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

ACTIVITY C –

MULTIDISCIPLINARY MONITORING

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)

This report can be cited as follows:

De Boois, I.J. and R. van Hal 2015. **Towards a joint monitoring programme for the North Sea and the Celtic Sea: Activity C Multidisciplinary monitoring.** Document produced as part of the EU project: 'Towards joint Monitoring for the North Sea and Celtic Sea' (Ref: ENV/PP 2012/SEA). 58 pp.

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Contents

Summary 5

1. Introduction 6

1.1 Framework 6

1.1.1 Objectives of the activity 6

1.1.2 Relations with other activities in the project 6

2. Monitoring design 7

2.1 Case-studies 8

2.2 Meeting the objectives 8

2.2.1 Workshop 8

2.2.2 Output 9

3. Combining monitoring on platforms 17

3.1 Overview of current experiences 17

3.1.1 ICES Workshop on Evaluation of current ecosystem surveys (WKECES) 17

3.1.2 JPI Oceans 17

3.1.3 ICES Working Group on Integrating Surveys for the Ecosystem Approach (WGISUR) 19

3.2 Limitations 22

3.2.1 Priorities 22

3.2.2 Practical issues 22

3.2.3 Data quality 22

3.3 Benefits 22

4. Gaps and needs 23

4.1 Data 23

4.1.1 Exchange 23

4.1.2 Accuracy and precision 23

4.2 Methodologies 23

4.2.1 Sampling techniques 23

4.2.2 Calculation of indicators 23

4.3 Coordination 23

4.4 Adding activities to current monitoring 24

4.5 Outsourcing data collection 24

References 24

Annex 1. Project Management Plan Activity C 26

Annex 2. Case-study descriptions 30

Indicator D5 Eutrophication: 5.2.1 Chlorophyll 30

Indicator D1 fish: demersal elasmobranch species 32

Indicator D1/D6 benthic habitat condition 34

Indicator D10 Marine litter: Seafloor Litter 36

Annex 3. List of participants 38

Annex 4. Questionnaire 39

Annex 5. Potential monitoring methods for the case-studies 40

Annex 6. 'Tender' for Joint Monitoring Programme in the North Sea 45
Scenario A 45
Scenario B 45
Scenario C 45
Annex 7. Output Scenario A, B and C by case-study 46
Chlorophyll-a 46
Scenario A 46
Scenario B 47
Scenario C 47
Demersal elasmobranchs 49
Scenario A 49
Scenario B 49
Scenario C 51
Benthic multi-metric indices 52
Scenario A 52
Scenario B 53
Scenario C 53
Marine litter 55
Scenario A 55
Scenario B 55
Scenario C 56
Annex 8. WGISUR products 57
Annex 8.1 Additional task table 57

Summary

This report contains the results of Activity C 'Multidisciplinary' within the EU project 'Towards a Joint Monitoring Program for the North Sea and Celtic Sea' (JMP NS/CS). The objectives of this part of the project are:

- To assess the technical and practical opportunities for extending the current monitoring programs to supply the data needed for the indicators specified below. This will be done for the three distinct monitoring platforms currently in use, e.g. boats, airplanes/satellites and permanent/stationary monitoring systems.
- Adding constraints and the additional costs and benefits to the output of objective 1. The constraints will in the first place be the policy objective of the monitoring program and the value of continuation of long term time series. Other constraints can be limited experience of the staff, lack of storage capacity, database concerns etc.

Based on the constraints a proposal for an achievable alternative monitoring programme can be made.

Both objectives were being dealt with in a 2.5 day workshop, held in Brussels 10-12 June 2014. 17 consortium partners joined the meeting.

The focus of this Activity is on extending existing monitoring activities. The reason is that cost-efficiency is a strong driver in current thinking about programmes. New programmes should be established to support MSFD data requirements (Borja and Elliott, 2013), and the expectation is that extending existing monitoring activities will be more cost-efficient than establishing new activities from the bottom up.

As it is very complicated to take all monitoring into account, solutions are sought for a selection of case-studies covered throughout the JMP NS/CS, focussing on:

1. Chlorophyll-a
2. Demersal elasmobranchs
3. Benthic multi-metric indices
4. Marine litter

By correspondence, experiences on combining multiple activities on a single platform were discussed, for which also information from the Joint Programming Initiative Healthy and Productive Seas and Oceans (JPI Oceans) and ICES Working Group on Integrating Surveys for the Ecosystem Approach (WGISUR) were incorporated. Main benefits of combining different monitoring activities on a single platform are the (1) cost reduction compared to all activities on different platforms and (2) direct spatial and temporal linkages between the data collected. Potential drawbacks are the limited amount of room for scientists and research equipment, and the difficulty to set priorities to the objectives. If the priority of the objectives is not well-defined, it is difficult to decide what to carry out and what not when the circumstances (e.g. weather, time constraints) change during an expedition.

When moving towards a Joint Monitoring Programme, either by combining multiple activities on a platform, combining (inter)national sampling effort or using multiple platform types for the data collection, it is important to oversee the steps that have to be taken to facilitate real joint monitoring. Gaps and needs were identified for:

- Data exchange
- Data accuracy and precision
- Definition and standardisation of sampling techniques
- Indicator calculation
- Coordination
- Adding activities to current monitoring
- Outsourcing data collection

Only when those topics are being dealt with, it is possible to make a step forward. All items relate to all types of sampling and indicators, although for some fields the gap might be bigger than for other fields.

1. Introduction

1.1 Framework

1.1.1 Objectives of the activity

The objectives of Activity C 'Multidisciplinary' are:

- To assess the technical and practical opportunities for extending the current monitoring programs to supply the data needed for the indicators specified below. This will be done for three distinct monitoring platforms currently in use, e.g. boats, airplanes/satellites and permanent/stationary monitoring systems.
- Adding constraints and the additional costs and benefits to the output of objective 1. The constraints will in the first place be the policy objective of the monitoring program and the value of continuation of long term time series. Other constraints can be limited experience of the staff, lack of storage capacity, database concerns etc.

Based on the constraints a proposal for an achievable alternative monitoring programme can be made.

1.1.2 Relations with other activities in the project

Activity C depended heavily on the output of Part I (Activities A and B), the catalogue of monitoring activities and the list of indicators and their data needs. The catalogue/database created in part I provides an overview of (a part of) the existing monitoring activities and of the MSFD indicators. The actual data needs of the indicators was not part of the database at the start of Activity C.

Activity C delivered a list of questions related to potential governance and policy constraints on altering the monitoring programs to Activity D. Here, we considered detailed restrictions on national jurisdiction and, for example, redistributing of monitoring tasks and funds between Member States. After consultation with Activity D, the list will be completed. Close communication between the Activity leaders is necessary.

Activity C provided input for Activity E. However, it also needed information provided by the GIS planning tools developed in Activity E. These tools will support the evaluation of adding monitoring activities, based on restrictions on spatial and temporal data needs of current surveys. This means that run-time of the two Activities partially overlapped.

2. Monitoring design

In the North Sea currently many different monitoring activities covering a range of ecosystem aspects exist. An inventory is made in Activity A ('Inventory of monitoring programmes') of this project. These mostly isolated activities are the pieces of a puzzle that should be combined to form a cost-efficient Joint Monitoring Program achieving the original objectives as well as the objectives of the MSFD. It is unlikely that combining the pieces of the puzzle will be sufficient to achieve all of the MSFD objectives, because the data requirements of the MSFD go well beyond the existing monitoring objectives. Therefore achieving the MSFD objective will require additional monitoring activities. These additions might be extensions to the data collection of existing monitoring creating multi-disciplinary activities (e.g. monitoring activities having multiple objectives) or new additional activities with the main objective to collect the required MSFD data.

The focus of this Activity is on extending existing monitoring activities. The reason is that cost-efficiency is a strong driver in current thinking about programmes. New programmes should be established to support MSFD data requirements (Borja and Elliott, 2013), and the expectation is that extending existing monitoring activities will be more cost-efficient than establishing new activities from the bottom up.
With respect to cost efficiency we consider the remark by Borja and Elliot (2013):" *a fear that rather than scientific criteria being used to define the level of monitoring, it is economics – i.e. the 'bean-counters' are now dictating the science to be undertaken such that we will reach a stage where monitoring is no longer fit-for-purpose or even, paradoxically, value-for-money"*.
It is tempting to add more and more activities to existing programs, to collect more for the same amount of money. Even though it is tempting, this way might lead to additional work that is not fit for purpose and value-for money. It will cause a risk for the main/original objective of the existing program as additional activities put pressure on the original work.

Adding to and altering existing monitoring activities is more or less the same as designing a new monitoring program. This means it should follow the same steps involved in designing monitoring:

1. Formulate the object: The objective of the monitoring for the MSFD is in most cases the indicator for which the data is required. The description of the indicators should contain the questions that need to be answered by the collected data. Define objectives (e.g. deliverables (data or processed indicators), description of data-use, knowledge gaps).
2. Data to be collected: The description of the data should contain the type of data (e.g. numbers, biomass, concentrations, presence/absence etc.) and it should describe temporal and spatial aspects. Define timing (e.g. frequency, duration).
3. Methods to be used: A specific sampling method could be required, however this might be of less importance as different sampling methods can be used to collect the same type of data. The assessment of data should then contain solutions to combine the data of the different techniques. Here also the staff expertise needs to be defined.
4. Quality of the data: Data quality is of importance especially when different sampling methods and collecting the data as secondary objective of a monitoring program are considered. Different sampling methods will provide data of different quality. Adding data collection to a survey with as first priority a different discipline might cause a risk to the data quality.
5. Degree of precision required: The degree of precision required is determined by the quality and quantity of the data collected. The degree of precision required involves scientific input as well as a management decision. It will ultimately determine the number of samples to be collected.
6. Sampling design: Sampling design involves randomisation, semi or pseudo randomisation, fixed locations, clusters, continuous measurements etc.

The steps need to be completed else organising the in-situ data collection will be impossible. Thus only when the step are completed, the actual organisation of the in-situ collection of samples can take place and the work of Activity C can have a start. Activity C involves the organisation of the in-situ data collection, which includes exploring down-time or spare capacity of existing monitoring activities. It might also involve integrating existing monitoring, creating multi-disciplinary activities, to make better use of the available budget.

The indicators in the catalogue of part I were lacking most of the required information for completing the steps. A more thorough look at the indicator descriptions by country also including the available proposal for

monitoring (The Netherlands, UK) did not provide much more of the required information. Only a single proposal contained the required detail to complete the steps, e.g. the Dutch proposal for monitoring benthos in its EEZ (Troost *et al.*, 2013, Anonymous, 2014).
In all the other cases the required details were missing or in cases were more detail was provide it was set in stone leaving no room for proposing changes to the monitoring. An example of the last is the OSPAR common indicator on seabed litter, its definition includes that it is sampled on the International Bottom Trawl Survey (IBTS). In this case it leaves no option for Activity C to organise this indicators data collection differently.

Therefore Activity C cannot go more in-depth than suggesting potential ways of organising multi-disciplinary monitoring, concrete realistic scenarios cannot be designed. Completing the steps for monitoring design is not included in this Activity, and is for a large part not even part of the current project.

2.1 Case-studies

The case-studies taken into account are shortly described below. Full descriptions can be found in Annex 2. Only indicators with clear data needs (requirements) were considered. This means that it should be known what should be monitored (metrics), when and where, how many data points etc.

Described above this detailed information was not available for the indicators. Solutions are sought for the case-studies covered within the JMP NS/CS:

1. Chlorophyll-a: Concentration of chlorophyll in waters during the growing season
2. Demersal elasmobranchs: For demersal elasmobranch species in the North Sea and Celtic Sea (Dransfeld, 2013):
   - Distribution of the species: % occurrence (number of hauls in which a species was found/total number of hauls carried out, by year)
   - Population abundance: CPUE by year
   - Differences in abundance
3. Benthic multi-metric indices: Benthic habitat condition can be assessed by benthic indicators, which mostly rely on species-abundance data. A wide variety of benthic indicators exists for marine systems (for a most recent overview see: http://www.devotes-project.eu/devotool/).
   Due to this diversity in benthic indicators, the following guidelines were given:

   - Not to use the multi-metric indicators themselves, but the underlying variables and parameters (i.e. species abundance, species richness, Bray-Curtis similarity (measures of species composition (turnover) / community hetero-/homogeneity), biomass, species sensitivity [AMBI, sum($ES50_{0.05}$)]). This will allow us to draw conclusions that are applicable to a wide set of multi-metric indicators.
   - To run the analyses at the level of selected multi-metric benthic indicators. Indicators defined under WFD, MSFD, Habitat directive, OSPAR or HELCOM can be selected for this purpose.

4. Marine litter: Large-scale seafloor surveys off the European coast have found widespread presence of bottles, plastic bags, fishing nets, and other types of plastics. Plastics are the most abundant litter found in the marine environment and comprise more than half of marine litter in European Regional Seas.

   In relation to marine litter the following indicators have been proposed by OSPAR:

   - **Common Indicators**:
     - Beach litter (all CP's)
     - Plastic Particles in Stomachs Fulmars (North Sea) as floating litter indicator (and impact on biota)
     - Seabed litter using International Bottom Trawl Surveys (IBTS)
   - **Candidate**: other target species/impact on biota indicators (outside North Sea) - in development
   - **Candidate**: micro-plastics (currently not defined, R&D will continue to close knowledge gaps)

2.2 Meeting the objectives

2.2.1 Workshop

Both objectives were being dealt with in a 2.5 day workshop, held in Brussels 10-12 June 2014. 17 consortium partners joined the meeting, the full list can be found in Annex 3.

All consortium partners were asked to deliver a list of potential participants for the workshop, following two criteria:

1. People who are able to think out of the box, and like to participate in brainstorm sessions
2. Diversity in expertise fields of the potential participants

Based on the contributions, a selection was made where countries, partners, and expertise fields were equally represented. The maximum number of participants was set to 20. All partners participating in this part of the project except for IFREMER, France, were represented.

The selected participants received an invitation together with a questionnaire where more specific questions were asked than needed for Activity A and B (inventories of monitoring and indicators). The questionnaire is in Annex 4.

Apart from one plenary brainstorm and plenary presentations, the workshop worked in subgroups, each dealing with one of the case-studies. The plenary brainstorm, as start of the workshop, was on potential methods for collecting information for the case-studies. Following on the brainstorm, the lists of methods (sampling gears) was extended with the technical and practical limitations of the specific method (Annex 5). Generic gaps and needs that resulted from the discussions, were listed in a separate document and added to this report in section 4.

The subgroups were asked, for their respective case-study, to report on three scenarios, being:

A. Joint Monitoring Plan only considering existing monitoring that has a main objective other than the data requirements of the specific case-study (non-dedicated)
B. Joint Monitoring Plan considering existing non-dedicated monitoring and other information sources (e.g. industry, ferry-boxes, etc.)
C. Joint Monitoring Plan taking into account all potential information, so also include dedicated monitoring

The full description of the scenarios is in Annex 6.

On top of that, all groups designed the optimal JMP for the respective case-studies. This scenario was presented to the over-all project lead at the end of the workshop.

2.2.2 Output

The output of scenarios A, B and C by case-study can be found in Annex 7. This paragraph only contains the most optimal scenario by case-study.

Chlorophyll: Optimal Joint Monitoring Programme for the North Sea Region

Vision

A multiplatform international chlorophyll monitoring programme for the North Sea combining fluorescence and direct water sample measurements from moorings, vessels and CTD sampling combined with validated remote sensing for offshore waters.

These samples will be taken for the 'growing season' March to October and integrated to calculate 90th percentile values for assessment purposes.

Optimal scheme

The programme will comprise:

1. Existing fixed point monitoring stations: Smart Buoys (England) and Marnet (Germany), regular (weekly and monthly) sampling stations (Scotland, Germany, Denmark, Netherlands), existing WFD inshore monitoring sites (All Member States (MSs)). This provides reasonable spatial and temporal coverage for Southern NS and inshore waters, leaving a gap for the central and Northern North Sea (trans-boundary areas).
2. New fixed monitoring locations for regular water sampling at platforms of opportunity: Oil and Gas platforms. This requires coordination with industry and new sample analysis costs. Approx. 5 new stations in central and Northern North Sea (stratified by water body).

3. Existing ferry-boxes installed on research vessels and ferry routes. These will require more robust programmes of fluorometer calibration to be adopted in a consistent manner to improve QA of the data currently collected.
4. Remote sensing (RS). Satellite imagery converted to chlorophyll concentration for the whole region. Validated using direct measurements at fixed stations. This will require an improved methodology across MSs for validation of RS data expanding on the existing programme of Belgium and emerging methodologies in the UK (See research needs in the Stages Policy-brief, 2014[1]).

Existing sampling not included in the current programme:

- Ad hoc oceanographic sampling and regular fluorometry data collected during hydrographic research and long term monitoring (oceanographic sections). It was considered these are not sufficiently frequent in the same space to be easily coordinated and included.
- Other platforms: planes, gliders, AUVs, fish farms. These platforms would all bring additional costs and coordination complexity. It was felt the programme comprising 1-4 above was sufficient for MSFD purposes.

Costs

1. The most significant additional costs will be associated with operationalising the oil platform water sampling and analysing those samples collected. This additional cost will be small in relation to the scale of the current programme.
2. Improving the calibration of ferry-box fluorometers will also incur additional costs in calibration sampling and sample analysis
3. Additional staff time resource will be required to fully develop the remote sensing validation programme for the North Sea.

Additional considerations needed

1. The JMP as described incorporates a range of measurements across institutes and platforms. Consistent methodologies for chlorophyll analysis (total by fluorometer, pigments by HPLC) and calibration of fluorometers by direct analysis of water samples is still needed.
2. A consistent approach to Remote Sensing validation
3. Statistical approaches needed to assess multiple data types and frequencies across the region and growing period. Assessment of 90th percentile against thresholds should be carried out.
4. Agreement of regionally specific thresholds to apply in assessment
5. Existing monitoring for chlorophyll rarely collects only this information, often these monitoring activities are already multi-disciplinary collecting a range of data. Suggestions for changing the current Chlorophyll data should consider all the other data collected as well.

Additional indicator data to be collected

The water sampling aspects and dedicated platforms of the proposed JMP will provide the opportunity to collect additional data relevant to other MSFD indicators:

a. Supporting environmental data relevant to several Descriptors such as Eutrophication (D5), Biodiversity (D1, 4 & 6), Hydrographical condition (D7), Non-indigenous species (D2): salinity, temperature, depth, turbidity, light (PAR), oxygen, nutrients, carbon, pH, air pressure, wind, sea state
b. Phytoplankton & zooplankton (D5, D1 & 4)
c. Marine litter – floating litter (remote sensing) and microplastics (D10)
d. Non-indigenous species (Cefas SmartBuoys have settling plates) (D2)
e. Carbonate chemistry (for ocean acidification)
f. Contaminants, metals – including passive samplers in the water column (D8)

[1] http://www.stagesproject.eu/stages-msfd-decision-support-resources

Demersal elasmobranchs

Vision

The North Sea is a habitat for a variety of elasmobranch fishes (sharks, skates, rays). Distribution and species diversity show an east-west gradient with highest species richness along the British coasts, and lowest species richness along the continental coast (Daan *et al.*, 2005).

In general, elasmobranchs have a low growth rate, late maturation and low reproductive output, which makes them highly vulnerable to overfishing. There are many examples of declining or even extirpated populations due to commercial fisheries (Walker and Heessen, 1996). To fulfil MSFD descriptors D1, D3 and D4 healthy elasmobranch populations will be required, and a monitoring scheme to measure relevant indicators has to be put in place. Data on distribution and abundance of shark and skate/ray species are available from a range of regularly conducted scientific surveys as well as from commercial landings/discard data from commercial fisheries (Ellis *et al.*, 2007, Daan *et al.*, 2005)

In this proposal we sketch a joint monitoring programme for elasmobranch fishes by using a combination of optimized existing fish monitoring schemes and additional schemes.

Optimal scheme

In the North Sea, and to a lesser extent the Celtic Sea, several monitoring schemes aimed at commercially exploited fish species are running.

1. Scientific surveys (i.e. bottom trawl and beam trawl surveys IBTS, BTS, both covering the North Sea and Celtic Sea)
2. Commercial landings data
3. Discard information/observer data

These monitoring schemes are aimed at commercially exploited fish species, but data on other species are collected systematically. Data on: species specific catch per unit effort, species specific LFD (length, frequency distribution) plus individual length and weight measurements (sometimes aggregated), sex and maturity information are available for the whole North Sea and Celtic Sea. This information is collected during IBTS and BTS, and to lesser extent in the two other schemes.

The existing schemes are not tailor-made for elasmobranch fishes and show several gaps: they have limited spatio-temporal resolution as they are focussed on commercial fish species that (could) have a different distribution than elasmobranch fishes, and elasmobranchs are not always reliably identified to species level (only group level) in the commercial landings data and discard information/observer data.

With some adjustments the IBTS and BTS surveys can yield more elasmobranch-targeted data; focus on areas of ecological interest and improve species identification. Additional ship time to survey these areas and extra staff may be needed.

Additional schemes:

1. Observer scheme fishing vessels

   Expand the observer scheme and send observers on board fishing vessels to collect data on elasmobranches according to a standardized North Sea and Celtic Sea wide protocol
2. Tagging “Fish & chips”

   Tagging of caught individuals; with archival tags and/or satellite pop-up archival tags depending on goals.
3. Egg case sampling on beaches “Egg case hunt” [2], which might be combined with the Beach litter monitoring.

Collected data

1. Observer scheme fishing vessels

   Size, age, sex, abundance (based on Species specific catch per unit effort); spawning and nursery ground identification
2. Tagging

[2] http://www.sharktrust.org/en/great_eggcase_hunt

Depending on tag type. Geographical position, depth distribution, activity patterns (size, age, sex) and eventually identification of spawning/nursing areas, spatio-temporal distribution (e.g. migration patterns)

3. Egg case sampling on beaches

   Presence-absence data; spawning and nursery ground identification

Arrangements

1. Observer scheme fishing vessels
   - Training of observers
   - Liaison programme
   - Two observers per country, one researcher for coordination, analysis etc

2. Tagging
   - Training of observers
   - Acquiring permits
   - Liaison programme (vessel access)
   - Recovery programme for tags
   - Same observers do the tagging; one overall researcher for coordination, analysis etc
   - Selection of tags in relation to goals. E.g. archival tags for abundance estimates via mark capture–recapture of sedentary species, or spatio-temporal distribution of migratory species via satellite tags
3. Egg case sampling on beaches
   - Develop beach combers app to document and upload records to online database
   - Liaison programme
   - Overall coordinator (could be a task of one: the coordinator of the observer scheme)
   - Start with building up a network of volunteers that collect data. In the future it can be possible to organize more dedicated surveys like a national or European-wide egg sampling weekend.

Benefits

1. Observer scheme fishing vessels
   - Large spatial and temporal coverage but focus on
   - Improved Species ID (species level instead of species groups)
2. Tagging
   - Collection of ecological and distributional data
3. Egg case sampling on beaches
   - Collect data on distribution of eggs can aid in identification of spawning areas
   - Raising awareness, public involvement

Table 1. Additional data on MSFD descriptors per scheme.

	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11
Existing schemes	X		x	x	X	x				X	
Observer scheme fishing vessels	X	x	x	x						X	
Tagging programme			x								
Egg case sampling										x	

Risks

The proposed additional schemes contain some risks, being:

1. Observer scheme fishing vessels
   - It might not be possible to get observers on board: co-operation of commercial vessels
   - Fishing effort is not focussed on elasmobranch species, which possibly/likely results in spatial and temporal mismatch between fishing grounds and important areas for demersal elasmobranchs
2. Tagging
   - Low recovery rate of archival tags
   - Technical problems with (satellite) tags could lead to reduced data reports
3. Egg case sampling on beaches

- Fading interest and cooperation of public (feedback important, visualize records via website e.g. like observation.org)
- Storage of collected data-> embed it in e.g. National History Museum

The risks can be assessed and minimized by conducting a pilot project to assess the feasibility and refocus on spatial and temporal coverage of the effort.

Costs

Costs for implementing the proposed monitoring need to be detailed but they include:

1. Optimizing existing monitoring schemes
    - Training in species ID and data collection for scientists on board
    - Salary for data collection, analysis and reporting (estimated at 4 weeks)
    - Additional ship time to visit important elasmobranch areas
2. Observer scheme fishing vessels
    - Training observers in species ID and data collection
    - Salary 2 observers per country
    - Salary 1 coordinating scientist per country
3. Tagging
    - Salary 2 observers per country, combined with option 2.
    - Salary 1 scientist, possibly combined with option 2. Material costs unknown; depending on number and type of tags. Satellite ‘time’ needs to be included for satellite tags
    - Recovery fee archival tags
4. Beach combers app
    - App development costs
    - Salary national contact person, combined with the scientist for the observer scheme

Requirements identified

Before setting up a monitoring scheme the requirements have to be defined. In the MSFD framework the goals are currently undefined. A description of Good Environmental Status is lacking. Furthermore, the required power of trend detection in changes in the MSFD-descriptors and indicators is unknown.

Benthic multi-metric indices

Vision
The majority of benthic assessment approaches rely on species abundance data. Species abundance data can be collected in a variety of ways (e.g. using cores, grabs, dredges, video, …). Presence or absence of a certain benthic species is one of the attributes that can be obtained through species abundance data. This information is needed to undertake the following MSFD assessments (under descriptor 1 and 6):

- Habitat condition assessment (e.g. using multi-metric benthic indicators)
- Species distribution (e.g. of biogenic reef, species for conservation importance)

A stratified (habitat) monitoring design (random, semi-random, fixed locations) is required to undertake the MSFD assessments outlined above. Currently, there is no common assessment or monitoring protocol or approach for collecting these types of data within the North and Celtic Sea regions. To have confidence in assessments carried out, appropriate numbers of samples in each habitat are required, which are determined by the power and effect size required to be captured and the natural variability of the characteristics of the habitat in question.

Though achieving these types of analyses on the required scale is beyond the scope of this exercise, we have tried here to capture ideas to work towards a regional, integrated monitoring strategy for assessing benthic communities.

Existing monitoring schemes
Benthos data (habitat and species) are mainly collected within the following frameworks:

- National monitoring programs, which are financed by the respective national governments (e.g. the Netherlands)
- Institutional monitoring of long term time-series (sometimes externally financed, mostly institutionally financed)
- Compliance monitoring by industry for permits and environmental impact assessment of human activities (constructions [harbours, wind farms], aggregate extraction, dredging and dredge disposal.

These different types of monitoring program are characterized by different objectives and each has its own mix of strategies, sampling designs and protocols. Some of the programs run independently, while most of the sampling is part of an integrated, multidisciplinary program (e.g. environmental monitoring of mainly biological and chemical aspects [CSEMP, ILVO Monitoring, …]). Ships are used as the platform for benthic surveys, and monitoring is typically dedicated to benthic work (e.g. benthic monitoring surveys do not usually include other data type collection).

Optimal scheme
Due to the variety of benthic sampling strategies employed within the North Sea region, a regional monitoring strategy is advisable to achieve a regional assessment of benthic habitat condition. This does not need to be a completely new and independent monitoring program from the national programs currently in existence. A good example of this can be seen within the ICES BEWG work, which has undertaken a North Sea wide benthos evaluation on two occasions to date (1986 and 2000, NSBS) (Rees *et al.*, 2007). The first study was based on a gridded sampling design that was sampled simultaneously by different institutes. The second was based on a voluntary collection of benthic data from the year 2000 originating from national or project related monitoring programs. Both exercises have shown that a regular evaluation of the benthos on North Sea scale can have benefits (Rees *et al.*, 2007, Reiss *et al.*, 2010).

Therefore, we propose that an ideal benthic monitoring scheme for MSFD purposes should be based on the following components:

- North Sea wide gridded approach required to provide requisite coverage of parameters at broad scale level (e.g. NSBS).
- Dedicated national surveys at MPAs and/or high pressure areas (risk based monitoring)
- Data from industrial monitoring (e.g. wind farms, aggregates) should be included where possible, providing an added value by increasing the data availability at regional scale.

Monitoring must be seasonally fixed across all programs, and all ‘common’ data needs to be collected and analysed based on agreed protocols (cf ISO 16665 norm). Scenario’s to determine the volume and distribution for an ideal benthic monitoring scheme will be assessed. More information is available in the Technical report of Activity E of this project.

Additional benthic samples may be sourced from:

- Other existing surveys collecting data within a North Sea wide grid (e.g. fishery survey)
- Alternatively, 'additional' benthic samples required from within the grid, in each countries national waters, can be sampled during the regular national benthic surveys by the individual countries.

Collected data

Species- abundance – (biomass) data. It is not difficult to take benthic samples with the regular techniques (cores or grabs). The handling of the samples on board and in the lab needs to be done by trained people (especially for the lab). A correct species identification based on a common taxonomic discrimination protocol is advised.

Arrangements

- An international sampling design needs to be created.
- A joint monitoring protocol is required, detailing data requirements:
    - Existing surveys from 1986, 2004 should be referred to inform Protocol scientifically (e.g. JMP Activity E)
    - Habitat type, season, pressure gradient measures, gear type, area, sieving size, etc… should be included
- A coordination group is required to steer the direction of monitoring (e.g. existing coordination bodies such as ICES [ICES-BEWG], OSPAR ICG-COBAM can be used). In fisheries monitoring such coordination groups exist, but these are lacking for environmental monitoring.

Benefits

- Existing monitoring platforms can be used to collect data.
- Existing monitoring data (national survey, monitoring facilitated by industry) can be used to increase regional data series (e.g. 1986, 2000,2015...).
- Joint co-ordination would be achieved using agreed protocols.
- Improved knowledge of sampling design and techniques.
- Possible financial savings, at least better value.
- Extra training.
- The collected data can be used for other applications (e.g. modelling, habitat ground-truthing)
- Increased coordination across fields (e.g. integrated monitoring and assessment of benthic systems)

Risks

- Failed collaboration (countries not monitoring regionally) leading to maintenance of Status quo
- Duplication of effort if national and regional monitoring programmes are not joint and/or integrated
- Accuracy dependent on protocols produced

Costs

- Efficiencies will be met by using existing monitoring platforms and collecting multiple monitoring data through integrated monitoring approach
- NO cost estimated at this stage, but a full benthic sample could be ~£350-400 per sample (including ID, biomass and enumeration of species).

Gaps and needs

- Sample resolution not yet defined (i.e. temporal and spatial coverage required). This will be a first important step to come to an appropriate regional benthic sampling design.
- Different assessment approaches and monitoring objectives can require different data collection methods and designs (e.g. time of year)
- Difficult to stratify monitoring sampling where background data are limited (e.g. habitat extents and boundaries)

- Multinational dedicated funding for Joint Monitoring development, coordination and implementation
- To come to a step wards process to join the monitoring effort for benthic habitats (regional scale), with the national surveys as the starting point.

Requirements Identified

More flexibility in funding streams should be arranged, e.g. IBTS EU contract restrictive regarding ship time. Multiple use of the ship should be facilitated by flexibility in the funding, e.g. that the IBTS can be extended with one or two days to collect benthos samples, those days not being paid for via the IBTS, but via a different EU funding regime.

Most Promising aspect of this Case Study

Supporting information collected by other non-dedicated monitoring informs monitoring design and improves sampling stratification, leading to added efficiencies and value for money

Project specific monitoring by industry may prove to be a rich source of benthic monitoring data.

Recommendation

A benthic co-ordination group should be created to progress and steer appropriate collaborative and integrated monitoring across the North Sea.

Marine litter

Due to time constraints, for marine litter only scenario studies were done. These can be found in Annex 7.

3. Combining monitoring on platforms

Experiences on combining multiple activities on a single platform were discussed, for which also information from the Joint Programming Initiative Healthy and Productive Seas and Oceans (JPI Oceans) and ICES Working Group on Integrating Surveys for the Ecosystem Approach (WGISUR) were incorporated. The text in paragraph 3.1 is often directly taken from the reports by those groups.

Although paragraph 3.1 mainly aims at work on board vessels, the limitations and benefits incorporate all platforms (boats, airplanes/satellites and permanent/stationary monitoring systems).

One should be aware that data collection for the MSFD often takes place on board of ships or planes, which means that once you leave there is no or limited possibility to get additional personnel or equipment on board. The same applies to stationary monitoring systems: once someone is underway to install equipment, it will take a lot of time and effort (and so: money) to return ashore to fetch anything that was forgotten.

3.1 Overview of current experiences

3.1.1 ICES Workshop on Evaluation of current ecosystem surveys (WKECES)

The Workshop on Evaluation of current ecosystem surveys (WKECES) met in Bergen, Norway in November 2012 (ICES, 2012b). 19 scientists representing 7 countries joined the meeting. The aim of the workshop was to evaluate four surveys with distinct ecosystem characteristics and to synthesize the results of this evaluation into advice to WGISUR as to the important considerations when developing 'ideal ecosystem survey' for the implementation of the ecosystem approach to management.

Two top level themes emerged as the causes of the strengths and weaknesses for all the surveys:

a) setting and prioritizing objectives and
b) survey design and the need to be able to elucidate process by explicitly linking dynamics in different ecosystem components.

It became clear that some of the strengths were mutually exclusive, either operationally or conceptually, and therefore an 'ideal ecosystem survey' on a single vessel, is unlikely to exist.

An ecosystem monitoring program that has at the heart of it one or more ecosystem surveys is required and these must go beyond strict status observations and link different ecosystem components with each other or the physical environment. The prioritisation of these surveys should be based on three factors:

- the characteristics of the ecosystem particularly with respect to the spatial and temporal scales of variability;
- the available resources in ships time, but also expertise and financial considerations. International pooling of resources will aid to increase efficiency and improve regional ecosystem assessments across national boundaries;
- the management, legal requirements and prioritisations for reporting. This is not a scientific criterion, but an ability to address the former will almost certainly have an impact on the availability of resources.

3.1.2 JPI Oceans

The JPI-Oceans Pilot Action on Multi-use of infrastructure for monitoring the North Sea[3] did field tests on extending current fish surveys into multi-disciplinary monitoring activities. Monitoring activities were added to the regular ICES coordinated fish surveys IBTS (International Bottom Trawl Surveys) and BTS (Beam trawl Survey). These survey cover a large part of the North Sea and seem therefore ideal to extend with additional data collection. Some of the scenarios above propose such additions.

The regular activity of these fish surveys is fishing and counting and measuring the catch. The abundance estimates, length distribution and biological information (gender, maturity, age) are provide to the ICES stock assessment working groups that use this information to provide advice on the fish Quotas.

[3] http://www.jpi-oceans.eu/multi-use-infrastructure-monitoring

When considering additional activities that could be added to the activity of fishing, it was noted that the surveys are already multi-disciplinary. On all vessels participating in these surveys additional information is collected. In the first quarter IBTS of 2014 the following additional activities took place (ICES, 2014):

Activity	**GFR**	**NOR**	**SCO**	**DEN**	**NED**	**SWE**	**FRA**
CTD (temperature+salinity)	x	x	x	x	x	x	x
Seafloor Litter	x	x	x	x	x	x	x
Water sampler (Nutrients)	x	x	x		x		
Egg samples (Small fine-meshed ringnet, CUFES)	x	x			x		x
By-caught benthic animals	x	x			x		x
Observers for mammals and/or birds		x					x
Additional biological data on fish	x	x			x	x	

Some of these were done as part of the JPI-Oceans pilot action but most are done on a more or less regular and/or coordinated basis.

Additional activities considered for JPI-oceans were:

1) collecting additional information from the catch (epibenthos, marine litter, eggs, jellyfish, etc.)
2) automated sampling (continues plankton recorder, microplastics, seafloor)
3) Additional deployment of equipment (benthos camera's, boxcores and dredges, CTD and water sampler)
4) Requiring additional steaming (transects for acoustic observations or observations of marine mammals and birds).

It was clear from the start that testing activities in the fourth category were out of the budget of the pilot. In most cases even the topics for point 3 are out of the budget. Thus tests focussed on the "low hanging fruits" collecting more information from the catch and using automated sampling.

The pilot studies indicated that not all the activities are as simple on all the boats involved in the survey. Even on the same vessel the effort might differ between the different surveys, e.g. having the boat in action does not guarantee that all the activities can take place.

Even the low hanging fruits like collecting information on benthos species from the catch involves costs and time. The benthos species have to be sorted from the catch, depending on the size and type of the catch this might involve a reasonable amount time, time that staff cannot spend on other activities. Identification of the benthos species has to take place. This identification in not the regular experience of the fish researchers on board. It requires benthos experts or training for the fish experts.

Additional deployment took place in some cases. CTD's are deployed regularly at the start or end of each fish tow and do not require further handling when the device is back on board. Deployments like the boxcores and dredges involve (a lot of) preparation, sometimes include dismantling the fishing gear, and require further handling and sample processing when the device is back on board. The time required for these types of sampling is limited available during the surveys (unless night time is available like in the third quarter IBTS and BTS). In the Dutch IBTS Q1 situation it was anticipated that one or two of these deployments could take place each day. At the end it resulted in two or three samples actually collected in the time of three weeks. Weather was a major factor disabling a number of potential opportunities, practical limitations of the vessel to deploy different types of equipment increased the deployment time and reduced the number of successful samples collected. Planning of the cruise depends on the prime objective e.g. fishing, which resulted in ending up with an opportunity to deploy equipment in areas where it was not allowed (permits, legislation) or uninteresting for collecting data requirements for the MSFD.

Although the final results are not available yet, the overall feeling is that opportunities to collect additional data do exist. This might be cheaper than doing it on a separate cruise, but will in all cases involve additional costs. The possibilities to collect additional data differ between the vessels and surveys. For the MSFD requirements to depending fully on additional data collected poses a risk. It might result in a (too) small number of samples collected because priority will be given to the first objective. Adding more and more will make the prioritization even harder. Multi-disciplinary means taking more persons on board having specific expertise or investing in education of multi-disciplinary staff members (Jack of all trades, master of none). The master of none might even pose a treat for the prime objective, another risk for the prime objective is that the time to do it properly is under-pressure because other data has to be collected. Finally resulting in none of the activities being to sufficient.

There are thus serious risks to develop multi-disciplinary monitoring. However, we still think there are possibilities. But it will require more preparation of the monitoring activities, creating protocols on how to deal with the prioritization etc. It will also require more flexibility and currently available, in the duration of the cruise, legislation and permits, etc.

3.1.3 ICES Working Group on Integrating Surveys for the Ecosystem Approach (WGISUR)

WGISUR[4] exists since 2010 and during its life-span, the group has developed a number of tools and overviews related to ecosystem monitoring and to adding activities to current fish monitoring.

Adding tasks to current fish surveys

Adding tasks to existing surveys can be a very good method to obtain more data related to the ecosystem (e.g. Dickey-Collas *et al.* (2012)). WGISUR developed the so-called ‘additional task table’ (ICES, 2012a), which describes the additional tasks that might be carried out during the current fish surveys (first page in Figure 3.1; full overview in Annex 8.1).

	MSFD descriptor related to												Preparation
Task	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**Fisheries survey for data collection**	**Additional equipment**
Fish and shellfish (survey specific)													
Organism collection (e.g. for contaminants, fatty acids analysis etc.)	x	x	x	x				x	x			trawl, acoustic and ichthyoplankon	no
Stomach sampling	x		x	x								trawl, acoustic and ichthyoplankon	no
Additional biological data (e.g. isotopes, biological data of other than standard species)	x	x	x	x				x				trawl, acoustic and ichthyoplankon	no
Disease/parasite registration	x	x	x		x			x	x			trawl, acoustic and ichthyoplankon	no
Genetic information	x		x									trawl, acoustic and ichthyoplankon	sampling equipment, ethanol
Lipid content				x								trawl, acoustic and ichthyoplankon	Fat meter; Calibation series for the specie
Sonar observations pelagic fish			x									all	scientific sonar
Tagging			x									trawl, acoustic and ichthyoplankon	Tags and fish handling
Bioactive materials in marine species (e.g. for medical purposes)												trawl, acoustic and ichthyoplankon	no
Echosounder observations pelagic fish	x	x	x									all	no
Other sampling of fish/shellfish not taken in main gear	x	x		x								trawl, acoustic and ichthyoplankon	Alternative appropriate gear
Physical and chemical oceanography (e.g. CTD, chlorophyll, oxygen, nutrients, turbidity, etc.)													
Continuous underway oceanographic measurements [from the ship]							x					all	dependent on variables collected
Station oceanographic measurements							x					all	dependent on variables collected
Continuous underway oceanographic measurements [autonomous devices]							x					all	dependent on variables collected
Water movement							x					all	ADCP
Station nutrient samples					x							all	Water sampler
Biological oceanography													
Station microbiological samples	x	x	x	x				x				all	Water sampler
Station phytoplankton samples	x	x	x	x	x			x				all	Water sampler
Continuous phytoplankton samples	x	x	x	x	x			x				all	CPR/fluorometer
Station zooplankton samples [towed]	x	x	x	x				x				all	Towed samplers
Station zooplankton samples [dipped]	x	x	x	x				x				all	Dipped samplers
Continuous zooplankton samples	x	x	x	x				x				all	CPR
Gelatinous zooplankton samples	x	x	x	x								all	Various plankton nets towed/hauled slow
Invertebrates													
Infauna	x	x		x		x						all	Grab/corer, sieve
Epifauna [towed]	x	x		x		x						all	Beam trawl/dredge/sledge/bottom trawl
Epifauna [video]	x	x		x		x						all	Video
Pelagic	x	x		x								all	Trawl, seines and plankton nets
Megafauna													
ESAS sampling (birds, sea mammals)	x	x		x								all	binoculars
Towed hydrophones	x	x		x								all	Towed hydrophone
Habitat description													
Camera [towed/dropped]	x	x				x						all	Towed/dropped camera
Side-scan sonar	x					x						all	Side-scan sonar
Multi beam echosounder	x					x						all	Multi beam echosounder
Ground truthing	x					x						all	Grab/corer, sieve
Pollution													
Floating litter										x		all	no
Sinking litter										x		trawl and tv/video	no
Pollution in the water column								x	x	x		all	dependent on variables collected
Pollution in the sediment								x	x	x		all	Grab/corer
Pollution in organisms								x	x	x		trawl, acoustic and ichthyoplankon	Selected gear appropriate for sampling th
Environmental conditions													
Weather conditions							x					all	no
Sea state							x					all	no

Figure 3.1 Additional task table as developed by WGISUR (ICES, 2012a)

[4] http://www.ices.dk/community/groups/Pages/WGISUR.aspx

Four different ICES survey groups, provided their view on the table to WGISUR:

1. Additional tasks undertaken to address the 'ecosystem approach' are likely to impact the existing surveys, unless sufficient additional resources (staff, ship time, equipment) become available. For a number of surveys, it is unlikely that most additional tasks can be conducted without these additional resources.
2. Consultation of experts is necessary to exactly specify additional staff, equipment and financial requirements.
3. Any additional tasks that require the survey vessels to stop or slow down or divert course from the original survey plan will seriously impact the quasi-synoptic nature of acoustic and ichthyoplankton surveys.
4. Established systems for survey data storage could put constraints on the ability to store data for the EAFM. Post-survey database developments for new data collection should explicitly be taken into account.
5. Each individual country might be providing views on what good environmental status (GES) might be for those descriptors, including methods that could be used to determine status, leading to different data requirements for different countries.
6. The specific need for additional resources for data collection might vary between different survey types.
7. The need for additional laboratory facilities after the survey to analyse samples depends on the lab: a lab might not have any room for more analysis, so this should always be checked.
8. Standardisation of data storage and recovery is very important and should be arranged before additional data collection takes place.

One of the potential impacts of adding more ecosystem data collection to existing monitoring is a decrease in the number of tows or transects devoted to the original objective. In turn, the impact in the reduction of tows is expected to be reflected in a decrease in the precision (or increase in CV) for the products from the existing monitoring.

Developing an ecosystem survey from scratch

WGISUR developed a stepwise approach to design an ecosystem survey (ICES, 2012a). One of the major questions in the design of an ecosystem survey is which ecosystem is going to be monitored, as 'the' ecosystem does not exist. Pressures, threats and so objectives, will vary. International collaboration is needed when an ecosystem cannot be monitored on a national level as it is spread out to neighbouring countries.

When current surveys are changed into one or more ecosystem surveys, current time-series should be taken into account. This does not necessarily mean that it is not possible to design an ecosystem survey. One of the options for internationally coordinated surveys could be to leave the survey as it is for a number of countries, and to start an ecosystem survey with other countries. After some time the parallel time-series can then be compared and maybe translated into each other.

As an ecosystem survey is complex, it is very important to follow a clear procedure when designing it, on one hand to manage expectations and on the other hand to be able to respond to unexpected situations. The outline of the process, including the major steps that have to be taken into account is shown in Figure 3.2. The flow diagram follows the regular steps for designing a new survey, but as many parties have to and will be involved in the design and conduction of an ecosystem survey, it is very important to communicate clearly to keep all parties working together along the same line.

The teams involved in the different phases in the flow diagram might vary as the tasks per phase require different skills. It therefore is important to create clear output at the end of each phase, and to evaluate at the end of every phase if the output is in line with the output of earlier steps.

Any synoptic survey, if designed for purpose, needs to be designed in the context of the processes that govern the system we are monitoring. If this is not the case, then we are largely, simply taking snap shots of the "State" of the system with-out being able to say how that state might have arisen and where that state might progress to, under prevailing conditions.

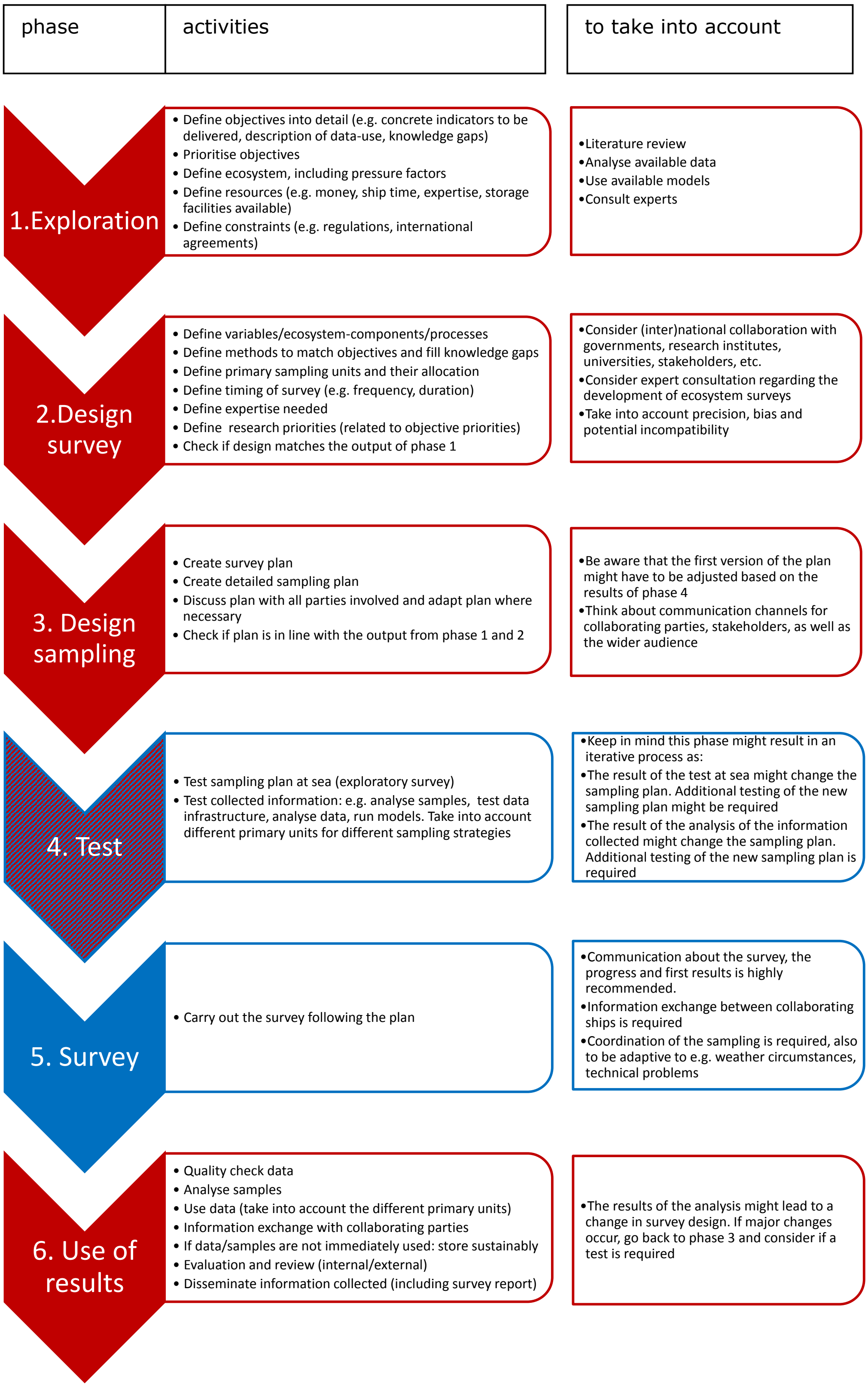

Figure 3.2 Flow diagram for starting an ecosystem survey (red boxes=on land, blue=at sea. Phase 4 (testing) at sea and on land) (ICES, 2012a).

3.2 Limitations

3.2.1 Priorities

Carrying out many activities on one platform requires a clear description of the objectives, and their prioritisation. Whichever platform is chosen, as soon as people are busy collecting data, they should not have to consider which data collection is more important. Money is an easy way to prioritise: if someone pays for the data collection, it will get higher on the priority list. Without any (financial) resources one cannot guarantee that data collection will be carried out in suboptimal circumstances (e.g. bad weather, delay due to technical problems, limited personnel capacity, limited expertise, etc.).

3.2.2 Practical issues

Even when priorities for data collection are clearly set, one should check a number of things before taking off. The lists below can be extended when necessary.

Planes and/or ships:

- Can all the work be carried out within the time-span of the expedition? E.g. if all data have to be collected on a daily basis in daylight, all activities should fit in one day
- Is there sufficient room for the personnel (experts and non-experts) needed for all sampling?
- Can all samples be stored?
- Which equipment can be used simultaneously and which cannot? E.g. if two sampling gears need the same winch, time is needed to shift from one to the other.
- Which activities need experts, and is the expertise available during the expedition?
- ....

All:

- Is additional data storage needed, and is it possible to digitally store the data (especially relevant in case of acoustic data, or when using cameras)
- ….

From the evaluation of ecosystem surveys (ICES, 2012b) it became clear that some of the strengths of the ecosystem monitoring were mutually exclusive, either operationally or conceptually, and therefore an 'ideal ecosystem survey' on a single vessel, is unlikely to exist.

3.2.3 Data quality

Data collection for multiple purposes might need different spatial and/or temporal resolution for different variables. As a result, data collected may lose precision. It should be investigated beforehand which precision is needed, and if it can be achieved in the proposed design.

3.3 Benefits

Carrying out multiple activities on one platform means that the costs of the platform can be shared, resulting in a decrease of the data collection costs.

From a scientific point of view, temporal and/or spatial related data from different compartments of the ecosystem can be a valuable source of information, for example fish stomach data in combination with catch information, or chlorophyll-a data combined with nutrient, temperature and salinity information.

4. Gaps and needs

When moving towards a Joint Monitoring Programme, either by combining multiple activities on a platform, combining (inter)national sampling effort or using multiple platform types for the data collection, it is important to oversee the steps that have to be taken to facilitate real joint monitoring. Only when the topics listed below are being dealt with, it is possible to make a step forward. All items relate to all types of sampling and indicators. However, as the level of international coordination highly varies between the expertise fields, not all items listed below can be classified as a 'gap' in all fields.

4.1 Data

4.1.1 Exchange

Data exchange, exploration and sharing is crucial in joint monitoring. First of all, combining, exploring and analysing data from current monitoring programmes should be encouraged before deciding if more data is needed or different data can be collected which are easier to retrieve. Secondly, data from separate or combined monitoring for a specific area should be exchanged and shared to prevent double effort and to facilitate consistency.

For some scientific fields, international data exchange is quite well organised, but for others it should be put in place before it is possible to really create joint monitoring.

4.1.2 Accuracy and precision

Joint monitoring often means (also) combining multiple techniques on one platform. This cannot be carried out endlessly. Before setting up good joint monitoring programmes having multiple objectives, one should know how many different types of information can be collected without losing precision and accuracy. This precision and accuracy depends on the power needed for the indicators. It is the policy makers' responsibility to decide on the detection limits. Scientists can advise on methodologies for calculating power.

4.2 Methodologies

4.2.1 Sampling techniques

International agreement on methodologies facilitates joint monitoring and data interpretation. It is important to realise than not all sampling techniques are allowed in all countries, so if possible, chose one that is. If there is agreement on the sampling technique, the central North Sea can provide a good opportunity for international calibration/validation of techniques.

When moving towards a standardised methodology, time-series should be taken into account and if those should be kept, changing methodologies is only possible when comparative sampling has been carried out and analysed.

4.2.2 Calculation of indicators

As all MSs have to report the environmental state, internationally agreed methodologies for data-processing and –reporting should apply. If two neighbouring MSs decide to handle the data in a different way, e.g. by reporting only part of it, the level of GES might be different on two sides of the 'border', even when sampling methodologies are identical.

4.3 Coordination

International coordination of monitoring, even if only on a topical level, leads in general to more efficient use of sampling time and data collection. Furthermore, data exchange is easier when the monitoring is internationally coordinated as the scope of data ownership broadens from a national level to the international level. Specifically, for chlorophyll as well as benthos sampling it is recommended that monitoring coordination groups are created, taking the fish sampling planning groups for the ICES area (e.g. WGIPS, WGBEAM, IBTSWG) as an example.

(Inter)national staff exchange also supports alignment of monitoring and consistency in methodologies, as a fresh view leads to re-evaluation of the procedures used. As most monitoring is already in place for a longer time period, some processes can be made more efficient due to technical developments without changing the monitoring methodologies itself. Staff exchange is easier to arrange when monitoring is coordinated internationally, as the relevant people get to know each other on a personal level.

When monitoring is coordinated and carried out internationally, it often happens (e.g. currently in fish surveys) that MSs/institutes sample outside their national EEZ. Simplifying the permit process when sampling outside the national EEZ. Currently, permit requests have to be sent in 3-6 months prior to the sampling, and the permit is often granted last minute.

Existing sources of information, e.g. EUROFleets [5], should be used to collect knowledge on available platforms in specific areas. If necessary, these sources of information should be updated and maintained well for future use.

4.4 Adding activities to current monitoring

There are multiple ways to add activities to current monitoring. The most important for work on board vessels is to use downtime (e.g. current day-time monitoring leaves room for night time data collection) and/or free space (e.g. during ferry-box samplings) to collect additional data, especially on trips lasting longer than one day and further offshore. Ship time is expensive, and should be used as efficient (cost and scientific wise) as possible. It is however important to realise that there will be a logistical limit to the amount of work that can be done on one platform during one cruise, and that primary objectives will always prevail over secondary objectives. Priority of objectives is a matter of money. If a client pays for data collection, only unforeseen circumstances can lead to limited data collection. If data is not being paid for, the data can only be collected when the primary objectives can be met.

The main issue is to know the demands for additional data collection. Currently, there is no other way than either on a national level collate the requests, or use the international bodies to get insight in data needs. To facilitate insight in data needs and available time on various platforms, it might be worth to create a pan-European virtual platform serving as a 'market place' where demands and supplies can be exchanged.

Furthermore, flexibility in planning of the current monitoring, e.g. stay during IBTS for two days on Dogger Bank to take benthos samples and then proceed with IBTS will facilitate sharing ship time. Other ways of creating flexibility would be to prepare a stepwise approach:

1. collect the data as secondary objective added to an existing survey
2. If insufficient samples are collected try to use a second existing survey.
3. If this is insufficient have a dedicated survey ready to collect the left over samples.

This approach will lead to additional preparation cost as preparations for step 2 and 3 have to start before it is known if steps 1 or 2 will bring sufficient data. But in the years step 1 and 2 are able to collect sufficient data, money will be saved by reducing ship time of the dedicated survey. This might than be used to collect data for other programs. Of course it should be realistic that step 1 and 2 should be able to collect a reasonable amount of data, and will only fail with terrible weather conditions or malfunction of the vessel or equipment. Or the costs involved in step 1 and 2 should be very small in order to let them try to collect some samples which in the best scenario might lead to spare time in step 3.

4.5 Outsourcing data collection

Outsourcing aspects of monitoring is one of the ways to enhance efficiency. For example, personnel on oil rigs might take offshore water samples on a regular basis, or beach litter monitoring can be carried out by volunteers. In all cases, relevant specialist training of staff is necessary. Training should incorporate:

1. Clear sampling procedures, i.e. HOW to sample
2. Good information on WHY the sampling takes place (to ensure data quality and continuity)

Furthermore, the use of external partners for data collection needs a communication strategy for dissemination of the results. Information on the achievements and the use of data motivates people to keep on carrying out the sampling in the best way possible.

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[5] http://www.eurofleets.eu/

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Annex 1. Project Management Plan Activity C

Part II: Integration

Activity C	MULTI-DISCIPLINARY
To assess the opportunities for multidisciplinary marine monitoring programmes and what strategies are needed in order to make these applicable in practice and fulfil all related policy requirements	

Responsible Partner	IMARES
Contact person(s)	Ralf van Hal (ralf.vanhal@wur.nl) Ingeborg de Boois (ingeborg.deboois@wur.nl)

Objectives

1. To assess the technical and practical opportunities for extending the current monitoring programs to supply the data needed for the indicators specified below. This will be done for the three distinct monitoring platforms currently in use, e.g. boats, airplanes/satellites and permanent/stationary monitoring systems.
2. Add constraints and the additional costs and benefits to the output of objective 1. The constraints will in the first place be the policy objective of the monitoring program and the value of continuation of long term time series. Other constraints can be limited experience of the staff, lack of storage capacity, database concerns etc.
   Based on the constraints a proposal for an achievable alternative monitoring programme can be made.

Indicators to be used:

- Eutrophication: Chlorophyll-a
- Demersal elasmobranch species in the North Sea and Celtic Sea: distribution of the species and population abundance
- Benthic multi-metric indices

Activities and Deliverables

Activity C will provide a detailed overview of opportunities and constraints for developing and altering a monitoring program which can meet MSFD requirements within the currently existing monitoring, or by combining monitoring effort into a new monitoring programme. This overview is necessary as input for the optimisation tools and routines that will be developed in Activity E. These tools need to consider all these aspects in order to propose a joint monitoring programme in Activity G.

Overview of activities

Activity no.	Date	Type of activity	Goal	Partners involved	Related deliverable (if any)

C.a1	Mar 2014	Questionnaire (fact sheet)	Get insight in the crucial factors for data collection for a selection of indicators	All supporting partners	
C.a2	June 2014	Workshop	Discuss the possibilities for data collection for the indicators described in the objectives, following the current monitoring programmes, including practical implications	All supporting partners	
C.a3	July/Aug 2014	WebEx	Finalise the outcomes of the workshop	Workshop participants	C.d1
C.a4	July 2014	WebEx	Communicate preliminary output of Activity C	Leaders Activity C, D, E	C.d1
C.a5	July-Sep 2014	Correspondence	Finalisation of report (preliminary table of contents: see below)	All supporting partners	C.d1

Overview of deliverables			
Deliverable no.	**Date**	**Deliverable type**	**Description**
C.d1	October 2014	Report (preliminary table of contents: see below)	Detailed overview of opportunities and constraints for developing and altering a more ecosystem focussed monitoring program.

RELATION TO OTHER ACTIVITIES
General description of relation to other activities

Activity C will heavily depend on the output of Part I (Activities A and B), the catalogue of monitoring activities and the list of indicators and their data needs. Activity C will clearly indicate early information needs to Activities A and B.

Activity C will deliver a list of constraints to Activity D where potential governance and policy constraints on altering the monitoring programs are discussed and added to the list. Here, we consider detailed restrictions on national jurisdiction and, for example, redistributing monitoring task and funds between nations. After consultation with Activity D, the list will be completed. Close communication between the Activity leaders is necessary.

Activity C will provide input for Activity E. However, it also needs information provided by the GIS planning tools developed in Activity E. These tools will support the evaluation of adding monitoring activities, based on restrictions on spatial and temporal data needs of current surveys. This means that run-time of the two Activities will partially overlap and that close communication between the Activity leaders is necessary.

<table>
<tr><td colspan="4">Schematic overview of relation to other activities</td></tr>
<tr><td colspan="4">Input from other Activities</td></tr>
<tr><td>Output Activity A
Inventory of current marine monitoring programmes and their methods (criteria, indicators) in the North Sea and the Celtic Sea sub regions</td><td>Output Activity B
Overview of the contribution of the current marine monitoring programmes to meeting MSFD needs for these sub regions</td><td>Output Activity E
Information provided by the GIS planning tools developed in Activity E</td><td></td></tr>
<tr><td colspan="4"></td></tr>
<tr><td colspan="4">Activity C

1. Which information can be collected on the current mon. programmes?

2. What are the practical implications? (--> list of opportunities and constraints)</td></tr>
<tr><td>1.For a selection of indicators (based on output Activity B), prepare a list of current platforms/monitoring programmes (based on output Activity A) which can contribute to that indicator

Examples of questions to be addressed:

- which factors are leading for the indicator? (e.g. geographical extent, spatial coverage, seasonality, sampling frequency, time-series)

-which parameters should be measured in the programme to meet MSFD requirements?</td><td>2. Examples of questions to be addressed:

- What are the limitations of the platform(s)? How can the effect of those limitations be minimised?

- Is the additional monitoring cost-effective? If not, what is needed (personnel, platform operation time, storage capacity, etc.) to conduct the additional monitoring?

- Will a combination of different monitoring on one platform lead to less platforms to be used?</td><td></td><td></td></tr>
</table>

Output to other Activities

Output to **Activity D** and **Activity E** (Apr 2014-Jul 2014)

Overview of possible data collection for the specific indicator(s) within the current monitoring programmes	List of constraints affecting the potential data collection. If possible, solutions will be presented		

Risks

The risks for Activity C are:

1. Output of Activity B is delayed or incomplete. As the output from Activity B is needed to make a selection of indicators to use as case-studies, any delay in, or incompleteness of the final deliverable of Activity B will affect the start of Activity C.
2. Activity C does not receive a good description of the indicator, including a description of the type of data to be collected from Activity B, making it impossible to decide which monitoring programmes might be suitable to collect information for the indicator.
3. Activity C does not receive information about current monitoring programmes from Activity A in time, or receives incomplete information.
4. Insufficient representation/expertise on different monitoring platforms: ships, airplanes and stand-alone monitoring platforms (buoys, satellites, etc.) in the Activity participants.

Mitigating measures (numbers relate to Risk numbers)

1. Activity B to inform Activity C about progress, and offer indicator(s) for which information is available even when the list is not complete
2. Participants of Activity C will create tentative output based on their own assumptions.
3. Participants of Activity C will create tentative output based on their own knowledge of current monitoring programmes.
4. Inform partners in Activity C about the need for a variety of expertise fields, and stimulate the partners to send people that can cover one or multiple fields to contribute to this Activity. Let participants fill in their expertise at the start of Activity C to get an overview of the fields represented (via questionnaire). If expertise fields are missing, ask partners if they have any expertise on the missing fields available.

Annex 2. Case-study descriptions

Indicator D5 Eutrophication: 5.2.1 Chlorophyll

Indicator:

Concentration of chlorophyll in waters during the growing season

Indicator status:

Already used for WFD and OSPAR Comprehensive procedure assessments and HELCOM. Proposed Common Indicator for D5 by OSPAR

Constraints:

Chlorophyll is currently monitored for various purposes by MSs from a variety of platforms using multiple sampling techniques and analytical methods. Statutory monitoring is undertaken for WFD (coastal zone), OSPAR COMPP (marine waters not screened out) and in the Baltic for HELCOM eutrophication assessments. Measurements are taken by direct water sampling, fluorometry (vessel deployed instruments, moorings, underway monitoring) and remote sensing and samples (for direct measurement or calibration of fluorometers) are analysed using a variety of techniques targeting various photosynthetic pigments. These techniques are summarised briefly below:

Most commonly, uncorrected Chlorophyll a is measured by either spectrometry or fluorometry. These techniques include the influence of phaeophytin on the measurement which can be corrected for using an acidification step in the sample preparation. Phaeophytin can be quantified separately using such a technique. More accurate quantification of chlorophyll a and b can be achieved using HPLC with UV or diode array detection. However, the values returned from such a procedure are lower than derived from fluorometry as other pigments are not contributing to the measured signal response in samples.

Further, assessments of monitoring data are undertaken using a variety of metrics and thresholds depending on the purpose of the monitoring programme and national approach taken to assessment. Preliminary analysis of the national reports submitted under Article 11 of MSFD already suggests that a range of metrics (mean, 90th percentile etc.) of data are assessed against regionally varying thresholds.

For the purposes of regional assessment under MSFD, some standardisation is required both of monitoring technique, analysis, assessment methodology and threshold setting, while allowing flexibility for innovative monitoring approaches that could allow cost savings such as remote sensing. Previous attempts to intercalibrate chlorophyll measurements between MSs for WFD have been unsuccessful. Therefore this case study will trial a standardised approach to monitoring.

Geographical:

Whole regions: Greater North Sea and Celtic Sea (noting limitations at coastal zone associated with suspended solids for some techniques).

Temporal:

"Growing Season" for phytoplankton Time period currently varies by MS but within March to October.

Data need:

Interesting aspects of this indicator:

There are substantial data sets available for chlorophyll already:

- Direct measurement of water samples (ICES database)
- Fluorometry (calibrated by above) from deployed instruments, vessels and moorings (ICES database)
- Satellite remote sensing data

- In spite of many years data collection for multiple purposes, differences in approach and lack of standardisation of methods means broad scale assessments are difficult to achieve.
- The need to assess the same indicator measured from multiple techniques and platforms

Actions needed to develop case study

1) Identify case study (co)leads

2) Review existing documentation (OSPAR background document, ICES TIMES manuscripts, QUASIMEME reports on intercalibration) and recommend a single analytical methodology (for discrete / calibration samples) appropriate for the range of monitoring. Learn from ICES Marine Chemistry advice in preparation.

3) Collate information on existing use of analysis techniques, platforms and assessment methodologies (links to activity A/B) to describe 'current state' for assessing the implications of change.

4) Define a consistent monitoring and assessment methodology (including metrics and thresholds/targets) to allow consistency across MSFD regions, incorporating the range of monitoring platforms/types and remote sensing. Consider how to integrate innovative approaches (ferry-boxes, remote sensing) into the programme.

5) Demonstrate and test the methodology for certain platforms (vessels / moorings) using planned project partner monitoring activities (links to activity D). there is potential to expand this to multiple platforms and involve a wide range of project partners.

6) Assess the cost / benefits of the new standardised approach versus 'current status' assessments to define the cost / resource benefits of the recommended approach.

Workpackage C

- An assessment of platform uses and potential uses for chlorophyll monitoring and the limitations on standardisation imposed by different constraints.

Workpackage D

- An assessment of the reasons behind institutional differences in monitoring platform, technique, analysis, calibration, assessment metric, thresholds etc

- testing and trialling of the recommended standardised approach on platforms (vessels / moorings).

- Cost benefit analysis of implementing the standardised approach versus 'business as usual'

Workpackage E

- Application of the toolbox to determine most effective spatial / temporal application of the standardised approach for the 2 regions.

Contact person:

TBC but following involved:

Jo Foden Cefas; Karin Westland Sweden; Pam Walsham MSS; Lucia Pineau IFREMER; Hans NL. Belgium, Workpackage CDE leads. Invite others through consortium and OSPAR?

Indicator D1 fish: demersal elasmobranch species

Indicator:

For a suite of selected species: demersal elasmobranch species in the North Sea and Celtic Sea (Dransfeld 2013):

- Distribution of the species: % occurrence (number of hauls in which a species was found/total number of hauls carried out, by year)
- Population abundance: CPUE by year
- Differences in abundance

Indicator status:

No official status, based on Dransfeld (2013)

Constraints:

Data deficiency due to low abundance, suboptimal fishing gears, low sampling frequency. Only possible to use trend analysis, no targets due to data deficiency.

Geographical:

The greater North Sea (including English Channel) and Celtic Sea. Information from all areas is relevant, especially because the natural distribution patterns vary per species.

Temporal:

The whole year round.

Data need:

Which data?

As data deficiency is an issue for this indicator, take all data-collections into account, such as:

- Regular field monitoring (e.g. fish surveys)
- Commercial fish data (e.g. discard sampling programmes, market sampling programmes, VMS data, etc.)
- Tagging experiments
- DNA samples
- ….

1. Abundance (numbers and/or weight) information for the following species:
   Starry ray *Amblyraja radiata*
   Tope *Galeorhinus galeus*
   Cuckoo ray *Leucoraja naevus*
   Thornback ray *Raja clavata*
   Spotted ray *Raja montagui*
   Spurdog *Squalus acanthias*
   Smoothhounds *Mustelus sp.*
2. Information on catch date and catch position
3. Optional: information on length distribution
4. Optional: information on sex composition

Interesting aspects of this indicator:

- No specific monitoring method has been defined yet => opportunity to look for options of combining survey data from various international and national surveys (Act. E); opportunity to consider various sampling methods and platforms, compare table below (Act. C)
- Applicability of the obtained data to several indicators

- Reference to the IUCN list of threatened and declining species => While no OSPAR Common Indicator or MSFD indicator has been fully defined yet, the intention of including monitoring of elasmobranch fishes into the description of GES can be expected.

Foreseen challenges:

- Identification of species (and possible related errors in data bases)
- Combining sources of information in relation to identification (e.g. fish survey data where species are identified to the species and landing data where only broader categories such as 'rays and skates' are reported)
- Access to national, non-public data bases

Contact person:

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References:

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Indicator D1/D6 benthic habitat condition

This case study is proposed by benthos experts from within JMP NSCS and/or the ICES Benthos Ecology Working Group (BEWG), the latter having a long-standing interest and expertise in benthic indicators for ecosystem health and benthic monitoring activities.

Indicator:

Benthic habitat condition can be assessed by benthic indicators (univariate, multi-metric, multi-variate[6]), which mostly rely on species-abundance data. A wide variety of benthic indicators exists for marine systems (for a most recent overview see: http://www.devotes-project.eu/devotool/).

Due to this diversity in benthic indicators, we propose for this case study:

- Not to use the multi-metric indicators themselves, but the underlying variables and parameters (i.e. species abundance, species richness, bray-curtis similarity (measures of species composition (turnover) / community hetero-/homogeneity), biomass, species sensitivity [AMBI, sum($ES50_{0.05}$)]). This will allow us to draw conclusions that are applicable to a wide set of multi-metric indicators.
- To run the analyses at the level of selected multi-metric benthic indicators. Indicators defined under WFD, MSFD, Habitat directive, OSPAR or HELCOM can be selected for this purpose.

Indicator status:
Benthic habitat condition is an important aspect taken into account by all EU MSs (MSs) under the different nature directives, including MSFD. A few EC MSs (i.e. UK, Belgium, Denmark) already mentioned multi-metric benthic indicators in their MSFD Articles 9 and 10 reports to the EC. Others are expected to implement the use of such indicators within their MSFD 1st cycle assessments. The (draft) OSPAR ICG-COBAM common approach for benthic habitat assessment identifies that benthic multi-metric indicators (wide variety available) are essential for determining habitat condition. This common approach does not define a common benthic indicator for all OSPAR regions.

Constraints:

The following (non-exhaustive list of) aspects determine the monitoring and related quality assessment of benthic habitats:

- Level of detail in habitat definition: a broader definition of a benthic habitat type (e.g. EUNIS A5: sublittoral sediment) can lead to a higher variability in its characteristics than a narrow definition (e.g. EUNIS A5.2 sublittoral sand).
- Areal extent of the habitat type: the difference in spatial distribution of a habitat (widely distributed versus local) may have an influence on the monitoring design needed.
- Habitat heterogeneity/homogeneity: community composition heterogeneity may differ between different habitat types. Therefore, heterogeneous habitat types will have other monitoring requirements that homogeneous habitat types (less variable characteristics).
- Sampling techniques: benthic habitats can be surveyed by different grab, core or even dredge sampling techniques and benthic samples may be handled differently (e.g. sieve mesh size, sieving alive or after fixation).
- Period of sampling (more than once a year, yearly, every 2-3 years, …): the benthos shows a clear seasonal and year-to-year variability, which will influence the monitoring design.
- Variables /indicator demands: different variables will show different value ranges, sensitivity to outlier values (maxima) and levels of variability, which has its effect for example on the sample intensity requirements. For example, you need more samples to scope the variability in biomass (values highly variable among species) than number of species to reach a certain statistical power.

Geographical:

Both the greater North Sea (and Celtic Sea) may be targeted in this case study: the final selection will be based on data availability and suitability. The applicability of the results to other geographical areas will be assessed.

Data need:

Ideally, analyses on benthic data of the greater North Sea (and Celtic Sea), collected on a spatial and temporal scale are needed to investigate the above mentioned constraints. The following spatial datasets of the greater North Sea (Figure 1) will first be used to tackle spatially-oriented research questions.

[6] Both multi-metric and multi-variate indicators are further referred to as multi-metric indicators.

These datasets, compiled by BEWG, are readily and publicly available, and have been scrutinised for consistency during earlier work by BEWG.

- The North Sea Benthos Survey 1986 data (NSBS 1986): macrobenthos samples were collected in a standardised way, on a regular grid covering the whole of the North Sea, and analysed by scientists from 10 laboratories (http://www.vliz.be/vmdcdata/nsbs/about.php).
- The North Sea Benthos Project 2000 data (NSBP 2000): integrating macrobenthic infaunal data (1999-2001) available from various sources, including national monitoring surveys, in North Sea soft bottom sediments (http://www.vliz.be/vmdcdata/nsbp/datasets.php).

Analyses:

Which data?

The above mentioned data sets are required to develop an effective benthic monitoring program in the near future. Current status is that Member States are in the process of proposing the national monitoring programs in relation to the MSFD. Only a limited number of these proposal is publically available at the moment.

Information on the national proposal for benthos monitoring:

- Prescribed sampling methods
- Sampling frequency
- Geographical extend
- Species selection
- Required statistical power
- Etc.

Data analyses of the above mentioned datasets (and other datasets, if available in time) will allow tackling various research questions, highly important for developing efficient and effective benthic monitoring programmes. The main analytical principle behind these analyses is to investigate the relationship between monitoring efficiency and sample size. The main assessment criteria for monitoring efficiency (and effectiveness) will be quality assessment accuracy (average of quality) and reliability (variance in quality).

Interesting aspects of this indicator:

The case study will contribute to the development of an efficient regional approach to monitoring benthic condition assessment. It will as such inform on:

- the possibilities to integrate (nationally proposed or efficient monitoring program) sampling effort (minimally) needed into interdisciplinary monitoring campaigns
- the potential of complementarity of monitoring designs (cross-boundary) throughout the greater North Sea (and Celtic Sea)
- the applicability of a wide set of analytical tools in developing efficient monitoring programmes

Contact persons:

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Indicator D10 Marine litter: Seafloor Litter

Seafloor Litter:

Large-scale seafloor surveys off the European coast have found widespread presence of bottles, plastic bags, fishing nets, and other types of plastics. Plastics are the most abundant litter found in the marine environment and comprise more than half of marine litter in European Regional Seas.

OSPAR Contracting Parties have made agreements on **Common and Candidate Indicators** to be used by as many Contracting Parties (and EU MS in their MSFD Monitoring plans) as possible without obligations. In relation to marine litter the following indicators have been proposed:

- **Common Indicators**:
  - Beach litter (all CP's)
  - Plastic Particles in Stomachs Fulmars (North Sea) as floating litter indicator (and impact on biota)
  - Seabed litter using International Bottom Trawl Surveys (IBTS)
- **Candidate**: other target species/impact on biota indicators (outside North Sea) - in development
- **Candidate**: microplastics (currently not defined, R&D will continue to close knowledge gaps)

This study will examine the following procedures:

- Seafloor marine litter sampling
- Sampling protocols and analysis
- Data analysis and aggregation; e.g. rules for combining data from different fisheries surveys
- Thresholds and assessments; e.g. reporting for national purposes, OSPAR, EU

Monitoring of marine litter is carried out in the N-E Atlantic by Contracting Parties in accordance with the recommendations from the OSPAR Intercorrespondence Group on Marine Litter and the guidelines of the EU MSFD Technical Subgroup 10. OSPAR provides specific guidelines for monitoring beach litter and plastic in fulmars, used in litter assessments (QSR, EcoQO). Guidelines for monitoring of benthic marine litter can be found in the advice from TSG10 and as an annex in the ICES IBTS manual.

Indicator status:

Seafloor litter is an indicator specified in the MSFD Commission Decision and is an OSPAR Common Indicator.

Constraints:

No dedicated surveys or monitoring program. The Seafloor litter indicator is included in the IBTS manual, but participation is still voluntary and done differently on the vessels. Furthermore the geographic distribution of the IBTS might be too limited to pick up trends in the amount of seafloor litter. There might me could opportunities to extend the IBTS data with other sources of data.

Geographical:

This study will focus firstly on the southern North Sea, but can easily be expanded to the Celtic Sea if other fisheries surveys than the International Bottom Trawl Survey (IBTS) are included.

Temporal:

The monitoring and assessment period is from 2012 onwards as data from most CPs will start then.

Data need:

Which data?

As data deficiency is an issue for this indicator, take all data-collections into account, that might collect data by the guidelines of TSG10/IBTS manual such as:

- Regular field monitoring (e.g. fish surveys)
- Commercial fish data (e.g. discard sampling programmes, etc.)
- Benthic sampling
- Fishing for litter activities

Interesting aspects of this indicator:

There are agreed protocols for monitoring seafloor litter (TSG10) and most partners of this consortium carry out fish stock surveys. There is an increased focus on marine litter from EU, OSPAR and the general public. It is widely recognised that it is a "new" science and gaps are still present. Marine litter data and assessments need to be harmonised and improved for MSFD purposes and between OSPAR Contracting Parties. However a first study of Cefas has indicated that the power to detect trends which might be an effect of implemented measures are rather low. To improve these trends a higher number of monitored stations is required. Therefore there is a need for a harmonised monitoring approach across different MS/CPs. If the monitoring burden of all these stations could be split across MS/CPs and assessed as a whole we can determine trends with increased power ("united we stand strong" > similar to contaminant monitoring and assessments). This study will look at whether the apparent surveys are significant different and will potentially propose ways of more closely aligning procedures in the future.

Actions needed to develop case study:

An assessment and reporting tool

- ICES is currently developing a seafloor marine litter database
- the EMECO Datatool (www.emecodata.net) could be used intermediately

Thomas Maes, Thomas Sorensen, Marie Vanden Berghe, Ralf van Hal will conduct a seafloor marine litter study. Other MSs (e.g. Sweden, France, Germany and others) have indicated their interest in contributing to the work, comparing their national methods and data with the rest of the consortium.

Contact person:

Thomas Maes (thomas.maes@Cefas.co.uk)

Annex 3. List of participants

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Karl-Johan Stæhr	Denmark	DTU-aqua
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Francisco Marco-Rius	Germany	TI-SF Hamburg
Sam Shepherd	Ireland	Marine Institute
Steve Geelhoed	Netherlands	IMARES
Peter de Boer	Netherlands	RWS
Ralf van Hal	Netherlands	IMARES
Ingeborg de Boois	Netherlands	IMARES
Gerrit Vossebelt	Netherlands	RWS
Daniel Bergman-Sjöstrand	Sweden	SMHI
Silvana Birchenough	UK (England)	CEFAS
Jo Foden	UK (England)	CEFAS
Joey O'Connor	UK (Scotland)	JNCC
Kees Borst	Netherlands	RWS
Matt Gubbins	UK (Scotland)	MSS

Annex 4. Questionnaire

Questionnaire: Data collection on indicator D5 Eutrophication

Country:

Contact person fact sheet:

Part A: When you already collect data related to this indicator.	
1	Which data related to this indicator do you currently collect?
2	Which platform do you use for this data collection? (e.g. airplane, ship, autonomous, etc.). Please specify name or device
3	If the monitoring is dedicated to the indicator, which additional data do you collect for other purposes?
4	If the monitoring is not dedicated to the indicator, which data collection is the main objective of the monitoring?
5	How much effort do you spend and which costs are involved in this monitoring program? (e.g. field days, man-hours, preparation, lab work, data processing etc.)
6	What are the main constraints of the current data collection related to the indicator? (e.g. temporal resolution, spatial resolution, seasonal effects, sampling gear, sampling frequency, etc.)
7	How could the constraints be solved?
8	Which additional resources do you need for the data collection related to the indicator? (e.g. extra personnel, storage capacity, data storage capacity, ship time)
9	Which other opportunities do you see for additional data collection to improve the indicator?

Part B: If you don't collect data related to this indicator	
10	Which of your current monitoring programmes might be adequate to collect data related to the indicator?
11	Which data collection is the main objective of the current monitoring?
12	Which platform do you use for this monitoring? (e.g. airplane, ship, autonomous, etc.)
13	What will be the main constraints of the additional data collection related to the indicator? (e.g. temporal resolution, spatial resolution, seasonal effects, sampling gear, sampling frequency, etc.)
14	Which additional resources will you need for the data collection related to the indicator? (e.g. extra personnel, storage capacity, data storage capacity, ship time)
15	If you do not see any opportunity to collect data related to the indicator on one of your monitoring programmes, which other opportunities do you see for additional data collection to improve the indicator?

Annex 5. Potential monitoring methods for the case-studies

chlorophyll					
Method	**Platform**	**Data quality**	**Scientific limitations**	**Practical limitations**	**technical limitations**
chlorophyll watersamples	all except remote	depending on AQC, depth of sampling		Choice of method, pigments measured. Expensive analysis. Large amount of bottles needed	Very specific skill needs training
Fluorescents	all except remote	Depth of sampling, uncertainty of calibration curve. Frequency of calibration!	Calibration needs, Doesn't measure chl a!	Cleaning, calibrate, maintenance, number of calibration samples	Deciding when, where how to take calibration samples
on board fluorometer	Ferrybox	weather and roughness?		Limited access to maintain and calibrate and download	Depth of water intake, contamination of sensors in harbour
Remote sensing	Planes of opportunity, satellites	Cofounding factors	Turbidity influences, very surface waters only, measures a different combination of pigments	weather, cloud cover, don't currently have the kit to put in planes	Currently can't be integrated with other data
static fluorometer	Moorings	continues, single location	Very spatially limited	Battery life, service and calibration frequency. Mentioned was a necessary monthly check up.	
Continues Plankton Recorder (CPR)	boats	continues, varying spatial position	Measures the wrong thing: plankton not chlorophyll		
Cameras	Boats, windmills		Qualitative only, waves ,light and turbidity	Angle of view?	Installation
on board fluorometer	Gliders, AUVs	Location uncertain		Frequency of calibration	
Modelling	PC	Predicted only, spatially excellent	Accuracy of model	Needs real time weather data. Do we forecast or hindcast?	

Benthos					
Method	**Platform**	**Data quality**	**Scientific limitations**	**Practical limitations**	**technical limitations**
box corer	ship	quantitative	sample area	only soft substrates (no hard, no gravel)	winch (speed)
video sledge	ship	qualitative	only qualitative, only surface fauna	visibility, weather, only soft substrate, (gravel)	winch (speed)
dredge	ship	quantitative, but only for larger species		Destructive method on small scale	larger winch (speed), more skills
grab (Van Veen, Day grab)	ship	quantitative	sample area	soft substrate	winch (speed)
Hamon grab	ship	quantitative	sample area	gravel, mixed sediments	winch (speed)
fish trawls	ship	Qualitative	only for certain benthic species (mainly surface)	added data collection, extra standardisation of data	larger winch (speed), more skills
drop camera	ship	qualitative	only qualitative, only surface fauna	visibility, extra skills by first screening	winch (speed)
ROV	ship	qualitative	only qualitative, only surface fauna, screening	visibility, extra skills by first screening	larger winch (speed), more skills
Divers	ship	qualitative, quantitative	subjective, qualitative	depth,	costs', skill
SPI	ship	qualitative	Habitat structuring species (eg Sabellaria)		winch (speed)
Side scan sonar	ship	screening, groundthruting	large		calibration
Fisheries echosounder	ship	bottom roughness	course method		
Environmental DNA	ship		in development		
Fish stomachs					
AUV	AUV	qualitative			
Environmental DNA	ship	qualitative under development	still on early stages, experimental	needs to be extracted form a grab sample, cost	winch (speed)
Fish stomachs	ship	qualitative	limited coverage	limited number of species	winch (speed)

Elasmobranchs						
Method	**Platform**	**Data quality**	**Scientific limitations**	**Practical limitations**	**technical limitations**	**Possible improvements**
Diver report	Diver	Poor	Species ID, spatio-temporal resolution	ad-hoc sampling, highly localized, non-standardized	depth coverage, habitat coverage	visual (foto/video) records, standardization through training
Environmental DNA samples	RV	unknown	unknown decay rates of DNA fragments in the sea? Unknown sample size/volume of water needed		depending on sample size, on-board processing or storage of samples limited	
Egg collection (1)	Beach sampling	questionable	non-random presence/absence data	ad-hoc sampling, highly localized, non-standardized	none	improved ID & temporal coverage
Egg collection (2)	RV (Bottom trawls, Dredges, etc.)	unknown sampling efficiency	spatio-temporal resolution	suitable substratum for egg deposition possibly not suitable for sampling	suitable substratum for egg deposition possibly not suitable for sampling	add possible sampling locations, use alternative methods: video (compare video recording)
Video recording	RV (Sledge)	spatial coverage/catchability/detection probability low. However, could be used for egg collection/sampling better than bottom trawls/dredges etc.		Requires existing and dedicated survey on habitat/benthos as video methods are difficult to apply on existing bottom trawl surveys.		Could be used to quantify sampling field/swept area and catchability/detection probability to possibly identify nursery/spawning areas and estimate abundance
Commercial landings data	Port sampling	good for states that record species ID	no spatio-temporal data, unknown catchability of gear employed for elasmobranch species			

Commercial discard data	Fishing vessel	depending on species ID	non-random sampling with limited spatial coverage, unknown catchability of gear employed for elasmobranch species	access to vessels, limited observer staff		
Scientific surveys	RV (Bottom trawls, Dredges, etc.)	high, possible issues with species ID	spatio-temporal resolution	ship time	surveys designed for a rather small suite of assessed species	
Recreational fisheries	Angler	variable	Species ID, spatio-temporal resolution, non-random sampling, difficult measurement of effort	ad-hoc sampling, highly localized, non-standardized	habitat coverage, very limited sampling volume	
Tagging studies	Anglers, Commercial vessels, Research vessels	Depending on tag-type: "classical tags" require large number of tagged individuals. Quality of PSATs depending on reporting rates but generally good. Post-release mortality unknown.	Depending on recapture rate and reporting rate; tagging studies usually have other scientific objectives rather than population monitoring	trained staff, access to vessels, tagging logistics	expensive satellite pop-up tags, small species are difficult to tag, unknown post-release mortality	

Seafloor litter						
Method	**Platform**	**Data quality**	**Scientific limitations**	**Practical limitations**	**technical limitations**	**Needs/adaptation indicator**
fish trawl/ OTB	vessel	not fit for purpose	fixed stations its partial settlements	cleaning net	catchability	
fish trawl/ TBB	vessel	not fit for purpose	fixed stations its partial settlements		catchability	
video	vessel/rov/auv		fixed stations its degradation.	small footprint/ turbidity/	identification of items/ limitation items covered	
benthic sampling	vessel			limited size of items		
divers	human	poor		depth limitation/turbidit y	motivated people	
fishing for litter	vessel			better manuals		
experimental boxes	stationary	good	settlement in a fixed period	large boxes; logistics		
use models	computer					where will it end up
metal detector						
x-rays						
floating litter						
visual observation	vessel					
video ferry, commercial vessels	ships of opportunity					
satellite						
video planes/hd video	planes					
manta trawl	vessel					
Micro-plastics						
continues water-samplers	vessel					
CPR	ships of opportunity					
biological samplers/filter feeders						

Annex 6. 'Tender' for Joint Monitoring Programme in the North Sea

Workshop 'Multidisciplinary work', Brussels, 10-12 June 2014

In this tender process we request you to create three scenarios to collect the data required for one of the case studies (or another indicator proposed). The scenarios should be realistic and cost efficient. There is no need to come up with large additional monitoring activities as these budget will not be made available. The required data should be collected with a scientifically sound method, and an indication of the quality of the data should be given.

The three scenarios should be:

D. Joint Monitoring Plan only taking existing monitoring that is NOT dedicated for the case-study data requirements into account
E. Joint Monitoring Plan taking into account using existing non-dedicated monitoring and other information sources (e.g. industry, ferry-boxes, etc.)
F. Joint Monitoring Plan taking into account all potential information, so also add dedicated monitoring

Scenario A

1. Which data related to the case-study will be collected?
2. Which existing non-dedicated monitoring will be taken into account?
3. Which techniques will be used?
4. Which platforms will be used?
5. Which countries will be involved in data collection?
6. Which additional data will be collected (as an outcome from the non-dedicated monitoring used) and to which MSFD descriptor/indicator do they relate?
7. Which resources do you need to collect the information needed?
8. Will the non-dedicated monitoring be influenced by the new data collection? If yes, how (e.g. spatial, temporal, number of stations, etc.)

Scenario B

Questions 1-8 from scenario A

9. Which data related to the case-study will be collected by using existing platforms?
10. Which techniques will be used?
11. Which platforms will be used?
12. Which countries will be involved in data collection using new sources?
13. Which additional data might be collected from the new sources and to which MSFD descriptor/indicator do they relate?
14. Which resources do you need to collect the information needed from new sources?
15. Which arrangements have to be made before the new monitoring can take place?

Scenario C

Questions 1-8 from scenario A
Questions 9-15 from scenario B

16. Is there any dedicated monitoring for the case-study? If yes, proceed. If no, scenario B and C should be the same.
17. Which data related to the case-study will be collected from the dedicated monitoring?
18. Which techniques will be used?
19. Which platforms will be used?
20. Which countries will be involved in data collection?
21. Which additional data will be collected and to which MSFD descriptor/indicator do they relate?
22. How will the dedicated monitoring be influenced by adding other data sources? (e.g. number of stations, spatial coverage, temporal coverage)

Annex 7. Output Scenario A, B and C by case-study

Chlorophyll-a

Contributors: Jo Foden, Ralf van Hal, Kees Borst, Matt Gubbins, Henrik Fossing

Scenario A

1. What data related to the case-study will be collected?
   - Measurements (or proxies) of growing-season chlorophyll concentration; February to October
   - Fluorescence and calibration samples
   - Maximum, mean and 90th percentile values
2. What existing non-dedicated monitoring will be taken into account?
   - IBTS Quarter 1 sampling in January-February
   - No IBTS Q2 sampling
   - IBTS Q3 the Cefas Endeavour and the Dutch Q3 beam trawl survey
   - Standard oceanographic sampling and hydrographic surveys (e.g. Ministry of Defence, the UKHO); sections with CTD casts along a specified line
   - Herring acoustic surveys (June and July)
   - Satellite imagery
3. What techniques will be used?
   - Fluorometry on CTD down casts
   - Fluorometer on a flow-through system e.g. Ferry-box system
   - Must take samples and store (freeze) filter-papers for later lab analysis as a minimum
4. What platforms will be used?
   - IBTS research fishing vessels
   - Oceanographic survey vessels
   - Satellite imagery
5. What countries will be involved in data collection?
   - UK: England & Wales, Scotland
   - France
   - the Netherlands
   - Norway
   - Sweden
   - Germany
   - Denmark
6. What additional data will be collected (as an outcome from the non-dedicated monitoring used) and to What MSFD descriptor/indicator do they relate?
   - Eggs
   - pCO2
   - temperature
   - salinity
   - microplastics
   - nutrients
   - oxygen
   - turbidity
7. What resources do you need to collect the information needed?
   - Flow-through system with fluorometer
   - CTD with fluorometer & water sampler for calibration samples
   - Staff resource implications for running and maintaining the instrumentation, for filtering samples and freezing filter papers.
   - Satellite MyOcean products (free).
   - A satellite image expert is needed to analyse the products for assessment purposes.
8. Will the non-dedicated monitoring be influenced by the new data collection? If yes, how (e.g. spatial, temporal, number of stations, etc.)
   - Not significant effect on the programme timescale. However, extra effort is required if a flow-through system is installed and CTD casts & water samples are to be taken for

filtering. Filtering can be done without affecting the cruise schedule, if sufficient staff is available.

Scenario B

Questions 1-8: see scenario A

9. What data related to the case-study will be collected by using existing platforms?
   - Fluorescence and chlorophyll in the growing season
   - Surface sampling
10. What techniques will be used?
    - Automated systems (e.g. Ferry-box flow-through system)
    - Water samples (as in Scenario A)
11. What platforms will be used?
    - Oil rigs
    - Planes
    - Commercial ferries (400 ferry routes) equipped with Ferry-box
    - Freight ships with regular routes in the North Sea (or Celtic Sea) equipped with Ferry-box
    - Citizen-science observations by sailors for reports of blooms
    - Autonomous underwater vehicles (AUVs) e.g. gliders
    - Fish farms
    - Wind farms – boats delivering workers to the sites
    - Fishing vessels
12. What countries will be involved in data collection using new sources?
    - Any surrounding the North Sea
13. What additional data might be collected from the new sources and to What MSFD descriptor/indicator do they relate?
    - Only fluorescence and chlorophyll
    - Possible to use the water samples for also measuring nutrients, temperature, salinity
14. What resources do you need to collect the information needed from new sources?
    - Ferry-box systems
    - Water sampling equipment – Niskin, water filter rig, consumables, freezer, transport considerations (keeping sample frozen)
    - Trained personnel for taking and storing water samples – will require a trainer to ensure sampling and filtering is correctly carried out to an SOP.
    - Subsequent laboratory analyses – likely to be the most expensive part of the programme
15. What arrangements have to be made before the new monitoring can take place?
    - Takes approx. 1 year to set up a working Ferry-box system on a commercial ferry
    - Will require training of personnel to take & store samples
    - Arrangements for transporting the frozen samples to a laboratory
    - Costs of lab analysis

Scenario C

Questions 1-8: see scenario A; Questions 9-15: see scenario B

16. Is there any dedicated monitoring for the case-study? If yes, proceed. If no, scenario B and C should be the same.
    - Yes.
17. What data related to the case-study will be collected from the dedicated monitoring?
    - Fluorescence; surface and through the water column
    - Water samples at surface and through the water column
18. What techniques will be used?
    - Water column profiles using CTDs and sampling rosette
    - Ferry-box
19. What platforms will be used?
    - Research vessels
    - Moorings – automated sampling and measuring

- Chartered vessels (e.g. fishing boat with trained personnel)
- Satellite imagery

20. What countries will be involved in data collection?
    - Ireland
    - UK: England & Wales, Scotland
    - the Netherlands
    - Sweden
    - Denmark
    - France
    - Belgium
    - Germany
21. What additional data will be collected and to which MSFD descriptor/indicator do they relate?
    - Supporting environmental data: salinity, temperature, depth, turbidity, light (PAR), oxygen, nutrients, carbon, pH, air pressure, wind, sea state,
    - Phytoplankton & zooplankton
    - Marine litter – floating litter and microplastics
    - Non-indigenous species (Cefas SmartBuoys have settling plates)
    - Carbonate chemistry (for ocean acidification)
    - Contaminants, metals (D8), including passive samplers
22. How will the dedicated monitoring be influenced by adding other data sources? (e.g. number of stations, spatial coverage, temporal coverage)
    - The dedicated monitoring already incorporates various parameters listed in 21.

Demersal elasmobranchs

Contributors: Matthias Schaber, Samuel Shepard, Francisco Marco-Rius, Steve Geelhoed, Peter de Boer

Scenario A

1. What data related to the case-study will be collected?

   Species specific catch per unit effort, species specific LFD plus individual length and weight measurements (sometimes aggregated), sex and maturity information, limited spatio-temporal distribution
2. What existing non-dedicated monitoring will be taken into account?
   - Scientific surveys (i.e. bottom trawl and beam trawl surveys)
   - Commercial landings data
   - Discard information/observer data
3. What techniques will be used?

   All survey and commercial fishing gear
4. Which platforms will be used?

   Commercial fishing vessels and research vessels
5. Which countries will be involved in data collection?

   All North Sea coastal states
6. What additional data will be collected (as an outcome from the non-dedicated monitoring used) and to which MSFD descriptor/indicator do they relate?
   - Fish CPUE (D1- biodiversity, D3 – population abundance, D4 – food web e.g. large fish indicator)
   - Hydrography (e.g. Temperature, Salinity, Oxygen concentration profiles) (D5 – eutrophication)
   - Ad-hoc sampling of large epibenthos (D6 – sea floor integrity)
   - Ad-hoc sampling of marine litter (D10 – marine litter) and non-indigenous species (D2).
7. What resources do you need to collect the information needed?

   Existing surveys (e.g. IBTS, BTS) and commercial fishery sampling programs. Survey and commercial catch data (catches, discard and landings) should be recorded to species level. Focused spatio-temporal coverage desirable (increased number of sampling stations). Balance between number of stations and number of samples per station. Possible inclusion of DNA samples for species identification.
8. Will the non-dedicated monitoring be influenced by the new data collection? If yes, how (e.g. spatial, temporal, number of stations, etc.)

   Improved species ID may improve the quality of the existing data collection. Increased number of sampling stations may decrease sampling frequency per station.

Scenario B

Questions 1-8: see scenario A

9. What data related to the case-study will be collected by using existing platforms?
   - Geographical position, depth distribution, activity patterns (size, age, sex)
   - Size, age, sex, abundance, spawning and nursery ground identification
   - Presence-absence data
   - Spawning and nursery ground identification, presence-absence data
   - Quantification of abundance, identification of spawning and nursery grounds
   - Presence-absence, size, age, sex, geographical position
   - Species ID
   - Geographical position, species ID, presence-absence data
10. What techniques will be used?
    - Archival tags/satellite pop-up archival tags
    - Targeted commercial observers
    - Trained divers
    - Egg case sampling
    - Video recording
    - Recreational fisheries

- Environmental DNA sampling
- Aerial observation (e.g. Basking Sharks)

11. What platforms will be used?
    - Recreational anglers/vessels, commercial fishing vessels, research vessels, satellites
    - Commercial fishing vessels
    - Individual divers
    - Two possible sampling schemes: 1) Beach sampling (platform: volunteers) 2) Sampling with bottom trawls/dredges etc. (platform: research vessels)
    - Research vessels, ROVs, AOVs, Hab Cam, camera networks, moored observation systems
    - Anglers and recreational fishing boats
    - Sampling method unknown. Research vessels?
    - Planes
12. What countries will be involved in data collection using new sources?
    All North Sea coastal states
13. What additional data might be collected from the new sources and to which MSFD descriptor/indicator do they relate?
    - D3 (Fish distribution).
    - High resolution biological data, possible identification of spawning aggregations, seasonal distribution patterns, quantification of litter, identification of non-indigenous species (D1, D2, D3, D4, D10).
    - Divers could record marine litter (D10) and at least provide a proxy for eutrophication (through visibility, D5) and also could assist in sea bed classification/monitoring sea bed integrity (D6) as well as detect and monitor non-indigenous species (D2).
    - Beach litter (D10) for beach surveys. Pls. refer to 6) in Scenario A for descriptors possibly addressed by established non-dedicated surveys.
    - Marine Litter (D10), seafloor integrity (D6), Fish diversity and distribution (D1, D3), non-indigenous species (D2)
    - Fish diversity and distribution (D1, D3), non-indigenous species (D2)
    - Fish diversity (D1), non-indigenous species (D2)
    - Floating marine litter (D10), Marine mammals, seabirds (D1), eutrophication (D5)
14. What resources do you need to collect the information needed from new sources?
    - Trained staff, ship time, data analysis, depending on type of tags: recapture programme.
    - Trained observers, fishing industry liaison programme, additional data analysis
    - Trained divers, guidance programme (websites, flyers, courses), additional analysis
    - (trained) volunteers, guidance programme (websites, flyers, apps etc.), additional analysis
    - (Towed) video cameras, trained staff, ship time, data storage and analysis
    - Trained anglers, guidance programme (websites, flyers, apps), data analysis
    - Lab facilities, data analysis, DNA database, vessel time, trained staff
    - Trained staff/observers, flight time, data analysis
15. What arrangements have to be made before the new monitoring can take place?
    - Define monitoring objectives: ad-hoc (train everyone and provide everyone with material) or dedicated (update existing surveys, find a time slot on possible surveys/fishing trips). Pre-arrange satellite data transfer (depending on tags employed).
    - Establish industry liaison programme, identify sampling focus, train observers
    - Establish objectives, guidance and training programmes, app development, online database for observations
    - Establish objectives, guidance and training programmes, app development, online database for observations
    - Establish objectives, get ship time
    - Establish objectives, guidance and training programmes, app development, online database for observations
    - Establish common sampling protocol and sampling/analysis techniques
    - Define survey period, area and transects, train staff, establish database

Scenario C

Questions 1-8: see scenario A; Questions 9-15: see scenario B

16. Is there any dedicated monitoring for the case-study? If yes, proceed. If no, scenario B and C should be the same.
    No. As there is no specific monitoring programme for elasmobranch species in place, this scenario is identical to scenario B.

Benthic multi-metric indices

Contributors: Gerrit Vossebelt, Joey O'Connor, Gert Van Hoey, Silvana Birchenough, Daniel Bergman Sjostrand, Karl Johan Staehr

For this case-study, a specified area and time-frame was taken into consideration, as it turned out to be too complicated to oversee the monitoring opportunities for the greater North Sea and all-year round.

Area: Dogger Bank (UK, Germany, Dutch waters)

Time of year: Q3 (Autumn)

Sampling time: Day/night

Scenario A

1. What data related to the case-study will be collected?
   - Species composition
   - Numbers per species.
   - Biomass (quantitative)
2. What existing non-dedicated sampling will be taken into account?
   - IBTS
   - BTS
   - Industry sampling (i.e. for windfarm, oil and gas, spatial planning)
   - Eutrophication surveys
   - MPA management surveys
3. What techniques will be used?
   - Grab
   - Core
   - Dredge
4. What platforms will be used?
   - Ship
5. Which countries will be involved in data collection?
   - Germany
   - Netherlands
   - UK

   Note: all NS countries involved for NS scale monitoring
6. What additional data will be collected (as an outcome from the non-dedicated monitoring used) and to which MSFD descriptor/indicator do they relate?
   - Grab content for marine seafloor litter (D10) and foodwebs (D4)
   - PSA (D6 (supporting)
   - Organic matter (D3, D4)
   - Chemical analysis/metals (D8)
   - Invasive sps (D2)
   - Sandeels (D3)
7. What resources do you need to collect the information needed?
   - Vessel
   - Staff (2 crew, 1 technical specialist as minimum though skills easily trainable (different skills needed for on-board processing or not))
   - Storage and handling of formalin (i.e. COSSH in UK)
   - 20-60 minutes per sample (depth dependent)
   - Specialised equipment for data collection (i.e. Grab, Dredges etc)
8. Will the non-dedicated monitoring/sampling be influenced by the new data collection? If yes, how (e.g. spatial, temporal, number of stations, etc.)
   - Extra time may be required to collect samples
   - Sampling may be combined with extra sampling (e.g. CTD) to add value
   - Downtime can be used (i.e. at night during day-only sampling cruises)

Scenario B
Questions 1-8: see scenario A

9. What data related to the case-study will be collected by using existing platforms?
    - Species composition
    - Presence/absence
    - Substrate and habitat extent and distribution
    - Fishing effects (e.g. trawl marks from video/sidescan sonar)
    - Epifaunal communities

    Note: No abundances or biomass
10. What techniques will be used?
    - Fish stomach analysis
    - AUV
    - Acoustic techniques (e.g. MBES bathymetry and backscatter, sidescan sonar)
    - VMS data interpretation
    - Environmental DNA
    - Underwater optical techniques
11. What platforms will be used?
    - Ships
    - Fixed platforms (wind mills, platforms), with camera
12. Which countries will be involved in data collection using new sources?
    - Germany
    - Netherlands
    - UK

    Note: all NS countries involved for NS scale monitoring
13. What additional data might be collected from the new sources and to which MSFD descriptor/indicator do they relate?
    - Species composition (D1, D2, D4)
    - Presence/absence
    - Substrate and habitat extent and distribution (D6)
    - Fishing effects (D3)
    - Epifaunal communities (D1, D4)
14. What resources do you need to collect the information needed from new sources?
    - Technique R&D
    - Specialist skills
    - Equipment
    - Vessel time for testing as well as sampling
    - Funding
15. What arrangements have to be made before the new monitoring can take place?
    - Technique R&D
    - Funding
    - Co-ordination
    - Data QA/QC, standardisation and dissemination procedures

Scenario C
Questions 1-8: see scenario A; Questions 9-15: see scenario B

16. Is there any dedicated monitoring for the case-study? If yes, proceed. If no, scenario B and C should be the same.
    - Yes, though different countries have different approaches and aims. These include:
        - Regular monitoring programmes over time and space (policy driven)
        - Project specific monitoring focussing on human impacts (e.g. of industry such as wind farms, engineering, aggregate extraction)
        - Marine Protected Area monitoring
17. What data related to the case-study will be collected from the dedicated monitoring?
    - Species composition

- Numbers per species.
- Biomass (quantitative)

18. What techniques will be used?
    - Grab
    - Core
    - Dredge
19. What platforms will be used?
    - Ship
20. What countries will be involved in data collection?
    - All North Sea coastal states
21. What additional data will be collected and to which MSFD descriptor/indicator do they relate?
    - Grab content for marine seafloor litter (D10) and foodwebs (D4)
    - PSA (D6 (supporting)
    - Organic matter (D3, D4)
    - Chemical analysis/metals (D8)
    - Invasive sps (D2)
    - Sandeels (D3)
    - Species composition (D1, D2, D4)
    - Presence/absence
    - Substrate and habitat extent and distribution (D6)
    - Fishing effects (D3)
    - Epifaunal communities (D1, D4)
22. How will the dedicated monitoring be influenced by adding other data sources? (e.g. number of stations, spatial coverage, temporal coverage)
    - Stratification of sampling will be influenced by
        - Habitat
        - Pressure
        - Management measures (e.g. under environmental legislation i.e. MSFD, Habitats Directive etc.)

Marine litter

Contributors: Matthias Schaber, Samuel Shepard, Francisco Marco-Rius, Steve Geelhoed, Peter de Boer

Scenario A

1. What data related to the case-study will be collected?
   Geographical position, depth, presence, absence, litter type, weight/volume
2. Which existing non-dedicated monitoring will be taken into account?
   Scientific surveys (i.e. bottom trawl and beam trawl surveys)
3. What techniques will be used?
   Fishing gear of various types
4. What platforms will be used?
   Research vessels and possibly also commercial fishing vessels
5. What countries will be involved in data collection?
   All North Sea coastal states
6. What additional data will be collected (as an outcome from the non-dedicated monitoring used) and to which MSFD descriptor/indicator do they relate?
   Fish CPUE (D1- biodiversity, D3 – population abundance, D4 – food web e.g. large fish indicator)
   Hydrography (e.g. Temperature, Salinity, Oxygen concentration profiles) (D5 – eutrophication)
   Ad-hoc sampling of large epibenthos (D6 – sea floor integrity) and non-indigenous species (D2).
7. What resources do you need to collect the information needed?
   Existing surveys (e.g. IBTS, BTS) and commercial fishery sampling programs.
8. Will the non-dedicated monitoring be influenced by the new data collection? If yes, how (e.g. spatial, temporal, number of stations, etc.)
   no

Scenario B

Questions 1-8 from scenario A

9. What data related to the case-study will be collected by using existing platforms?
   Presence/Absence, abundance and possibly type of litter
10. What techniques will be used?

    Sea Floor Litter

    a) Benthic grabs
    b) Hydrographic models
    c) Divers
    d) Experimental boxes
    e) Video recording

    Floating Litter

    f) Video recording from ferries
    g) Visual observations from planes/ships
    h) Satellite imagery
    i) Manta trawls

11. What platforms will be used?
    a) research vessels
    b) Computers/Software
    c) Individual divers
    d) research vessels
    e) research vessels, ROVs, AOVs, Hab Cam, camera networks, moored observation systems
    f) Ferries
    g) Planes/Ships

   h) Satellites
   i) Research vessels
12. What countries will be involved in data collection using new sources?
    All North Sea coastal states
13. What additional data might be collected from the new sources and to which MSFD descriptor/indicator do they relate?
   a) D1, D2, D6
   b) D5, D7
   c) D2, D5, D6
   d) none
   e) D1, D2, D3, D6
   f) D1, D5
   g) D1, D5
   h) D5
   i) none

Due to time constraints, the answers to questions 14 and 15 are incopmplete

14. What resources do you need to collect the information needed from new sources?
   a) Trained staff, ship time, data analysis.
15. Which arrangements have to be made before the new monitoring can take place?

Scenario C

Questions 1-8: see scenario A; Questions 9-15: see scenario B

16. Is there any dedicated monitoring for the case-study? If yes, proceed. If no, scenario B and C should be the same.
    No. As there is no specific monitoring programme for elasmobranch species in place, this scenario is identical to scenario B.

Annex 8. WGISUR products

Annex 8.1 Additional task table

List of activities, MSFD descriptor related to, and additional resources needed for preparation (ICES, 2012b)

	MSFD descriptor related to												Preparation
Task	1	2	3	4	5	6	7	8	9	10	11	Fisheries survey for data collection	Additional equipment
Fish and shellfish (survey specific)													
Organism collection (e.g. for contaminants, fatty acids analysis etc.)	x	x	x	x				x	x			trawl, acoustic and ichthyoplankon	no
Stomach sampling	x		x	x								trawl, acoustic and ichthyoplankon	no
Additional biological data (e.g. isotopes, biological data of other than standard species)	x	x	x	x				x				trawl, acoustic and ichthyoplankon	no
Disease/parasite registration	x	x	x		x			x	x			trawl, acoustic and ichthyoplankon	no
Genetic information	x		x									trawl, acoustic and ichthyoplankon	sampling equipment, ethanol
Lipid content				x								trawl, acoustic and ichthyoplankon	Fat meter; Calibation series for the specie
Sonar observations pelagic fish			x									all	scientific sonar
Tagging			x									trawl, acoustic and ichthyoplankon	Tags and fish handling
Bioactive materials in marine species (e.g. for medical purposes)												trawl, acoustic and ichthyoplankon	no
Echosounder observations pelagic fish	x	x	x									all	no
Other sampling of fish/shellfish not taken in main gear	x	x		x								trawl, acoustic and ichthyoplankon	Alternative appropriate gear
Physical and chemical oceanography (e.g. CTD, chlorophyll, oxygen, nutrients, turbidity, etc.)													
Continuous underway oceanographic measurements [from the ship]							x					all	dependent on variables collected
Station oceanographic measurements							x					all	dependent on variables collected
Continuous underway oceanographic measurements [autonomous devices]							x					all	dependent on variables collected
Water movement							x					all	ADCP
Station nutrient samples					x							all	Water sampler
Biological oceanography													
Station microbiological samples	x	x	x	x				x				all	Water sampler
Station phytoplankton samples	x	x	x	x	x			x				all	Water sampler
Continuous phytoplankton samples	x	x	x	x	x			x				all	CPR/fluorometer
Station zooplankton samples [towed]	x	x	x	x				x				all	Towed samplers
Station zooplankton samples [dipped]	x	x	x	x				x				all	Dipped samplers
Continuous zooplankton samples	x	x	x	x				x				all	CPR
Gelatinous zooplankton samples	x	x	x	x								all	Various plankton nets towed/hauled slow
Invertebrates													
Infauna	x	x		x		x						all	Grab/corer, sieve
Epifauna [towed]	x	x		x		x						all	Beam trawl/dredge/sledge/bottom trawl
Epifauna [video]	x	x		x		x						all	Video
Pelagic	x	x		x								all	Trawl, seines and plankton nets
Megafauna													
ESAS sampling (birds, sea mammals)	x	x		x								all	binoculars
Towed hydrophones	x	x		x								all	Towed hydrophone
Habitat description													
Camera [towed/dropped]	x	x				x						all	Towed/dropped camera
Side-scan sonar	x					x						all	Side-scan sonar
Multi beam echosounder	x					x						all	Multi beam echosounder
Ground truthing	x					x						all	Grab/corer, sieve
Pollution													
Floating litter										x		all	no
Sinking litter										x		trawl and tv/video	no
Pollution in the water column								x	x	x		all	dependent on variables collected
Pollution in the sediment								x	x	x		all	Grab/corer
Pollution in organisms								x	x	x		trawl, acoustic and ichthyoplankon	Selected gear appropriate for sampling th
Environmental conditions													
Weather conditions							x					all	no
Sea state							x					all	no

During survey

Task	Additional skills	Extra personnel	Extra shiptime	Facilities
		During survey		
Fish and shellfish (survey specific)				
Organism collection (e.g. for contaminants, fatty acids analysis etc.)	no	dep on the amount of samples	no	sample storage
Stomach sampling	no	yes	dep on the amount of samples	preservation facilities, sample storage
Additional biological data (e.g. isotopes, biological data of other than standard species)	dep on sampling type additional skills might be required	dep on the amount of samples	no	no
Disease/parasite registration	knowledge of fish diseases/parasites	dep on the amount of samples	dep on the amount of samples	dep on data request: preservation facilities, sample storage
Genetic information	training required to prevent cross-contamination	dep on the amount of samples	no	dep on data request: preservation facilities, sample storage
Lipid content	skills for operation of the device	dep on the amount of samples	no	dep on data request: preservation facilities, sample storage
Sonar observations pelagic fish	skills for operation of the device	dep on variables collected	no	data storage, synchronisation unit
Tagging	tagging skills	dep on the amount of samples	dep on the amount of samples	fish handling facilities
Bioactive materials in marine species (e.g. for medical purposes)	no	dep on the amount of samples	no	preservation facilities, sample storage
Echosounder observations pelagic fish	no	dep on variables collected	yes (equipment calibration)	data storage, synchronisation unit
Other sampling of fish/shellfish not taken in main gear	no	dep on variables collected	dep on the amount of samples	preservation facilities, sample storage
Physical and chemical oceanography (e.g. CTD, chlorophyll, oxygen, nutrients, turbidity, etc.)				
Continuous underway oceanographic measurements [from the ship]	skills for operation of the device	dep on variables collected	no	dep on the device used, pumped clean seawater supply
Station oceanographic measurements	skills for operation of the device	dep on variables collected	yes (deploy/recover)	dep on the device used
Continuous underway oceanographic measurements [autonomous devices]	skills for operation of the device	operation of the device	yes (deploy/recover)	no
Water movement	skills for operation and analysis	no	no	no
Station nutrient samples	skills for operation of the device	no	yes (deploy/recover)	no
Biological oceanography				
Station microbiological samples	skills for operation of the device	yes	yes (deploy/recover)	lab facilities, preservation facilities
Station phytoplankton samples	skills for operation of the device	yes	yes (deploy/recover)	preservation and storage facilities
Continuous phytoplankton samples	skills for operation of the device	yes	yes (deploy/recover)	preservation and storage facilities
Station zooplankton samples [towed]	skills for operation of the device	yes	yes (deploy/recover)	preservation and storage facilities
Station zooplankton samples [dipped]	skills for operation of the device	yes	yes (deploy/recover)	preservation and storage facilities
Continuous zooplankton samples	skills for operation of the device	yes	yes (deploy/recover)	preservation and storage facilities
Gelatinous zooplankton samples	skills for operation of the device		yes (deploy/recover)	preservation and storage facilities
Invertebrates				
Infauna	sorting and identification skills	yes	yes	preservation and storage facilities
Epifauna [towed]	sorting and identification skills	dep on the amount of samples	yes, except for beam trawl surveys	preservation and storage facilities
Epifauna [video]	skills for operation of the device	operation of the device	yes	no
Pelagic	sorting and identification skills	dep on the amount of samples	yes, except for pelagic trawl (acoustic) surveys	preservation and storage facilities
Megafauna				
ESAS sampling (birds, sea mammals)	identification, knowledge of methodology	yes (expert)	no	observation platform
Towed hydrophones	skills for operation of the device	yes (expert)	yes (deploy/recover)	data storage
Habitat description				
Camera [towed/dropped]	skills for operation of the device	yes	yes	data storage, synchronisation unit
Side-scan sonar	skills for operation of the device	yes (expert)	yes (deploy/recover)	data storage, synchronisation unit
Multi beam echosounder	skills for operation of the device	yes (expert)	no	data storage, tide gauge (costs), synchronisation unit
Ground truthing	knowledge on positioning of stations, dep on level of analysis required	yes (expert)	yes	storage facilities dep on analysis required
Pollution				
Floating litter	no	yes	depends on gear and number of samples	observation platform/preservation and storage dep on required analysis
Sinking litter	no	no	depends on gear and number of samples	preservation and storage facilities
Pollution in the water column	skills for operation of the device	dep on variables collected	yes (deploy/recover)	dep on variables collected
Pollution in the sediment	skills for operation of the device	dep on variables collected	yes (deploy/recover)	dep on variables collected
Pollution in organisms	skills for operation of the device	skills for operation of the device	skills for operation of the device	dep on variables collected
Environmental conditions				
Weather conditions	no	no	no	no
Sea state	no	no	no	no

After survey

Task	Additional personnel	Facilities	Lab facilities	Sample storage	Data storage	Analytical instrumen	Analysis software
			After survey				
Fish and shellfish (survey specific)							
Organism collection (e.g. for contaminants, fatty acids analysis etc.)	yes	yes		x	x	x	
Stomach sampling	yes	yes	x	x	x	dep on analysis	
Additional biological data (e.g. isotopes, biological data of other than standard species)	yes	yes	x	x	dep on analysis (e.g. otoliths)		dep on analysis (e.g. otoliths)
Disease/parasite registration	yes	yes	x	x	x		
Genetic information	yes	yes	x	x	x	x	x
Lipid content	yes	yes	x	x	x	x	x
Sonar observations pelagic fish	yes	yes			x		x
Tagging	yes	yes			x		
Bioactive materials in marine species (e.g. for medical purposes)	yes	yes	x	x	x	x	
Echosounder observations pelagic fish	yes	yes			x		x
Other sampling of fish/shellfish not taken in main gear	yes	no			x		
Physical and chemical oceanography (e.g. CTD, chlorophyll, oxygen, nutrients, turbidity, etc.)							
Continuous underway oceanographic measurements [from the ship]	yes	yes			x		
Station oceanographic measurements	dep on variables collected	no			x		
Continuous underway oceanographic measurements [autonomous devices]	dep on variables collected	yes			x		
Water movement	yes	yes			x		x
Station nutrient samples	yes	yes	x	x	x	x	x
Biological oceanography							
Station microbiological samples	yes	yes	x	x	x	x	
Station phytoplankton samples	yes	yes	x	x	x	x	
Continuous phytoplankton samples	yes	yes	x	x	x	x	
Station zooplankton samples [towed]	yes	yes	x	x	x	x	
Station zooplankton samples [dipped]	yes	yes	x	x	x	x	
Continuous zooplankton samples	yes	yes	x	x	x	x	
Gelatinous zooplankton samples	yes	yes	x	x	x	x	
Invertebrates							
Infauna	yes	yes	x	x	x	x	
Epifauna [towed]	yes	yes	x	x	x	x	
Epifauna [video]	yes	yes			x		x
Pelagic	yes	yes	x	x	x	x	
Megafauna							
ESAS sampling (birds, sea mammals)	no	no					
Towed hydrophones	yes	yes			x		x
Habitat description							
Camera [towed/dropped]	yes	yes			x		x
Side-scan sonar	yes	yes			x		x
Multi beam echosounder	yes	yes			x		x
Ground truthing	yes	yes	x	x	x	x	
Pollution							
Floating litter	yes if analysis not conducted at sea		x	x	x	x	
Sinking litter	yes if analysis not conducted at sea		x	x	x	x	
Pollution in the water column	yes	yes	x	x	x	x	x
Pollution in the sediment	yes	yes	x	x	x	x	x
Pollution in organisms	yes	yes	x	x	x	x	x
Environmental conditions							
Weather conditions	no	no			x		
Sea state	no	no			x		