Towards a Joint Monitoring Programme for the North Sea and the Celtic Sea (JMP NS/CS)

ACTIVITY E – Tools for designing a joint monitoring programme and case study Elasmobranchs

May 2015

EUROPEAN COMMISSION
DIRECTORATE-GENERAL
ENVIRONMENT
Directorate D - Water, Marine Environment & Chemicals

Co-funded by the European Union - DG Environment

Grant Agreement No. 07.0335/2013/659567/SUB/C2
Programme New Knowledge for an integrated management of human activity in the sea (ENV/PP 2012/SEA)

<u>This report can be cited as follows</u>:

Anne Sell, Francisco Marco-Rius, Julia Wischnewski & Holger Haslob, 2015. **Tools for designing a joint monitoring programme.** Activity E Report produced as part of the EU JMP NS/CS project: 'Towards a Joint Monitoring Programme for the North Sea and Celtic Seas' (Ref: ENV/PP 2012/SEA). 17 pp.

<u>Authors & contributors</u>:

Anne Sell, Francisco Marco-Rius, Julia Wischnewski & Holger Haslob, Gert Van Hoey, Henning Reiss, Hanneke Baretta-Bekker, Anouk Blauw, Malin Mohlin, Patrik Strömberg, Sven Kupschus and Sophy McCully.

<u>Acknowledgements:</u>

We also like to thank all people involved in the JMP NS/CS project or participating in the project meetings for their contributions and discussion on the project outcome.

<u>The JMP NS/CS project partners are as follows:</u> RWS (NL), RBINS (BE), MSS (UK/Scot), DTU Aqua (DK), IMARES (NL), CEFAS (UK/Eng), TI (GE), JNCC (UK/Eng), ILVO (BE), AU DCE (DK), IFREMER (FR), MI (IE), SLU (SE), SMHI (SE), SwAM (SE), IMR (NO), BfN (GE), BSH (GE).

Contents

LIST OF FIGURES

Tools for designing a joint monitoring programme

1. Introduction

We present here a number of tools we have developed within the JMP NS/CS project in order to aid the search for an efficient design of a joint monitoring programme. Some of these tools provide visualization through maps; most of them are statistical tools to evaluate alternative survey designs.

Within the project, we developed our analyses on the basis of case studies, namely three examples representing different components of the North Sea ecosystem: Sharks & rays (Elasmobranchs), benthic invertebrates, and chlorophyll. In order to illustrate our approach we use the example of the elasmobranch case study. For the other case studies we refer to the project deliverables on Benthos and Chlorophyll.

While the focus of this document will be on the elasmobranch CS, the tools presented have been applied in all three case studies. A paper of this work containing more technical information will be submitted for publication at a later stage.

1.1 Joint monitoring – why?

The Marine Strategy Framework Directive calls for measures to achieve 'Good Environmental Status' in European marine ecosystems by 2020. The quality status of the marine ecosystem will be assessed in a 6-year cycle and will be based on indicators. National monitoring programmes for MSFD have been reported in Autumn 2014. These contain common indicators (developed in Regional Sea Conventions) and additional indicators that are indicative of ecosystem quality of local to national scale. Member States have an obligation to develop coherent assessment schemes and develop monitoring for each of the 11 Descriptors. The first round of MSFD implementation has shown that coherence between member states is far from optimal (Article 12 assessment). This is partly due to the federal structure of the EU, where each country will report for their waters, and partly to the time needed to achieve better coherence. At the same time it is acknowledged by member states and the European Commission that ecological processes are not restricted by national boundaries, and that ecosystem understanding requires a holistic approach.

The work in this project envisages to support cross-border coherence by developing tools and options for joint monitoring. A joint monitoring programme in EU waters would:

- Include complementary sampling schemes of the countries involved => provide full coverage and avoid duplication;
- Assure standardization of methods;
- Allow monitoring the indicators of ecosystem status at the relevant spatial scales across the region of the European sea;
- Increase efficiency by finding the best options for coupled monitoring of multiple indicators;
- Optimize the effort invested through combination of various sampling programmes, with synergies being created through coupled monitoring for multiple indicators.

Within JMP NS/CS, we developed a suite of tools to aid the planning of a joint monitoring programme, and applied them in a series of case studies on chlorophyll, benthos and Elasmobranchs. Together, they cover different key components of the marine ecosystem of the North Sea. We here present the JMP tools with a focus on the case study on Elasmobranchs, *i.e*. 8 species of sharks and rays, which are representative of vulnerable North Sea top predators.

1.2 Elasmobranch case study

Sharks and rays (Elasmobranchs) are of interest for several reasons: They are targeted to different degrees by fisheries. Some of the species are of no economic interest at all, but are possible indicators of ecosystem state. A few species appear on the IUCN red list.

Opportunities in this case study

Existing international research surveys with long-term data series, suitable to follow temporal trends in species abundance.

Challenges

Overall, data are deficient due to low abundances of sharks and rays, leading to the need to judge population status based on rare occurrences.

Access to additional data beyond the international fisheries surveys is very limited.

Existing fisheries surveys have independent core objectives, and hence an ideal sampling for elasmobranchs – and also the case study we develop here – is difficult to implement in current monitoring programmes.

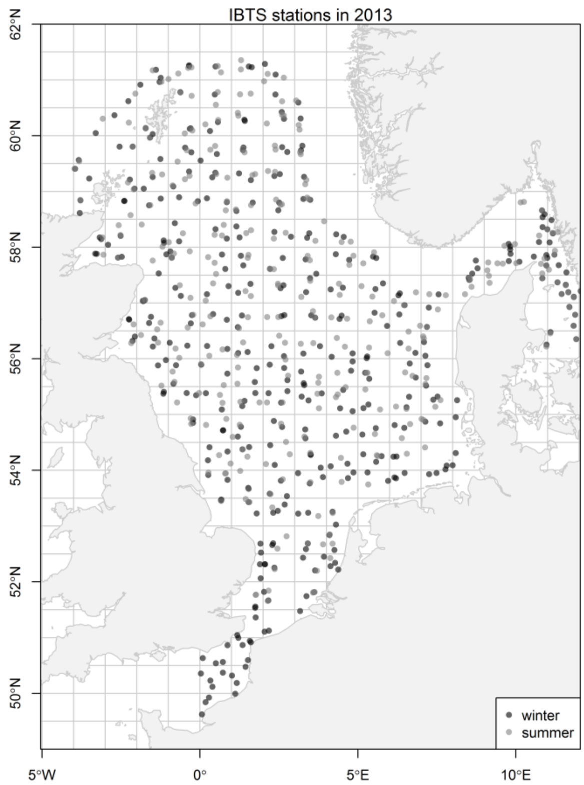


Fig. 1. Distribution of IBTS stations in the North Sea during one year.

The ICES International Bottom Trawl Survey uses a systematic grid of ICES rectangles, sampled twice annually. In the following, we propose alternative sampling designs, which proved more efficient for our case studies. However, in reality, the IBTS has multiple additional objectives, which are not covered in our analysis. Therefore, our case outlined below is not meant to propose an entire new IBTS - although the real survey is currently undergoing an evaluation of several aspects of its design.

2. Development of tools for the planning of a joint monitoring programme

2.1 A statistical approach to sampling design - stratification

Goal: Choosing the most efficient sampling for an indicator.
Achieving the best representation of the entire population/indicator with a given amount of effort. The sampling effort needed for same accuracy may be reduced through stratification.

Process of stratification
Dividing the survey area into suitable (spatial) subunits, which are sampled and evaluated separately. Stratification produces spatial subunits of the entire survey area. Stratified sampling is possible when it makes sense to partition the population into groups based on a factor that may influence the variable that is being measured.

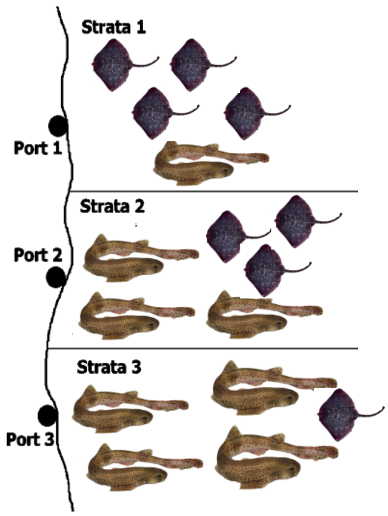


Fig. 2. Example of stratification: Distributions of two species of Elasmobranchs vary according to a North-South gradient. A subdivision for ship based sampling decreases the variability within strata. Modified from FAO.org.

The goal in this is to obtain more similar measurements within each of the strata, and clearer differences between different strata. This increases the certainty – or reliability – of the measurements.

Several North Sea surveys use defined spatial units, such as country border (EEZs). But these do typically not represent a biologically meaningful border, and therefore don't improve the results.

The best criterion for the stratification is not always visible and obvious, and therefore one approach is to use regression models to identify the most suitable parameter. We here tested for the most suitable factor to define spatial subunits for the assessment of sharks and rays in the North Sea.
A mathematical approach (regression tree) allowed us to determine the most suitable factors in order to define spatial subunits for the assessment of sharks and rays in the North Sea and try to improve the current sample. It turned out that in this case, latitude and longitude were the best factors which could easily produce strata for an optimized sampling of a suite of 8 elasmobranch species. The four strata are color-coded in Figure 3.

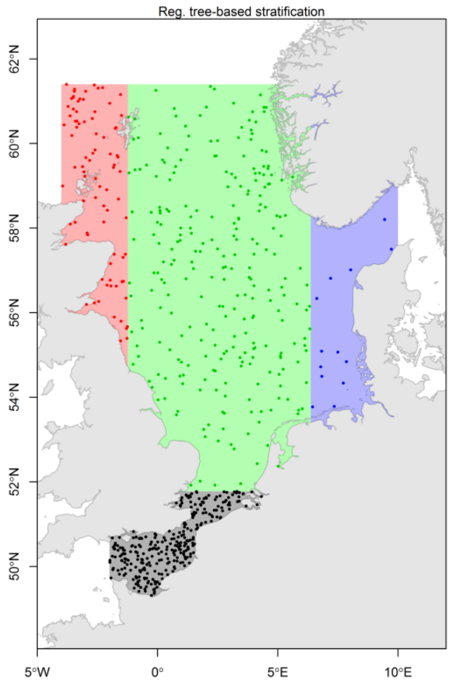


Fig. 3 Simple geographical stratification for a suite of 8 species of sharks and rays based on latitude and longitude.

This regression analysis demonstrated for the combined group of sharks/rays in the Case Study, or for individual species, that simple geographical structuring would improve the quality of their assessment. In the example here, the reliability of the estimate of the abundance of these eight shark and ray species would be enhanced, if the four colored subunits of the North Sea would be sampled separately and at different intensity. The so-called 'regression tree' defined the boundaries of these four areas. Station position and depth were tested as potential sorting criteria, but only Latitude and Longitude of the stations proved to be relevant parameters.

2.2 Tool 1: Methods for the allocation of stations

After definition of the most suitable strata (spatial subunits for the sampling), the most appropriate distribution of stations between these different strata has to be found. Different options exist for allocating stations to the previously defined strata. One option is to allocate sampling stations proportional to the size of the area monitored, where more samples are needed to assess a larger area.

Within JMP, we applied a similar, but yet more refined approach: the so-called Neyman allocation, which derives the best distribution of samples between strata by involving both the proportional area of the stratum and the variability of the measured parameter in each stratum. The more variable the measured indicator, the more stations are needed to get a reliable estimate. In JMP, we applied the Neyman allocation procedure, because it most effectively maximized survey precision (reduction of variance).

2.3 Stratification for multiple purposes in a Joint Monitoring Programme

The regression tree approach presented before (Fig. 3) is helpful when optimizing the sampling for a single indicator. It is adapted to measure the particular parameter needed for this indicator, in our case study this was the abundance of sharks and rays. However, the purpose of the JMP project is to work towards a joint monitoring approach, and we therefore looked for a type of stratification that would be applicable for a whole range of indicators at the same time. During a workshop with specialists for the three case studies in JMP and external experts, we decided to use strata, which are based on ecosystem characteristics. The main idea in this is that the key characteristics of the ecological subregions of the sea would be rather stable, compared to the indicators measured. And hence, they could be maintained over a long term and for many indicators. We decided to apply a stratification scheme, which was developed in the just finalized EU project VECTORS[1] to be applied in a North Sea-wide ecosystem model 'Atlantis' (Hufnagl et al., unpublished data).

Ecosystem-based stratification

This form of stratification is based on a combination of environmental and ecological parameters in subsections of the survey region, which remain rather constant over time. Therefore, we expected them to be suitable for long-term monitoring programmes.

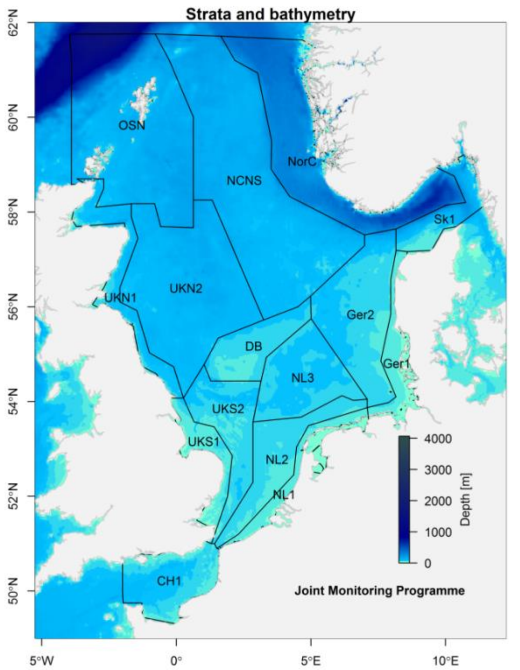


Fig. 4. Strata of the ecosystem model 'Atlantis', modified for JMP to reduce the number of strata. Here overlaid with bathymetry.

[1]http://www.marine-vectors.eu/

Applying the ecosystem-based 'Atlantis' stratification to the elasmobranch case study, we can obtain the following proposal for the allocation of sampling stations in the North Sea (right hand panel of Fig. 5).

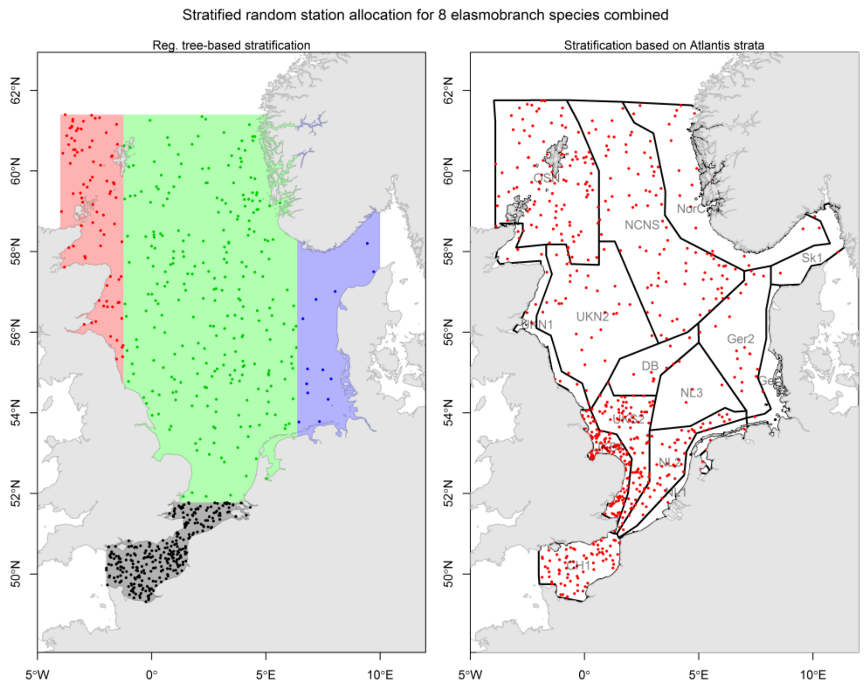


Fig. 5. Stratification and allocation of stations for combined abundance of 8 species of sharks and rays. This is based on a. regression tree analysis using longitude and latitude (left panel) and b. a combination of environmental and ecological parameters, i.e. 'Atlantis' strata (right panel). Here, the density of red dots is higher where more stations are needed to obtain a reliable result.

2.4 Tool 2: Changepoint analysis and optimal number of stations

Changepoint analysis to identify an appropriate sample size

We now wanted to find a way to determine the compromise between the sampling effort and the quality of estimate. For this, a changepoint detection approach was performed using the total abundance of 8 elasmobranchs species combined. This analysis involves a graphic representation of explained variability at a certain sample size and the division of that variability in different similar parts.

The graph in Figure 6 shows on the y-axis the uncertainty of the measurement, and on the x-axis the number of stations sampled. This analysis is based on the pooled measurements of IBTS data from 2000-2013, which amounted to roughly 9000 stations. With fewer stations, the uncertainty of the estimated abundance (here presented as standard deviation) is higher. The upper curve (black circles) represents the current IBTS sampling. For the elasmobranch species, the uncertainty in the resulting abundance estimate is rather high, and it would only get lower if more than about 3000 samples are taken. In a single survey event, we take about 300 samples (1/10th of that). The surveys are carried out twice each year, *i.e*. approximately 600 samples.

The various alternatives analysed in Figure 6 reveal that the abundance of sharks and rays could be estimated with highest certainty when the ecosystem-based stratification 'Atlantis' was used, and stations were allocated to individual strata with the Neyman method, which takes the variability of the measured parameter within each stratum into account (light blue line in Fig. 7). - In this case, the ecosystem-based stratification would be the most efficient one, even for monitoring of a single indicator (abundance of sharks & rays).

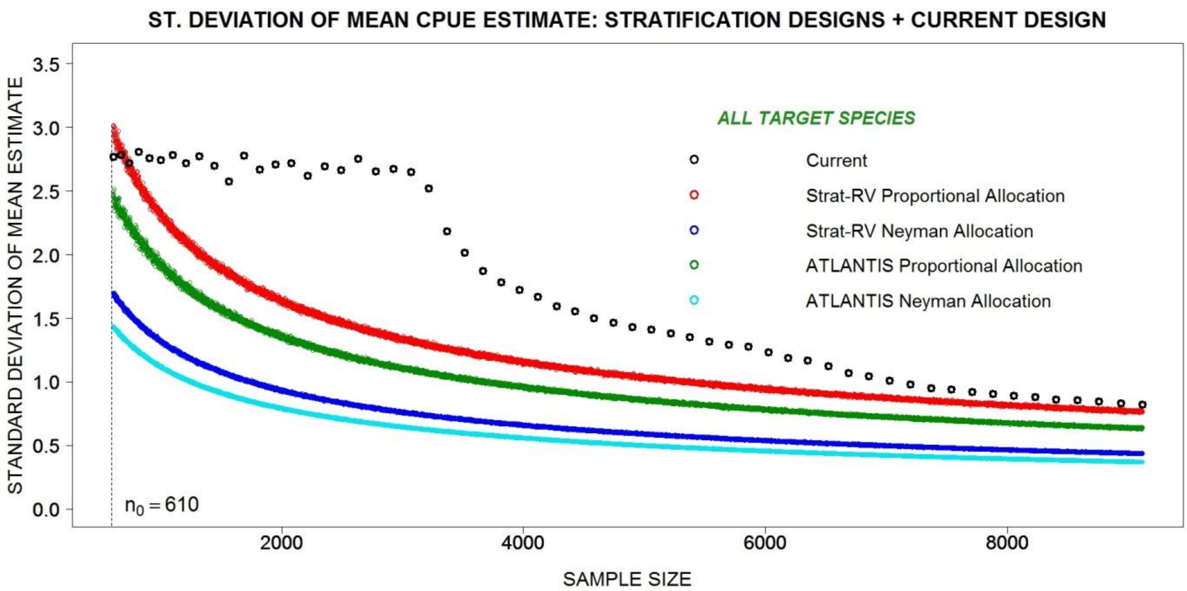


Fig. 6. Effect of sampling design and number of stations on the standard deviation (SD) of the estimated abundance (catch per unit effort, CPUE) of all 8 target elasmobranch species combined. (A lower SD can be considered to provide a more reliable estimate.) "Current": Current design, observed data from IBTS sampling in its traditional form. "Strat-RV": Modelled data with stratification based on the response variable measured, here analogous to the stratification in Fig. 5, left panel. "ATLANTIS": ecosystem-based stratification, analogous to Fig. 5, right panel. "Proportional" and "Newman" are the two different methods applied for station allocation between strata.

We applied a systematic method to determine the changepoint in these curves, in order to identify the number of stations that would be needed to improve the quality of the estimated indicator. The criterion is a considerable improvement in the certainty – or phrased inversely, a reduction in the standard deviation of the estimate (Figure 7a, y-axis).

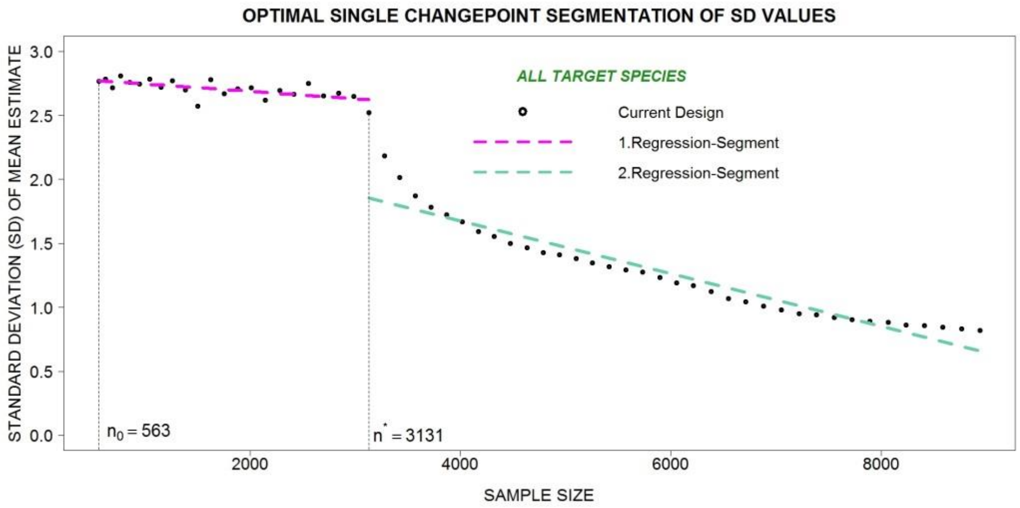


Fig. 7. Changepoint analysis for IBTS sampling design. The curve is split into two segments, where the greatest reduction of uncertainty (SD) per additional station defines this changepoint: for the current IBTS, at 3131 stations for the selected combination of sharks and rays in the case study. This would be equivalent to about 5 years of sampling 2-times a year (an average of 563 stations are sampled per year).

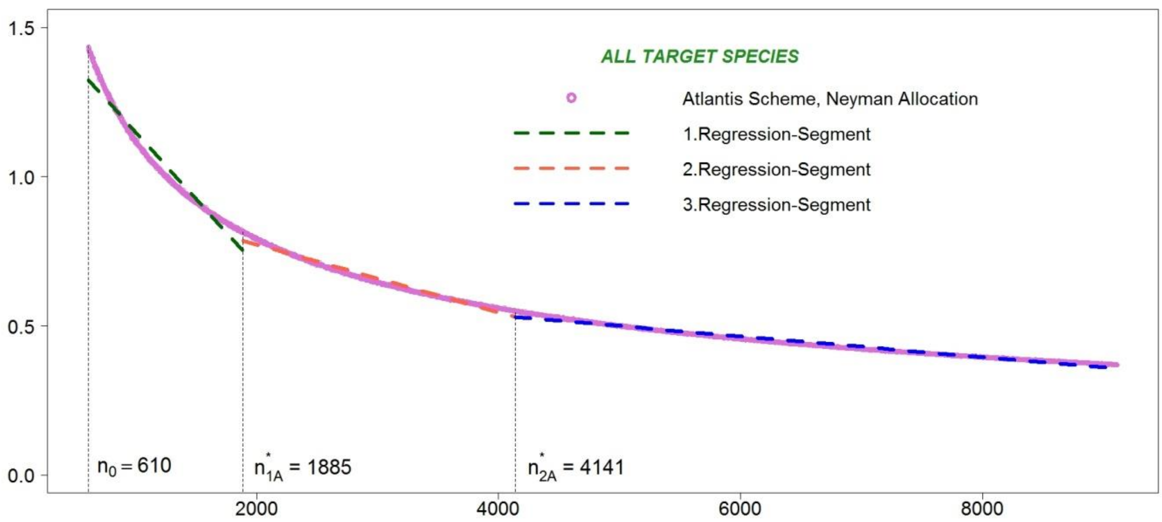


Fig. 8. The equivalent of Fig. 7 for Atlantis sampling design. Atlantis sampling design would already reduce the uncertainty (SD) by about 79%, even if the number of stations (ca. 600) would stay the same as currently sampled in the IBTS in one year (compare values at y-axis to Fig. 7).

Consequently, in these two methods 600 stations would already produce a better estimate of this indicator than over 3000 stations of the first design. Beyond ca. 2360 stations, the gain in certainty is much lower, and therefore under either method of stratifications (response-variable based or ecosystem-based), the monitoring of more than 2360 stations would be of little use.

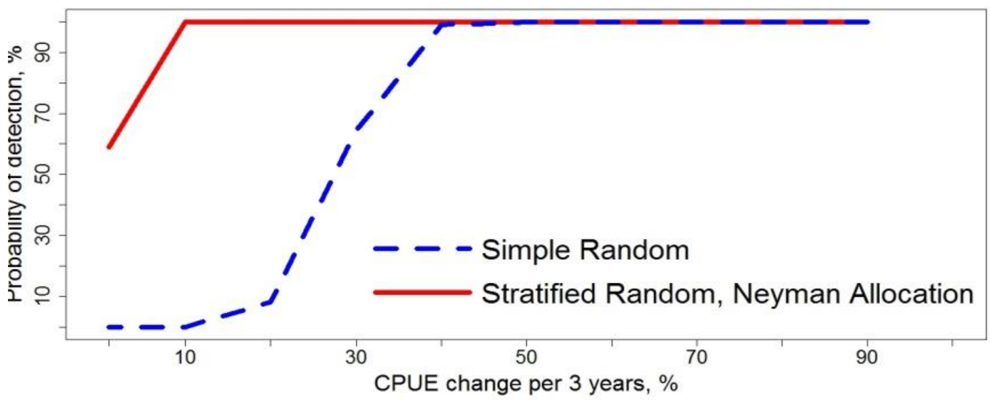
Optimal number of stations to detect abundance trends

The assessment of MSFD indicators will in many cases be a trend-based assessment. Therefore, we need to know when we can be certain that a difference we observe in the data is really a change in the trend. In a related analysis, we investigated how likely would we be to detect a difference if the abundance (CPUE) of a species changed by 10, 20, or 30% over a given time period.

For the example of Thornback ray (*Raja clavata*), also with the better stratification, a certain minimum amount of sampling points are needed to detect a change in abundance with a defined certainty (Fig. 9). For the example that 400 stations are monitored per year, a 10-% change can be noted with almost 100% probability when 'Atlantis' stratification and Neyman allocation are applied (red curve).

In case of the more evenly distributed Lesser spotted dogfish, there is a less pronounced effect of a the stratification. That means, if several species should be assessed together, the decision about a change in survey design should take the more unevenly distributed species into account primarily – in this case the ray species.

a) *Raja clavata* - Thornback ray



b) *Scyliorhinus canicula - Lesser spotted dogfish*

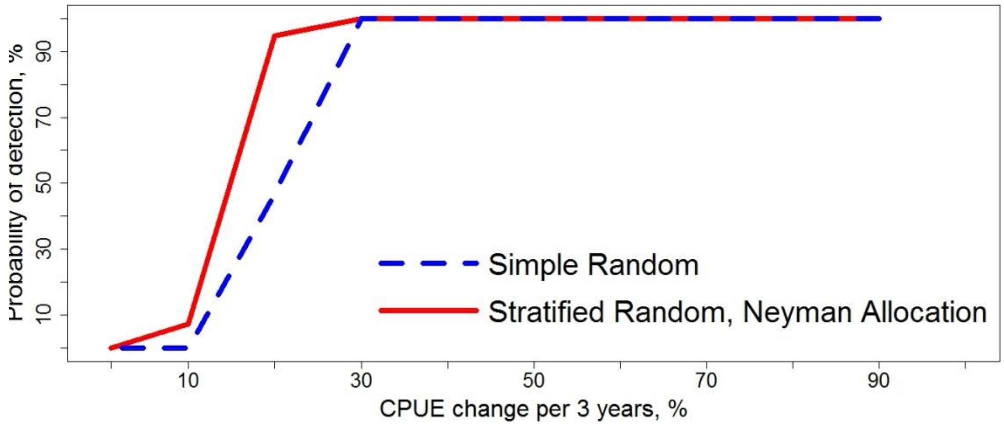


Fig. 9. Probability of detection of a change in abundance (CPUE) for a ray species (a) and shark species (b), using 1200 stations per 3-yr period (~ 400/ yr), with simple random sampling (blue line), or with 'Atlantis' stratification and Neyman allocation of stations (red line). In each case, the changes in CPUEs are considered for the entire survey area of the North Sea (in the stratified design, all strata combined).

It is concluded that stratified sampling ('Atlantis' strata) increases significantly the power to detect a change in the abundance of this ray, when compared to a simple random sampling over the entire North Sea (dashed blue line). Compared to alternative scenarios with more or less stations monitored, the sampling with 1200 stations provided a useful compromise between effort and precision, if the goal is to detect a change of 10% between two 3-year periods (and with a likelihood of almost 100%). Obviously, for the planning of a monitoring programme, the number of stations, which can realistically be covered in one year, define a limitation to the programme. Therefore, we presented here an example where 3 years of monitoring data are combined, naturally with the disadvantage, that changes in abundances could then only be detected at the respective longer than annual time intervals.

2.5 Tool 3: combining stations for multiple indicators

In order to present options for creating a Joint Monitoring Programme for the North Sea, we explore here a (rather hypothetical) example, where the goal would be to combine the monitoring for the three JMP NS/CS case studies on a single monitoring cruise. Important considerations are:

a. Sampling for chlorophyll in integrated surveys would be relevant during the growing season (March 1st – September 30th). With reference to the chlorophyll case study, ship-based samples would be needed to calibrate satellite measurements. The satellite measurements would provide the high frequency monitoring over the entire growing season, which is needed for chlorophyll assessment, while the ship based calibration would for instance occur at the beginning, middle and end of the growing season. Chlorophyll has not been included in the optimized design, since national data were incomparable and requirements for satellite calibration were unknown. We assume that the number of stations needed for a calibration survey is much lower than in the current chlorophyll monitoring.

b. Rays and sharks are presently recorded, *e.g*. from the North Sea wide IBTS survey, twice annually. The number of current IBTS stations per survey event, combined with the IBTS design, is not sufficient for a reliable assessment of many shark or ray species. Here, we therefore assume a station allocation which is quite different from the real, current IBTS sampling. Referring to the analyses above we assume that 1885 stations would be needed for a reliable assessment, which could be achieved by pooling 3 years of 610 stations visited each year (= current IBTS).

c. A regular benthos survey on North Sea scale is necessary, and should at least be executed once in the MSFD assessment cycle. This example shows how it could be combined with other surveys in theory or aligned with running national surveys. It was estimated that 777 stations would be needed for a reliable assessment of benthic species richness in the different strata, which is more than the amount of stations in 1986 (231), but less than the benthos sampling effort executed by the North Sea member states in 2000 (1294). This shows the potential that such amount of data can be collected based on national monitoring.

A combined monitoring design for Elasmobranchs and benthos is depicted in Figure 10. Here, the minimum number of stations needed for an assessment of both groups of organisms yield a fairly densely allocation of stations, especially in the southern part of the North Sea, all visited once for a single assessment. Given the considerations above and assuming that a continuation of sampling effort in the same order as the current IBTS is realistic, we propose that this sampling scheme is divided over three years.

Realistically, a joint monitoring programme would best be created when as many as possible MSFD indicators are defined and operationalized. Then, it would be most effective to decide – based on the requirements of each indicator with respect to its temporal and spatial resolution – which parameters would be monitored together during one cruise. Useful combinations may differ between seasons.

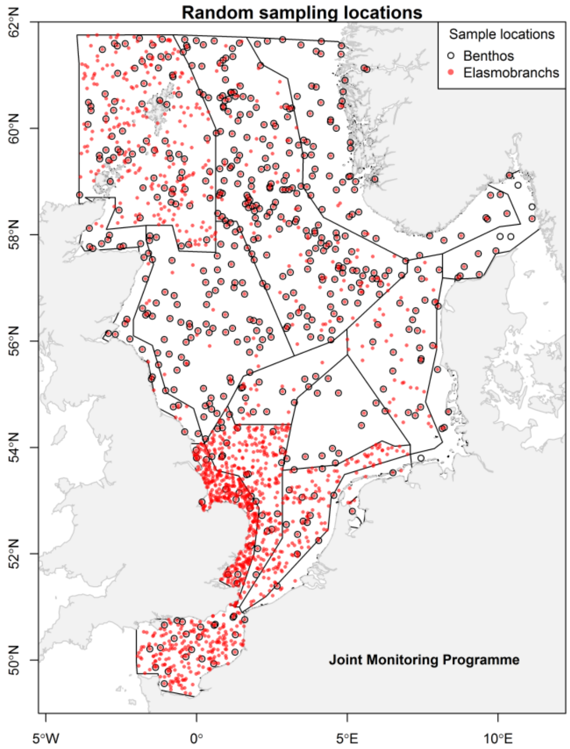


Fig. 10. Joint monitoring programme for elasmobranchs and benthos, based on ecosystem-based stratification ('Atlantis'), and allocation of stations to the individual strata according to Neyman approach.

Stations in map: samples recommended per indicator for one common sampling event.

Total station number is reduced where possible through combined sampling for 2 indicators.

2.6 Tool 4: Analysis of survey efficiency

One of the main drivers of this project is to increase efficiency and cost effectiveness of monitoring. Information on the costs of national monitoring programmes is not readily available. As a proxy the project determined sampling effort and ship time needed for sampling the respective indicators. In this, the "traveling salesman approach" was used to find the shortest steaming distances for research vessels for the given conditions of stratification and number of stations. These analyses have been done for single indicators, looking at the possible benefit from a change in sampling design through stratification and sample allocation. The same tool is applicable for the combination of sampling for multiple indicators in a joint monitoring programme, and can then help to substantially reduce ship time needed. Figure 11 depicts the optimized path of the combined survey.

With the aim to create a comparison between a potential joint monitoring programme and the current situation of the monitoring of case studies, the mean number of stations of IBTS in one year, *i.e.* quarter one and quarter three, can be used as an indicator of the current monitoring situation for elasmobranchs. It is important to remark that IBTS was not created to perform elasmobranchs monitoring but other specific target species. However, the information obtained from IBTS can be used in Elasmobranch assessments and eventually as a baseline of a potential dedicated elasmobranchs monitoring programme.

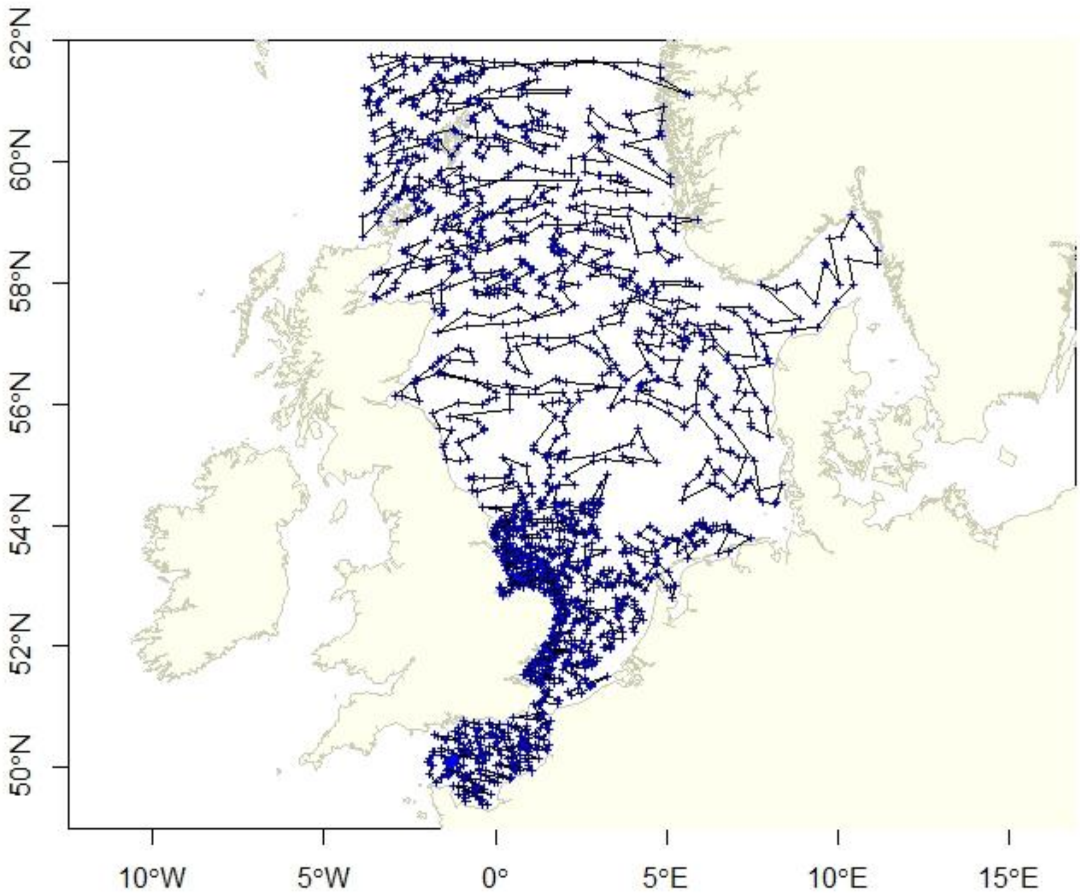


Figure 11. Salesman travelling problem applied to the proposed joint monitoring programme The route shown is the minimal route to link all the stations following the shortest track. The algorithm is also used to calculate the number of total nautical miles. It assumes that one survey vessel visits all stations, without visiting any harbour.

In the absence of a recent overview of national benthos monitoring, down to the level of stations and monitoring data, we considered the benthos datasets from the grid based North Sea Benthos Survey of 1986 and the North Sea Benthos Project of 2000, which is a voluntary and incomplete compilation of national or project benthic data. These do not reflect the current situation in the monitoring status of the North Sea and therefore the sampling effort calculated under 'current design' in Table 1 is unreliable. Nevertheless, the a large part of the North Sea was covered in both years and hence, the dataset can be used to calculate the variance in benthos data and the effort necessary to cover the entire North Sea. For evaluating changes in species richness it seems that a set of 777 samples is appropriate to have a "similar" variance level as the 1986-2000 dataset, which contains twice as many stations. Of course this is under the assumption that we stratify (Atlantis) and we allocate the samples following the Neyman allocation.

The current effort of chlorophyll sampling in the North Sea could be calculated using the ICES database, but we were not able to determine an optimized sampling design.

Table 1 presents a comparison between 'current' sampling effort and the optimized designs of benthos and Elasmobranchs expressed as sampling effort: number of stations visited and nautical miles travelled per ship. See Figure 10 for the distribution of stations and a example of how sampling for benthos and Elasmobranchs can be combined.*Table 1. Comparison of sampling effort in 'current' monitoring programmes and an optimized design for the North Sea. The optimized design uses Atlantis stratification and Neyman allocation of stations for Elasmobranchs and benthos monitoring. The effort needed for one joint assessment can be divided over 3 years, using the current IBTS programme as a basis. Chlorophyll has not been included in the optimized design, since national data were incomparable and requirements for satellite calibration were unknown. The sampling efforts were calculated following the Salesman Traveling Problem through all the stations and are expressed in nautical miles.*

		'Current' design, see comment		**Optimized design**		**Comment**
Purpose	**Minimum no. stations needed for an assessment**	**Number of stations**	**Distance steamed (nm)**	**Number of stations**	**Distance steamed (nm)**	
Chlorophyll	unknown	1900	165394	-	-	2006, national monitoring in ICES database
Elasmobranchs	1885	610	156694	1885	498146	2013, IBTS Q1 + Q3
Benthos		228	72693	-	-	1986, coordinated grid survey
		1297	207995	-	-	2000, incomplete compilation of national or project benthic data
	777	1525	275460	777	169571	1986 and 2000 taken together in one analysis
JMP = Elasmobranchs + benthos		-	-	1885	498146	Theoretical example of integrated monitoring

Observations made on the basis of this exercise:

a. The added value of joint monitoring in terms of costs is difficult to assess. The project used a proxy for sampling effort, *ie.* number of stations visited and distance travelled by ship, not taking into account the costs of processing the samples;
b. We assume that monitoring of the entire North Sea is needed for a North Sea wide assessment, taking into account the different subdivisions (strata) which can be used as assessment areas. This requires sampling in offshore areas that currently are less intensively visited than coastal areas, except for the IBTS programmeIn general, an increased sampling effort in offshore areas may increase the steaming distance. Likewise, a more evenly distributed pattern of stations across a wider area generates a larger steaming distance than clusters of monitoring stations;
c. The 'optimized' joint spatial monitoring design has been developed for indicators that show relatively little annual variability (Elasmobranchs and benthos). Thus, the data from several years can be pooled for one assessment. This is especially important for sharks and rays,

where assessments have been hampered by lack of data. The combined sampling of benthos and Elasmobranchs requires no additional sampling effort compared to Elasmobranch sampling alone. The project shows that improved sampling design can greatly enhance the confidence of the assessment, with a sampling effort similar to the current IBTS. However, it should be noted that the grid-based design of IBTS is not the best solution for decreasing the variance of the measurements.

d. The project did not take into account the 'risk based approach' to sampling, where monitoring would be more intensive in areas under high human pressure. We also did not consider legal requirements, *eg*. related to marine protected areas or licensing for human activities;
e. For parameters with high seasonal and/or annual variability, such as chlorophyll, more intensive sampling is required during the relevant season. The project did not further explore optimal temporal design.
f. Compared to the other indicators chlorophyll is intensively sampled, ie. many stations, large steaming distance, due to its high variability. Alternative approaches, such as high resolution remote sensing can be expected to significantly decrease the costs of chlorophyll monitoring (see chlorophyll text box).

3. Summary and conclusions

- We developed tools – using visualization and statistical techniques – which can be applied to optimize the sampling for MSFD indicators:

    1. Allocation of stations and explained variance
    2. Changepoint analysis and optimal number of stations
    3. Combining stations for multiple indicators
    4. Analysis of survey efficiency

- These tools have been demonstrated for selected case studies, but are ready to be adapted for "real" MSFD indicators. Thus, the stratification approach and the proposed Neyman allocation for designing the spatial sampling pattern of the North Sea can greatly improve the confidence of the monitoring results for the assessment of an indicator against a target.

- If many indicators are to be assessed in a joint monitoring programme, an ecosystem-based stratification was found to be most suitable ('Atlantis' strata). The possibilities for combinations will become better as more indicators are operational and can be considered jointly.

- The added value of joint monitoring in terms of costs is difficult to assess. The project used a proxy for sampling effort, *ie.* number of stations visited and distance travelled by ship. The optimized spatial designs we developed reveals that:
    1. for sharks and rays the required monitoring effort for an assessment cannot realistically be met in one year. Pooling data over several years is needed;
    2. Benthos sampling can be improved in a joint design and can be combined with demersal fish surveys. Sea also the report on Activity C Multidisciplinary monitoring.

- A most efficient joint monitoring programme may select the best option for the monitoring, which could involve several joint assessments for the indicators, for which the benefit of joint sampling is highest.
- Different combinations could be useful for different seasons or even years, depending on the required frequency of the individual assessments.
- The JMP NS/CS project provides the tools to optimize a future REAL Joint Monitoring Programme.