INTRODUCTION AND BACKGROUND FOR THE MONITORING

The steering group of the Sound Water Co-Operation in 1997 asked the working group to provide an outline of a monitoring programme for the Sound. The working group found the task difficult without a knowledge of the environmental objectives forming the basis of the monitoring programme, and the group therefore prepared a proposal for operational environmental objectives for the Sound, which were then published by the Sound Water Co-Operation.

The starting point for the proposal for a monitoring programme is the EU framework directive on water and the proposals for operational environmental objectives (for the...
button fauna of the Sound) which were prepared for the Sound Water Co-Operation.
Both the EU directive and the operational environmental objectives focus on the
biological diversity in connection with environmental assessments. The operational
environmental objectives for the Sound were sent for a hearing with most of the
authorities involved and were discussed at a special workshop. A majority of the
authorities had a positive attitude towards these objectives. The recently released
“backgrounds for assessments” from the Swedish Agency for the Protection of Nature
also notes that the occurrence of certain organisms indicates a certain environmental
state. Both Sweden and Denmark have also signed the international convention on the
conservation of biological diversity (BDC – Biodiversity Convention).

An ideal monitoring programme must be undertaken in a dynamic way enabling a
correction of the programme based on the gained experience and in such a way that
intensive studies are undertaken in case of “catastrophes” (e. g. oxygen depletion or
toxic algal blooms), and these studies must be followed by ecological succession
studies. A readiness to do this must exist. A feedback mechanism must be generated
between the structure and results of the monitoring programme and the research sector
and its fresh knowledge.

The Sound Water Co-Operation has as a proposal divided the area of the Sound in a
northern, a central and a southern part.

A SURVEILLANCE MONITORING PROGRAMME FOR THE SOUND

The directive 2000/60/EC of the European Parliament and of the Council establishing a
framework for Community action in the field of water policy (in the following “the
framework directive”) sets up four different types of monitoring i. e. surveillance
monitoring, operational monitoring, investigative monitoring and additional monitoring
for protected areas. Two types of monitoring have been described in the so-called
DPSIR-system which is used by e. g. the European Environmental Agency i. e. status
monitoring and effect monitoring. “Surveillance monitoring” and “status monitoring”
are here taken to cover the same concept i. e. activities such as provision of data and
information for:

- supplementing and validating the procedure for impact assessments,
- the design of future monitoring programmes,
- the assessment of long-term changes in natural conditions,
- the assessment of long-term changes resulting from widespread
  anthropogenic activity,
- determining the requirements for other monitoring programmes.
The Sound Water Co-Operation has elaborated a proposal for a common Danish-Swedish surveillance monitoring programme for the Sound with the following elements:

- monitoring of trends in time as proposed in the discussion report “Nye mål for Øresund?” (“New Targets for the Sound?”) including a control of the presently valid operational objectives*,
- monitoring of geographical trends as proposed in the discussion report “Nye mål for Øresund?” (“New Targets for the Sound?”) including a control of the presently valid operational objectives,
- monitoring of the biological diversity in selected (especially sensitive and/or interesting) biological communities as proposed in the discussion report “Nye mål for Øresund?” (“New Targets for the Sound?”) including a control of the presently valid operational objectives (may optionally be provided as a special additional programme, see below).

These elements have been constructed around three scientific pillars:

1. **The physico-chemical aquatic variables** are measured and supplied to a model calculating their distribution in the monitored area of the Sound. This provides an improved fundament for explaining the changes that are observed in the biological part of the monitoring programme (the framework directive: “the assessment of long-term changes in natural conditions and the assessment of long-term changes resulting from widespread anthropogenic activity”),

2. **The biological variables** in the Sound including the biological diversity.

3. **Other variables** in the Sound so far only the frequency and the geographical coverage of oxygen depletion incidents.

These three scientific pillars have in the following been specified by means of maps indicating the positions of sampling stations and transects as well as tables of the variables to be measured, the measuring frequencies etc. in the northern (N), the central (C) and the southern (S) parts of the Sound. The planning of the sampling and of the frequency of measuring by sensor devices must be based on statistical considerations (e.g. power analyses) in order that conclusions may be trustworthy. Methods and techniques must as far as possible be co-ordinated making data and results comparable; conversion factors must at least be available.

* The operational objectives, which were proposed in the discussion report, are not final (but dynamic) and should undoubtedly be supplemented by elements from the framework directive such as ecotoxicological objectives.
THE PHYSICO-CHEMICAL VARIABLES
(The map may also be consulted):

The open waters

If reasonably accurate residence times and transports of nutrients are to be determined, then the frequency of measuring must reflect the velocity of the sea currents. The Danish Environmental Research Institution has used statistical analyses to investigate the optimal measuring frequencies with the usual current velocities. It is evident, however, that the frequency will be so high that registration from a boat is not possible. Fixed measuring buoys must be established. The investigation has inter alia shown that a demonstration of changes in the order of 1 – 2 % per year requires time series with an approximate length of 30 years.

Hydrographic data
Three measuring stations should be established in the Sound. The stations are used as monitoring stations and for validation of the results of model calculations. Border data are used for model simulations. A station must therefore be located at each end of the model area, and a third station must be placed in the middle of the model area. Profiling probes should be set to measure the variables proposed in the table. The frequency will be decided upon through the aforementioned analyses. The measuring stations may be established as permanent measuring buoys or be attached to permanent structures such as the existing lighthouses located in the open sea.

Hydrochemistry
In-situ analysers are established at each of the three measuring stations for analyses of the inorganic nutrient salts nitrates, phosphates and silicates. Measurements are done at the surface and at the bottom. The frequency will be decided upon through the aforementioned analyses.

Total N and total P are measured as the inorganic nutrients at the surface and above the sea floor. An auto sampler mounted on the same rack as the in situ analysers takes flow-proportional samples. The current meter controls the sampling.

Meteorological data from existing data suppliers are used as required for model calculations. Such data could inter alia involve the atmospheric deposition of nitrogen compounds.

The coastal areas

Hydrography and hydrochemistry
Regional controls are performed as part of the servicing of the automatic measuring equipment at the permanent measuring stations. Hydrographic profiles are measured at the regional stations and hydrochemical samples are taken. The permanent stations should be serviced every two to three weeks. The number of stations is chosen to consider regional conditions and the sampling in connection with the framework directive.
## Table of physico-chemical variables

<table>
<thead>
<tr>
<th>Variables</th>
<th>Sample type</th>
<th>Number of stations</th>
<th>Frequency</th>
<th>Location in the Sound (N-C-S)</th>
<th>Comment</th>
<th>Map legend</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salinity, temperature, oxygen, pH, fluorescence, turbidity, chlorophyll, light, current (velocity and direction), water level</td>
<td>Profile measurement from permanent buoys</td>
<td>3</td>
<td>Every 10th minute</td>
<td>1-1-1</td>
<td>Auto logger</td>
<td>Red asterisks</td>
</tr>
<tr>
<td>Ammonium, nitrate, phosphate, silicate</td>
<td></td>
<td></td>
<td>Every 2 hours</td>
<td></td>
<td>In situ analysis</td>
<td></td>
</tr>
<tr>
<td>Total nitrogen (TN) and total phosphorus (TP)</td>
<td></td>
<td></td>
<td></td>
<td>Auto sampler flow proportional</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Salinity, temperature, oxygen, pH, fluorescence, turbidity, chlorophyll</td>
<td>Profile measurement from boat</td>
<td>3 – 4 (regional)</td>
<td>24</td>
<td>Regional</td>
<td>Probe; As far as possible in connection with the servicing of auto loggers and samplers</td>
<td>Red Circles</td>
</tr>
<tr>
<td>Ammonium, nitrate, phosphate, silicate</td>
<td>Water sampler from boat</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TN, TP</td>
<td></td>
<td></td>
<td></td>
<td>1-4-3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
THE BIOLOGICAL VARIABLES
(The map may also be consulted):

Plankton

In addition to the variables listed below chlorophyll (which is measured in the physico-
chemical section) is a good measure of the phytoplankton. The physical conditions to a
large degree control the occurrence of the phytoplankton, and the special conditions in
the Sound with more saline water in the north and more brackish water in the south
require that the stations should be distributed all over the Sound. As point sources and
watercourses lead to higher impacts from nutrients in coastal areas than in the central
parts of the Sound sampling stations should be located in both areas.
Biomass determinations should be performed through measurements of the cells and not
just through values taken from the literature (which is done at the Swedish side). This
provides a more genuine picture of the true amount of carbon in the sample. In order to
save time and money the biomass determinations could be done at some stations only at
each sampling occasion, while the remaining determinations could be saved till the end
of the year, when selected interesting samples are analysed.
Both a quantitative and a qualitative (landing net sample) method in order not to miss
any species determine the species composition. One method may overlook species that
are found by another (this also applies for the fixation of samples). The species
composition also provides answers as to which harmful species and indicator species
are present.
The primary production provides an overall description, and experience has shown that
the correlation between addition of nutrients and the primary production is good.
Table of phytoplankton variables

<table>
<thead>
<tr>
<th>Variables</th>
<th>Sampling type</th>
<th>Number of stations</th>
<th>Number of measurements per year</th>
<th>Location in the Sound (N-C-S)</th>
<th>Comment</th>
<th>Map legend</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biomass</td>
<td>Integrated sample 0-10 m and 10-20 m</td>
<td>2</td>
<td>24</td>
<td>0-1-1</td>
<td>Accurate measurement of the cells Optional analysis at end of year</td>
<td>Green triangles △</td>
</tr>
<tr>
<td></td>
<td>Integrated sample 0 m – bottom</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>6</td>
<td>24</td>
<td>1-4-1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primary production</td>
<td>Integrated sample 0-10 m and 10-20 m</td>
<td>2</td>
<td>24</td>
<td>0-1-1</td>
<td>Optional analysis at end of year</td>
<td>Green triangles △</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6</td>
<td>24</td>
<td>1-4-1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Species composition</td>
<td>Integrated sample 0-10 m and 10-20 m</td>
<td>2</td>
<td>24</td>
<td>0-1-1</td>
<td>Provides even toxic species and indicator species. Optional analysis at end of year</td>
<td>Green triangles △</td>
</tr>
<tr>
<td></td>
<td>Quantitative and landing net sample</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>6</td>
<td>24</td>
<td>1-4-1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Bottom fauna**

In this context the EU framework directive on water is based on the diversity of the bottom fauna and on the species density as well as on sensitive species and species that can be regarded as pollution indicators under specific conditions. One could add that it should be of interest to establish possible impacts from important local sources of pollution and to see these in the perspective of the diffuse impacts occurring.
For which questions are answers desired?

The main question should be how the environmental condition is changed. Another question concerns the alterations of natural environments that ought to be protected or changes in the occurrence of species that are more or less specific for the area. The third question is how stations close to point sources of pollution differ from more peripheral ones, and how stations close to the sources develop when steps are taken to reduce the pollution.

The design with coastal stations and stations further away from the coast can generally provide an idea whether differences exist between these areas. This would be interesting as the model simulations of the Sound Water Co-Operation seem to indicate a higher load of nutrients along the coast, as the discharged substances in the shallow coastal areas are diluted in a smaller volume. As the current in these areas is not so strong, a given impact caused by the discharges will be greater in these water areas.

The following variables must be included:

1. Diversity – may preferably be measured through the number of taxa, but could even be measured through a diversity index (Shannon-Wiever, Margalef). One could emphasise indicator species (e. g. crustaceans and molluscs). A special interest may be given to these groups without losing the holistic perspective.
2. Density of individual organisms – number of individuals per m².
3. Sensitive species – these must be listed (an attempt has been made in the proposal for operational environmental objectives for the bottom fauna and even includes species living in deep sediments).
4. Taxa indicating pollution (an attempt has been made in the proposal for operational environmental objectives for the bottom fauna).
5. Biomass – g per m².
6. Unique species or species worth protecting. These are emphasised in international contexts.

How should the studies be performed?

The choice of sampling technique determines the degree of comparability between results from different points in time and between sampling points. The techniques at sediment bottoms (“soft” bottoms) are completely different from those at hard bottoms. In addition different techniques for sediment bottoms are used at the Danish and Swedish sides of the Sound. The former technique has also been changed in recent years due to the introduction of area monitoring.

Sediment bottoms

The technique that was formerly used at these stations must also be used in future to maximise the comparability. This provides a maximal possibility for comparing results.
from different points in time, although it then becomes difficult to compare different stations. This is also practically advantageous and eliminates lengthy discussions as to which technique is the better. Each technique has its advantages and disadvantages. A recent assessment of data from Swedish sediment bottoms shows that changes can be statistically demonstrated by means of the agreed technique (Lindegarth 2001). Roughly speaking the technique implicates that a Haps-corer is used at most Danish stations and a Smith-McIntyre grab at most Swedish stations. The number of samples thereby varies between 5 and 50 depending on the equipment used. When completely new stations are introduced the Danish technique should be used at Danish bottoms and the Swedish technique at Swedish bottoms. The reason for this is that the inter station difference as a rule is larger than the difference between samples within the same station. Each station can therefor be considered unique.

**Hard bottoms and mussel banks**

Transects have been used for hard bottoms in many studies with several samples at each depth. Power analyses of the data collected at each locality should lead to the correct number of samples for differences to be detected.

Concerning *Modiolus* banks scrapings with a triangular tool has been used to give an impression of the species composition. This has been complemented with traditional sampling of the sediment bottom fauna (Smith-McIntyre).

**Time of sampling**

The sampling procedures should be co-ordinated at the two sides of the Sound in order to maximise the comparability. Most sampling activities have traditionally taken place in the spring, in April-May. Old data therefore mainly relate to this period, which should therefore be preferred. Long time series are important to understand developments and their causes.

Sampling in the late autumn would possibly be better and could provide a faster answer to possible impacts from oxygen depletion events. Such impacts ought, however, also to be discovered in samples from the spring. Two annual samples would be ideal, as this would provide an idea about the development of the fauna over the year, and one should be able to relate impacts more closely to the time of events that have occurred. Such a sampling programme is under inclusion in the coastal monitoring programme for the town of Helsingborg and should in the future be performed at some selected sampling stations within each natural community.

**Where should the studies be carried out?**

A majority of the natural communities ought to be monitored. Sampling stations should be located close to important sources of pollution, in suitable cases a number of stations at increasing distance from the source.
Animal communities
The five following communities occur in the Sound at sediment bottoms: The brackish water community (two main types), the Macoma-community, the Abra-community (two main types), the Amphipura-community (2 main types), the Haploops-community and the Modiolus-community. Local banks of blue mussels (Mytilus edulis) are found within the brackish water community and the Macoma-community.

The distribution of hard bottoms is limited, but larger areas are found at Kullen, the northwestern reef off Ven, north of Helsingborg and at the Limhamn/Drogden sill. The latter contains banks of blue mussels.

As a north-south salinity gradient influencing the species composition exists in the Sound, a certain coverage of the natural environments should be included in various subareas.

Larger sources of pollution loads
Sources of larger loads are especially the water purification plants at Helsingborg Malmö and Copenhagen, Kemira Kemi, Hydro Supra, the watercourses Kävlingeån, Höje Å, Saxån, Råån and Tryggevælde Å. A number of larger chemical industries are also located in Landskrona, Malmö and Copenhagen as well as around the Bay of Köge.

Criteria for the choice of sampling stations
1. The majority of the various natural environments are investigated in order to obtain an idea of the diversity in the Sound. These are often called communities (an attempt for a division in six main types has been made in the proposal for operational environmental objectives for the bottom fauna). On land we would not be satisfied just to take samples in the forest in order to study the environmental conditions.
2. As the fauna differs significantly, mostly in a north-south direction, the communities are studied at several locations.
3. The fauna is also studied adjacent to important sources of pollution loads. These studies ought in appropriate cases to be performed at increasing distances from the sources. The contents of environmental poisons are also investigated in mussels. We should find out not only how many animals there are but also their uptake of environmental poisons. The latter is much better than studies of the contents in the water and in sediments. We get more comparable samples if we study the organisms, and we also find out how the ecosystem is affected.
4. Already established stations with historical data should be considered when sampling stations are positioned so that the former can be used for assessment of the long-term environmental state.
5. Stations should foremost be positioned at relatively homogenous horizontal bottoms.
6. The chosen stations may be considered typical for larger areas. It is at present largely uncertain, if this is possible, as no general mapping for this purpose has been done.

Table of the location of the bottom fauna sampling stations in the various natural environments of the Sound
The annual frequency is once per year (spring) except at stations that are sampled twice a year. At the map the stations are marked with yellow asterisks.

<table>
<thead>
<tr>
<th>Naturmiljö:</th>
<th>Number of stations Northern Sound</th>
<th>Number of stations Central Sound</th>
<th>Number of stations Southern Sound</th>
<th>Number of stations / transects close to sources of pollution</th>
<th>Stations with annual sediment sampling (organic matter)</th>
<th>Stations with annual sediment sampling/blue mussels (env. poisons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BRACKISH WATER FAUNA/MYTILUS</td>
<td>2</td>
<td>5 (spring and autumn 2)</td>
<td>3</td>
<td>6</td>
<td>6</td>
<td>9</td>
</tr>
<tr>
<td>MACOMA-COMMUNITY / MYTILUS</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>8</td>
<td>8</td>
<td>11</td>
</tr>
<tr>
<td>ABRA (VENUS)-COMMUNITY</td>
<td>1 (spring and autumn)</td>
<td>5 (spring and autumn 1)</td>
<td>-</td>
<td>-</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>AMPHIURA-COMMUNITY</td>
<td>2 (spring and autumn 1)</td>
<td>2 (spring and autumn 1)</td>
<td>-</td>
<td>-</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>HAPLOOPS-COMMUNITY</td>
<td>2 (spring and autumn 1)</td>
<td>2 (spring and autumn 1)</td>
<td>-</td>
<td>-</td>
<td>3</td>
<td>-</td>
</tr>
<tr>
<td>MOLDIOLUS-COMMUNITY</td>
<td>1</td>
<td>2</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>HARD BOTTOM/MYTILUS COMMUNITY</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

**Bottom vegetation**

Power analyses of completed studies concerning eelgrass show that at least 10 stations are required to detect a significant change in an eelgrass area. The methodology required is a line assessment with a diver for occurrence in depth and degree of coverage. The diver performs about 5 to 6 observations at the same depth. For determinations of biomass and shoot density the same methodology was employed in
connection with the investigations of the impacts of the fixed link across the Sound. A frame of 25 x 25 cm was subjectively positioned in the densest part of the eelgrass meadow. Samples are taken at two to 3 depths with 5 to 6 samples per depth.

**Table of eelgrass variables**

<table>
<thead>
<tr>
<th>Eelgrass Number of stations</th>
<th>Location in the Sound</th>
<th>Variable</th>
<th>Frequency</th>
<th>Type of sample</th>
<th>Comment</th>
<th>Map legend</th>
</tr>
</thead>
<tbody>
<tr>
<td>40</td>
<td>0-20-20*</td>
<td>Depth occurrence</td>
<td>Once a year</td>
<td>Line assessment with diver</td>
<td><em>Uncertain if much eelgrass exists in the northern Sound.</em></td>
<td>Green lines</td>
</tr>
<tr>
<td>40</td>
<td>0-20-20*</td>
<td>Coverage</td>
<td>Once a year</td>
<td>Line assessment with diver</td>
<td></td>
<td>Green lines</td>
</tr>
<tr>
<td>40</td>
<td>0-20-20</td>
<td>Biomass</td>
<td>Once a year</td>
<td>Frame (25*25 cm) 5-6 replicates, 2-3 depths in densest part of meadow</td>
<td></td>
<td>Green lines</td>
</tr>
<tr>
<td>40</td>
<td>0-20-20</td>
<td>Shoot density</td>
<td>Once a year</td>
<td>Frame (25*25 cm) 5-6 replicates, 2-3 depths in densest part of meadow</td>
<td></td>
<td>Green lines</td>
</tr>
</tbody>
</table>

*10 stations are required in each area, when a change must be measurable.
Table of variables concerning macroalgae

<table>
<thead>
<tr>
<th>Macroalgae</th>
<th>Location in the Sound</th>
<th>Variable</th>
<th>Frequency</th>
<th>Type of sample</th>
<th>Comment</th>
<th>Map legend</th>
</tr>
</thead>
<tbody>
<tr>
<td>?</td>
<td>?</td>
<td>Species composition</td>
<td>Once a year</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Depth occurrence</td>
<td>Once a year</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Species sensitive for eutrophication?</td>
<td>Once a year</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Coverage</td>
<td>Once a year</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Other variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Sample type</th>
<th>Number of stations</th>
<th>Measurements per year</th>
<th>Location in the Sound (N-C-S)</th>
<th>Comment</th>
<th>Map legend</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oxygen, temperature, salinity</td>
<td>Oxygen depletion</td>
<td>Regional</td>
<td>1 - 2</td>
<td>C</td>
<td>Paravane-scan</td>
<td>?</td>
</tr>
</tbody>
</table>

OPERATIONAL MONITORING AND INVESTIGATIVE MONITORING IN THE SOUND

According to the framework directive operational monitoring is undertaken in order to establish the status of those water bodies identified as being at risk of failing to meet environmental objectives, and to assess changes of the status of such bodies resulting from the programmes of measures.

Investigative monitoring shall be carried out:

- where the reason for any exceedances is unknown,
- where surveillance monitoring indicates that the objectives for a water body are not likely to be achieved and operational monitoring has not already been established, in order to ascertain the causes of a water body or water bodies failing to achieve the environmental objectives, or
- to ascertain the magnitude and impacts of accidental pollution;
The operational monitoring and the investigative monitoring in the ideal monitoring programme for the Sound are implemented among others with the following elements:

- Monitoring of impacts with a possible significance for the health of human beings as well as for the health and occurrence of the flora and the fauna with operational objectives as proposed in the discussion report “Nye mål for Øresund?”
- Monitoring of the contents of anthropogenic substances and heavy metals in the sediments of the accumulation zones in the Sound (e. g. south of Ven and in bays with deep “holes” with sampling along transects from the largest assumed sources in such a way that the origin of the substances can be established and with operational objectives as proposed in the discussion report “Nye mål for Øresund?”

These monitoring activities also include monitoring in harbours, marinas and yachting harbours, estuaries and other localities where a high degree of adaptation is required because of the local sources of pollution and the local knowledge. The Sound Water Co-Operation can provide general recommendations, but the implementation is a matter for the local and regional authorities.

**Recommendations:**

**MONITORING OF LANDBASED DISCHARGES OF NUTRIENT SALTS, HEAVY METALS AND ANTHROPOGENIC SUBSTANCES**

**Discharges from water courses**
An examination of available data including transport statistics, the discharge of water from precipitation and the water flow etc should determine the extent to which this subject is dealt with. Which added benefits will arise from the deployment of current metres and sampling equipment?

**Discharges from water purification plants**
Daily flow proportional samples should be collected for the analysis of total nitrogen, total phosphorus and COD (chemical oxygen demand) from all water purification plants.
Analyses are performed for heavy metals and anthropogenic substances until basic data have been accumulated or changes of the running of the plants or of the loads justify that sampling is resumed in order to verify the changes.
<table>
<thead>
<tr>
<th>Variable</th>
<th>Sample type</th>
<th>Number of stations</th>
<th>Frequency</th>
<th>Location in the Sound (N-C-S)</th>
<th>Comment</th>
<th>Map legend</th>
</tr>
</thead>
<tbody>
<tr>
<td>TN, TP</td>
<td>Landbase d discharges</td>
<td>3 – 4 largest water courses</td>
<td>1 flow proportional (fp) sample per day</td>
<td>?</td>
<td>Auto-sampler</td>
<td>Water courses and brooks (Ξ)</td>
</tr>
<tr>
<td>TN, TP</td>
<td>Other water courses</td>
<td>12</td>
<td>?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TN, TP, COD</td>
<td>All purification plants</td>
<td></td>
<td>1 fp pr. day</td>
<td></td>
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<tr>
<td>Heavy metals</td>
<td>At discharge points of purification plants</td>
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<tr>
<td>Anthropogenic substances</td>
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**MONITORING OF PHYSICAL INTERVENTIONS AND DISTURBANCES**

Monitoring of environmental impacts caused by man made physical interventions and disturbances to the marine environment

A number of different types of interventions and disturbances may be cited:

- under water pipes
- cables
- dredging and areas in the Sound for disposal of dredged spoils
- areas in the Sound for extraction of sand
- areas in the Sound for filling (creation of new land in the open Sound)
- areas in the Sound for establishment of technical constructions (bridges, breakwaters, groins, wind mills and other constructions in the open Sound)
- areas for filling along the coast (creation of new land in direct connection with relevant land areas such as harbours).
The concrete monitoring techniques for these activities may vary (compare the monitoring programmes for the environmental impacts from the construction of the fixed link across the Sound and for the discharges from the nuclear power plant at Barsebäck), and they should be adjusted for each type of intervention/disturbance. A task for the regional co-operation concerning the Sound may be to provide maps describing the impacts that have been caused mainly on areas, which have been reclaimed.

**MONITORING OF OIL DISCHARGES**

Discharges of oil from establishments on land to e.g. harbour areas and from ships in harbours are controlled and monitored by the harbours themselves and by the local authorities (municipalities), which are responsible for this activity in Denmark and in Sweden. Discharges of oil from ships at sea are in Denmark and Sweden monitored from aircraft and by sampling the discharged oil and the oil in the ships’ tanks with subsequent comparison of the results of the analyses. This monitoring activity is in Denmark undertaken by co-operation between the armed forces (the air force and the navy) and the civilian authorities. In Sweden the coast guard undertakes this task. Existing agreements provide for bilateral co-operation that may be initialled with short notice. Proposals or recommendations from the Sound Water Co-Operation in this context do not seem to be justified.

**MONITORING OF THE FISH POPULATIONS AND THEIR PRODUCTION IN THE SOUND**

The fish populations in the Sound may for example be monitored by means of the methodology, which has been used by a number of the Danish counties in the regional monitoring programmes. The methodology is based on calculations of the intensity of the fishing activities (requires a knowledge of the marine area concerned and the depth conditions), whereupon the area is subdivided in fields each measuring approximately 100 hectares or an area adapted to the local conditions.

In each field at shallow water a pound net is set together with a special trap with a small mesh size. In the deep fields supplementary floating nets at a depth of app. 5 metres are set, and juvenile specimens are caught in special trawls.

The catch from the individual fishing tools is sorted according to species and every individual fish is measured and weighed. The mean net catches and the area-weighted catches are calculated.

This methodology is connected with some uncertainties especially under extreme temperature salinity and oxygen conditions and in case of school formation, but it is considered to be suitable for monitoring purposes in bays with not too large depths (until 10 metres). The Sound Water Co-Operation recommends that such a fish
monitoring be undertaken with regular intervals (5 years) in the bays of Hornbæk Nivå
Lundåkra and Lomma, in the Kalveboderne, in the Køge Bay and in Höllviken.
The data resulting from this monitoring may be supplemented with information from
the Fiskeriverket and the Danish Fisheries Investigations about the size of the edible
fish catches in the Sound.

**MONITORING OF HEAVY METALS AND ANTHROPOGENIC SUBSTANCES IN THE
MARINE ENVIRONMENT**

**Sediments**

Sediments are studied in both sedimentation areas (e. g. south of Ven) and in non-
 sedimentation areas (reference stations to be established) in the open Sound and along
the coasts (and in fishing zones). The stations should be located to provide information
about local conditions (harbours, marinas, and point sources, dredged spoil disposal
areas). Sediments around discharge points should be studied along transects for the
substances that are discharged in order to establish their dispersion and impact in the
environment. Further studies should only be undertaken following a close assessment of
previous studies (frequency 5 to 10 years). The positioning of regional stations should
be decided in co-operation with the regional authorities.

**Organisms**

Organisms are studied at various trophic levels. From the sediments (perhaps) two
different types of bottom dwellers are chosen: A deposit feeder e. g. a marine bristle
worm and a filter feeder e. g. blue mussels (*Mytilus*). Eelgrass, *Fucus*, flounder, eel and
cod are also analysed. Stations and frequencies are established in accordance with the
same guidelines as above (sediment).

Impacts of known environmental poisons on sensitive groups or organisms are
monitored. The sensitive organisms considered are especially gastropods (whelk,
(*Buccinum sp*), periwinkle (*Littorina littorea*) and *Hinia*).

**ADDITIONAL MONITORING FOR PROTECTED AREAS**

An additional monitoring programme is undertaken for protected areas (*areas with
protected habitats and species*, compare the framework directive) and for areas that are
worth protecting. This monitoring is organised locally and has to a large degree already
been established. The marine reserves at Kullen, Knåhaken (*Modiolus*-community),
Falsterbo/Höllviken, Saltholm and the stone reef at Gilleleje, the brackish water
community in the central Sound and the *Haploops*-community can be mentioned as
examples of such areas to which new areas may be added.
Special additional programmes that are considered necessary may be established although they may not immediately fit into the current programmes. The reasons may be that the studies are as a matter of fact important, but the development of the methods has not been finalised, or that their scope is research-like for which reason they are undertaken in co-operation with universities and are partly paid for by other parties. Examples could be a monitoring of the state and coverage of the banks of blue mussels between Saltholm and Sweden.

**DATA ANALYSES**

An ideal monitoring programme must include procedures for treatment analysis and interpretation of the data collected. The Sound Water Co-Operation will undertake this part of the monitoring programme with emphasis on statistical analyses such that the validity of observed impacts and conclusions is assured.
Example of the positioning of stations
The stations have been grouped as natural communities or parts thereof. The subcommunities are the same as previously suggested by the Sound Water Co-Operation. Stations with historical data are indicated in bold letters and their original names. Other stations have been numbered consecutively with even numbers on the Danish side and odd numbers on the Swedish side. Concerning local sources of pollution only the larger known sources have been indicated and stations have been positioned taking the point of discharge in consideration. The latter implicates for example that if the points of discharge are located at deep waters this is especially supposed to influence the deeper fauna and vice versa. At least one station has been positioned in each subarea and community on each side of the Sound. In some subareas where a certain community is expected to change its character and presumably covers relatively large areas two stations have been positioned on each side of the Sound.

THE BRACKISH WATER FAUNA (even Mytilus-community)
Northern Sound: 1, 2
Local discharge sources: Not known
Central Sound: TR01, TR02, TR9, TR13, TR14
Local discharge sources: Kemira Kemi AB, Saxån, Kävlingeån, Sege å
Southern Sound: Limhamn/Drogden-sill, TR20, 4
Local discharge sources: Tryggevälde å, Industries in the Köge Bay

THE MACOMA-COMMUNITY (even Mytilus-community)
Northern Sound: 6, HöS
Local discharge sources: Helsingborg Water Purification Plant
Central Sound: ÖVF3:2, 1877, 116
Local discharge sources: Råån = R0.4, R0.5, R1, R3, KE1.5, Höje å, Landskrona Chem.industries, Malmö Chem. Industriers, Copenhagen Chem. industries
Southern Sound: ÖVF5:2, 1727, Kö
Local discharge sources: Malmö Water Purification Plant

ABRA (VENUS)-COMMUNITY
Northern Sound: 8
Local discharge sources: Not known
Central Sound: B, ÖVF4:9, Middelgrund, 12
Local discharge sources: Not known
Southern Sound: Presumably not existing

AMPHIURA-COMMUNITY
Northern Sound: 1940, ÖVF1:3
Local discharge sources: Not known
Central Sound: M, 120
Local discharge sources: Not known: Supra AB = 0, Kemira Kemi AB = ÖVF2:3
Southern Sound: Not existing

**HAPLOOPS-COMMUNITY**
Northern Sound: P22, 14
Local discharge sources: Not known
Central Sound: W, HA (presumably does not exist on the Danish side in this subarea)
Local discharge sources: Not known
Southern Sound: Not existing

**MODIOLUS-COMMUNITY (presumably does not exist on the Danish side)**
Northern Sound: 3
Local discharge sources: Not known
Central Sound: Knåhaken, P4
Local discharge sources: Not known
Southern Sound: Not existing

HARD BOTTOM (Even *Mytilus*-community)
Northern Sound: Kullaberg, N Helsingborg
Local discharge sources: Not known
Central Sound: Hvens NW reef, Staffan’s Bank
Local discharge sources: Not known
Southern Sound: Limhamn/Drogden-sill
Local discharge sources: Not known