THE MERAMED PROJECT

Development of monitoring guidelines and modelling tools for environmental effects from Mediterranean aquaculture

A project supported by the European Commission through the 5th framework programme for
"Quality of Life and Management of Living Resources"
(Contract Q5RS-2000-31779)

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Newsletter 6 – July 2004

Report of a trial testing the semi-quantitative faunal analysis technique in fish farming sites in the western Mediterranean

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Summary

A semi quantitative benthos assessment (SQA) was performed on fish farms in the western Mediterranean using Norwegian Standard 9410. This standard aims at standardising impact assessment of aquaculture activities, and has been in use since 2000. The main advantage of a semi-quantitative faunal analyses are the costs which are only 1/10 of those of a full quantitative analyses. Because this less detailed analysis is not as time consuming, the results are deliverable much faster, which reduces the time between the survey and possibly necessary remedial action if required.

Within the MERAMED Project, a first approach for standardisation and generalisation (international adaptation) has been developed. The classification system is based on relative abundances of species and the absence/presence of indicator species (see table 3) (opportunistic species and species tolerant to organic enrichment) and normalised TOC content. The use of pollution tolerant species as an indicator for environmental conditions is not part of the Norwegian Standard. The number of classification levels was increased from 4 to 5.

The list of pollution tolerant species detailed in the Norwegian Standard are valid for the Norwegian coast only and is not be directly applicable for use in environmental monitoring in the Mediterranean Sea as these species do not occur in the region or necessarily have the same function in the Mediterranean ecosystem. Based on the results from the full quantitative benthos analyses performed in Meramed, the list and classification criteria based on the list will be refined to include the specific bio-indicators for organic enrichment in the Mediterranean Sea.

Most of the indicators used for detecting organic enrichment are opportunistic species.

Using these as indicator species instead of the pollution tolerant species would have changed the results only slightly. Opportunistic species are usually well known for the different habitats, which gives the opportunity to easily create a list of species, which preliminary can be used for environmental classification. Also, organic turnover rates differ and have to be to be taken into account when modifying the SQA method for use in the Mediterranean.

Remaining work within the Meramed project will include the comparison of SQA with the full quantitative benthic analysis, and detailed sediment analysis, topographical data and data from current measurements, to adapt the Norwegian Standards to the Mediterranean environment. The list of pollution tolerant species also be revised and probably extended.

Introduction

The semi-quantitative faunal analysis (SQA) is one example of the methods used for environmental monitoring of fish farms in Norway. Together with other techniques, it serves as a basis for the evaluation of monitoring procedures used in other areas and the development of protocols and techniques for the control of fish farms. Within the Meramed Project, the SQA technique was tested at fish farms in the western Mediterranean with a view of adapting the technique for the Mediterranean environment.

Materials and Methods

Sampling was undertaken at 7 different cage farms situated in Greece at different depths, at varying degrees of exposure to wave action, over different types of substratum, with different production levels, farmed species and feeding practices. At each site, 5 stations and one control station were sampled using a 0.1 m2 modified van Veen grab. The 5 stations were placed along a transect starting at the fish cages to 50 m away from the cages.

Semi-quantitative macro-faunal analyses were carried out for one biological sample per station. Samples for sediment characterisation also were taken at each station during the cruise. After rinsing the biological samples in the laboratory through a 1mm-sieve, the invertebrate taxa were sorted and identified by specialists to a practical taxonomic level. A list of taxa and their relative abundance was prepared for each sample. The classification of enrichment level is based on a combination of data on community structure, number of species/individuals (Environmental State as defined in NS 9410) and the occurrence of opportunistic and pollution tolerant species (bio-indicators, Rygg 1995). In cases where the same genus but a different species was found in the samples, the assumption was made that it was also a pollution tolerant species. For example in Rygg's species list for pollution tolerant species, Chaetozone setosa is listed, whereas another Chaetozone species was found in the samples. The classification criteria are listed in Table 4.

Table 1: Abundance and percentage of individuals per sample.

Abundance	Percentage of individuals per sample
present	one individual
few	< 15 % of individuals
abundant	15 – 90 % of individuals
very abundant	> 90 % of individuals

Table 2: Classification of environmental state according to NS 9410. The classification is based on the number of species and abundance of single species on the whole community.

Environmental state 1	At least 20 species present. None of the species represents more than 65% of the total number of individuals (normal species number)
Environmental state 2	5-19 species present. None of the species represents more than 90% of the total number of individuals (moderate species number)
Environmental state 3	1-4 species present (low species number)
Environmental state 4	No macro-fauna except Nematoda

Table 3: List of opportunistic and/or pollution tolerant species used for evaluation of the benthic communities (modified after Rygg 1995). + less distinct, ++ distinct.

Species	**Opportunistic (most common at low diversity)**	**Pollution tolerant**
Glycera sp.		++
Nephtys sp.	+	++
Prionospio sp.		++
Capitella capitata	++	++
Malacoceros fuliginosus	++	++
Malacoceros sp.	++	++
Chaetozone sp.	++	++
Paramphinome sp.	++	++
Pholoe sp.		++
Nereis sp.	+	++
Nemertinea indet		++
Oligochaeta indet	++	++

Table 4: Pollution level and characterisation of the community as a result of the combination of the two approaches (Rygg 1995 and NS 9410)

Pollution level	Characterisation	No of pollution tolerant species	Frequency of any pollution tolerant species	Total number of species	Classification after NS 9410
I	not affected	max. 6	present – few	20 or more	1
II	affected	max. 6	present – abundant	20 or more	1
II	affected	max. 4	present – few	5-19	2
III	moderately affected	max. 4	present – abundant	5-19	2
III	moderately affected	max. 2	present	1-4	3
IV	Heavily affected	max. 4	few - abundant	1-4	3
V	collapsed	max. 1	present	0-1	4

Analyses of total organic carbon (TOC) and sediment granulometry (% silt/clay) were carried out on samples from each station. The TOC analyses were carried out on the 0-2 cm sediment layer, whereas the granulometry analyses were carried out on the 0-4 cm layer, to take account of biological sediment mixing.

The Norwegian Pollution Control Authority (SFT) has adopted a system for classification of sediments according to Environmental Quality (Molvær *et al*. 1997). The scheme is used to categorise marine sediments in five classes: Very good, Good, Less good, Moderately disturbed and Severely disturbed, see Table 5. TOC concentrations are normalised for theoretical 100 % silt & clay fraction before classification by using following formula: normalised TOC = measured TOC + 18 * (1 – F), where F is the silt/clay fraction (less than 0.063 mm (Aure *et al.* 1993).

The type of substrate is given in the results, but it is only used as additional information for judging the species number. There is no equivalent in any of the cited literature.

Table 5: Classification criteria for sediment environmental quality, using normalised TOC content (mg/g). (SFT criteria)

	Marine sediments*)				
Environmental Quality Level	I	II	III	IV	V
	very good	good	less good	moderately disturbed	severely disturbed
Normalised TOC (mg/g)	>20	20-27	27-34	34-41	>41

*) Concentrations normalised to the fraction of fine particles (< 0,063mm), see Molvær *et al.* 1997.

Discussion

The Norwegian Standard 9410 has been in use since 2000, and was developed in cooperation with Akvaplan-niva AS, as a member of the Standardisation Committee.. This standard aims to standardise impact assessment of aquaculture activities. However, it is the first version and the method may still need to be refined. In particular, it should be made compatible with other international guidelines. Further, the method and interpretation of results should be standardised in a way that makes it possible even for non-specialist biologists to make a quick and reliable assessment of the environmental impacts. A new initiative for improvement of the methods and standardisation of the semi-quantitative faunal analysis in cooperation with the state pollution control authority has been started recently by Akvaplan-niva.

In this study, a first approach for standardisation has been developed and is still open for change or improvement. One change, in respect to the Norwegian Standard, is the use of pollution tolerant species as an indicator for environmental conditions. This resulted in the classification into 5 pollution levels, which seemed to be more appropriate in combination with the 5 TOC classes than the 4 environmental states used in the Norwegian Standard.

For the evaluation of Norwegian aquaculture sites, the fauna and sediment data are seen in combination with current intensity, current direction and orientation of the cages compared with the current data. Other information important for the evaluation of the environmental condition is the distance between the single cages - the greater the distance, the higher the chance for recovering from strong organic impacts.

Some short comments on advantages and disadvantages are given below.

Advantages

The costs of semi-quantitative faunal analyses are only 1/10 compared to a full quantitative. This is primarily due to the requirement for less detailed analysis which which results in faster analysis and results allowing the farmer to take remedial action quickly if required.

With lower costs, it is possible to take more samples, both per station and across the site. An identification of sources and extent of impacts might therefore be easier than with fewer but quantitatively analysed samples. In combination with a few additional quantitative stations, the semi-quantitative method can give an even better picture of the environmental state and makes the definition of “borders” of different recipients easier.

Around fish farms, the environmental conditions can change rapidly and early signals of change can be registered efficiently by using more samples, at a less detailed level of analysis. Additionally, the costs for the investigations can be more in proportion to the activities at the sites.

Table 6: An overview of the different activities involved in semi-quantitative faunal analysis and the time needed (Time consumption per site (5 samples + control))**.**

Type of activity	**Semi-quantitative**
Rigging	3 hours
Field work (incl. deployment of current meter)	10 hours (1 person)
Corn size and TOC analysis	12 hours
Semi-quantitative faunal analysis	18 hours
Current measurement-reading data & presentation	1 hour *
Hydrographical registrations incl O_2	1 hour*
Report writing	20 hours
Total time consumption	**65 hours**

Equipment rent, boat rent and travel costs are not included.
***Hydrographical registrations through the water column and** Current measurements, in 2-3 depths for one month, are usually required, but not carried out in the present survey.

Limitations

The assessment methods currently in use is subjective and very much depends on the taxonomic experience of the biologists analysing the samples. As polychaetes play the most important role in this kind of assessment of environmental impacts, in particular high competence in identification of polychaetes is required. In some cases, genera are registered with "several species", and some species are only recorded with family name and "indet". This is necessary because of the time limit during the analyses but it implicates a certain risk for misinterpretation in combination with the Norwegian Standard. Depending on the operator's experience, more or less species may be found in the same sample, which could change the interpretation of the results and consequently the classification of the site and recommended measures.

Future Improvements

Indicator species for high water quality as well as the type of substrate should in future be taken into consideration. This makes assessment of sites with naturally low species numbers easier to carry out in a standard manner.

Samples are analysed for the presence and absence of species from the main taxa Polychaeta, Mollusca, Crustacea and Echinodermata. This information is presented in Figure 1. One trend is obvious for all sites sampled: Echinodermata are the first to disappear with increasing organic enrichment. This is a well-known pattern from environmental investigations at fish farming sites and other areas affected by organic discharge. This could be used as an additional indicator for reduced environmental quality.

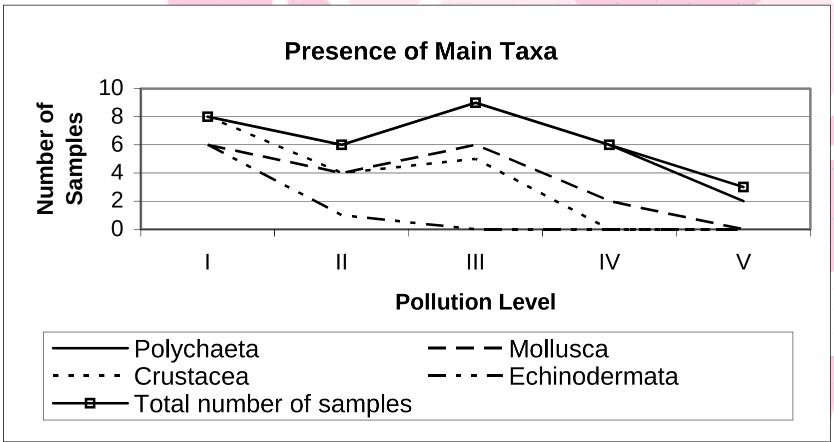

Figure 1: Presence of the main taxa Polychaeta, Mollusca, Crustacea and Echinodermata for each pollution level.

Application in the Mediterranean Sea

The list of pollution tolerant species from the Norwegian coast is probably not directly applicable for use in environmental monitoring in the Mediterranean Sea. The species listed do not necessarily have the same function in the Mediterranean ecosystem and perhaps do not even occur. Therefore further research and literature studies are essential to define specific bio-indicators for organic enrichment in the Mediterranean Sea.
In

Table 3 it is shown that most of the indicators used for detecting organic enrichment also are opportunistic species. Using these as indicator species instead of the pollution tolerant species would have changed the results only slightly. Opportunistic species are usually well known for the different habitats, which allow a preliminary list of species to be created which can be used for environmental classification.

With respect to the species number, additional research and literature studies also have to be conducted to adjust the species numbers used for classification in Norway to the conditions found in the Mediterranean Sea.

There are many differences between the environments of Greece and Norway, and organic turnover rates will be different. As a consequence, the classification system for environmental quality must be adapted for the Mediterranean.

This study will be compared with the full quantitative benthic analysis, detailed sediment analysis, topographical data and data from current measurements, to allow the adaptation of the Norwegian methodology and standards for the Mediterranean environment.

Parallel to the full-scale quantitative investigation, the list of pollution tolerant species should be revised and probably extended in cooperation with specialist benthos-ecologists.

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