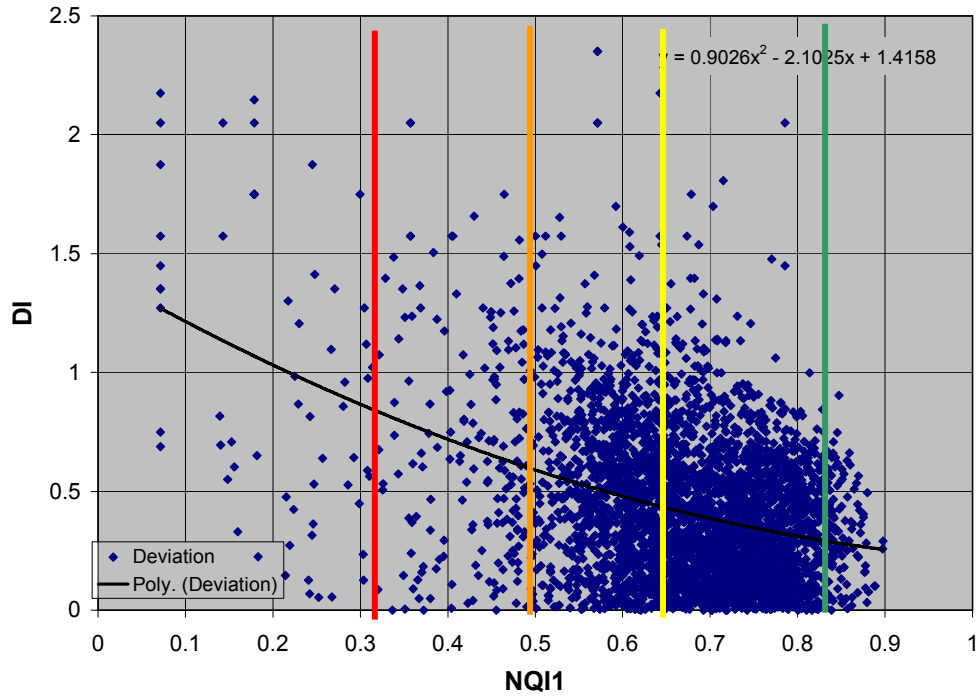


Figure 8. Correlation between DI and NQI1. Upper border values for NQI1 status classes are indicated in colors. Intersection points with the regression line define the corresponding border values for DI (shown in **Table 1**).

Table 1. DI status classes and corresponding fauna densities.

Status	DI index value	Abundance 0.1 m ²	
High	0-0.30	56-224	
Good	0.30-0.44	225-309	41-55
Moderate	0.44-0.60	310-446	28-40
Poor	0.60-0.85	447-794	16-27
Bad	0.85-2.05	795-12589	0-15

Figure 9 illustrates the dependence of DI index values (log₁₀ values) on fauna density

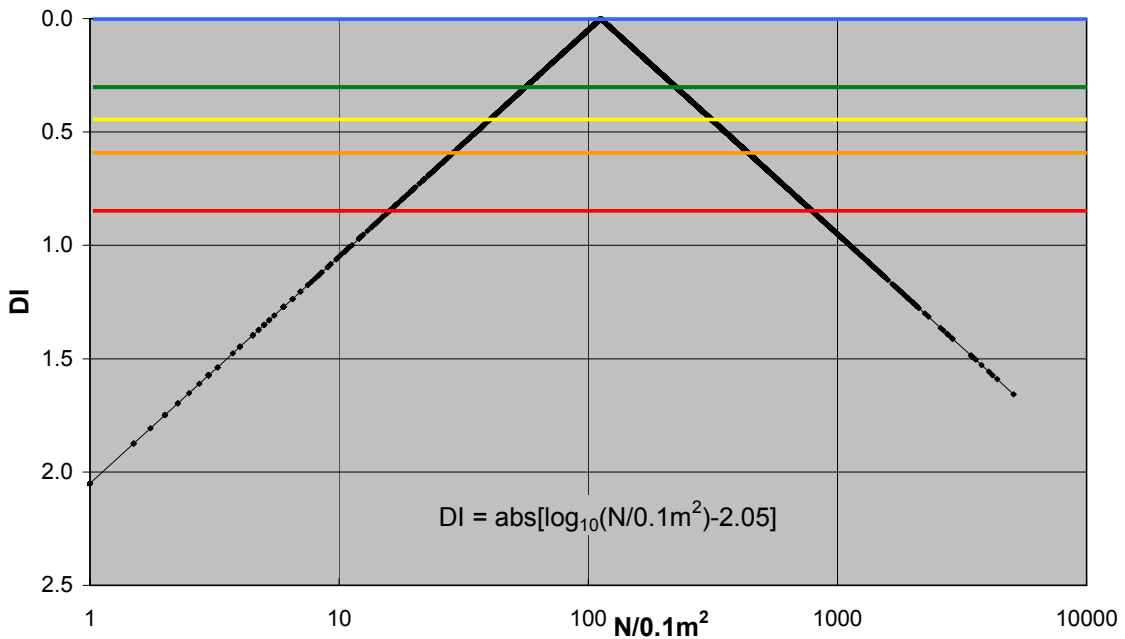


Figure 9. DI as function of fauna density. Upper border values for status classes (from Figure 8) are shown in colored lines.

An example from the Oslofjord (Olsgard 1995) is shown in Figure 10 and on the front page of the present report. Closest to Oslo harbour, where the pollution is strongest, fauna density varied from 0 to over 1000 per 0.1 m², whereas density at distances beyond 10 km got normalised to between 50 and 300.

Macrofauna Inner Oslofjord 1993

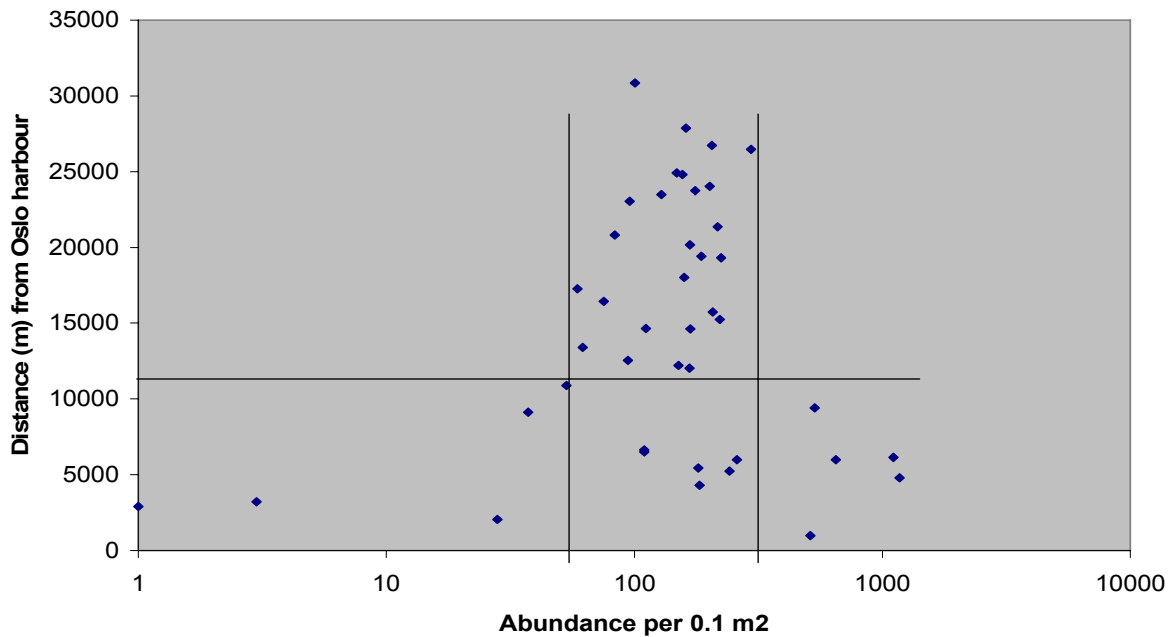


Figure 10. Fauna density in Oslofjord vs distance from Oslo city harbour.

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