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REPORT OF THE JOINT MEETING OF THE WORKING GROUP ON ENVIRONMENTAL ASSESSMENT AND MONITORING STRATEGIES AND THE WORKING GROUP ON STATISTICAL ASPECTS OF ENVIRONMENTAL MONITORING

Stockholm, Sweden

14–16 March 1996

International Council for the Exploration of the Sea

Conseil International pour l'Exploration de la Mer

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1 OPENING OF THE MEETING

The Joint Meeting of the Working Group on Environmental Assessment and Monitoring Strategies (WGEAMS) and the Working Group on Statistical Aspects of Environmental Monitoring (WGSAEM) was opened by the Chairman, Rob Fryer, at 10.00 hrs on 14 March 1996. Anders Bignert welcomed everyone on behalf of the Swedish Museum of Natural History.

2 ADOPTION OF THE AGENDA

The terms of reference (C.Res.1995/2:14:7) for the meeting are given below:

A joint meeting of the Working Group on Environmental Assessment and Monitoring Strategies and the Working Group on Statistical Aspects of Environmental Monitoring will be held from 14-16 March 1996 in Stockholm, Sweden under the chairmanship of Dr R. Fryer (UK) to:

a) review and agree on a final text for the draft ICES Techniques in Marine Environmental Sciences document on detailed objectives for temporal trend monitoring programmes;

b) review and report on progress on setting objectives for, and the design of, spatial monitoring programmes.

The agenda is appended in Annex 1, the list of participants in Annex 2, and the list of working documents in Annex 3.

3 REVIEW OF DRAFT TIMES DOCUMENT ON OBJECTIVES

Rob Fryer reported on the progress of the draft document on setting detailed objectives for temporal monitoring programmes, that is being prepared for publication in the ICES Techniques in Marine Environmental Sciences (TIMES) series. A draft document had been circulated in February 1996 to volunteer reviewers from the group. The responses of the reviewers had been generally favourable, although there were specific points that needed to be added, amended, or clarified.

A revised draft was presented to the group. The group commented on the draft, section by section, and agreed on a number of further alterations. It was clear that a final draft would not be ready by the end of the meeting. However, the group felt that the document was sufficiently advanced that they could recommend it for acceptance in the TIMES series, subject to the agreed revisions being made. Rob Fryer, Mike Nicholson, and Ian Davies agreed to make the revisions by the end of May. Hartmut Heinrich and Steffen Uhlig agreed to provide a final review. It was also agreed to ask Jack Uthe to comment on the revised version. The final text will be sent to the Secretariat by the end of August 1996.

4 OBJECTIVES AND DESIGN OF SPATIAL MONITORING PROGRAMMES

Otto Swertz presented a paper (Annex 4) describing how sites were chosen in a programme to monitor contaminants in the sediments of Dutch marine areas. The programme was designed to compare contaminant levels in marine areas with target values, and to provide information on temporal trends. The chosen sites were a mixture of existing sites used for trend detection in other programmes, and new sites chosen according to a stratified random design. Once selected, the sites would then be fixed. It was noted that fixing sites provides more powerful trend detection. However, it does pose problems when comparing levels in the marine area with target values, since biases in the estimated levels can persist from one assessment period to the next. The data collected in the programme will also inevitably be used to provide maps of contaminant levels in the survey area, although the design is not optimal for this purpose.

Ian Davies reported on a paper by Nies et al. (1990). The most important point arising from this paper for the present meeting is that different kinds of sampling equipment can affect the contaminant levels measured in the sediment in different ways. This should be accounted for in the design of a sediment monitoring programme.

Ian Davies delivered data for estimating variance components from various sediment monitoring and quality control programmes. These data have been reported by the Working Group on Marine Sediments in Relation to Pollution

(WGMS) (1995 Annex 6, 1996). The purpose was to determine whether sufficient information was available to design programmes to meet any of the sediment monitoring objectives identified at last year's joint meeting (JEASA, 1995). Ian Davies informed the group that this subject was also pertinent to the following term of reference addressed to WGEAMS:

> Assist in the development of monitoring guidelines for polycyclic aromatic hydrocarbons in sediments (with WGMS) and biota (with MCWG), including the number of replicate samples per area to characterize the sampling area (OSPAR 1.1).

The group welcomed the provision of these data. There was some discussion about how such data should be reported. It was noted that when summary statistics are reported, it should be stated explicitly how those summary statistics have been obtained. There was a request for guidance on how this should be done. There was also a request for an explicit specification of the data required to design a programme to meet each of the sediment monitoring objectives. It was suggested that WGSAEM could discuss this matter further.

A sub-group was formed to consider whether there was sufficient information to design a programme to characterize an area in terms of PAHs in sediment. Although not strictly within the term of reference, another sub-group was formed to identify whether there was sufficient information to design a temporal monitoring programme for contaminants in sediment.

4.1 Sediment Programmes to Characterize an Area in Terms of PAHs

The sub-group discussed how a sampling area, i.e., the area to be characterized, should be selected. One of the most important requirements is that the area should be homogeneous. This might mean that the area is geologically homogeneous, or that it has been subject to a consistent degree of pollution, or that it is statistically homogenous.

The sub-group suggested that the initial step should be to identify the area as a geologically homogeneous region within which the sediments can be considered to be cogenetic. Cogenetic series of sediments arise from the physical mixing of two end member sediments, often thought of as fine-grained material and coarse-grained material. Such series of sediments may be identified through studies of stable properties of the sediments such as the mineralogy, or of the major element chemistry, which should show clear relationships to grain size distribution.

Once such an area has been identified, it is possible to consider the degree of pollution. In the case of lipophilic organic contaminants, this essentially means that the concentrations through the area are controlled by a series of equilibrium partitionings between the liquid phase, compartments in biota, and the solid phase (expressed as concentration in organic carbon). Further, there should be internal equilibrium within the sediment solids, such that the contaminant-to-carbon ratios in different grain size fractions should be equal.

These concepts are not so clearly established for inorganic contaminants, although work is in hand to develop them. As an initial step, the ratio of metal to normalizing variable (e.g., aluminium or lithium) should be constant.

Homogeneity can also be considered in statistical terms. Loosely, an area can be considered homogeneous if the spatial variability of concentration (or log-concentration) is the same in all parts of the area, although concentrations may vary between different parts of the area. It should be investigated whether statistical homogeneity corresponds to geological homogeneity.

It was agreed that, in most cases, the area to be characterized will show considerable variation in sediment type from muds to sands, and this will introduce considerable variation in contaminant concentrations. Most contaminants are found to co-vary with the fraction of fine-grained material, or with organic carbon. The variance of measurements within the area can therefore usually be reduced by expressing the data in normalized form (as the ratio to a normalizer such as aluminium or carbon), provided that the analytical variance of the determination of the normalizer is sufficiently low (see below).

The conditions when normalization will be useful can be formalized as follows. Consider normalizing the concentration of PAH by the concentration of carbon. Denote the measured concentrations of PAH and carbon by Y and X, respectively, and let $T = Y / X$ be the normalized variable. Suppose that the measured PAH concentration, Y, is affected by the sampling location (u,v), and by the true carbon concentration, X_0 say, according to the model

$$\log(Y) = f(u,v) + \log(X_0) + \varepsilon.$$

In this setting, f(u,v) is a function which represents how PAH-concentration changes with location, having removed the effect of carbon. Further, ε denotes the pure random part of the model, and is a mixture of natural variation, sampling error and analytical error. The question of whether to normalize or not, can then be phrased in statistical terms as whether to treat X_0 as a fixed or a random effect.

If no normalization is done, the carbon concentration X_0 is treated as random. This means that X_0 is not taken into account in the statistical analysis, and so increases the variance of log(Y):

$$\mathrm{Var}(\log(Y)) = \mathrm{Var}(\log(X_0)) + \mathrm{Var}(\varepsilon).$$

If normalization is done, then the random effect of X_0 can be removed by replacing Y by T = Y / X, where X denotes the measured carbon concentration. Denote the error term due to sampling (replicate sampling at the same location) and analysis of carbon by ε_X, so that

$$\log(X) = \log(X_0) + \varepsilon_X.$$

Hence log(T) can be written:

$$\log(T) = \log(Y) - \log(X) = f(u,v) - (\log(X_0) + \varepsilon_X) + \log(X_0) + \varepsilon = f(u,v) - \varepsilon_X + \varepsilon,$$

with variance

$$\mathrm{Var}(\log(T)) = \mathrm{Var}(\varepsilon_X) + \mathrm{Var}(\varepsilon).$$

Therefore, the variance of log(T) is lower than the variance of log(Y) if

$$\mathrm{Var}(\varepsilon_X) < \mathrm{Var}(\log(X_0)).$$

It only makes sense to normalize if this condition is satisfied. This condition is more simply expressed on the concentration scale (rather than the log-concentration scale) in terms of coefficient of variations (CV): normalization should only be considered if the CV of carbon concentrations measured in samples taken from effectively the same place is small compared to the CV of true carbon concentrations throughout the survey area.

Note that other considerations are also important when deciding whether to normalize. In particular, if absolute PAH concentrations (rather than normalized PAH concentrations) are of specific interest, then normalization would not be appropriate. In this case, it might still be possible to account for the carbon effect by spatial modelling of carbon concentrations, but this would require some statistical effort.

The sub-group also discussed the use of the variogram as a basic tool to obtain insight into the spatial structure in an area, and as a tool to define a homogeneous area. The sub-group noted that the variogram is affected by the analytical error in concentration measurements. For example, Figure 4.1a shows an idealized variogram with no analytical error, and Figure 4.1b shows how the variogram changes when analytical error is introduced. In particular, if the analytical error is large, relative to the spatial variability within the area, then it diminishes the ability to characterize the area in statistical terms. Based on the data provided, the analyical error may account for up to 50% of the total standard deviation, although it should be noted that the data came from different sources, so they may not be compatible.

4.2 Temporal Trend Monitoring Programmes of Contaminants in Sediment

Consider designing an annual monitoring programme to detect temporal trends in the contaminant levels in the sediment from a specified area. (The term level is used to avoid specifying the scale of measurement, since level could refer to either concentration or log-concentration.) In particular, consider a programme in which R samples are taken from the area, at random, each year. Estimates of four variance components are required:

σ_y the random between-year sampling variation,
σ_w the within-year sampling variation,
τ_y the between-year analytical variation,
τ_w the within-year analytical variation,

(see, e.g., WGSAEM, 1995, Section 9.3). Note that σ_w is the variation in contaminant levels in samples taken at random from within the area at any one time. It thus reflects the spatial variation in contaminant levels within the area, and will depend on the size of the area.

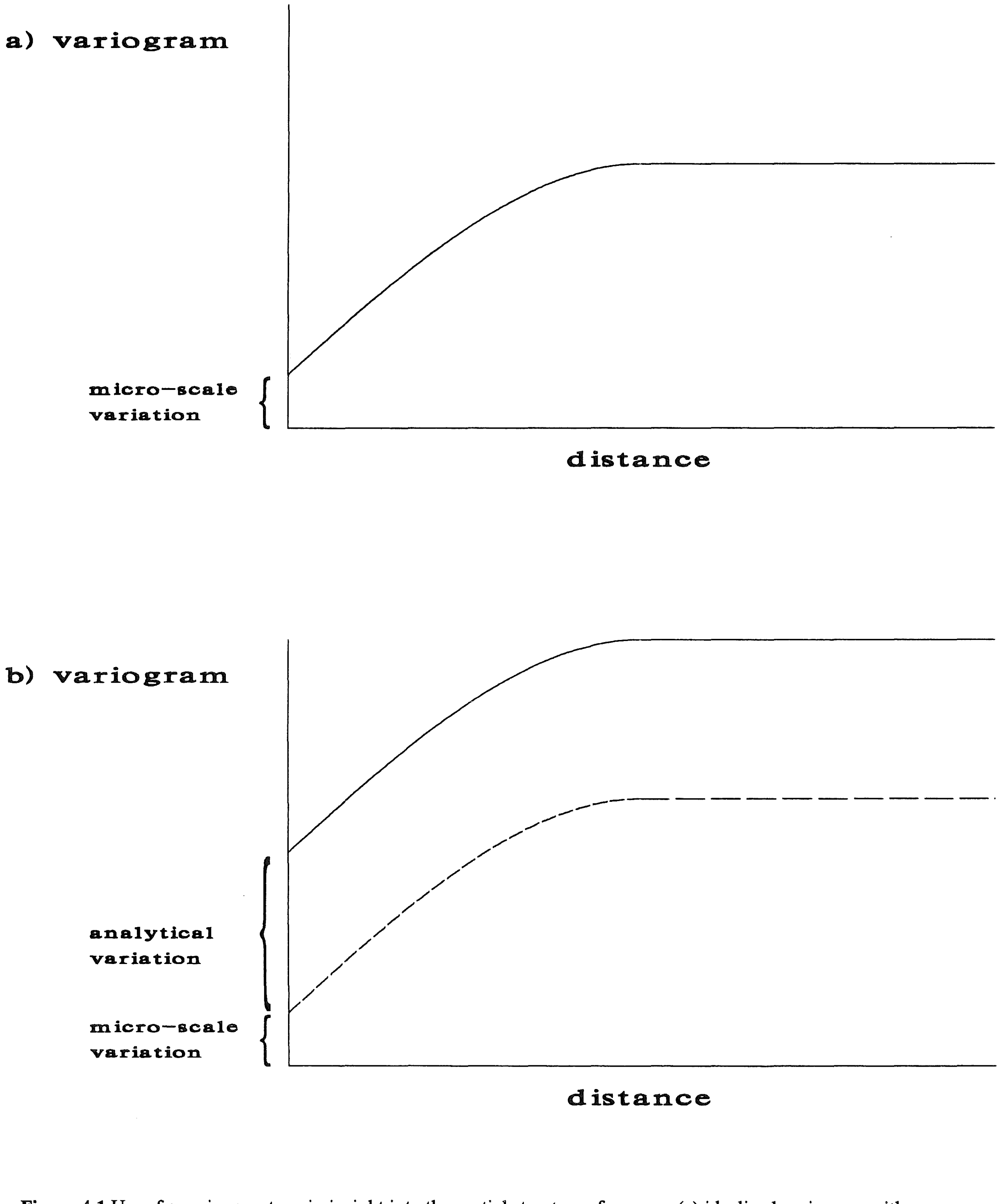

Figure 4.1 Use of a variogram to gain insight into the spatial structure of an area: (a) idealized variogram with no analytical error, (b) change in variogram when analytical error is included.

The following table shows those variance components for which estimates were available:

	σ_y	τ_y	σ_w	τ_w
metals	✓	✓	✓	✓
PCBs		✓	✓	✓
PAHs			✓	✓

Estimates of σ_w were available for 'very small' areas—effectively point locations—for all three contaminant groups. Estimates of σ_w for metals were also available for an area of 500 m square.

Clearly there are potential dangers in combining variance estimates from different sources, and in applying variance estimates from one area to areas with different, e.g., hydrographic or geological, characteristics. Bearing this in mind, the table shows that it would be possible to make a first attempt at designing a temporal monitoring programme for metals in sediment. However, the estimates of σ_y come from just one region, so it would be beneficial to have estimates from other regions. More information would be required to design a temporal monitoring programme for PCBs or PAHs in sediment. In particular, estimates of σ_y for PCBs, and estimates of σ_y and τ_y for PAHs are required.

Since this was the first time that estimates of all four components of variation had been available to the group, it was decided to estimate the possible effectiveness of a temporal monitoring programme for metals in sediment. The % yearly change detected in a ten-year programme with 90% power, or 'detectable trend', was used to measure effectiveness (see, e.g., WGSAEM, 1995). The table below shows the detectable trend at a point location (taking one sample), and in an area of 500 m square, taking R = 1, 5, and 20 samples. Note that no estimates of σ_w were available for Cr, Ni, or As for an area of 500 m square.

metal	point location	500 m square		
	R = 1	R = 1	R = 5	R = 20
Cu	6.7	8.4	6.6	6.2
Zn	2.3	3.8	2.6	2.4
Pb	3.5	3.6	2.6	2.3
Cd	14.6	17.3	15.4	15.0
Hg	5.9	12.3	7.3	5.9
Cr	4.4	-	-	-
Ni	3.5	-	-	-
As	5.1	-	-	-

Thus, the power of a sediment programme will vary with contaminant. For example, based on the variance estimates used, a ten-year programme could be designed to detect a trend of about 3% per year in zinc or lead. However, the same programme would only detect a trend of 15% per year in cadmium or 6% in mercury.

Note that more samples are required in the 500 m square area to achieve the same detectable trend as at the point location. This is because of the increase in σ_w. However, there can be advantages in considering larger areas. If decrease, say, is detected at a point location, it is only possible to say that levels have gone down at that location; it is not possible to infer that levels have also gone down at locations nearby. However, if a decrease is detected by sampling within a 500 m square area, then it means that levels have gone down, on average, throughout the area.

4.3 Future Work

Following the reports of the two sub-groups, the group discussed how work on the objectives and design of sediment monitoring programmes should continue. The group agreed that:

- Considerably more time would be needed to consider the issues fully.

- The provision of data for obtaining variance estimates has given a large impetus to developing this topic.

- It would be appropriate to hold a workshop dedicated to the objectives and design of sediment monitoring programmes (similar to the sub-group that considered temporal trend monitoring programmes of contaminants in biota in 1994).

- The workshop should consist of a small number of people, including a member from each of WGEAMS, WGSAEM, WGMS, and MCWG.

5 TEMPORAL TREND MONITORING GUIDELINES

During the meeting of the OSPAR *Ad Hoc* Working Group on Monitoring (MON 1995) in Copenhagen, 13–17 November 1995, many countries expressed the wish to revise the existing temporal trend monitoring guidelines. In particular, the need for individual analyses of fish tissue was questioned. In addition, as discussed in previous meetings of WGSAEM and joint meetings with WGEAMS, more information is required about spatio-temporal sources of variation. MON 1995 therefore proposed a Voluntary International Contaminant monitoring programme (VIC) to provide more information about these sources of variation. The basic requirements of VIC are a minimal amount of extra sampling, and as few additional analyses as possible.

The principles behind the VIC programme are described in more detail in WP6.1. The following points were made in discussion:

1) VIC was generally well received at the 1996 meeting of the OSPAR Working Group on Concentrations, Trends and Effects of Substances in the Marine Environment (SIME), with several countries offering to participate.

2) VIC seems to be a good idea, and will, hopefully, provide useful information about spatio-temporal variation.

3) VIC is limited to gathering information about 'chemistry'-oriented monitoring. It is important to be aware of the current movement towards integrated chemical and biological effects monitoring programmes (ACME, 1995).

4) Even though any VIC-inspired revisions to the current trend monitoring programme may be superseded if the current programme is replaced, the VIC results will provide useful information for the effective design of the new programme.

5) If this new programme is to include biological effects such as EROD, VIC could be extended to provide information about spatio-temporal variation in these parameters as well.

The Group recognized the importance of obtaining sufficient information to design an effective integrated chemical and biological effects programme. The group therefore recommended that a programme be developed to estimate the variance components affecting biological effects measurements, with a view to establishing effective sampling schemes for the currently developing integrated chemical and biological effects programmes.

6 ANY OTHER BUSINESS

Two issues were considered under this heading:

1) Practical advice on using power. Although the concept of power is now well understood in theory, there is still some confusion about how it is used in practice. The group discussed some ways of developing an intuitive feeling for power, and a sub-group was formed to develop the ideas.

2) Future joint meetings between WGEAMS and WGSAEM.

6.1 Practical Advice on Using Power

The concept of power (the probability that a specified trend will be statistically significant) has been widely discussed in the context of designing temporal trend monitoring programmes. It has been accepted as a useful guide to the effectiveness of a monitoring programme, for example, in reporting the number of years which must elapse before a specified trend is likely to be detected. However, there is still some confusion about how to specify a target detectable trend or an appropriate level of power.

More experience in using power will help. So will more exposure to particular case studies, such as the one described in the TIMES document in Section 3, above. But some initiatives for accelerating the development of an intuitive feel for 'power' would be beneficial. The group felt that there is also a need to:

1) broaden the discussion about formulating quantified expressions of monitoring objectives, for example, by

- considering objectives phrased in terms of attaining environmental quality standards,
- using the techniques described in Section 6.1.1, below, to relate changes in inputs to expected changes in other compartments,
- using a decision-making framework in which there is some evaluation of the risk associated with different outcomes;

2) improve the interaction between persons involved in developing the technical ideas about quantified objectives, and persons involved in implementing them.

Possible ways of encouraging and focusing this activity would be to hold a theme session at an ICES Annual Science Conference, a symposium, or an EU-funded workshop.

6.1.1 Report of the sub-group on defining targets for detectable trends

The context for temporal trend monitoring of contaminants is assumed to be that contaminant levels in some compartment (water, sediments, biota) are high, prompting a demand for a reduction in inputs. Inputs are then reduced by a prescribed amount over a period of years. Levels in the compartment, e.g., biota, are then monitored to verify the effectiveness of the reduction in inputs.

Suppose, for example, that inputs are to be reduced by 50% over a ten-year period. Suppose further that this can be represented by an exponential decline of approximately 5% per year. It is tempting to simply look for a corresponding trend in biota. However, this makes a very strong assumption about the relationship between inputs and the corresponding levels in, e.g., biota. In practice, changes in levels in biota may be smaller and develop more slowly than the changes in inputs. A simple 'black box' model may help to quantify this.

Figure 6.1 shows an exponential decline in inputs from an initial high level towards a new low level. This decline is characterized by the relative difference between the two levels, and the speed with which the new level is approached, measured, e.g., by the half-life of passage between them.

Figure 6.2 shows the corresponding change in levels in biota. The exponential decline is assumed to be the same, but the relative difference may be smaller and the half-life may be longer.

Figure 6.3 shows the resulting trends in inputs (slope = $-b_{inputs}$) and biota (slope = $-b_{biota}$) levels on a log-scale; b_{biota} will be less than b_{inputs} when the corresponding relative change is less or when the half-life is longer. The consequence will be $b_{biota} = kb_{inputs}$, where, for simplicity $0 < k \leq 1$.

The parameter k might be thought of as a sort of transmission or efficiency factor for a chosen monitoring organism or medium. A value of $k = 1$ would be totally efficient in the sense that it would be as effective as monitoring inputs themselves. To explore the effects of this reduction in efficiency, suppose that a monitoring programme is designed to detect a trend b in 10 years with a 90% power (where b is based on changes in inputs on a log-scale). This implies that the ratio of b to the residual standard deviation has value $|b|/y = 0.409$ (Nicholson *et al.* 1995). Suppose now that $k = 0.6$ in the chosen organism. Then the realized trend in that organism will be 0.6b, and we find that the power corresponding to $0.6|b|/y = 0.6 \times 0.409 = 0.245$ is 50%. Alternatively, the number of years required to detect this realised trend of 0.6b with a 90% power is increased to 14 years.

Figure 6.4 shows how the true power to detect a given trend in 10 years or the true number of years to detect a given trend with 90% power changes with the organism efficiency k.

This figure may be helpful when setting targets for detectable trends in particular compartments:

- If k is known, it provides an immediate link between imposed changes in inputs and the corresponding changes that could be realized in the monitoring programme.

- If k is not known, it may be possible to set a lower limit for the efficiency, and then make a more informed decision about the achievable power.

Figure 6.1

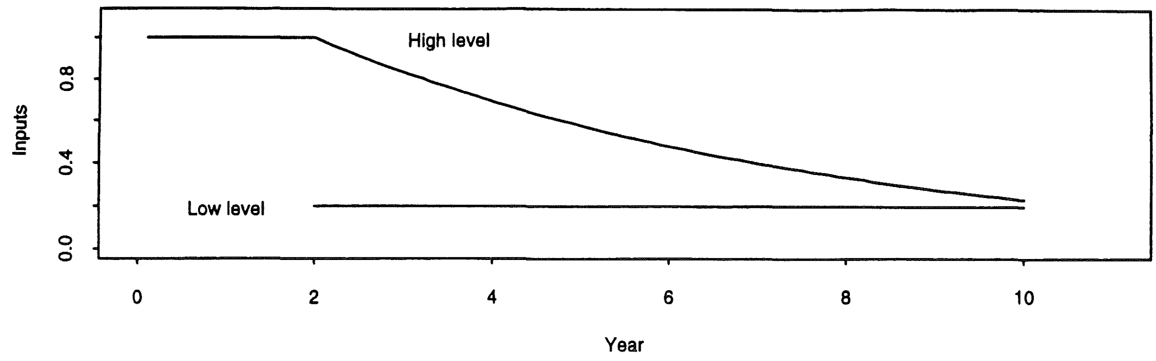

Figure 6.2

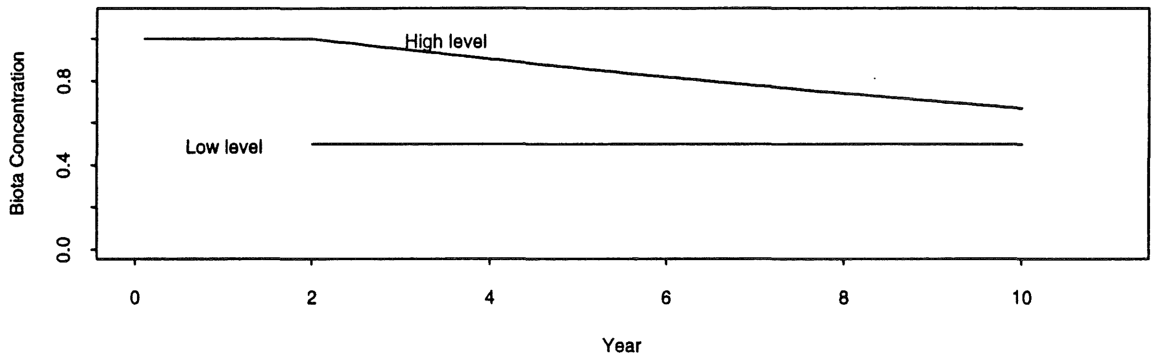

Figure 6.3

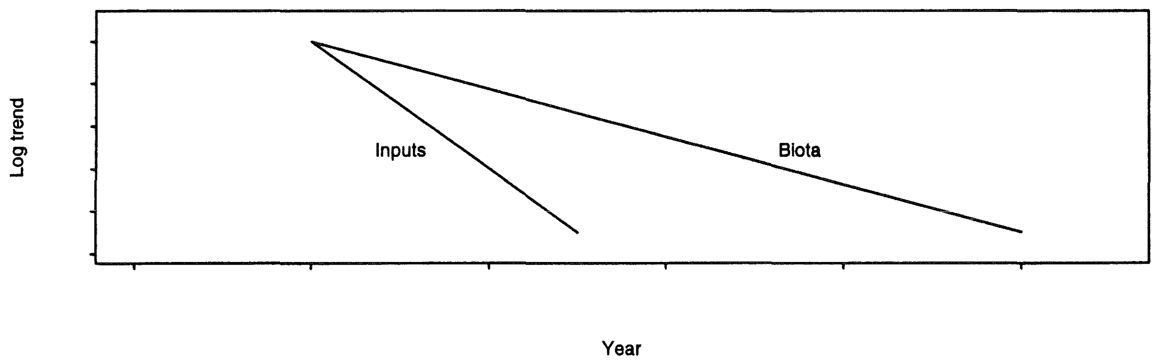

Figure 6.4

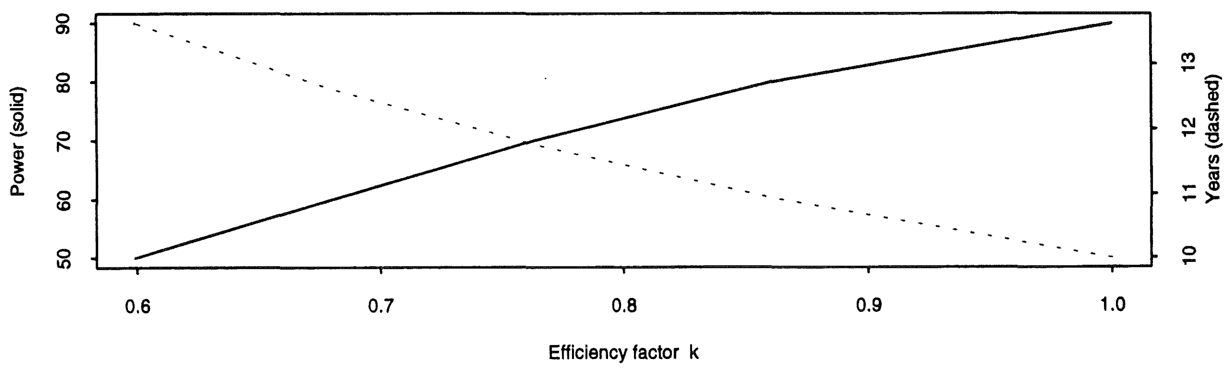

Figure: Example of a decline in inputs of a contaminant (Figure 6.1), the assumed corresponding change in concentrations of this contaminant in biota (Figure 6.2), the resulting trends on a log-scale (Figure 6.3), and the change in the power or number of years to detect a trend with the efficiency factor k.

- If it is not even possible to set a lower limit, then the monitoring exercise might be seen as speculative, perhaps providing an opportunity to estimate k.

In addition to identifying meaningful detectable trends, information about k would also provide an objective criterion for choosing between compartments, between organisms, and between tissues.

It may be possible to tabulate k by compartment/contaminant combination (perhaps even on a coarse High/Medium/ Low efficiency scale) by exploiting:

- experience and intuition,
- observed relationships between inputs and corresponding contaminant time series,
- results of published laboratory experiments.

6.2 Future Joint Meetings Between WGEAMS and WGSAEM

The following points were made:

a) The group was concerned that the joint meetings are becoming an annual event;

b) The joint meetings work best when the agenda has specific, concrete objectives, with clear deliverable products;

c) The motivation for a further joint meeting next year should come from WGSAEM and/or WGEAMS—not from the joint meeting. The joint meeting therefore considered it inappropriate that it recommends to meet again. Such a recommendation should come from WGSAEM and/or WGEAMS.

7 RECOMMENDATIONS

The joint meeting of WGEAMS and WGSAEM recommend that:

1) ACME accept the draft document on setting objectives for temporal trend monitoring programmes for publication in the ICES TIMES series, once the revisions agreed by the meeting have been made and reviewed.

2) ACME note the need for a programme to estimate the variance components affecting biological effects measurements, with a view to establishing effective sampling schemes for the integrated chemical and biological effects programmes that are currently under development; further, that ACME consider ways of developing such a programme.

3) ICES/ACME organize an appropriate forum (e.g., a workshop, a theme session at the ICES Annual Science Conference, or a symposium) to discuss risk evaluation in environmental monitoring programmes, and other methods of formulating quantified monitoring objectives.

4) A small sub-group (including one member from each of the ICES Secretariat, WGEAMS, WGSAEM, WGMS, MCWG) should meet for five days at ICES expense to consider the objectives and design of sediment monitoring programmes. Specifically, the sub-group should consider:

    a) the data requirements for designing programmes to meet different sediment monitoring objectives;

    b) techniques for designing sediment monitoring programmes, using appropriate data where available.

8 ACTION LIST

1) Make agreed changes to draft TIMES document by the end of May 1996 (Rob, Mike, Ian).

2) Referee draft TIMES document by the end of June 1996 (Hartmut, Steffen).

3) Make final changes to TIMES document and send to ICES Secretariat by the end of August 1996 (Rob).

4) Collate data that give information on k, as defined in Section 6.1.1, above, (Ian, Mike, Anders).

5) Produce case studies investigating variance components for use in designing sediment monitoring programmes (Rob and Ian, Mike and Andrew, Otto and Foppe, Hartmut and Steffen).

9 CLOSURE OF THE MEETING

Rob Fryer thanked all the participants for their industry and enthusiasm, and Anders Bignert for being an excellent host. He closed the meeting at 14.25 hrs on 16 March 1996.

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ANNEX 1

AGENDA

1. Opening of meeting.

2. Review terms of reference and tasks for the meeting.

3. Adoption of the agenda and organisation of work.

4. Term of reference. Review and agree on a final text for the draft ICES Techniques in Marine Environmental Sciences document on detailed objectives for temporal trend monitoring programmes.

5. Term of reference. Review and report on progress on setting objectives for, and the design of, spatial monitoring programmes.

6. Temporal trend monitoring guidelines.

7. Any other business.

8. Recommendations.

9. Closure of the meeting.

ANNEX 2

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ANNEX 3

LIST OF WORKING DOCUMENTS

JEASA 1996	4.1	Draft TIMES document on objectives.
JEASA 1996	4.2	Memo from Benoit Beliaeff.
JEASA 1996	5.1	Monitoring of contaminants in Dutch marine sediments.
JEASA 1996	5.2	Annex 6 from WGMS 1995.
JEASA 1996	5.3	Variance of sediment analyses.
JEASA 1996	5.4	Results from DIFFCHEM.
JEASA 1996	5.5	Sampling variability, Foppe Smedes.
JEASA 1996	5.6	Nies, H., Albrecht, H., Rechenberg, V., Goroncy, I., Dahlgaard, H., Weiss, D., and Brügmann, L., 1990. Intercomparison of sediment sampling techniques by means of radionuclide and heavy metal analysis.
JEASA 1996	5.7	Analytical variance of the determination of organic contaminants in marine sediments.
JEASA 1996	5.8	Analytical variance of the determination of trace metals in marine sediments.
JEASA 1996	5.9	Analytical variance of the determination of PAHs in standard solution, cleaned sediment extract and raw sediment extract.
JEASA 1996	6.1	Proposal for Voluntary International Contaminant monitoring (VIC) for temporal trends with the aim to test sampling strategies for a co-operative revision of guidelines by 1998. SIME 96/23/1-E.
JEASA 1996	6.2	Proposal for Voluntary International Contaminant monitoring (VIC) for temporal trends with the aim to test sampling strategies for a co-operative revision of guidelines by 1998. Norman Green and Mike Nicholson.

ANNEX 4

Memorandum for the joint meeting of WGEAMS and WGSAEM
Stockholm 1996

Monitoring of contaminants in Dutch marine sediments

Otto Swertz[1]

This memorandum describes the choices RIKZ made for the monitoring of contaminants in the sediments of the Dutch marine water systems. This was the result of the evaluation of the national monitoring programme. Until now, only reports in the Dutch language are available. The goal of the memo is to inform the joint meeting of WGEAMS and WGSAEM about the general lines of the design of the programme. Selection of substances and the sampling and analytical methods are not mentioned.

There are two goals defined for the chemical monitoring: 1. target value assessment; 2. trend detection. For the first water quality targets are quantified in policy documents. In general, the 90-percentile of the contamination level in the water system is used to assess against the target value. For trend detection, also, people are interested in trends in the content in the water system.

It was decided to monitor the content in sediments to fulfil the two goals. A programme for the sediment monitoring was designed. A frequency of once in the three years was chosen. The reason not to sample every year was that the time scale of expected changes is in the order of, say, five year. The frequency of three years is according the current JAMP-rules, but also it was practically executable (1996: Wadden Sea, 1997: North Sea; 1998: marine Delta waters, and so on).

For the design of the sample sites the following criteria were used:
1. The ideal sampling strategy is: choose random sites from homogenous sub-areas; sample these sites on a fixed base.
2. At least ten but not more than twenty sites should be chosen, this is a statistically based advice.
3. The sites should cover the total area, that is including sedimentation and erosion areas.
4. The sites should preferably fit with sites in other programmes: 1. JAMP, 2. TMAP (Wadden Sea); 3. Biology (zoöbenthos); 4. Surface water.
5. Existing time series should be continued.

A first, but not definitive yet, choice of sites was made, but is not presented now. Chosen are 44 sites in four areas of the Dutch part of the North Sea. The areas were defined during the evaluation. Once every six year 20 additional sites will be sampled to get a more detailed map of the contamination level. Whether this map will be accurate enough, should be worked out later this year. In Figure 1, the 100 sites of the zoöbenthos program in the Dutch part of the Noth Sea are presented. These are chosen according the first and fifth criterion.

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Overview of the macrobenthos sites in the Dutch part of the North Sea