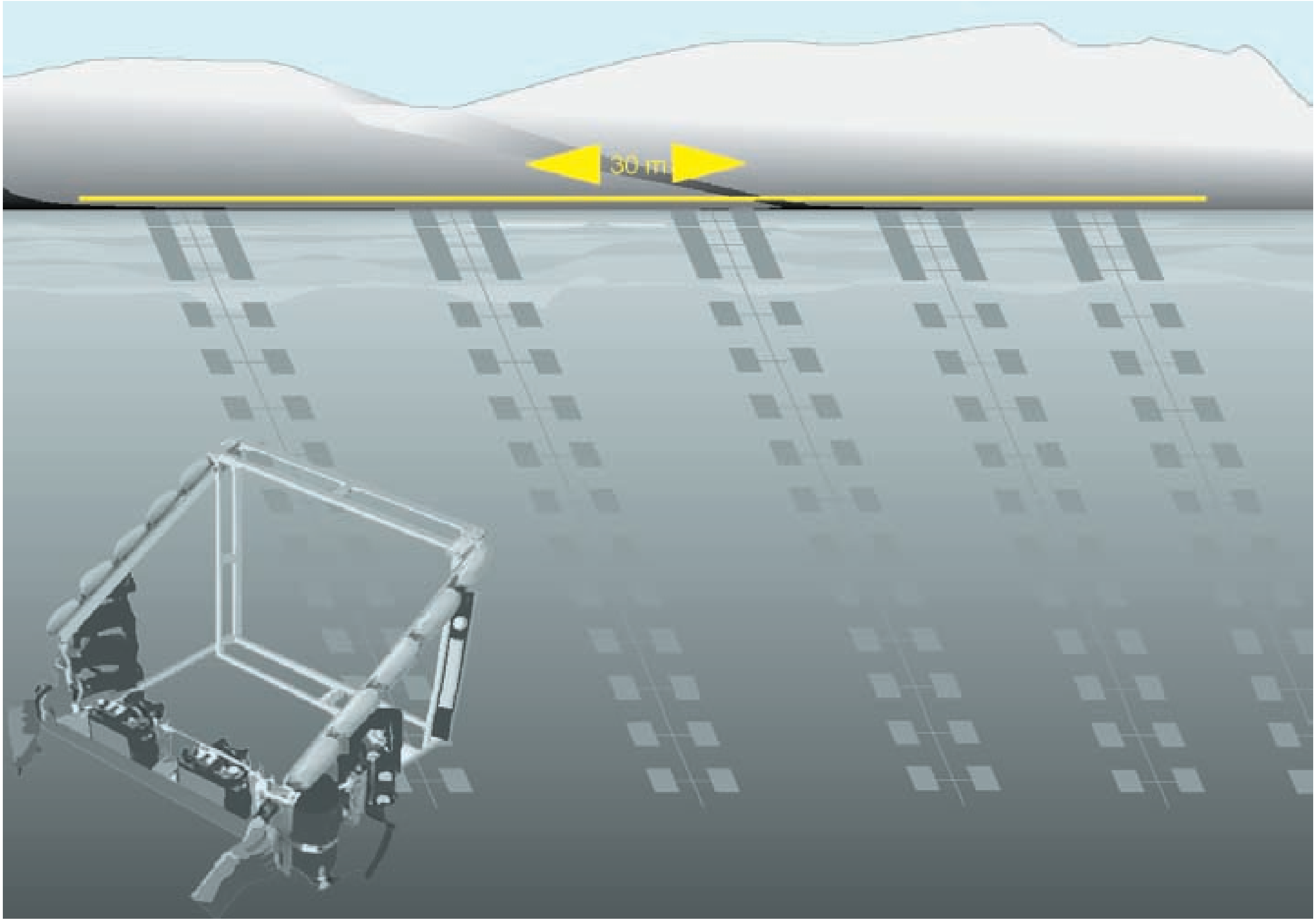

MONITORING OF THE PHYTAL SYSTEM ON THE SWEDISH WEST COAST - A PILOT STUDY

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SUMMARY

The programme has been run since 1989 with the main goal of developing the technique for monitoring changes in the macroalgal communities. Thus there is too short a time for looking at trend analyses of the results achieved within this programme. However, long-term studies or revisits of old sites in other areas show which trends can be expected. The localities can be considered as representative for areas without direct impact from local sources of pollution. They were mainly chosen for monitoring of long-term trends of changes within these communities (including the possibility of using them as reference sites for the regional programme for comparable studies). The composition of macroalgae showed "typical" patterns for the northern part of the Swedish west coast, the sites so far not showing the general modifications of eutrophicated localities. However, no historical data are available for true comparisons, neither of quantities nor of detailed depth distributions. The results presented show that:

* It is possible to use a non-destructive sampling method. Photographs from the field transects are suitable for further analysis in the laboratory, which reduces the diving time considerably. Both macroalgae and sessile fauna can be studied. Field notes taken by the diver are a good complement to the photos and provide additional data on the deepest level of distribution of the dominant species. The slides can be stored on computor for future analyses.

* Digitizing of the slides by using image analy ses provided % coverage data for different taxa, giving a good information of the frequencies and abundances of algae in the different substrata, in many cases on the species levels, for some algae on the level of genera, while for less conspicious algae functional form groups can be used. For canopy species and most sessile macrofauna also number of indivduals can be recorded. Approvements for better slide quality and a higher resolution in the image analysis are suggested.

* The patchiness of the algal belt has to be taken into account when planning the programme and the effect of heterogeneity was tested. Also introduced nonindigenous species have been encountered in the transects by random. The information achieved is thus valuable for other projects as well, and the results can also serve as a baseline for biodiversity studies.

* The use of three randomized transects in combination with duplicate quadrats on the different depth intervals makes it possible to analyse the results statistically. The results are compared between years and within years (the latter not included in the report), and by regarding the sites as fixed or as random. The different methodological approaches, including some weaknesses and ways to overcome them, are discussed

* The variation of the material from the macroalgal communities in many cases needs transformations before using further statistical analyses. The results for some selected taxa are briefly discussed.

* The power analyses performed for several taxa can provide information on how long time should be needed for recording changes with the existing variation in the data. This was analysed for different levels of monitoring (times, localities/depths)

INTRODUCTION

The macroalgal communities are characteristic elements in areas with many rocky shores such as in the archipelagoes of the northern Swedish west coast and provide the marine ecosystem with:

1) Fixing of solar energy and nutrients into comparatively large biomasses, partly binding carbon and nutrients in long-lived perennial seaweeds, partly in ephemerals, which fluctuate over the year and thus by their break-down give pulsed releases of both carbon and nutrients back to the marine ecosystem.

2) Architectural structure comprised by especial ly the large perennial brown algae (as well as the sea grasses), where changes to smaller species (e.g. filamentous algae), due to their enhancement by eutrophication, reduce the system from a 3-dimensional to a more or less 2-dimensional system. This in turn has a high impact on macro fauna and fish in the community (e.g. Isaksson & Pihl in press), incl. also effects on commercially important species, which uses these communities for foraging and shelter. Furthermore, the mosaic pattern of different species in areas with only a small degree of antropogenic impact creates several niches for the fauna, while at the same time unfortunately hampering an easy analysis of the results on an overall basis. On the other hand the mosaic pattern is readily recognized and thus can be taken into account already at the planning of the programme.

3) A high biodiversity of macroscopic organisms, where the gene pools might be different from the populations on the Atlantic shores due to isolation and/or sterility. Also the microscopic epiphytic/epilithic elements have a high diversity (e.g. Kuylenstierna 1989-90), which, however, mostly has been poorly studied and these benthic microalgae are not included in the running programme.

4) Includes several elements of introduced foreign species such as the brown algae *Sargassum muticum*, *Fucus evanescens* and *Colpomenia peregrina*, the green alga *Codium fragile* and the red alga *Bonnemaisonnia hamifera*. *Sargassum*, *Fucus* and *Codium* have a large structural importance in the communities and the first two species are increasing in abundance in several areas (e.g. Karlsson 1988, Karlsson et al. 1992), while *Codium* might be decreasing. Within the present study, the introduced Japanese brown alga *Sargassum muticum* turned up in some of the randomized transects. Such changes ought to be documented in the sea, too.

The macroalgae have a life span which makes them suitable for detecting integrated effects caused by environmental impact: (a) directly (increases or decreases by additional nutrient levels, increased incorporation of nutrients in the tissue) (b) indirectly (decreases due to more turbidity caused by eutrophication, changed competition etc.). Also xenobiotic substances such as heavy metals or radioactive isotopes are stored and can be monitored. Furthermore, their benthic life strategies make them reflect only factors influencing the area studied.

Changes in the phytobenthic communities are often readily observed, also by the general public. Large amounts of drifting algae, mainly filamentous, have been a hinderance to both fishery and recreation, and *Sargassum muticum* have started to be a nuisance in some areas (Karlsson et al. 1992). Thus there will always be a high demand for information of changes in these communities. Changes favouring the opportunistic macroalgae may also affect other subsystems such as the sea grasses (as epiphytes or by covering the substrate) and have an impact on the shallow sediment bottoms by releases of nutrients and organic material from drifting algae (e.g. Sundbäck et al. 1990).

The Swedish west coast

The Swedish west coast (i.e. the shores of the Kattegat, the Skagerrak and in some respects also the Öresund) represents a transitional area between the fully marine Atlantic Ocean and the brackish Baltic Sea. The influences of tides are sparse (maximum level ca 0.3 m), while the water levels may change about a metre or more during the year due to winds or changes in the atmospheric pressure. Considerable changes in the phytobenthic communities have occurred in some areas of the Kattegat over the last 20 years (e.g. Wennberg 1987, 1992, Rosenberg et al. 1990, M. Pedersén pers. comm. - mainly caused by antropogenic pollution including eutrophication), in the Kiel Bight (e.g. Breuer & Schramm 1988, Vogt & Schramm 1991 - here also other factors have been discussed besides eutrophication, cf. also Gerlach 1988), and there are several indications of changes also in the bays and along the shores of the Skagerrak (Michaneck 1967, Rex 1976, Lundälv et al. 1986, Svane & Gröndahl 1989, Isaksson & Pihl in press, H. Kautsky pers. comm., C. Larsson pers. comm.).

For macroalgae these changes often include disappearance or decrease of fucoids, mainly *Fucus vesiculosus* (for references see above), as well as increasing amounts of the opportunistic filamentous or sheet-like/tubular species or groups such as *Bonnemaisonia hamifera* (tetrasporophytes), *Ectocarpus* spp., *Pilayella littoralis*, *Cladophora* spp., *Percursaria percursa*, *Enteromorpha* spp. and *Ulva* spp. There are indications that the kelps and fucoids are decreasing, at least in their depth distribution, and the filamentous/sheetlike forms of macroalgae are increasing also in the fjords of the Skagerrak (see above). Similar changes have occurred also in the Baltic Sea (e.g. Wallentinus 1981, 1988, 1991 Kangas et al. 1982, Kautsky et al. 1986, 1992, Hällfors et al. 1987, Kautsky 1991).

Previous and running montoring programmes
The earlier national monitoring programme covering the Swedish west coast does not include the macroalgal communities found in the phytal zone. However, in the new regional monitoring programme of the province of Bohuslän (N Swedish west coast), surveillance of both macroalgae and sessile macrofauna have been included, starting in 1991 and 1992, respectively. These biota will be the included also in the monitoring programmes of the provinces further south along the coast. However, these regional programmes focus their attention mainly on inner coastal areas, many of these already affected by anthropogenic discharges. Thus there is a strong need for reference sites, which should be included in the national programme. Those regional programmes will be evaluated and coordinated with the national programme in the near future, but they could not be a substitute for a national programme. Also some local monitoring programmes have included plants in the sea (e.g. in the bay of Kungsbackafjorden, outside some sewage discharges, in connection with building of oil refineries, etc.).

In Denmark and Norway, several of the national and regional surveys include monitoring of the benthic macroalgae and sea grasses. (e.g. Jespersen et al. 1988, Anon. 1991, Moy & Walday 19-92, Nielsen & Helmig 1992). In several coastal areas changes have been documented in those studies, mainly increased occurrences of opportunistic algae in eutrophicated areas (e.g. Rueness 1973, Klavestad 1978, Rueness & Fredriksen 1991), but also lately an increase of some fucoids in the inner Oslofjord due to improvements in sewage treatment and discharge practices (Bokn et al. 1992).

THE PRESENT PILOT STUDY

From 1989 to 1991 a pilot monitoring study of the sublittoral flora was undertaken in the northern part of the Swedish west coast (Fig. 1) The

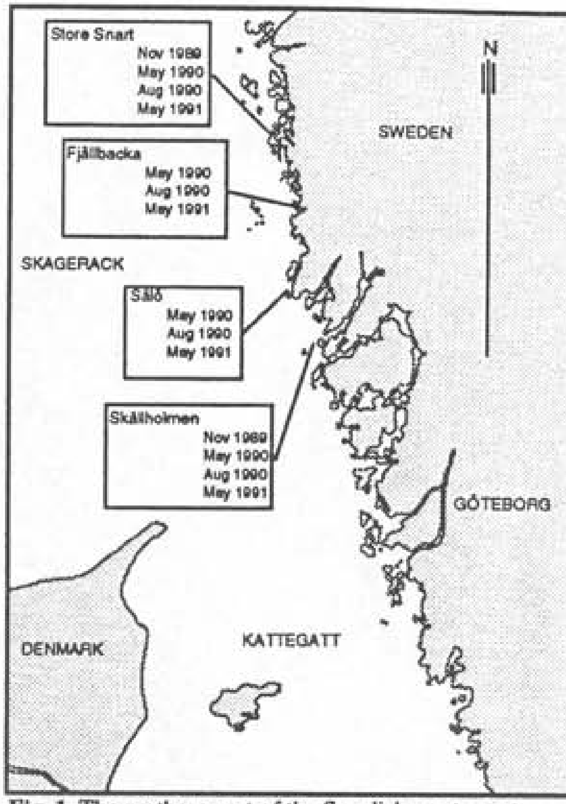
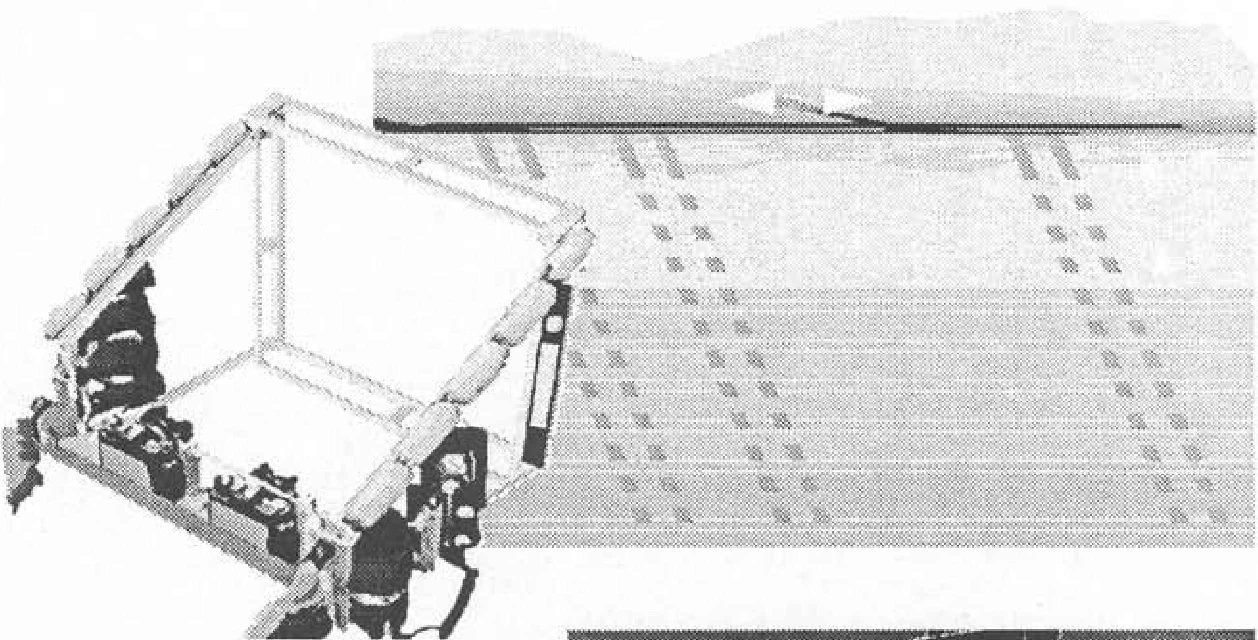


Fig. 1 The northern part of the Swedish west coast with the localities visited

goal was to test a non-destructive monitoring technique to document changes of the biota in the macroalgal community and its variation in time, as well as to adopt the techniques into routine methods for a monitoring programme. The quantitative importance of the temporally fluctuating macroalgae for the biomass turnover and hereby pulses of carbon and nutrients to the system could not be fully taken into account due to limited resources. This part, as well as sampling the benthic microflora, could be incorporated in the field programme, but needs further financial support.

The study has been run in close co-operation with research programmes in Marine botany. This has enabled the use of data also for studies of population dynamics of some species (Karlsson & Åberg 1992) and to follow the distribution of some rather sparse species (cf. Karlsson et al. 1992). For further development of the techniques within the monitoring programme, incl. the statistical analyses, such a close co-operation is necessary, and a future monitoring programme needs to be both planned and evaluated by scientists. The need of a close co-operation between projects in basic and applied sciences with the monitoring programmes was also emphasized by the evaluation of Swedish environmental research carried



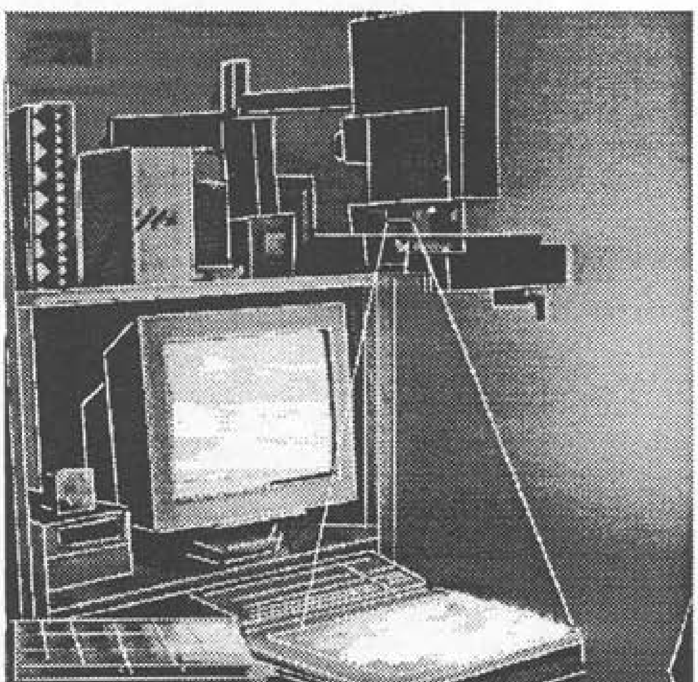


Fig. 2 Field plot and measurements
At each locality a 30 m fixed part of the shore served as a baseline for 3 randomly placed transects. Two slide replicates (Kodachrome 25, 35 mm) were taken at 0, 0.5, 1, 2, 3, 4, 6, 8, 10, 12, 14, 16, 18 and 20 m depths using two syn chronized Nikkonos V cameras with Nikkor 15 mm lenses. Four Dyfo SL32 strobes provided light.

Slides were projected in mono onto a Kurta IS/ADB digitizing tablet using a Zett slide projector. Data were processed on a Macintosh IIfx computer using the following software: Image 1.45 (image analysis), Microsoft Excel 3.0, Systat 5.2, SuperAnova and DeltaGraph Professional.

Table 1 Species or groups analysed in this report

Species or genus	Group
Brongniartella byssoides	Branched red algae
Ceramium rubrum	"*incl. Ceramium, Polysiphonia, Rhodomela, Cystoclonium*"
Chondrus crispus	Finely branched red algae
Corallina officinalis	"*incl. Scagelia, Pterosiphonia, Callithamnion, Aglaothamnion*"
Delesseria sanguinea	Foliaceous red algae
Dumontia contorta	"*incl. Delesseria, Phycodrys, Membranoptera, Apoglossum*"
Furcellaria lumbricalis	Cartilagineous red crusts
Phyllophora spp.	"*incl. Cruoria, Petrocelis, Haemescharia*"
Rhodomela confervoides	Calcareous red crusts
Trailliella/Spermothamnion	"*incl. Phymatholithon, Litothamnion, Lithophyllum*"
Chorda tomentosa	Dead red crusts
Chordaria flagelliformis	Filamentous brown algae
Desmarestia aculeata	"*incl. Pilayella, Ectocarpus, Giffordia*"
Dictyosiphon sp.	Brown crusts
Fucus serratus	"*incl. Ralfsia, Pseudolithoderma, Lithoderma*"
Halidrys siliquosa	Filamentous green algae
Laminaria digitata	"*incl. Spongomorpha, Acrosiphonia.*"
Laminaria saccharina	Foliaceous green algae
Pseudolithoderma/Lithoderma sp.	"*incl. Ulva, Monostroma, Gayralia*"
Enteromorpha spp.	

out by the Royal Swedish Academy of Sciences in spring 1992. They also stressed the importance of publishing the results in international journals, and of quality control.

FIELD WORK

The field work was carried out in co-operation with Dr Björn Tunberg and Mr John Andersson, Kristineberg's Marine Biological Station (KMBS), who performed a study on sessile animals. The study started in autumn 1989. During October-November 1989 only two localities were visited. Four stations (Fig. 1) were visited in May and August 1990 and in May 1991. Two restrictions were set up when choosing the localities. Firstly, the localities should be accessible during "normal" weather conditions, and secondly, each site should hold a part with a gentle slope suiting the botanical part of the field work, and a steep side suiting the preferences of the KMBS-team.

- At each station a fixed horizontal distance (30m) was chosen at the time of the first visit, serving as a baseline during the following visits.
- Before each visit three coordinates were chosen at random on the baseline, giving the starting points of three transects perpendicular to the baseline.
- At each transect two separate stereophotographs (Littler 1971, Lundälv 1971), covering 0.25 m^2, were taken at fixed depths, between 0 m and a maximum depth of 20 m (Fig. 2). The two replicates were positioned at random within a two metres horizontal distance from the transect line. When necessary, canopy species (*Laminaria* spp., *Fucus* spp., *Halidrys siliquosa*) were gently moved aside after documentation, for appropiate recording of the underlying strata.
- The upper and lower limits of the dominating species as well as the largest depth of non crustose vegetation was recorded (Appendix I).
- Complementary notes (general impression, canopy data, identity of tiny taxa etc.) were made on a plastic sheet.
- Bottom topography was recorded via echo-sounding.

The layout of the field work is summarized in Fig. 2.

ANALYSIS OF SLIDES

The field work generated a bank of slides, from which different kinds of data can be extracted and analysed. The slides will within shortly be read into a computor-based system (CD ROM).

Data input

Slides were projected in mono onto a digitizing tablet connected to a computer and the following parameters were recorded:

Macroalgae

- Cover (%) of each taxa in the 0.25 m^2 frame.
- Stratum group (Appendix II)
  0=Crusts
  1= Basal layer

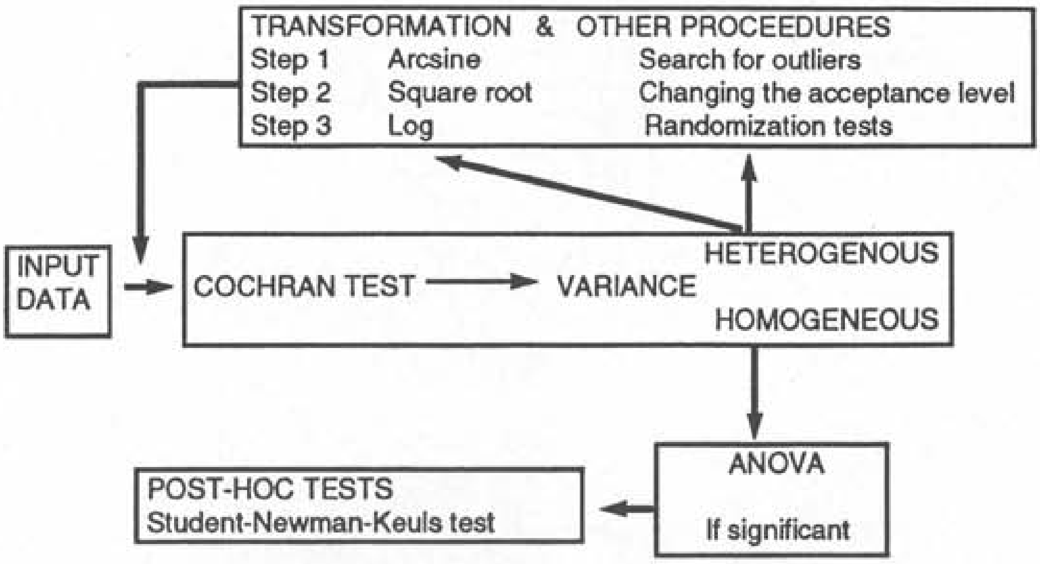


Fig. 3 Schematic drawing of the ANOVA proceedure

2= Intermediate layer (incl. epiphytes on 1)
3= Canopy including epiphytes on canopy).

- Number of patches of the taxon in question, and number of individuals for canopy species, mainly *Laminaria* spp.

Macrofauna

- Cover (%) of dominating sessile macrofauna.
- Number of individuals of the dominating sessile macrofaunal species.

A stereoscope was used for identifying difficult taxa or for assessing the number of strata in the slide-picture. The aim was to identify taxa to the species level. When not possible, higher ranks were used (genus or family). When difficult to read the proper area covered due to obscuring strata, the taxon was recorded as present (P).
Also the sessile fauna was documented by photographs, but these data have not been further analysed due to lack of time (it should be pointed out that these data are from different sites than those covered by the macrofauna studies, see above)

Problems encountered during field work and data input

Dense vegetation obscuring lower strata. – Can be compensated for by field data protocols or by combining data from the two slides of the stereo set.
Difficulties in identifying some filamentous red algae and sheet-like green algae, as well as small (< 25 mm) filamentous algae in general to species level. – Can mostly be overcome by accepting identification to the generic level, by placing the taxa into a functional-form group or by taking additional field samples.
Distinguishing intermingled filamentous taxa. – Additional point-sampling analysis should be used in future analysis.
Reflections from suspended particles often resulted in poor image quality.
Pale coralline crusts frequently reflected the strobes, resulting in poor image quality, and stratification of the water (pycnocline present) sometimes resulted in out-of-focus effects.

STATISTICAL ANALYSIS

The slides produced in autumn 1989 haveso far not been digitized. Complete data sets exists for May 1990, August 1990 and May 1991. There are three types of data bases for each locality and visit: *Coverage*, *Stratum* and *Patches*.

The data sets allow a comparison between years (spring vs spring) and a comparison between seasons during a year (spring vs late summer). A between years' comparison of late summers is not relevant in this study, because the 1989 recordings were made too late in the season, and do not represent the summer climax situation desired.

The design of the field work, with replicates at each level, makes it possible to analyse the material with factorial analysis of variance (ANOVA). For each depth interval, at each location, each transect and for each date, there are two replicates. This basic design allows you to pool depths which gives rendering more replicates (see below).

The data set have been analysed using two different ANOVA models:

Model A: Locations are fixed
In this model, each locality is considered to be specifically chosen. Data from one locality should not be extrapolated to a wider geographic area. The model consists of an ANOVA with locality, date, depth intervall and transect as main factors, and locality is treated as a fixed factor (see Appendix III: ANOVA MODEL A).

Model B: Locations are random
The location of each locality is chosen at random, and they represent a specific kind of habitat in a region (e.g. N Bohuslän). Significant changes represent development in a wide geographic area. The model consists of an ANOVA with locality, date, depth intervall and transect as main factors, and locality considered as a random factor (see Appendix III: ANOVA MODEL B).

In the present report, tests are mainly based on percent coverage data. Common taxa, as well as pooled data of common functional-form groups (Table 1) are analysed. The pooled data of functional form groups are of interest when discussing e.g. effects of eutrophication (cf. p. 2-3) Tests originally included comparisons within a year (spring vs autumn) and between years (spring vs spring), using both model A and model B ANOVA. When using the data set, taxa recorded as present (P) were removed.

The depth profile was divided into three depth intervals:

- Interval I (0-2 m) representing an unstable environment experiencing stochastic events.
- Interval II (3-6 m) roughly covering the kelp zone.
- Interval III (>6 m) covering the deeper and more stable areas.

The input matrix of the ANOVA was balanced by selecting replicates by random, based on the smallest number of replicates found in any of the depth intervals I-III.

Homogeneity of variances were tested with Cochran's test (Winer et al. 1991). If variances were heterogeneous, data were transformed (either $\sqrt{\text{arc sin } x}$, $\sqrt{x+1}$ or ln(x) in that order). Analyses were run using SuperAnova 1.1 or Systat 5.2 for Apple Macintosh. The basic steps of the analysis are given in Fig. 3.

POWER ANALYSIS

The power of a test is a measure of its capability to detect differences between groups. In order to calculate power, estimates of the following parameters are necessary:

- The magnitude of the effect that one wants to detect.
- The number of observations on which each effect estimate is based.
- The variance within groups to be tested.
- The predetermined probability (α) of committing a type I error (the risk of stating that a difference exists, when in fact differences were only due to chance). This is the standard significance level α, commonly set to P=0.05.
- The predetermined probability (ß) of committing a type II error (the risk of stating that there is no difference between groups, when in fact such a difference exists). Presently, there is no generally accepted standard value for β, and the choice is left to the researcher.

The estimations can be derived from pilot studies, or, when the system is very well known, can be set by experience. The power of a test is then given by 1-ß (Underwood 1981, Winer et al. 1991).

Power estimations for the effect *Sampling date* x *Depth interval*, which expresses changes in depth characteristics over time, were derived from Model B ANOVA runs (Appendix III) of some of the taxa discussed below, and were calculated as:

$$\Phi^2 = \frac{(l^*t^*r/d^*s)^*\Sigma(\text{Observed effect deviations})^2}{MS_{DT(LS)},\ df=2:32}$$

Power for the effect *Date* (Model B ANOVA, Appendix III) was calculated from:

$$\Phi^2 = \frac{(l^*d^*t^*r/^*s)^*\Sigma(\text{Observed effect deviations})^2}{MS_{LS},\ df=1:3}$$

Φ is distributed as a non-central F-distribution. From the appropriate degrees of freedom and F, the power of a test can be estimated (Winer et al. 1991).

Calculating the observed effect deviations from the ANOVAs returns the power of the current

Table 2 Approximate powers for some parameters in survey alternatives

Model	Effect	Power
A	Year x Region	~0.80
	Year x Region x Depth	~0.95
B (alt 1)	Year x Region	~0.65
	Year x Region x Depth	~0.95
B (alt 2)	Year x Region	~0.50
	Year x Region x Depth	~0.90
B (alt 3)	Year x Region	~0.40
	Year x Region x Depth	~0.70

configuration. The different power figures of the present study, as well as the powers for alternative setups of the field programmes are shown in Figs 4 & 7. The 50% increase was calculated supposing a change from 4 to 6 localities (Localities occurring in both the nominator and the denominator of the F-quote). The corresponding decrease was based on a wish to keep the number of localities up as much as possible (regional concern), choosing to cut the number of replicates from 3 to 2, which all together resulted in a 50% decrease.

Using the same formula, it is also possible to estimate how long time it will take to detect a certain change using the current field study configuration (setting $\beta = 0.8$). In the present case, calculations were based on an annual change of 10% for the *Date* effect and 20% for the *Date* x *Depth interval* effect (Figs 5 & 8)

It is also possible to estimate the magnitude of the change needed in order to get significant deviations between two sampling dates (setting $\beta = 0.8$). Calculations were made to see the impact magnitude needed in order to have a significant difference at the next visit. The results are shown in Figs 6 & 9.

When studying the overall effect between years for, e.g. *Phyllophora* spp (Fig. 4), the power in the present study was found to exceed 0.95, which means that, given the same layout as in this pilot study, the probability of detecting a significant difference is more than 95 %. With this efficency it will take us about 4 years to detect a regional change of 10% (Fig. 5). In order to detect a significant change between one occasion and the next, the magnitude of change must be approximately 35% (Fig. 6). We can also see that if the sampling effort is cut by 50%, this means a reduction in power down to 60% (Fig. 4). On the contrary, increasing the effort with 50 % yields no power increase, but results in shorter period for detecting a 10 % difference (Fig. 4), as well as lowering the impact needed for us to see a result in one year (Fig. 6)

For the filamentous brown algae group the same increase in sampling effort would result in a power of more than 95%, and conversely, with a 50 % reduction the power would drop to 40% (Fig. 4). Increasing the sampling effort with 50%, reveals that the time needed to detect a 10% change (Fig. 5), or the impact required to detect a change in one year (Fig. 6), still remains high (9 years and 120%, respectively). The results for the effect *Date* x *Depth interval* are shown in Figs 7, 8 & 9.
The low power seen in many taxa can be attributed to either a very stable situation, with little changes at all, or to a patchy distribution causing variation. This emphazises the im portance of an adequate replicate area in relation to the size of the alga studied (Littler & Littler 1985). For some species (e.g. *Laminaria* spp.) the number of individuals could be a better parameter than the coverage data now used.(see also discussion on heterogeneity).

Future power
In the following an attempt to calculate the power resulting from different monitoring alternatives is presented (Appendices V & VI). The program incorporate two regions (*General* in Appendix V) and at least one intensive study area (*Intensive study* in Appendix V). When comparing regions (e.g. the Kattegat vs the Skagerrak, N Bohuslän vs S Bohuslän) and sampling is done in two different seasons each year, a more complex ANOVA model can be used (see Appendix III: ANOVA MODEL C). If sampling is performed just once a year, a simpler model is used, which does not include the seasonal factor. This latter model includes a combination of fixed and random factors that makes pooling of some variance components necessary. The actual formulas for this proceedure are given in textbooks (e.g. Winer et al. 1991). In Appendix V the term complex denotes such pooled variances. Since this pilot study does not involve multiregional field data, this approach is for future purposes.

A proper analysis of the suggested alternatives requires a knowledge of the variation between regions and seasons. In the absense of such data, approximate power estimations can be made for specific alternatives. A simple example is given in Table 2, which estimate the power of tests if during a three year period the difference between

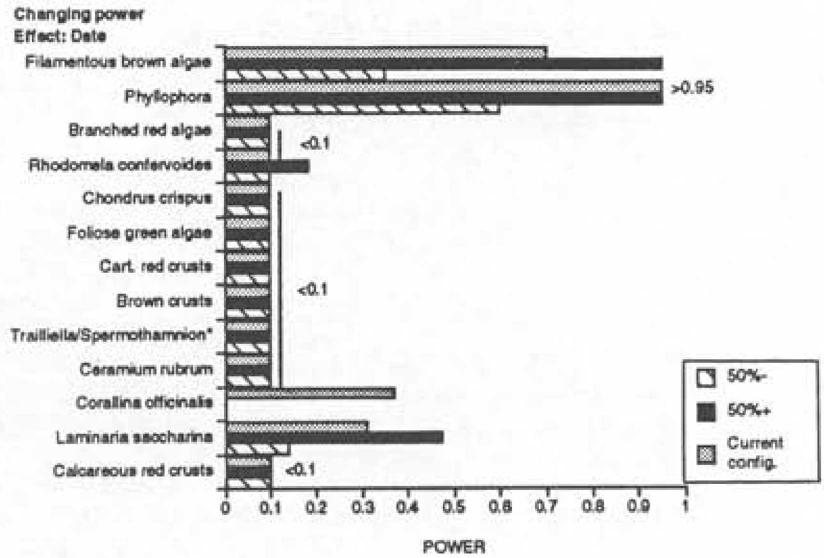


Fig. 4 Changing power

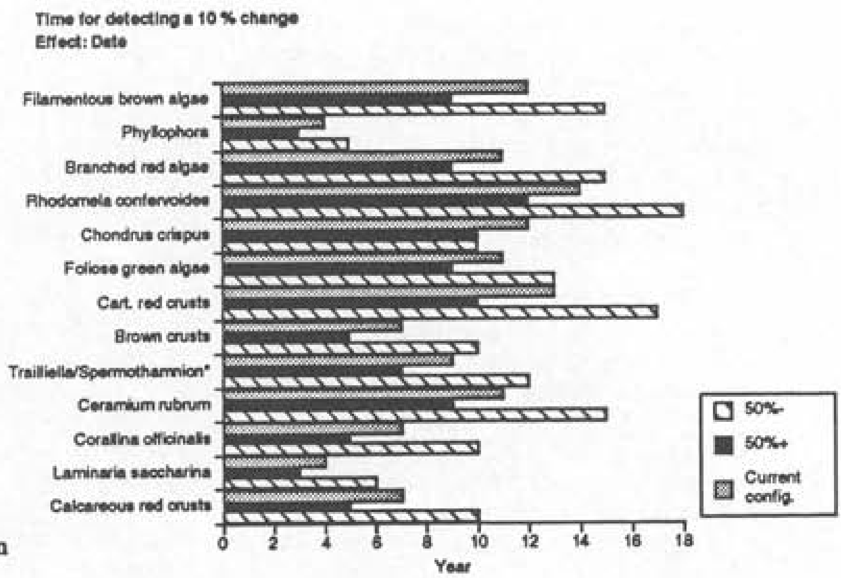


Fig. 5 Time needed for detection

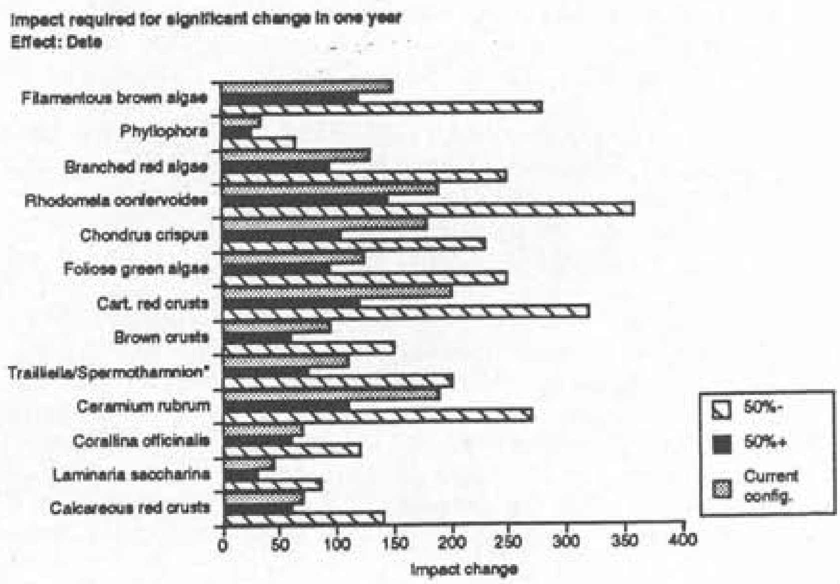


Fig. 6 Impact needed

regions becomes as large as the variance within regions (difference between groups = variance within groups).
As can be seen (Table 2), the power to detect overall differences between regions with time decreases considerably when sampling only once per year. However, the ability to detect differences in the development of depth charcteristics between regions is not influenced to the same extent.

FUTURE MONITORING PROGRAMMES

As discussed in the introduction there is concern also among the general public to have the changes in these rocky shore communities monitored. Furthermore, a future monitoring programme should be designed to cover the main subsystems of the Swedish coast.

We feel that a future monitoring programme should rest on a framework that could be tested statistically in a straightforward way. As has been shown above it is possible to detect changes within the macroalgal community, and also to give a sound biological interpretation of statistically significant changes for regions, times and depth intervals for several of the components.

When making the decision of a future monitoring programme the ordering authority (e.g. the Swedish Environmental Protection Agency) must state what they want to achieve:

- Do we want to follow a particular site in time?
- Do we want to monitor regional changes?
- Are we interested in gradients?
- Are we interested in monitoring more than one occasion per year?
- Do we want to cover different kinds of habitats?
- Are there some geographical areas that are of special concern?

The questions are a prerequisite, and must be answered by the authority before we can start to design future programmes. In some cases the same design can be used to answer multiple questions, for others there have to be separate designs.

The pilot study reported here only included sites along the Skagerrak coast, but a future programme also must comprise the Kattegat coast (Appendix III: ANOVA Model C), and preferably also some offshore areas such as the Fladen and the Middelgrund in the Kattegat, and some offshore island in the Skagerrak (separate designs could be needed). The offshore areas would cover areas less affected by coastal waters. The Öresund, with its steep and divers gradients, should be treated as a separate monitoring area, with its own programme.

So far only semi-exposed sites have been included. In Sweden, such sites have a higher species diversity than the more exposed ones, including the perennial species such as the large fucoids and kelps. Sheltered sites, on the other hand, would seldom cover the depth interval desired. This will add the factor *"Habitat"* to the model, and will, provided the current field setup is kept, increase the number of sites needed.

From a scientific point of view at least two seasons per year should be included in a future monitoring program and for stations in areas of special concern it should be carried out four times a year. Sampling in late summer would potentially include most of the annual macroalgal taxa encountered in increasing amounts in e.g. eutrophicated areas such as most summer annual green algae. On the other hand sampling in late spring (May) is the period most suitable for detecting changes in an overall species composition of the macroalgae, which facilitates observation of changes

Less regular sampling than once/year should not be used, since that strongly diminish the possibility to study long-term changes. Nor should a running interval be used. This design is not suitable for comparisons in regions where climatic changes between years can be considerable.

The power analyses (see Figs 5-9) were performed for two alternatives compared to the present pilot study: a) 50% increase in sampling/analysing effort, b) 50% decrease in sampling /analysing effort. This could be achived in various ways, changing either the number of localities, transects or the number of depth intervals used in the analysis, depending on the test preferred.

Another approach is changing the number of visits per year (see Table 2). As shown this decreases the ability to detect overall changes between regions. If the number of sites due to financial resources could not exceed 6 sites studied once a year, these ought not to be split between the different regions, but should rather be concentrated along some part of the coast. However, this would mean that there are no reference sites for regional programmes in all regions.

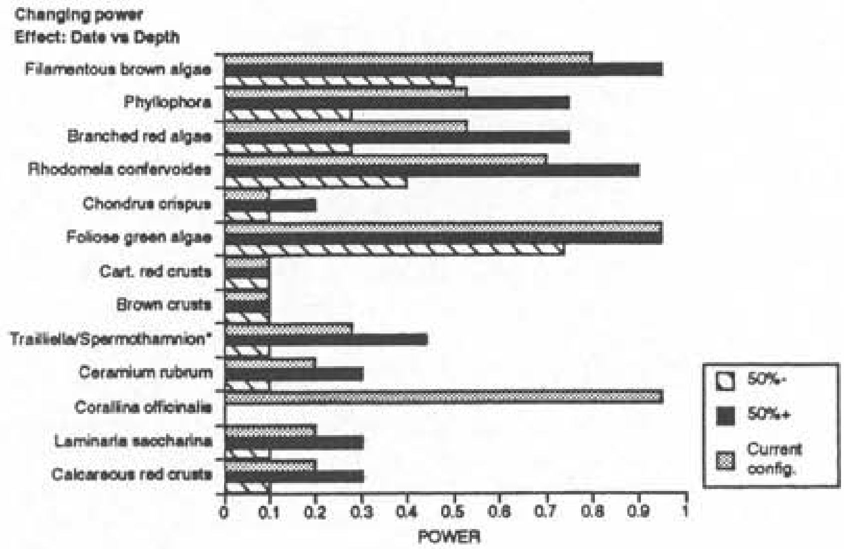


Fig. 7 Changing power

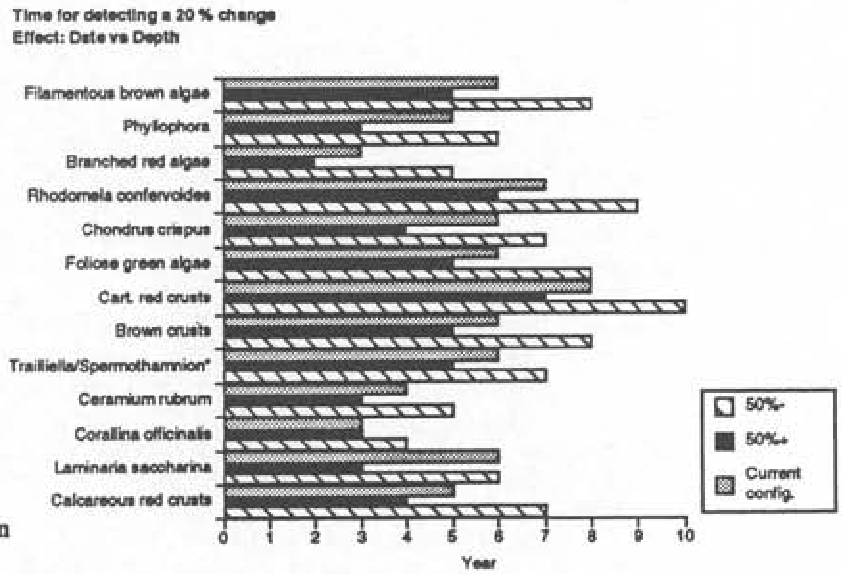


Fig. 8 Time needed for detection

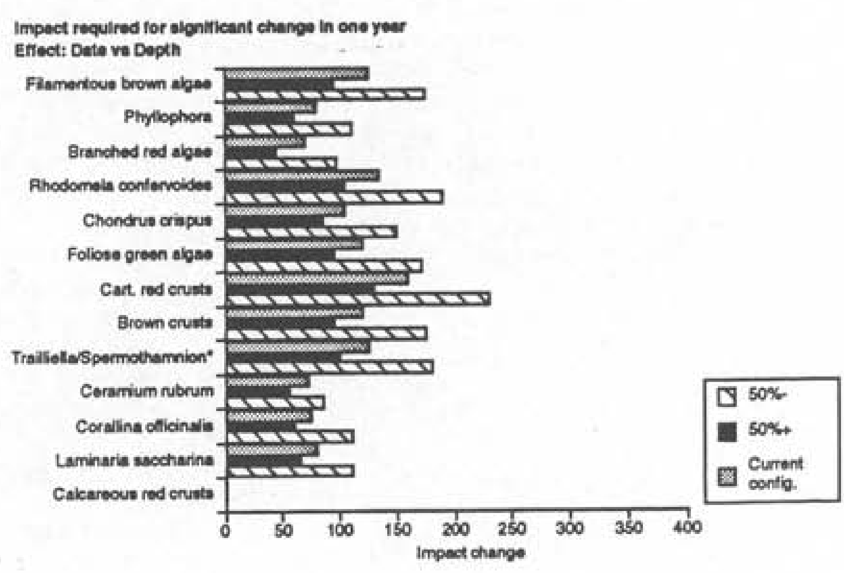


Fig. 9 Impact needed

If two samplings per year could not be accommodated within a future monitoring programme, the macroalgae and macrofauna of the rocky shore communities should be sampled in the same time period, keeping maximum efficency.

QUALITY CONTROL

The field work and digitizing of the data have been performed by the same person, thus enabling a thorough knowledge of the localities which facilitates the digitizing of the slides. Jan Karlsson is a well trained Ph D student (thesis will be finished in 1993) in marine botany at the university of Göteborg, with several years of experience of seaweeds both within his own research and in teaching at the university in both macroalgal taxonomy and marine ecology. He has also published papers in international journals, several of these dealing with new algal records for Sweden, which shows his great ability for making relevant observations. The results of the programme will be published in an international journal. They will also be compared with data sets from a study on *Laminaria* populations in N Bohuslän, to accomplish a correlation between what was seen in a picture and what was really there.

The statistical analyses have been performed in co-operation with Ph D P. Nilsson, a marine ecologist who during several years has been working with these type of statistical analyses and above all understands the problems of inferring statistics on biological data.

The use of photographs for identification of the taxa further enables rechecking of data (including checking by other experts). This will be further facilitated by the computor-based storage. In contrast destructive sampling would mean that most organisms after sorting and drying are not easily identified. Furthermore, such sampling would be much more time-consuming for samples from the Swedish west coast with its high biodiversity in comparison with the reduced number of species in the same communities in the Baltic Sea. The destructive sampling would, however, be more useful for projects needing biomass data and the mobile macrofauna would be included, too.

SELECTED RESULTS

Results from the ANOVA analyses based on percent coverage of taxa with homogenous variances are discussed below. Some taxa or functional form groups of special environmental interest, but with heterogenous variances, are also discussed. It should be pointed out that the results in the latter group should be interpreted with care. It is clear from the material that there are both bad and good runs. The header "Selected results" does not imply that only the favourable ones have been chosen.

Crusts

Crusts included in the analysis were calcareous red crusts, cartilagineous red crusts, brown crusts and dead red crusts. (see Table 1 for taxa included) All three groups were accepted in the Cochran tests. Crusts are of special interest since they are potentially sensitive to increasing sedimentation. Some of the calcareous red crusts may also be affected indirectly by increased grazing on kelp by sea urchins.

<u>Calcareous red algae</u> (Appendix IV: Fig. 1 a-d, Table 1) (not transformed)
There is no significant change in the region as a whole, and no trend in common for depth characteristics. However, this group shows significant variation between localities: there is a decrease in coverage in the more southernly situated localities Skällholmen and Sälö, and an increase at Fjällbacka and St Snart to the north. In the region, this group of crusts is common in depth interval II (3-6 m). The locality at Sälö differs significantly with higher values at depths >6m (depth interval III).

<u>Cartilagineous red crusts</u> (Appendix IV: Fig. 2 a-d, Table 2) (log transformed)
There is no significant change in the region as a whole, and no trend in common for depth characteristics. Again there was a significant variation between localities. The Sälö locality differed since the group was missing in the two upper depth intervals(0-6 m, depth intervals I & II).

<u>Brown crusts</u> (Appendix IV: Fig. 3 a-d, Table 3) (arcsine transformed)
There is no significant development pattern characterizing the region. A distinct preference for depths greater than 6 m can be noted.

<u>Dead red crusts</u> (log transformed)
Failed in the Cochran test which suggests careful interpretation. A slight non-significant increase in

the area. Depth characteristics are significantly different and develop significantly in different ways with time.

Branched red algae (Appendix IV: Fig. 4 a-d, Table 4) (arcsine transformed)
In this group branched forms such as *Ceramium* spp., *Polysiphonia* spp. and *Rhodomela confervoides* have been included. There is a significant change in depth characteristics between the two years in the whole region, caused by an increase in cover at depths below 3 m, and a decrease in depths between 0-2 m There are also significant differences between localities: Skällholmen and Sälö show an increase, while Fjällbacka and St Snart show a decrease in the coverage of branched red algae. At Sälö there is a significant increase in depths between 3-6 m. For *Rhodomela confervoides* (Appendix IV: Fig. 5 a-d, Table 5) (log transformed) the pattern is the same, with a significant increase in deeper regions, and a decrease nearer the surface, indicating a favourable year. However, there is variation between localities, which is non-significant, presumably because of significant variation within localities. *Ceramium rubrum* (Appendix IV: Fig. 6 a-d, Table 6) (log transformed) show no regional change, but there are again significant differences between localities. In the northern part, Fjällbacka and St Snart show a decrease, while Skällholmen and Sälö in the southern part show an increase, indicating the dominance of this species in the branched red algal group
For both *R. confervoides* and *C. rubrum* the Sälö locality deviates because of a richer vegetation in depths between 3-6 m.

Bonnemaisonia hamifera *(Trailliella-*phase) & ***Spermothamnion repens*** (Appendix IV: Fig. 7 a-d, Table 7) (log transformed)
In the field it is impossible to distinguish between these two species. The filamentous tetrasporophyte of *B. hamifera* was about a decade ago claimed to have increased at the expense of perennial species such as *Halidrys siliquosa* (T. Lundälv pers. comm.). The present study found no significant regional differences, while significant variation occurred between localities. The Sälö locality differed in lacking this species at depths above 6 m.

Corallina officinalis (Appendix IV: Fig. 8 a-d, Table 8) (arcsine transformed)
There have been indications that this species have decreased in some areas in the Kattegat region (Karlsson 1986). In the region now studied, the data shows an almost significant regional decrease in time (p=0.075). However, a significant decrease in the two upper depth intervals studied (0-2, 3-6 m) can be seen, while lower depths shows no such decrease. The locality at Sälö differs, showing lower values at depths between 3 and 6 m.

Chondrus crispus (Appendix IV: Fig. 9 a-d, Table 9) (arcsine transformed)
No common change for the region has been demonstrated. Among localities, St Snart shows a significant decline at depths below 6 m. Sälö shows lower values in all depth intervals than the rest of the localities.

Phyllophora spp. (Appendix IV: Fig. 10 a-d, Table 10) (log transformed)
There is a significant regional increase at all depth intervals, with levels below 6 m contributing the most. This can be seen as a trend for all the localities. There is also a significant increase of *Phyllophora* at depths below 6 m for Sälö and for St Snart.

Laminaria saccharina (Appendix IV: Fig. 11 a-d, Table 11)
While being rather stable in the region, the *Laminaria* population shows a non-significant trend of increasing at all localities, except for Fjällbacka. Sälö differs, showing lower values in the two upper depth intervals (<6 m), than the rest of the localities. There is considerable variation within and between localities.

Foliaceous green algae (Appendix IV: Fig. 12 a-d, Table 12) (log transformed)
During the period there was a regional decrease at depths between 0-2 m, and an increase at depths between 3-6 m. There was significant variation between localities, with Sälö showing a general increase, the depths between 3-6 m contributing the most.

Taxa showing heterogenous variances
Many of the tested variables still showed heterogeneous variances, even after being transformed, as demonstrated by the Cochran test. This included species or groups which are of specific interest for monitoring. The results from the ANOVA tests involving these variables should be used with caution, as cited significant p-values may be incorrect. Patchy distribution of macroalgal species is a well known phenomenon (e.g. Hawkins & Hartnoll 1983, 1985). There are several ways to avoid this problem:

1) Restrict tests to dates or depth intervals where the particular species is common.
2) Test for heterogenous variances using a detection level of e.g. P=0.01. If variances are homogenous at this level, subsequent ANOVA tests are performed at this level, too.
3) Pool the values for several samples. However, this means that important interactions may be hidden.
4) Randomization procedures can be used to construct data-specific "F-distributions", not sensitive to variance heterogeneity.

Filamentous brown algae (log transformed)
For this group a significant decrease in the whole region was demonstrated at all depths, and the decrease was significantly larger at greater depths.

Foliaceous red algae (log transformed)
This group consists of the delesseriaceans, to which *Delesseria sanguinea* contributes the most. For the group as a whole, there is no significant regional change, although there is a significant change in the occurrence between localities. Future studies of this group would benefit from applying different ranges when constructing the depth intervals. For the group as a whole, the Sälö locality differs showing a marked increase, while there is a decline at the Fjällbacka locality during the period. For *D. sanguinea* (log transformed) the pattern is similar.

Fucus serratus (log transformed)
There is no regional change over the period. The preference for shallow habitats in this species can clearly be seen. Fjällbacka differs in having a distinct *F. serratus* belt, while Sälö shows just scattered individuals.

Halidrys siliquosa (log transformed)
Halidrys siliquosa was claimed to have decreased during the the late 1970s, after which it increased slowly (Lundälv et al. 1986). In this study there was no significant regional change. A depth gradient is clearly visible with significant dominance in depths between 3-6 m. No significant variation between localities.

Desmarestia aculeata (log transformed)
Future studies of this species must involve application of different ranges when constructing the depth intervals. Because of very few records above 6 m (Sälö being the exception), the analysis is biased. Keeping this in mind, a significant regional increase at greater depths can be seen, with considerable variation between localities.

Filamentous green algae (log transformed)
Includes *Spongomorpha* spp. and *Acrosiphonia* spp. No regional change, but considerable variation between localities, both in over all occurrences and in depth characteristics.

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Appendices I-VI

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Appendix Ia

TABLE Depth range of taxa.

Min = min. depth, Max = max. depth, both recorded from slides. *f*Max = additional max. depth based on field data. Only given if exceeding Max. Freq. = proportion replicates where found.

Locality: Fjällbacka ->	Fba	Fba	Fba	Fba	Fba	Fba	Fba	Fba	Fba	Fba	Fba	Fba
Date ->	9005	9005	9005	9008	9008	9008	9105	9105	9105	9005	9008	9105
Taxon	Min	Max	*f*Max	Min	Max	*f*Max	Min	Max	*f*Max	Freq.	Freq.	Freq.
Ahnfeltia plicata				4	4					0	2	0
Apoglossum ruscifolium				8	12					0	6	0
Bonnemaisonia asparagoides										0	0	0
Brongniartella byssoides	3	12	12	3	14		8	8		12	41	2
Cartilag. red crusts	1	14		2	12		2	14		20	38	29
Ceramium cf. strictum				1	1					0	2	0
Ceramium rubrum	1	12		0	14		0	14		62	75	64
Ceramium spp.	2	2		0	0					2	6	0
Chondrus crispus	1	16		2	16		1	13		61	81	54
Corallina officinalis	1	8	8	2	10		2	12		45	54	51
Cystoclonium purpureum	1	8		2	8		1	6	6	17	24	24
Dead crusts	3	3		2	4		2	4		2	6	10
Delesseria sanguinea	6	16		8	8	13	3	16		50	2	36
Dilsea carnosa										0	0	0
Dumontia contorta										0	0	0
Furcellaria lumbricalis	2	14		2	12	14	3	12		33	33	24
Hildenbrandia rubra	1	1		0	1		0	8		3	10	8
Lomentaria clavellosa	8	8								2	0	0
Membranoptera alata				3	3					0	2	0
Nemalion multifidum				0	0					0	3	0
Odonthalia dentata	10	10		12	12	14				2	3	0
Peysonnelia spp.	14	14		10	16					2	10	0
Phycodrys rubens	2	16		12	14		3	16	16	24	5	15
Phyllophora pseudoceranoides										0	0	0
Phyllophora sp.	2	16		2	16		2	16		61	67	73
Phyllophora truncata	12	12								2	0	0
Phymatolithon purpureum	2	3		3	4		3	3		3	3	2
Calc. red crusts	1	16		1	16		1	16		77	75	80
Polyides rotundus	2	6		2	8		2	6		5	5	7
Polysiphonia brodiaei				0	0					0	2	0
Polysiphonia elongata	2	14		4	14	14	10	10		6	30	2
Polysiphonia nigrescens	1	12		0	6		1	13		14	13	15
Polysiphonia spp.	8	10	12							6	0	0
Polysiphonia urceolata	2	15		12	12		4	14		36	2	39
Polysiphonia violacea	1	1								3	0	0
Porphyra spp.	3	3								2	0	0
Porphyra umbilicalis										0	0	0
Rhodomela confervoides	1	13		6	6		4	14	14	36	2	47
Trailliella/Spermothamnion	2	13		2	14		3	14		55	65	36
Chorda filum	6	6		6	8	8				3	5	0
Chorda tomentosa										0	0	0
Chordaria flagelliformis										0	0	0
Cutleria cf. Aglaozonia	10	10		8	12					2	8	0
Desmarestia aculeata							4	4		0	0	2
Desmarestia viridis							4	4		0	0	2
Dictyosiphon sp.							4	10		0	0	15
Ectocarpales sp.	1	10		2	6		4	12		18	17	14
Ectocarpus sp.	4	8								12	0	0
Fucus serratus	1	3	3	0	4		0	6		18	32	36
Fucus spp.										0	0	0
Fucus vesiculosus	1	1		0	2		0	1		2	10	5
Halidrys siliquosa	3	6		3	6	8	3	8		6	11	5
Laminaria digitata	2	3		1	1	2	1	2		3	2	5
Laminaria hyperborea										0	0	0
Laminaria saccharina	1	11	12	1	14	14	1	13		55	59	63
Laminaria sp.										0	0	0
Petalonia sp.				0	0					0	2	0
Pilayella littoralis										0	0	0
Pseudolithoderma/Lithoderma sp.	2	16		2	16		2	16		59	60	51
Ralfsia spp.										0	0	0
Sargassum muticu-	4	4	6	2	3	6	4	4		2	3	2
Scytosiphon lomentaria										0	0	0
Sphacelaria cf plum....										0	0	0
Sphacelaria cirrosa										0	0	0
Sphacelaria spp.				6	6		4	8		0	2	3
Acrosiphonia sp.										0	0	0
Bryopsis sp.										0	0	0
cf Bryopsis green filaments	3	3								3	0	0
Chaetomorpha melagonium										0	0	0
Cladophora rupestris	1	2		0	10		1	6		6	17	7
Cladophora spp.	3	3		0	0					2	3	0
Codium fragile										0	0	0
Enteromorpha spp.	1	3		0	1					5	8	0
Monostroma spp.	3	3								2	0	0
Spongomorpha spp.	1	6					1	10		6	0	14
Ulothrix/Urospora spp.	1	1					0	0		3	0	2
Ulva/Ulvaria sp.	1	6		0	8		2	12		20	22	20

Appendix Ib

TABLE Depth range of taxa.
Min = min. depth, Max = max. depth, both recorded from slides. *f*Max = additional max. depth based on field data. Only given if exceeding Max. Freq. = proportion replicates where found.

Locality: Skällholmen ->	Skällh	Skällh	Skällh	Skällh	Skällh	Skällh	Skällh	Skällh	Skällh	Skällh	Skällh	Skällh
Date ->	9005	9005	9005	9008	9008	9008	9105	9105	9105	9005	9008	9105
Taxon	Min	Max	*f*Max	Min	Max	*f*Max	Min	Max	*f*Max	Freq.	Freq.	Freq.
Ahnfeltia plicata	1	2	2	0	1		1	2		8	8	14
Apoglossum ruscifolium										0	0	0
Bonnemaisonia asparagoides										0	0	0
Brongniartella byssoides	4	14		8	10		6	6		36	5	3
Cartilag. red crusts	2	16		2	10		3	15		26	14	29
Ceramium cf. strictum										0	0	0
Ceramium rubrum	0	14		1	14		1	10		70	50	19
Ceramium spp.										0	0	0
Chondrus crispus	0	14		1	14		1	12		70	53	53
Corallina officinalis	0	14		0	10		1	18		64	49	54
Cystoclonium purpureum	1	4		1	8		1	6		12	21	7
Dead crusts	2	10		0	6		1	2		9	15	3
Delesseria sanguinea			18	2	18		8	18		0	42	36
Dilsea carnosa				14	18				16	0	5	0
Dumontia contorta				0	1		1	1		0	9	1
Furcellaria lumbricalis	4	10	12	1	12		4	8	9	16	27	21
Hildenbrandia rubra	0	1		1	1		8	8		7	1	3
Lomentaria clavellosa										0	0	0
Membranoptera alata				2	3					0	8	0
Nemalion multifidum	0	3								3	0	0
Odonthalia dentata				12	12					0	1	0
Peysonnelia spp.	14	14					8	14		1	0	4
Phycodrys rubens				1	18		4	10	17	0	12	3
Phyllophora pseudoceranoides										0	0	0
Phyllophora sp.	2	18	18	1	18		1	18		54	78	71
Phyllophora truncata										0	0	0
Phymatolithon purpureum										0	0	0
Calc. red crusts	0	18		0	18		1	18		81	82	92
Polyides rotundus	3	3		3	3		2	2		1	1	3
Polysiphonia brodiaei	1	1								3	0	0
Polysiphonia elongata	10	14		6	6					8	3	0
Polysiphonia nigrescens				2	2		1	3		0	1	10
Polysiphonia spp.	4	4								1	0	0
Polysiphonia urceolata				6	16		10	14	16	0	15	6
Polysiphonia violacea				1	1		1	1	1	0	4	8
Porphyra spp.										0	0	0
Porphyra umbilicalis				1	1					0	1	0
Rhodomela confervoides				2	16				14	0	41	0
Traillieila/Spermothamnion	6	12		1	18		1	16		27	28	43
Chorda filum	4	4								1	0	0
Chorda tomentosa				1	10		8	8		0	6	1
Chordaria flagelliformis										0	0	0
Cutleria cf. Aglaozonia							14	16		0	0	6
Desmarestia aculeata	10	10	12	8	12		8	10	16	3	18	11
Desmarestia viridis										0	0	0
Dictyosiphon sp.									8	0	0	0
Ectocarpales sp.	2	8	12	0	10		1	12		11	12	43
Ectocarpus sp.	3	4								4	0	0
Fucus serratus	1	8		1	6		1	4		16	13	11
Fucus spp.	3	3								1	0	0
Fucus vesiculosus	0	1								3	0	0
Halidrys siliquosa	2	10		1	10		1	6	10	15	19	19
Laminaria digitata	1	2	4	1	2	2	1	2	2	5	9	13
Laminaria hyperborea										0	0	0
Laminaria saccharina	1	14	12	1	14		1	14	14	35	60	46
Laminaria sp.										0	0	0
Petalonia sp.										0	0	0
Pilayella littoralis				0	1					0	6	0
Pseudolithoderma/Lithoderma sp.	6	18		4	18		4	18		49	44	54
Ralfsia spp.	0	1								7	0	0
Sargassum muticum										0	0	0
Scytosiphon lomentaria										0	0	0
Sphacelaria cf plum....										0	0	0
Sphacelaria cirrosa										0	0	0
Sphacelaria spp.	6	8		8	8		1	6		3	1	3
Acrosiphonia sp.				0	0				0	0	3	0
Bryopsis sp.							2	2		0	0	1
cf Bryopsis green filaments										0	0	0
Chaetomorpha melagonium	1	6					1	1		4	0	1
Cladophora rupestris	0	8		1	4		1	4		14	6	22
Cladophora spp.	1	1								1	0	0
Codium fragile							12	12		0	0	1
Enteromorpha spp.										0	0	0
Monostroma spp.										0	0	0
Spongomorpha spp.				1	1		1	4		0	1	11
Ulothrix/Urospora spp.										0	0	0
Ulva/Ulvaria sp.	1	10		1	10		1	6	7	11	18	7

Appendix Ic

TABLE Depth range of taxa.
Min = min. depth, Max = max. depth, both recorded from slides. *f*Max = additional max. depth based on field data. Only given if exceeding Max. Freq. = proportion replicates where found.

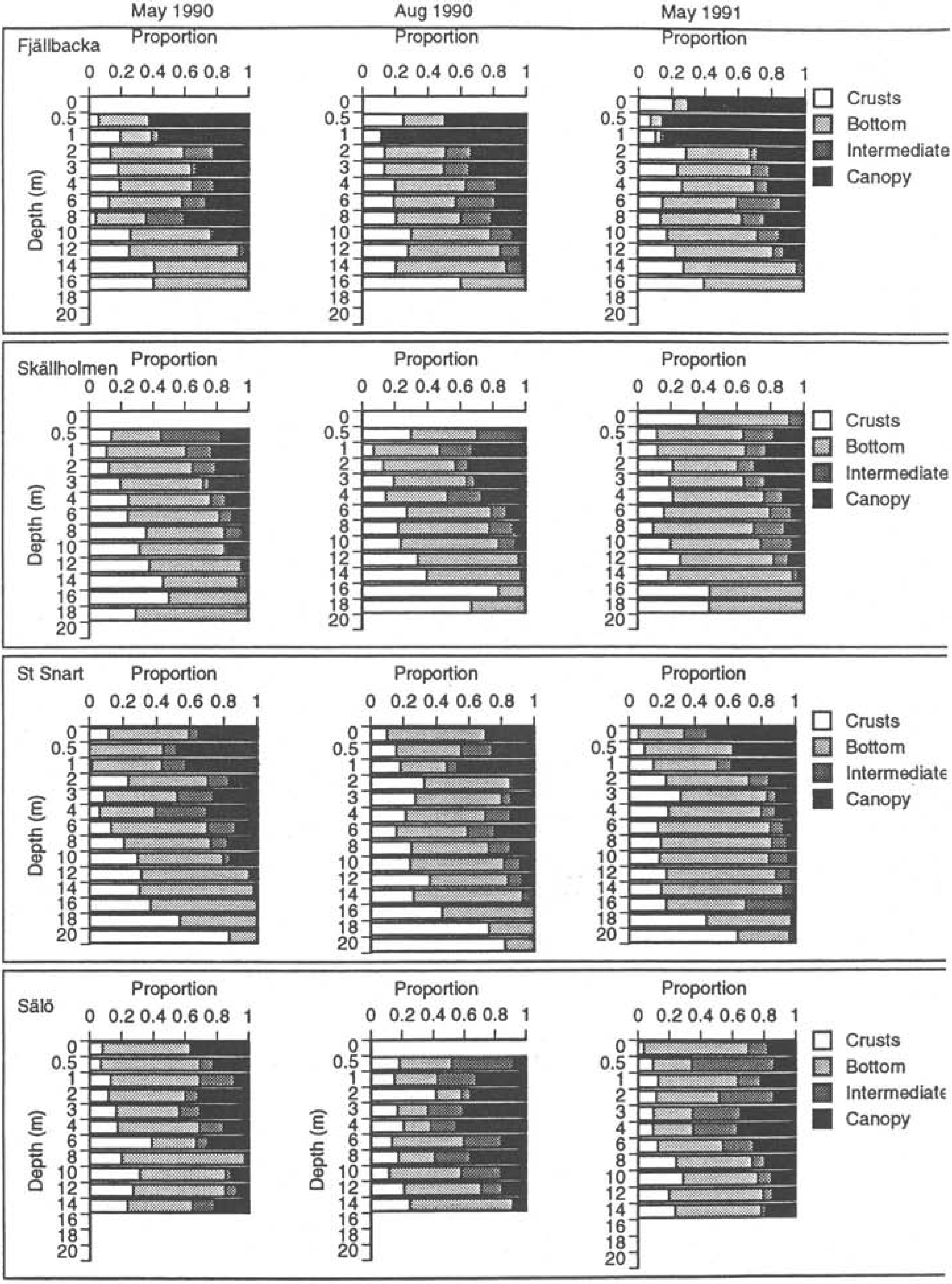
Locality: St Snart ->	St Snart	St Snart	St Snart	St Snart	St Snart	St Snart	St Snart	St Snart	St Snart	St Snart	St Snart	St Snart
Date ->	9005	9005	9005	9008	9008	9008	9105	9105	9105	9005	9008	9105
Taxon	Min	Max	*f*Max	Min	Max	*f*Max	Min	Max	*f*Max	Freq.	Freq.	Freq.
Ahnfeltia plicata	1	1		1	1					1	1	0
Apoglossum ruscifolium	10	16								5	0	0
Bonnemaisonia asparagoides										0	0	0
Brongniartella byssoides	4	10		12	12		3	10		13	1	20
Cartilag. red crusts	2	20		3	20		2	18		49	31	35
Ceramium cf. strictum	0	1					0	4		5	0	2
Ceramium rubrum	0	14		0	18		0	12	1	56	57	56
Ceramium spp.	1	3		1	1		0	4		3	3	11
Chondrus crispus	1	16		0	16		0	14		58	51	54
Corallina officinalis	1	14		0	16		0	14		58	49	64
Cystoclonium purpureum	1	4		0	14		0	8	1	10	10	15
Dead crusts										0	0	0
Delesseria sanguinea	14	18	20	3	18	18	6	20		5	49	43
Dilsea carnosa	14	14		16	16					3	1	0
Dumontia contorta				0	0					0	1	0
Furcellaria lumbricalis	4	14		6	14		2	14		14	10	25
Hildenbrandia rubra	0	3		1	4		0	2		13	14	7
Lomentaria clavellosa				3	20		6	10		0	8	6
Membranoptera alata							6	6		0	0	1
Nemalion multifidum	0	0				0				1	0	0
Odonthalia dentata				14	14		12	16		0	1	4
Peysonnelia spp.	12	14					12	14		4	0	2
Phycodrys rubens	6	16	20	1	20	18	2	18	18	6	56	24
Phyllophora pseudoceranoides				2	16		6	6		0	13	1
Phyllophora sp.	0	20	20	1	20		1	20		74	74	58
Phyllophora truncata	16	16		2	20		4	16		3	19	2
Phymatolithon purpureum	2	3		2	4		2	3		9	17	7
Calc. red crusts	1	20		0	20		1	20		88	79	64
Polyides rotundus	4	6		3	6		6	6		4	3	1
Polysiphonia brodiaei	1	1								1	0	0
Polysiphonia elongata	1	8		10	10		1	1		4	1	1
Polysiphonia nigrescens	1	3		6	6		0	1		3	3	4
Polysiphonia spp.				1	1		1	4		0	1	4
Polysiphonia urceolata	10	10		1	20		1	18		1	55	40
Polysiphonia violacea							0	1		0	0	10
Porphyra spp.										0	0	0
Porphyra umbilicalis										0	0	0
Rhodomela confervoides	8	8		0	16		0	14	16	3	38	29
Trailliella/Spermothamnion	0	16		3	16		2	16		68	40	50
Chorda filum										0	0	0
Chorda tomentosa				1	1		2	8		0	1	17
Chordaria flagelliformis										0	0	0
Cutleria cf. Aglaozonia	14	14								1	0	0
Desmarestia aculeata	6	10		8	14		4	10	12	6	13	8
Desmarestia viridis				8	14		3	3		0	10	1
Dictyosiphon sp.										0	0	0
Ectocarpales sp.	1	6		4	18		0	10		9	22	35
Ectocarpus sp.							6	6		0	0	1
Fucus serratus	0	1	1	0	6		0	1	1	14	13	10
Fucus spp.										0	0	0
Fucus vesiculosus	0	1				1	0	0		4	0	1
Halidrys siliquosa	6	10		3	10	6	3	6		4	9	4
Laminaria digitata				1	4		0	1		0	3	2
Laminaria hyperborea										0	0	0
Laminaria saccharina	1	16		0	14		1	12	12	55	62	51
Laminaria sp.							14	14		0	0	1
Petalonia sp.										0	0	0
Pilayella littoralis										0	0	0
Pseudolithoderma/Lithoderma sp.	3	20		3	20		4	20		70	62	56
Ralfsia spp.										0	0	0
Sargassum muticum										0	0	0
Scytosiphon lomentaria				0	0					0	1	0
Sphacelaria cf plum....				8	8					0	1	0
Sphacelaria cirrosa	6	6								1	0	0
Sphacelaria spp.	6	6					3	3		1	0	1
Acrosiphonia sp.							2	2		0	0	1
Bryopsis sp.				4	4		2	4		0	1	4
cf Bryopsis green filaments							2	3		0	0	2
Chaetomorpha melagonium	1	3		10	10		1	10		3	1	6
Cladophora rupestris	1	2		0	2		1	2		6	5	11
Cladophora spp.	0	3					2	4		5	0	10
Codium fragile										0	0	0
Enteromorpha spp.	0	6				1			0	6	0	0
Monostroma spp.							0	1		0	0	6
Spongomorpha spp.				0	1		0	4		0	3	17
Ulothrix/Urospora spp.				1	1		0	0		0	1	1
Ulva/Ulvaria sp.	1	16		0	16		0	10	1	38	31	38

TABLE Depth range of taxa.
Min = min. depth, Max = max. depth, both recorded from slides. *f*Max = additional max. depth based on field data. Only given if exceeding Max. Freq. = proportion replicates where found.

Locality: Sälö ->	Sälö	Sälö	Sälö	Sälö	Sälö	Sälö	Sälö	Sälö	Sälö	Sälö	Sälö	Sälö
Date ->	9005	9005	9005	9008	9008	9008	9105	9105	9105	9005	9008	9105
Taxon	Min	Max	*f*Max	Min	Max	*f*Max	Min	Max	*f*Max	Freq.	Freq.	Freq.
Ahnfeltia plicata	1	1		1	1		2	2		9	3	1
Apoglossum ruscifolium	12	14								7	0	0
Bonnemaisonia asparagoides							8	8		0	0	1
Brongniartella byssoides	3	13								30	0	0
Cartilag. red crusts	6	14		4	14		6	10		9	15	9
Ceramium cf. strictum										0	0	0
Ceramium rubrum	1	13		0	14		0	14		93	81	49
Ceramium spp.	1	1		0	3		0	4		21	29	16
Chondrus crispus	1	14		0	14		0	14		35	47	36
Corallina officinalis	1	14		0	14		0	14		60	86	72
Cystoclonium purpureum	1	12		1	14		3	3	8	40	53	1
Dead crusts	3	12		1	10		1	6		11	17	9
Delesseria sanguinea	12	14		3	14		10	14		4	39	16
Dilsea carnosa	12	13		14	14					5	2	0
Dumontia contorta				0	1		0	3		0	7	17
Furcellaria lumbricalis	4	13		6	10		3	14		16	5	31
Hildenbrandia rubra	1	1					0	1		2	0	7
Lomentaria clavellosa	13	13		12	12					2	2	0
Membranoptera alata										0	0	0
Nemalion multifidum										0	0	0
Odonthalia dentata				14	14					0	3	0
Peysonnelia spp.										0	0	0
Phycodrys rubens	12	14		4	14		12	14		5	20	7
Phyllophora pseudoceranoides										0	0	0
Phyllophora sp.	4	14		3	14		3	14		30	64	42
Phyllophora truncata										0	0	0
Phymatolithon purpureum										0	0	0
Calc. red crusts	1	14		0	14		0	14		96	93	89
Polyides rotundus				2	12		4	4		0	10	1
Polysiphonia brodiaei	1	1								21	0	0
Polysiphonia elongata	8	13		8	14					4	5	0
Polysiphonia nigrescens	12	12		0	14		2	3		2	27	2
Polysiphonia spp.				0	0					0	2	0
Polysiphonia urceolata				1	14		1	14		0	24	58
Polysiphonia violacea				0	2		1	2		0	12	6
Porphyra spp.										0	0	0
Porphyra umbilicalis										0	0	0
Rhodomela confervoides	8	8		2	14		3	3	5	2	32	1
Trailliella/Spermothamnion	6	14		8	10		3	14		33	3	10
Chorda filum	3	6				6	3	4		19	0	7
Chorda tomentosa	4	4		0	8		0	8		2	19	40
Chordaria flagelliformis	1	6		0	6		1	2	3	33	46	17
Cutleria cf. Aglaozonia										0	0	0
Desmarestia aculeata	6	13		1	14		10	10	11	23	41	1
Desmarestia viridis	6	6		2	8				8	2	17	0
Dictyosiphon sp.										0	0	0
Ectocarpales sp.	4	4		4	4		1	10		2	2	37
Ectocarpus sp.							1	1		0	0	1
Fucus serratus				4	8		3	3	6	0	8	1
Fucus spp.										0	0	0
Fucus vesiculosus							0	0		0	0	1
Halidrys siliquosa	1	8		3	6		1	6		14	10	19
Laminaria digitata	1	2		0	4		2	2	4	16	10	1
Laminaria hyperborea							10	14	14	0	0	2
Laminaria saccharina	4	14		1	14		3	14	14	40	63	27
Laminaria sp.										0	0	0
Petalonia sp.				0	0	1	0	2		0	3	12
Pilayella littoralis							0	2		0	0	9
Pseudolithoderma/Lithoderma sp.	6	14		4	14		3	14		26	34	44
Ralfsia spp.										0	0	0
Sargassum muticum	8	10				8			6	4	0	0
Scytosiphon lomentaria				0	0					0	2	0
Sphacelaria cf plum....										0	0	0
Sphacelaria cirrosa										0	0	0
Sphacelaria spp.	8	8								4	0	0
Acrosiphonia sp.							1	1		0	0	2
Bryopsis sp.										0	0	0
cf Bryopsis green filaments										0	0	0
Chaetomorpha melagonium	10	10					0	3		2	0	4
Cladophora rupestris							3	3		0	0	2
Cladophora spp.	12	12								2	0	0
Codium fragile							4	4		0	0	1
Enteromorpha spp.							0	0		0	0	1
Monostroma spp.				0	3		0	2	0	0	17	11
Spongomorpha spp.				0	4		0	6		0	42	31
Ulothrix/Urospora spp.										0	0	0
Ulva/Ulvaria sp.	3	12		1	12		1	14		40	31	42

Appendix II

Proportions of strata. Graphs constructed from the average number of strata recorded in each depth.



Appendix III

Components of ANOVA models.

Model A Sampling more than one locality on different occasions.
Locality treated as a fixed factor

Main factors:
L= Locality
S= Sampling date
D= Depth interval
T= Transect
N= Replicates

Effect	Mean Square tested over	Degrees of freedom	Effect
L	T(LS)	(l-1)/(t-1)ls	1
D	DT(LS)	(d-1)/(d-1)(t-1)ls	2
S	T(LS)	(s-1)/(t-1)ls	3
LD	DT(LS)	(d-1)(t-1)/(d-1)(t-1)ls	4
LS	T(LS)	(l-1)(s-1)/(t-1)ls	5
DS	DT(LS)	(d-s)(s-1)/(d-1)(t-1)ls	6
LDS	DT(LS)	(l-1)(d-1)(s-1)/(d-1)(t-1)ls	7
T(LS)	Residual	(t-s)ls/lsdt(n-1)	8
DT(LS)	Residual	(d-1)(t-1)ls/lsdt(n-1)	9

Effects
1 Differences between localities, averaged over depth, and sampling date.
2 Differences between depths, averaged over locality, and sampling date.
3 Differences between sampling dates, averaged over locality and depth.
4 The tested variable shows different depth characteristics at different localities, averaged over sampling date.
5 The localities show different development with time, averaged over depth.
6 The depth characteristic of the tested variable changes with time, averaged over locality.
7 The depth characteristic of the tested variable changes in different ways at different localities.
8 Transects differ at a specific locality on a specific sampling date, averaged over all depth intervals.
9 The depth characteristic of the tested variable differs among the transects at a specific site on a specific sampling date.

If we are interested in monitoring the fate of specific localities, effects 5 and 7 are of special concern.

Model B Sampling more than one locality on different occasions.
Locality treated as a random factor.

Main factors:
L= Locality
S= Sampling date
D= Depth interval
T= Transect
N= Replicates

Effect	Mean Square tested over	Degrees of freedom	Effect
L	T(LS)	(l-1)/(t-1)ls	1
D	LD	(d-1)/(l-1)(d-1)	2
S	LS	(s-1)/(l-1)(s-1)	3
LD	DT(LS)	(d-1)(l-1)/(d-1)(t-1)ls	4
LS	T(LS)	(l-1)(s-1)/(t-1)ls	5
DS	DT(LS)	(d-1)(s-1)/(d-1)(t-1)ls	6
LDS	DT(LS)	(l-1)(d-1)(s-1)/(d-1)(t-1)ls	7
T(LS)	Residual	(t-s)ls/lsdt(n-1)	8
DT(LS)	Residual	(d-1)(t-1)ls/lsdt(n-1)	9

Effects
1 Differences between localities, averaged over depth, and sampling date.
2 Differences between depths, averaged over locality, and sampling date.
3 Differences between sampling dates, averaged over locality and depth.
4 The tested variable shows different depth characteristics at different localities, averaged over sampling date.
5 The localities show different development with time, averaged over depth.
6 The depth characteristic of the tested variable changes with time, averaged over locality.
7 The depth characteristic of the tested variable changes in different ways at different localities.
8 Transects differ at a specific locality on a specific sampling date, averaged over all depth intervals.
9 The depth characteristic of the tested variable differs among the transects at a specific site on a specific sampling date.

If we are interested in monitoring changes in a region are effects 3 and 6 of special concern.

Model C Comparing different regions on different occasions, and in each region sampling more than one locality. Locality treated as a random factor.

Main factors:
Y= Year
R= Region
L= Locality
S= Sampling date (represents a season, eg. spring)
D= Depth interval
T= Transect
N= Replicates

Effect	Mean Square tested over	Degrees of freedom	Effect
Y	YL(R)	(y-1)/(y-1)r(l-1)	1
S	SL(R)	(s-1)/(s-1)r(l-1)	2
R	L(R)	(r-1)/r(l-1)	3
D	DL(R)	(d-1)/(d-1)r(l-1)	4
YS	YSL(R)	(y-1)(s-1)/(y-1)(s-1)r(l-1)	5
YR	T(L(R)YS)	(y-1)(r-1)/(t-1)lrys	6
YD	YDL(R)	(y-1)(d-1)/(y-1)(d-1)r(l-1)	7
SR	SL(R)	(s-1)(r-1)/(s-1)r(l-1)	8
SD	DSL(R)	(s-1)(d-1)/(d-1)(s-1)r(l-1)	9
RD	DL(R)	(r-1)(d-1)/(d-1)r(l-1)	10
YSR	YSL(R)	(y-1)(s-1)(r-1)/(y-1)(s-1)r(l-1)	11
YSD	T(L(R)YS)	(y-1)(s-1)(d-1)/(t-1)lrys	12
YRD	YDL(R)	(y-1)(r-1)(d-1)/(y-1)(d-1)r(l-1)	13
SDR	DSL(R)	(s-1)(d-1)(r-1)/(d-1)(s-1)r(l-1)	14
YSDR	YSDL(R)	(y-1)(s-1)(d-1)(r-1)/(y-1)(s-1)(d-1)r(l-1)	15
L(R)	T(L(R)YS)	(l-1)r/(t-1)lrys	16
YL(R)	T(L(R)YS)	(y-1)(l-1)r/(t-1)lrys	17
DL(R)	DT(L(R)YS)	(d-1)(l-1)r/(d-1)(t-1)lrys	18
SL(R)	T(L(R)YS)	(s-1)(l-1)r/(t-1)lrys	19
YDL(R)	DT(L(R)YS)	(y-1)(d-1)(l-1)r/(d-1)(t-1)lrys	20
YSL(R)	T(L(R)YS)	(y-1)(s-1)(l-1)r/(t-1)lrys	21
DSL(R)	DT(L(R)YS)	(d-1)(s-1)(l-1)r/(d-1)(t-1)lrys	22
YSDL(R)	DT(L(R)YS)	(y-1)(s-1)(d-1)(l-1)r/(d-1)(t-1)lrys	23
T(L(R)YS)	Residual	(t-1)lrys/(n-1)lrysdt	24
DT(L(R)YS)	Residual	(d-1)(t-1)lrys/(n-1)lrysdt	25

Effects
1 There are differences between years, averaged over depth interval, region, sampling date and locality.
2 There are differences between sampling dates, averaged over year, depth interval, region and locality.
3 There are differences between regions, averaged over year, depth interval, sampling date and locality.
4 The tested variable shows different depth characteristics, averaged over year, sampling date and locality.
5 Different years have different characteristics with regard to sampling date (seasons behave in different ways between years), averaged over depth interval, region and locality.
6 Regions behave different with time (year), averaged over depth interval, sampling date and locality.
7 Depth interval characteristics differ between years, averaged over sampling date, region and locality.
8 Sampling date (seasonal) characteristics differ between regions, averaged over sampling date, region and locality.

9 The depth characteristics differ between seasons averaged over years regions and localities
10 Regions differ in deth characteristics averaged over years, sampling dates and localities.
11 Regions show different sesonal variation between years averaged over localities and depth intervals.
12 The seasonal development of depth characteristics differ between years.
13 The regional depth characteristics show different development with time averaged over seasons.
14 The seasonal depth characteristics differ between regions.
15 Regional devlopment of seasonal depth characteristics vary between years.
16 Localities within a region differ, averaged over year, sampling date and depth interval.
17 Localities within a region show different temporal development, averaged over depth interval and season.
18 The depth characteristics of localities in a region differ, averaged over year and sampling date.
19 Localities within a region show different seasonal development, averaged over depth interval and year.
20 The depth characteristics of localities in a region differ in temporal development, averaged over sampling date.
21 Seasonal development of localities in a region differ between years, averaged over depth interval.
22 The depth characteristics of localities in a region differ in seasonal development, averaged over years.
23 Seasonal depth characteristics of localities in a region differ between years.
24 Transects within a locality differ, averaged over depth intervals.
25 Depth characteristics of transects within a locality differ.

If we are interested in monitoring changes between regions, the effects 6 and 13 are of special concern. The effects 1 and 7 can be used to detect large scale changes common to all regions.

Appendix IV ANOVA effects and interaction plots

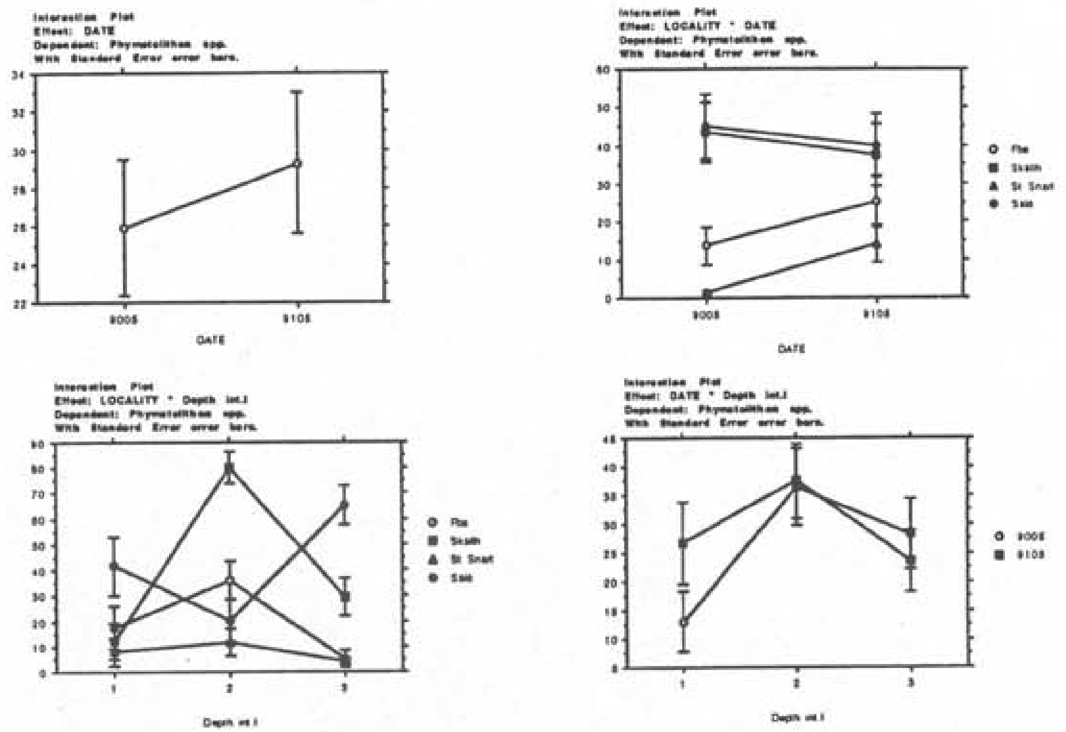


Fig.1 a-d Calcareous red crusts

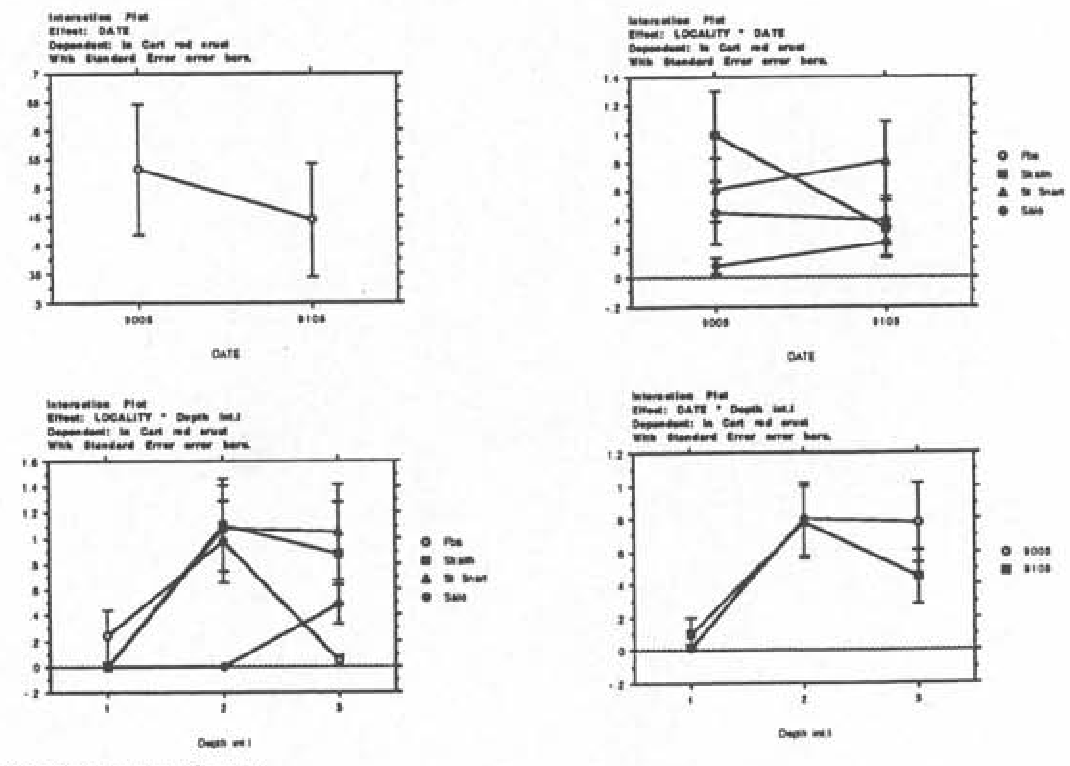


Fig.2 a-d Cartilagineous red crusts

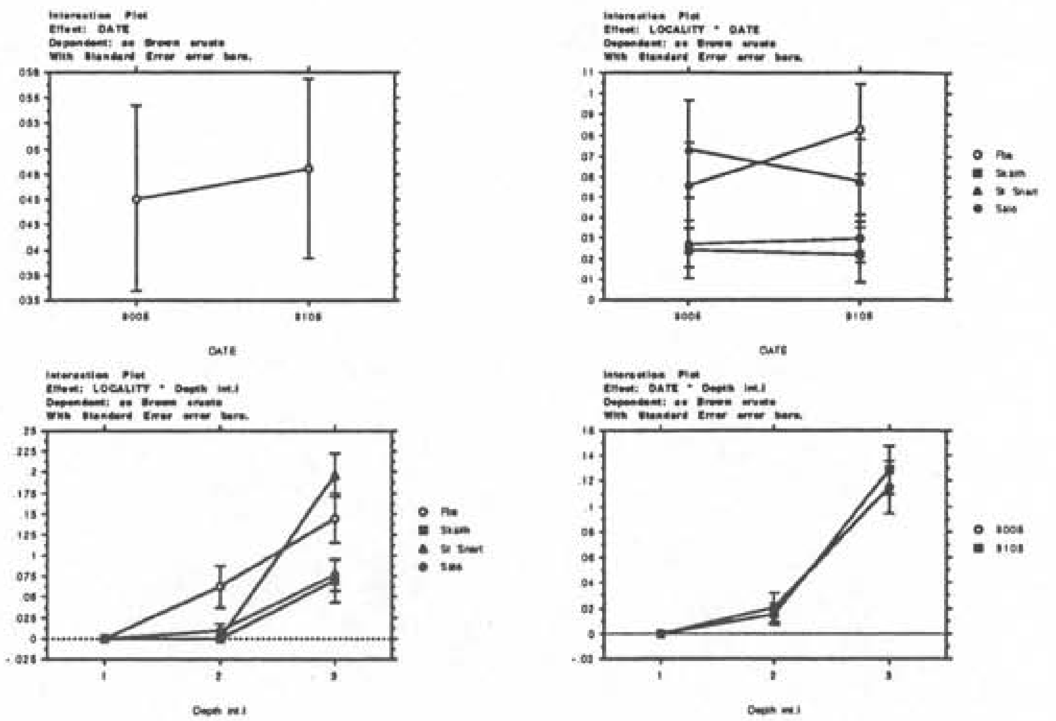


Fig.3 a-d Brown crusts

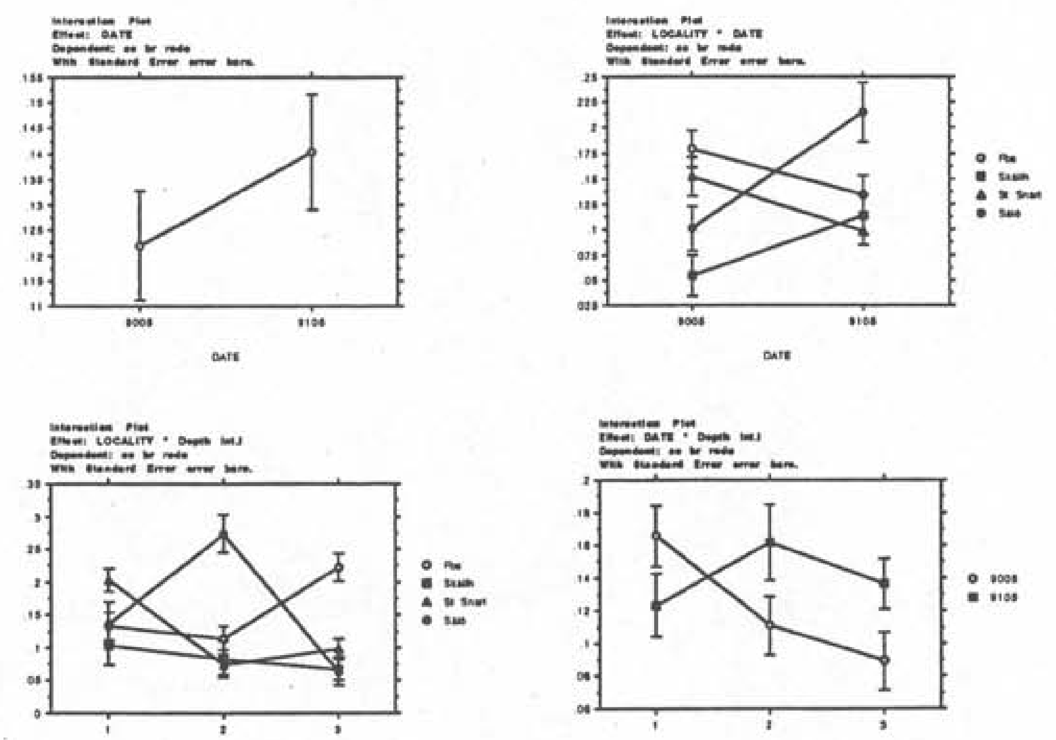


Fig.4 a-d Branched red algae

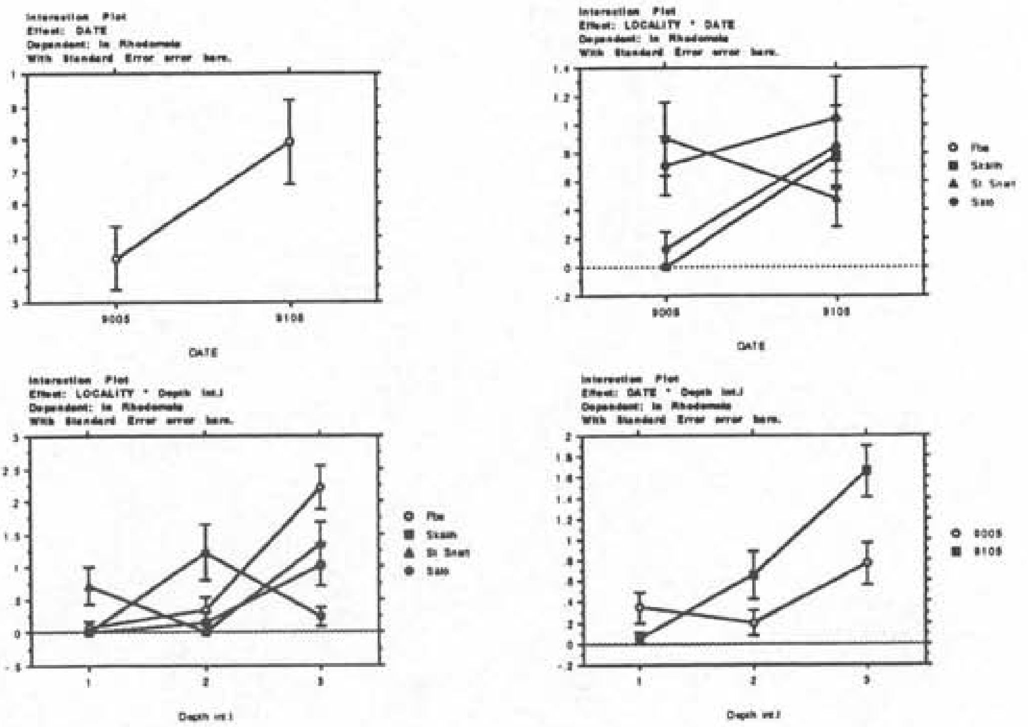


Fig.5 a-d *Rhodomela confervoides*

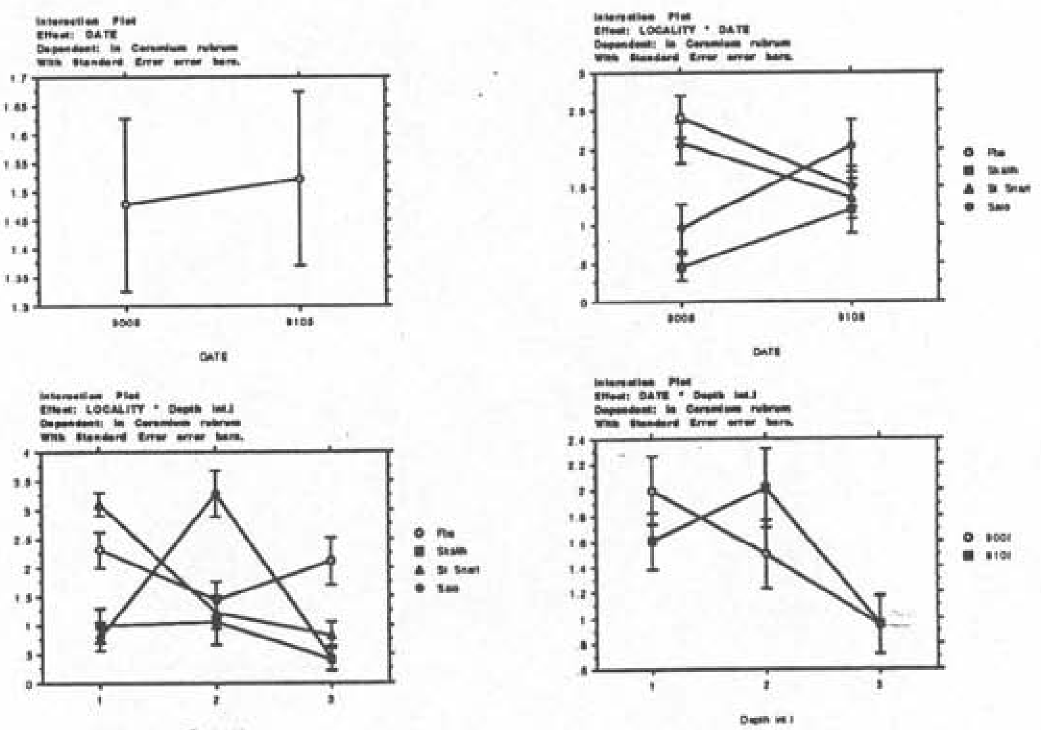


Fig.6 a-d *Ceramium rubrum*

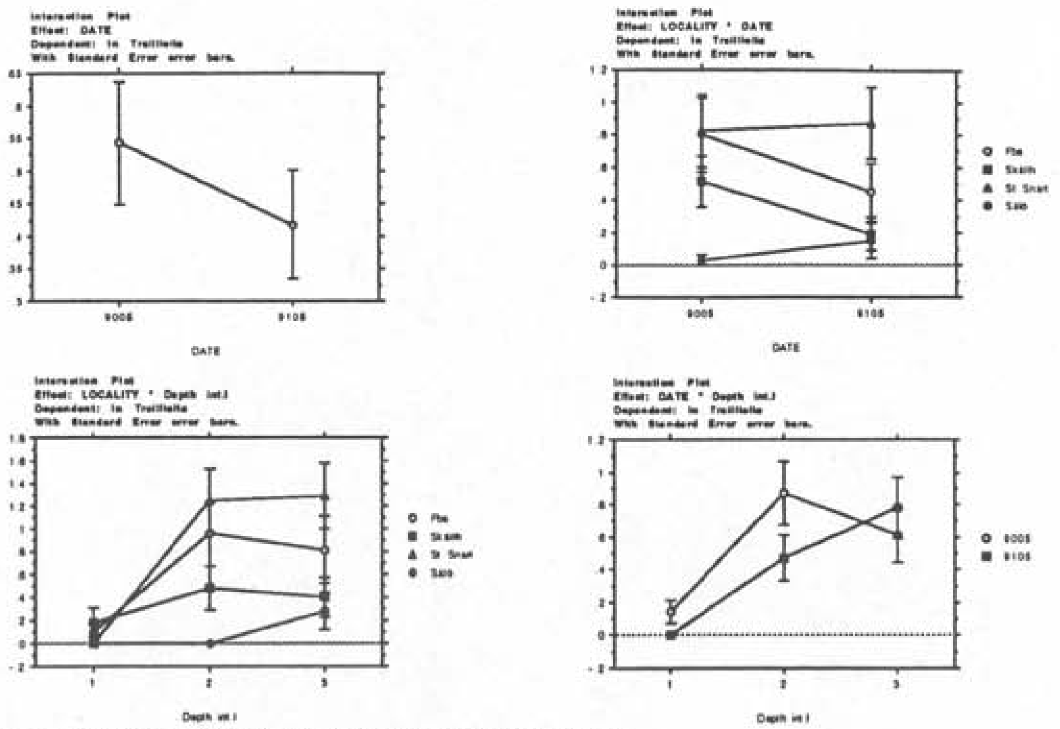


Fig.7 a-d *Bonnemaisonia hamifera* (t-phyte) & *Spermothamnion repens*

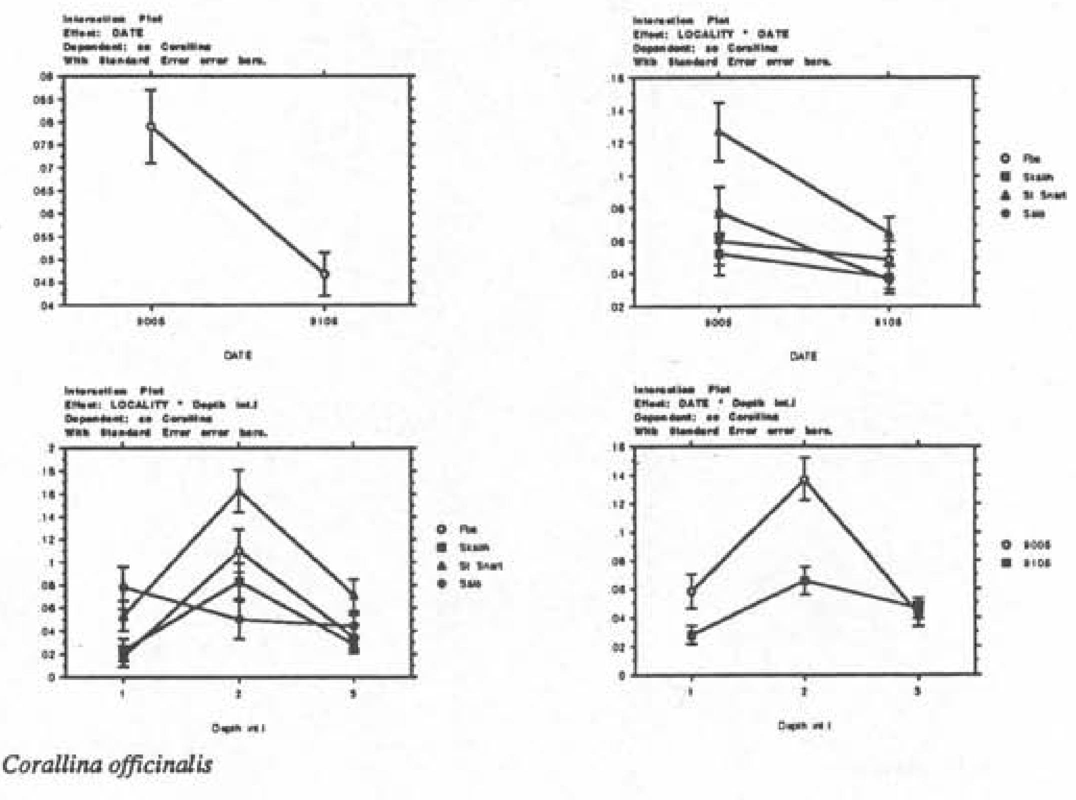


Fig.8 a-d *Corallina officinalis*

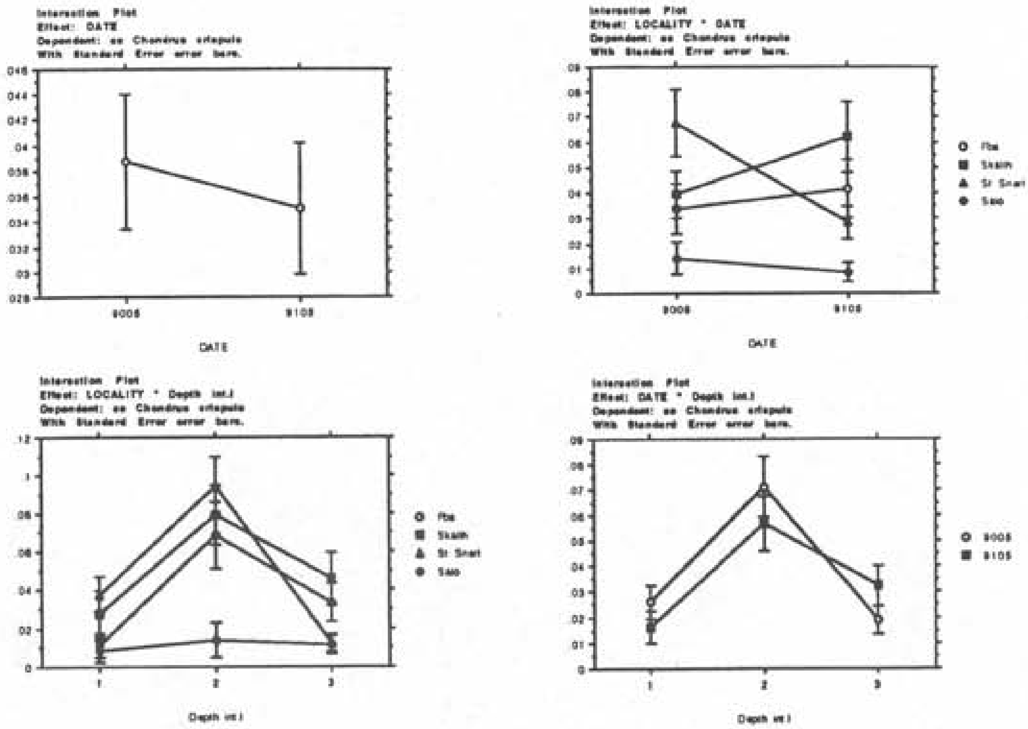


Fig.9 a-d *Chondrus crispus*

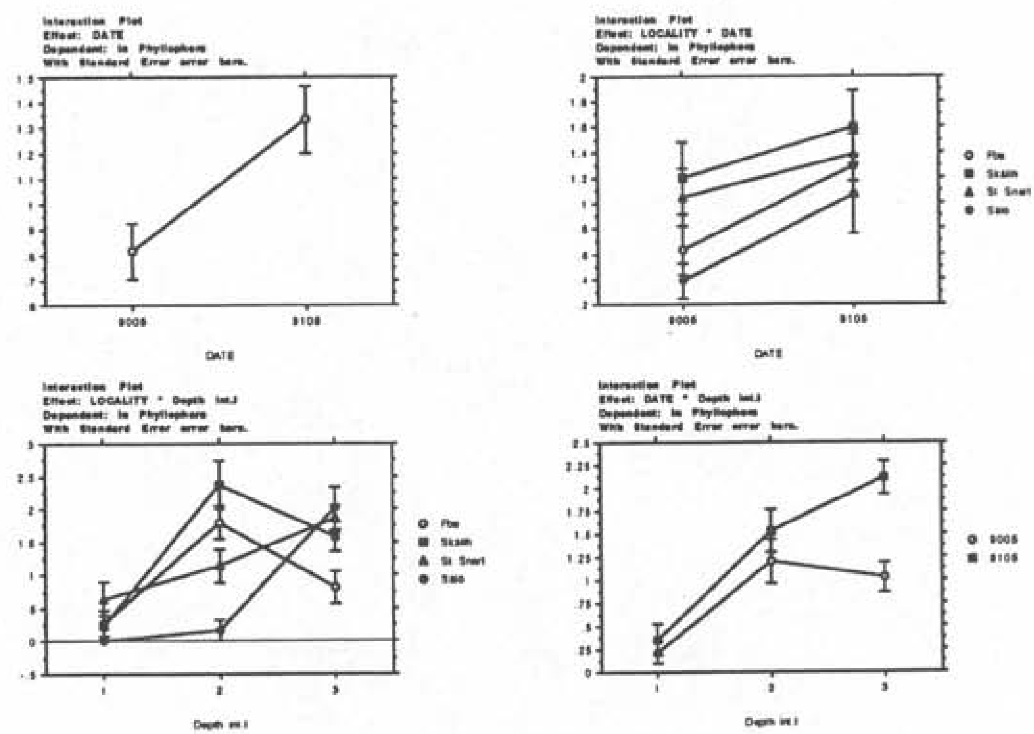


Fig.10 a-d *Phyllophora*

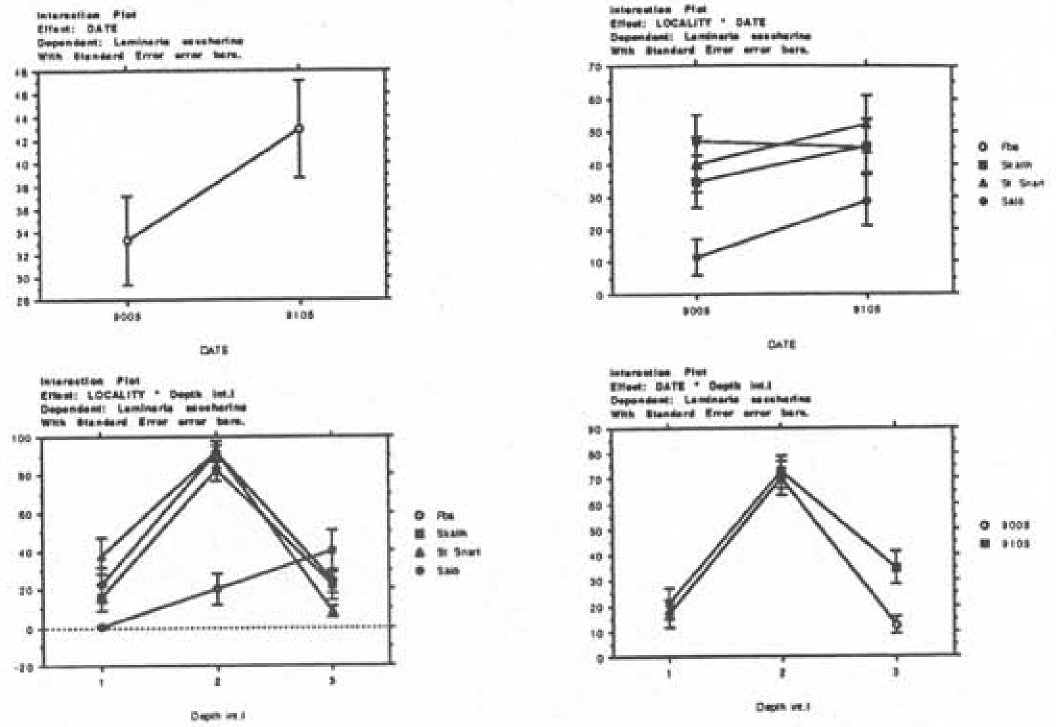


Fig.11 a-d *Laminaria saccharina*

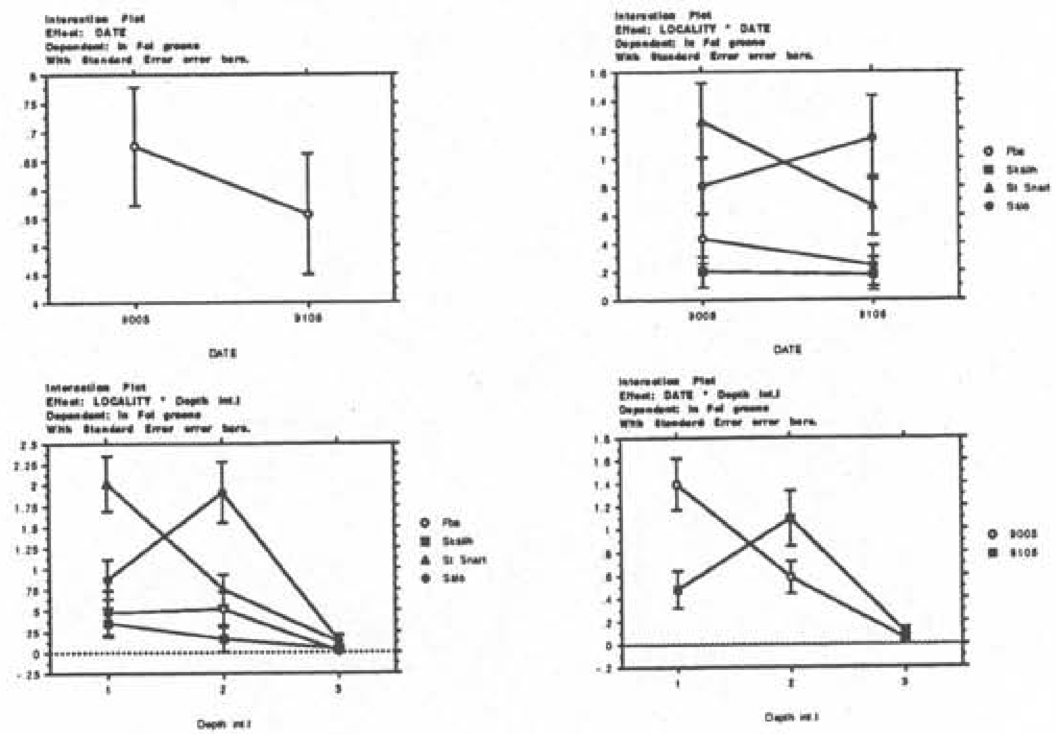


Fig. 12 a-d Foliaceous green algae

Table 1

Type III Sums of Squares

Source	df	Sum...	Mean S...	F-Value	P-Value	Error Term
LOCALITY	3	4.5E4	1.5139E4	4.625763E1	.0001	TRANSECT (LOCALITY, DATE)
DATE	1	6.1E2	6.1069E2	4.38283E-1	.5553	LOCALITY * DATE
Depth int.I	2	1.1E4	5.4256E3	5.32187E-1	.6127	LOCALITY * Depth int.I
LOCALITY * DATE	3	4.2E3	1.3934E3	4.2575237	.0217	TRANSECT (LOCALITY, DATE)
LOCALITY * Depth int.I	6	6.1E4	1.0195E4	1.111364E1	.0001	Depth int.I * TRANSECT (LOCALITY, DATE)
DATE * Depth int.I	2	3.2E3	1.5777E3	1.7199121	.1952	Depth int.I * TRANSECT (LOCALITY, DATE)
TRANSECT (LOCALITY, DATE)	16	5.2E3	3.2727E2	.38029405	.9852	Residual
LOCALITY * DATE * Depth int.I	6	2.2E4	3.6504E3	3.9794353	.0044	Depth int.I * TRANSECT (LOCALITY, DATE)
Depth int.I * TRANSECT (LOCALITY, DATE)	32	2.9E4	9.1733E2	1.065939	.3857	Residual
Residual	144	1.2E5	8.6058E2			

Dependent: Calcareous red crusts (not transformed)

Table 2

Type III Sums of Squares

Source	df	Sum...	Mean S...	F-Value	P-Value	Error Term
LOCALITY	3	1E1	3.42384	1.7474983	.1977	TRANSECT (LOCALITY, DATE)
DATE	1	4E-1	4.19E-1	1.98272E-1	.6863	LOCALITY * DATE
Depth int.I	2	2.1E1	1.0449E1	3.7938921	.0861	LOCALITY * Depth int.I
LOCALITY * DATE	3	6.339	2.11301	1.0784636	.3863	TRANSECT (LOCALITY, DATE)
LOCALITY * Depth int.I	6	1.7E1	2.7542	2.4162518	.0486	Depth int.I * TRANSECT (LOCALITY, DATE)
DATE * Depth int.I	2	1.612	8.061E-1	7.0717E-1	.5006	Depth int.I * TRANSECT (LOCALITY, DATE)
TRANSECT (LOCALITY, DATE)	16	3.1E1	1.95928	2.1732225	.0083	Residual
LOCALITY * DATE * Depth int.I	6	1.1E1	1.84899	1.6221176	.1732	Depth int.I * TRANSECT (LOCALITY, DATE)
Depth int.I * TRANSECT (LOCALITY, DATE)	32	3.6E1	1.13986	1.2643287	.1774	Residual
Residual	144	1.3E2	9.016E-1			

Dependent: Cartilagineous red crusts (log transformed)

Table 3

Type III Sums of Squares

Source	df	Sum...	Mean S...	F-Value	P-Value	Error Term
LOCALITY	3	9E-2	3.136E-2	4.7451838	.0149	TRANSECT (LOCALITY, DATE)
DATE	1	5E-4	4.724E-4	1.10428E-1	.7615	LOCALITY * DATE
Depth int.I	2	6E-1	3.112E-1	1.235092E1	.0075	LOCALITY * Depth int.I
LOCALITY * DATE	3	1E-2	4.278E-3	6.47298E-1	.5960	TRANSECT (LOCALITY, DATE)
LOCALITY * Depth int.I	6	2E-1	2.52E-2	4.6602268	.0016	Depth int.I * TRANSECT (LOCALITY, DATE)
DATE * Depth int.I	2	3E-3	1.658E-3	3.06653E-1	.7380	Depth int.I * TRANSECT (LOCALITY, DATE)
TRANSECT (LOCALITY, DATE)	16	1E-1	6.608E-3	1.3889786	.1549	Residual
LOCALITY * DATE * Depth int.I	6	3E-2	4.735E-3	.87558805	.5236	Depth int.I * TRANSECT (LOCALITY, DATE)
Depth int.I * TRANSECT (LOCALITY, DATE)	32	2E-1	5.407E-3	1.1365696	.2993	Residual
Residual	144	7E-1	4.758E-3			

Dependent: Brown crusts (arcsine transformed)

Table 4

Type III Sums of Squares

Source	df	Sum...	Mean S...	F-Value	P-Value	Error Term
LOCALITY	3	2E-1	6.468E-2	8.0070206	.0017	TRANSECT (LOCALITY, DATE)
DATE	1	2E-2	1.859E-2	2.04279E-1	.6820	LOCALITY * DATE
Depth int.I	2	4E-2	1.915E-2	1.6978E-1	.8478	LOCALITY * Depth int.I
LOCALITY * DATE	3	3E-1	9.1E-2	1.126611E1	.0003	TRANSECT (LOCALITY, DATE)
LOCALITY * Depth int.I	6	7E-1	1.128E-1	8.569152	.0001	Depth int.I * TRANSECT (LOCALITY, DATE)
DATE * Depth int.I	2	1E-1	4.977E-2	3.7809454	.0336	Depth int.I * TRANSECT (LOCALITY, DATE)
TRANSECT (LOCALITY, DATE)	16	1E-1	8.077E-3	1.3210984	.1919	Residual
LOCALITY * DATE * Depth int.I	6	1E-1	2.021E-2	1.5355223	.1985	Depth int.I * TRANSECT (LOCALITY, DATE)
Depth int.I * TRANSECT (LOCALITY, DATE)	32	4E-1	1.316E-2	2.1529583	.0012	Residual
Residual	144	9E-1	6.114E-3			

Dependent: Branched red algae (arcsine transformed)

Table 5

Type III Sums of Squares

Source	df	Sum...	Mean S...	F-Value	P-Value	Error Term
LOCALITY	3	7.547	2.51563	1.5888594	.2312	TRANSECT (LOCALITY, DATE)
DATE	1	6.826	6.82583	1.6237673	.2923	LOCALITY * DATE
Depth int.I	2	4E1	2.0196E1	2.3757834	.1738	LOCALITY * Depth int.I
LOCALITY * DATE	3	1.3E1	4.2037	2.6550318	.0838	TRANSECT (LOCALITY, DATE)
LOCALITY * Depth int.I	6	5.1E1	8.50082	7.1923639	.0001	Depth int.I * TRANSECT (LOCALITY, DATE)
DATE * Depth int.I	2	1.3E1	6.48802	5.4893804	.0089	Depth int.I * TRANSECT (LOCALITY, DATE)
TRANSECT (LOCALITY, DATE)	16	2.5E1	1.5833	2.3387787	.0042	Residual
LOCALITY * DATE * Depth int.I	6	1.4E1	2.28174	1.930532	.1060	Depth int.I * TRANSECT (LOCALITY, DATE)
Depth int.I * TRANSECT (LOCALITY, DATE)	32	3.8E1	1.18192	1.7458871	.0145	Residual
Residual	144	9.7E1	6.77E-1			

Dependent: *Rhodomela confervoides* (log transformed)

Table 6

Type III Sums of Squares

Source	df	Sum...	Mean S...	F-Value	P-Value	Error Term
LOCALITY	3	3.9E1	1.2924E1	7.5991007	.0022	TRANSECT (LOCALITY, DATE)
DATE	1	1E-1	1.06E-1	7.57234E-3	.9361	LOCALITY * DATE
Depth int.I	2	3.3E1	1.6689E1	8.51294E-1	.4727	LOCALITY * Depth int.I
LOCALITY * DATE	3	4.2E1	1.4004E1	8.2341544	.0015	TRANSECT (LOCALITY, DATE)
LOCALITY * Depth int.I	6	1.2E2	1.9604E1	9.99156	.0001	Depth int.I * TRANSECT (LOCALITY, DATE)
DATE * Depth int.I	2	7.413	3.70672	1.8892325	.1677	Depth int.I * TRANSECT (LOCALITY, DATE)
TRANSECT (LOCALITY, DATE)	16	2.7E1	1.70075	1.3121597	.1973	Residual
LOCALITY * DATE * Depth int.I	6	1.2E1	1.94587	9.91767E-1	.4475	Depth int.I * TRANSECT (LOCALITY, DATE)
Depth int.I * TRANSECT (LOCALITY, DATE)	32	6.3E1	1.96202	1.5137373	.0528	Residual
Residual	144	1.9E2	1.29615			

Dependent: *Ceramium rubrum* (log transformed)

Table 7

Type III Sums of Squares

Source	df	Sum...	Mean S...	F-Value	P-Value	Error Term
LOCALITY	3	1.7E1	5.80859	6.5013509	.0044	TRANSECT (LOCALITY, DATE)
DATE	1	8E-1	8.437E-1	1.0399549	.3829	LOCALITY * DATE
Depth int.I	2	1.8E1	9.05422	5.0841087	.0511	LOCALITY * Depth int.I
LOCALITY * DATE	3	2.434	8.113E-1	.90804578	.4590	TRANSECT (LOCALITY, DATE)
LOCALITY * Depth int.I	6	1.1E1	1.78089	2.8994116	.0226	Depth int.I * TRANSECT (LOCALITY, DATE)
DATE * Depth int.I	2	2.84	1.42022	2.31222	.1154	Depth int.I * TRANSECT (LOCALITY, DATE)
TRANSECT (LOCALITY, DATE)	16	1.4E1	8.934E-1	1.4007282	.1491	Residual
LOCALITY * DATE * Depth int.I	6	3.606	6.01E-1	9.78411E-1	.4558	Depth int.I * TRANSECT (LOCALITY, DATE)
Depth int.I * TRANSECT (LOCALITY, DATE)	32	2E1	6.142E-1	.96296985	.5306	Residual
Residual	144	9.2E1	6.378E-1			

Dependent: *Bonnemaisonia hamifera & Spermothamnion repens* (log transformed)

Table 8

Type III Sums of Squares

Source	df	Sum...	Mean S...	F-Value	P-Value	Error Term
LOCALITY	3	8E-2	2.724E-2	5.5259615	.0085	TRANSECT (LOCALITY, DATE)
DATE	1	6E-2	5.654E-2	7.2064087	.0748	LOCALITY * DATE
Depth int.I	2	2E-1	8.009E-2	4.6966085	.0592	LOCALITY * Depth int.I
LOCALITY * DATE	3	2E-2	7.846E-3	1.5916154	.2306	TRANSECT (LOCALITY, DATE)
LOCALITY * Depth int.I	6	1E-1	1.705E-2	5.0366865	.0010	Depth int.I * TRANSECT (LOCALITY, DATE)
DATE * Depth int.I	2	5E-2	2.585E-2	7.6355596	.0019	Depth int.I * TRANSECT (LOCALITY, DATE)
TRANSECT (LOCALITY, DATE)	16	8E-2	4.93E-3	1.9099701	.0238	Residual
LOCALITY * DATE * Depth int.I	6	3E-2	4.631E-3	1.3676828	.2575	Depth int.I * TRANSECT (LOCALITY, DATE)
Depth int.I * TRANSECT (LOCALITY, DATE)	32	1E-1	3.386E-3	1.3117143	.1435	Residual
Residual	144	4E-1	2.581E-3			

Dependent: *Corallina officinalis* (arcsine transformed)

Type III Sums of Squares

Table 9

Source	df	Sum...	Mean S...	F-Value	P-Value	Error Term
LOCALITY	3	5E-2	1.767E-2	1.027873E1	.0005	TRANSECT (LOCALITY, DATE)
DATE	1	7E-4	7.359E-4	.07772719	.7985	LOCALITY * DATE
Depth int.I	2	8E-2	4.006E-2	6.2350134	.0343	LOCALITY * Depth int.I
LOCALITY * DATE	3	3E-2	9.467E-3	5.5064243	.0086	TRANSECT (LOCALITY, DATE)
LOCALITY * Depth int.I	6	4E-2	6.425E-3	2.3976999	.0501	Depth int.I * TRANSECT (LOCALITY, DATE)
DATE * Depth int.I	2	8E-3	4.025E-3	1.5018858	.2380	Depth int.I * TRANSECT (LOCALITY, DATE)
TRANSECT (LOCALITY, DATE)	16	3E-2	1.719E-3	8.6258E-1	.6130	Residual
LOCALITY * DATE * Depth int.I	6	2E-2	3.936E-3	1.4687568	.2203	Depth int.I * TRANSECT (LOCALITY, DATE)
Depth int.I * TRANSECT (LOCALITY, DATE)	32	9E-2	2.68E-3	1.3444127	.1233	Residual
Residual	144	3E-1	1.993E-3			

Dependent: *Chondrus crispus* (arcsine transformed)

Type III Sums of Squares

Table 10

Source	df	Sum...	Mean S...	F-Value	P-Value	Error Term
LOCALITY	3	1.4E1	4.62788	2.9074633	.0668	TRANSECT (LOCALITY, DATE)
DATE	1	1.4E1	1.4428E1	3.362544E1	.0102	LOCALITY * DATE
Depth int.I	2	6.8E1	3.4056E1	3.7905832	.0862	LOCALITY * Depth int.I
LOCALITY * DATE	3	1.287	4.291E-1	2.69572E-1	.8464	TRANSECT (LOCALITY, DATE)
LOCALITY * Depth int.I	6	5.4E1	8.98434	7.6698548	.0001	Depth int.I * TRANSECT (LOCALITY, DATE)
DATE * Depth int.I	2	9.001	4.50049	3.8420316	.0320	Depth int.I * TRANSECT (LOCALITY, DATE)
TRANSECT (LOCALITY, DATE)	16	2.5E1	1.59172	1.937107	.0214	Residual
LOCALITY * DATE * Depth int.I	6	1.3E1	2.14859	1.8342339	.1236	Depth int.I * TRANSECT (LOCALITY, DATE)
Depth int.I * TRANSECT (LOCALITY, DATE)	32	3.7E1	1.17138	1.4255572	.0831	Residual
Residual	144	1.2E2	8.217E-1			

Dependent: *Phyllophora* spp. (log transformed)

Type III Sums of Squares

Table 11

Source	df	Sum...	Mean S...	F-Value	P-Value	Error Term
LOCALITY	3	2.4E4	8.1462E3	7.2839787	.0027	TRANSECT (LOCALITY, DATE)
DATE	1	5E3	4.9716E3	5.5924857	.0990	LOCALITY * DATE
Depth int.I	2	1.2E5	6.0784E4	5.9071237	.0382	LOCALITY * Depth int.I
LOCALITY * DATE	3	2.7E3	8.8898E2	7.94885E-1	.5145	TRANSECT (LOCALITY, DATE)
LOCALITY * Depth int.I	6	6.2E4	1.029E4	8.1716385	.0001	Depth int.I * TRANSECT (LOCALITY, DATE)
DATE * Depth int.I	2	4.5E3	2.2617E3	1.7961255	.1823	Depth int.I * TRANSECT (LOCALITY, DATE)
TRANSECT (LOCALITY, DATE)	16	1.8E4	1.1184E3	1.7629938	.0417	Residual
LOCALITY * DATE * Depth int.I	6	2.1E4	3.5192E3	2.7947264	.0267	Depth int.I * TRANSECT (LOCALITY, DATE)
Depth int.I * TRANSECT (LOCALITY, DATE)	32	4E4	1.2592E3	1.985033	.0034	Residual
Residual	144	9.1E4	6.3436E2			

Dependent: *Laminaria saccharina* (not transformed)

Type III Sums of Squares

Table 12

Source	df	Sum...	Mean S...	F-Value	P-Value	Error Term
LOCALITY	3	2.7E1	9.16057	1.843166E1	.0001	TRANSECT (LOCALITY, DATE)
DATE	1	8E-1	7.755E-1	3.87539E-1	.5777	LOCALITY * DATE
Depth int.I	2	3.2E1	1.5901E1	2.7570529	.1415	LOCALITY * Depth int.I
LOCALITY * DATE	3	6.003	2.00097	4.0260762	.0260	TRANSECT (LOCALITY, DATE)
LOCALITY * Depth int.I	6	3.5E1	5.78736	6.2659269	.0002	Depth int.I * TRANSECT (LOCALITY, DATE)
DATE * Depth int.I	2	1.9E1	9.48724	1.030738E1	.0004	Depth int.I * TRANSECT (LOCALITY, DATE)
TRANSECT (LOCALITY, DATE)	16	7.952	4.97E-1	8.28157E-1	.6521	Residual
LOCALITY * DATE * Depth int.I	6	1E1	1.72683	1.8761124	.1156	Depth int.I * TRANSECT (LOCALITY, DATE)
Depth int.I * TRANSECT (LOCALITY, DATE)	32	2.9E1	9.204E-1	1.533721	.0475	Residual
Residual	144	8.6E1	6.001E-1			

Dependent: Foliaceous green algae (log transformed)

Appendix V
Power of future monitoring alternatives
Program design and requirements for one year

Model A Effect	No. of General	No. of Intensive study
Region	2	2
Locality	4	2
Year	1	1
Sampling date	2	4
Transect	5	5
Depth	14	14
Replicate	2	2
Total replicates	2240	2240
Input effort	280 days	

Model B(alt 1) Effect	No. of General	No. of Intensive study
Region	2	2
Locality	5	1
Year	1	1
Sampling date	1	4
Transect	5	5
Depth	14	14
Replicate	2	2
Total replicate:	1400	1120
Input effort	157.5 days	

Model B(alt 2) Effect	No. of General	No. of Intensive study
Region	2	1
Locality	4	1
Year	1	1
Sampling date	1	4
Transect	5	5
Depth	14	14
Replicate	2	2
Total replicates	1120	560
Input effort	105 days	

Model B(alt 3) Effect	No. of General	No. of Intensive study
Region	2	1
Locality	3	1
Year	1	1
Sampling date	1	4
Transect	5	5
Depth	14	14
Replicate	2	2
Total replicate:	840	560
Input effort	87.5 days	

Appendix VI

Power of future monitoring alternatives
Terms tested

Model A

Effect	Test over	Df nom	Df denom	F
Year	YL(R)	1	6	5,99
Region	L(R)	1	6	5,99
Region x Depth	DL(R)	13	78	1,92
Region x Year	T(L(R)YS)	1	128	3,92
Region x Year x Depth	YDL(R)	13	78	1,92

Model B(alt 1)

Effect	Test over	Df nom	Df denom	F
Year	YL(R)	1	8	5,32
Region	complex	1	complex	Lacking pilot data
Region x Depth	complex	13	complex	Lacking pilot data
Region x Year	YL(R)	1	8	5,32
Region x Year x Depth	YDL(R)	13	104	1,83

Model B(alt 2)

Effect	Test over	Df nom	Df denom	F
Year	YL(R)	1	6	5,99
Region	complex	1	complex	Lacking pilot data
Region x Depth	complex	13	complex	Lacking pilot data
Region x Year	YL(R)	1	6	5,99
Region x Year x Depth	YDL(R)	13	78	1,92

Model B(alt 3)

Effect	Test over	Df nom	Df denom	F
Year	YL(R)	1	4	7,71
Region	complex	1	complex	Lacking pilot data
Region x Depth	complex	13	complex	Lacking pilot data
Region x Year	YL(R)	1	4	7,71
Region x Year x Depth	YDL(R)	13	52	1,92