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Revision and assessment of Norwegian RID data 1990-2007

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Summary:
Data from the Norwegian RID program is reported to OSPAR annually. The goal of this project was to make a complete assessment and review of the historical data and conduct new calculations to get better and more reliable estimates of inputs to the Norwegian coastal areas; and revise the Norwegian national RID-figures in the OSPAR database.
This report documents this review of historical figures and the reconstruction process.

Country:	Norway

Godkjent / Approved	Prosjektleder / Project leader
Øistein Vethe	Per Stålnacke

Preface

The Norwegian Pollution Control Authority (SFT) is responsible for the Norwegian RID programme (Riverine Inputs and Direct Discharges to Coastal Waters) and the corresponding reporting of results to OSPAR. The Norwegian Institute for Water Research (NIVA), the Norwegian Institute for Agricultural and Environmental Research (Bioforsk) and the Norwegian Water Resources and Energy Directorate (NVE) accomplish the practical and operational tasks of the RID programme, wherein NIVA is the project leader.

In this project, SFT has commissioned Bioforsk and NIVA to evaluate the historical data, harmonise the time series and adjust possible errors in the national OSPAR-database reported in the RID programme in the period 1990-2007.

The project started in autumn 2008 with continuation in 2009.

The report is based on cooperation between Bioforsk and NIVA. Project leader Per Stålnacke (Bioforsk) has been responsible for quality assurance and assessment of the river water data. Additional co-workers have been Eva Skarbøvik and Stale Haaland (quality assurance and selection of methods), Stein Turtumøygard and Thor Endre Nytrø (examination of data). At NIVA John-Rune Selvik has been the main responsible and has also been responsible for sewage plants, industry, aquaculture and the TEOTIL model. Other co-workers at NIVA have been Øyvind Kaste (choice of methods, follow-up activities); Tore Høgåsen (RESA database, programming) and Torulv Tjomsland and Knut-Erik Enerstvedt (data coordinates and point sources). Tjomsland has also worked with TEOTIL-data and the Regine-catchments.

Christine Daae Olseng who has been our contact person at SFT is thanked for constructive discussions during the project.

Ås, 1 November, 2009

Per Stålnacke
Project leader

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Summary

Data from the Norwegian RID program is analysed and reported to OSPAR annually. During the course of the programme, changes and improvements have occurred due to increased knowledge, improved techniques and methodological changes. Hence, trends are not necessarily due to real input changes, but could be due to improved analytical methods by laboratories (e.g., lower detection limits), changes in water discharge station location, or other changes that give non-comparable figures in historical time series. It was therefore a need to review the historical data and to perform recalculations, so that the long term data series can produce more realistic trends and more comparable data between years.

The goal of this project was to make a complete assessment and review of the historical data and conduct new calculations to get better and more reliable estimates of inputs to the Norwegian coastal areas; and revise the Norwegian national RID-figures in the OSPAR database.

Overview of the major activities in the project:

1. Reassessment of riverine inputs for 155 rivers (10+36+109) and database facilitation

The main focus has been to review and correct riverine concentration (checking existing database content against what is reported in the original report and identification of unusual values, or so-called 'outliers'). The task also includes re-calculation of catchment areas for water discharge and water quality stations, updating of water discharge data (mainly the 145 tributary rivers), preparation of a database for easier input and output and quality assurance of data, and to develop a slightly modified method for input calculations.

2. Reassessment on inputs of direct emissions (WWTP, industries and aquaculture), database management and quality assurance.

This activity included cooperation with external data suppliers (SFT, Statistics Norway and the Directorate of Fisheries). The focus has been on data collection from different sources, quality *assurance* of sampling locations (wastewater treatment plants and industry), identification of anomalies and gaps in the time series. A method for reconstruction and harmonization of annual data series is also given. For example, aquaculture has not been reported in the RID-context before 1999. In addition, data from aquaculture is often incomplete, even with regard to plant coordinates. With the help of estimated production rates for every county in previous years, the first overall estimate for the entire period 1990-2007 of the supplies of nitrogen, phosphorus and copper been done. The activity has also included preparation of a new historical database (to date there has not existed a 'database' of the historical data on direct emissions from 1990 and onwards). The progress of creating routines for an easy entry and output from the RESA-database has also been implemented.

This report documents this review of historical data and the reconstruction process.

1. Introduction

Data from the Norwegian RID program is analysed and reported to OSPAR annually. Besides usage in the OSPAR Programme and in other international fora, such as the EEA, the results and data are also used within Norway (e.g. http://www.miljostatus.no/).

During the course of the programme, changes and improvements have occurred due to increased knowledge, improved techniques and methodological changes. Hence, trends are not necessarily due to real input changes, but could be due to improved analytical methods by laboratories (e.g., lower detection limits), changes in water discharge station location, or other changes that give non-comparable figures in historical time series. It was therefore a need to review the historical data and to perform recalculations, so that the long term data series can produce more realistic trends and more comparable data between years.

Project goal:
The goal of this project was to make a complete assessment and review of the historical data and conduct new calculations to get better and more reliable estimates of inputs to the Norwegian coastal areas; and revise the Norwegian national RID-figures in the OSPAR database.

This report documents this review of historical figures and the reconstruction process.

2. Concentrations, water discharge and river drainage areas

2.1 Sampling frequency in the 155 RID rivers

The monitoring in rivers is carried out in 10 so-called 'main rivers' with monthly sampling or more; and since 2004 in 36 so-called 'tributary rivers' with sampling 4 times a year. In the period 1990-2003, the frequency of the latter group of rivers was only once per year. In addition, 109 tributaries were sampled for water chemistry once a year between 1990 and 2003. It is important to note that the name 'tributary' is only used to signify that these rivers are monitored more seldom than the main rivers, as they all drain directly into the sea.

The water discharge data are based on daily measured water levels in the main rivers and modelled water discharge levels in the tributaries (using NVE grid version of the HBV-model). In the reporting 1990-2003, the water discharge in the tributaries was based on a method that is now deemed to be too simplistic.

The river catchment coverage in relation to Norway's total land area is as follows:

- Main rivers (10) constitute about 30 %
- Main rivers (10) + the 36 tributaries constitute approximately 55 %
- Main rivers (10) + the 36 tributaries + the 109 additional tributaries constitute approximately 70 %

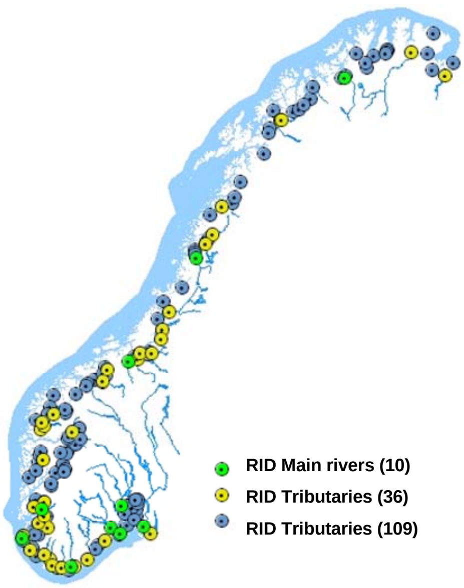

Figure 1 Stations in the RID program. RID main rivers includes 10 rivers, 36 tributaries sampled every quarter since 2004, and 109 tributary rivers sampled once a year from 1990-2003. Map Source: NIVA

2.2 Concentrations, general revisions

All raw data concentration data from the 155 RID rivers, were collected and imported to the RESA database (the NIVA database system). A print-out of the database was then sent to Bioforsk for further review and quality assurance. The following checklist was used:

1. Check of all missing values in the database, in relation to the originally submitted RID-reports
2. Check of the raw data in printed RID originals with data in the database.
3. Check of possible errors in decimal-point and units.
4. Identification of the detection limits (Level of Detection or LOD values) and an assessment of whether these had been set correctly
5. Identification of outliers, according to two options:
    1. Values 50 times higher or lower than the median value for all observations.
    2. Values 10 times higher or lower than the median value for all observations.
6. Check of whether there were available dates of sampling for the period 1990-2003 for the 145 tributaries (set to January 1st in the former database).

Bullet points 1 and 2 proved to be very labour-intensive; involving manual punching of data and search of raw data in former annual printed reports. For example: In river Tista we identified five arsenic data that was not included in the database.

In total, all 155 river systems have been examined. This corresponds to a dataset of 2824 measured data, which multiplied with a total of 40 parameter values give a total dataset material of 112,960 values.

520 possible outliers was also identified as 'suspicious' (see bullet point 5 above) and further scrutinized. More specifically, these were checked against the values in the RID written reports. If the data was found to be identical in the database and report the value as a rule was accepted. Generally, the problem with outliers appeared to be marked at the low concentration band (hence; of minor importance for total annual inputs). Very few extremely abnormally high values were found. High values could in most cases be explained, or was within what could be expected as normal large variability (see also the comment on mercury below).

In addition, 97 incorrectly coded commas as decimal digits was identified and replaced with dots.

2.3 Mercury and total phosphorus concentrations 1999-2003

As previously reported to the Norwegian Pollution Control Authority, a change of laboratory (1999-2003) gave generally higher mercury concentrations than in other periods, which also affected the input estimates (e.g. Borgvang et al. 2007).

Parallel samples in 9 rivers, analyzed by both KM-Lab in Sweden (under Aquateam project management) and NIVA-lab, showed that the KM-lab reported 2 to 8 times higher concentration in 8 of the rivers compared to the NIVA lab. Only in the agriculture dominated Orreelva, the Hg concentration from the KM-lab showed lower concentrations compared to the NIVA lab.

Wiederborg et al. (2001) concluded that it was not possible to determine which laboratory method that gave the most correct result. KM-lab used an 'atomic fluorescence' method while NIVA lab used the 'gold trap and AAS' method.

Regardless of which laboratory having the 'most correct' analytical results, the present database gives an impression that inputs to the Norwegian coast increased during the period 1999-2003, while it is more likely that this is caused by changes in the laboratories and laboratory methods .

Suspicious elevated total phosphorus values can also been noted in the same period. This is exemplified in the RID report for 2007 (Skarbøvik et al. 2008) and at Miljøstatus.no. In the same period was it also noted that the relationship between total phosphorus and suspended solids was less clear than in other periods, as commented by Borgvang et al. 2007.

In this project, a thorough analysis of all the total phosphorus concentrations was done and it was concluded that the above described problems with total phosphorus are prominent in a great majority of the RID rivers.

After discussion with SFT, it was decided that mercury values and tot-P concentrations in 1999-2003 are deleted from the database and replaced with an estimated annual concentration value according to the non-parametric regression equation (Theil-Slope; see Chapter 3.4).

2.4 Catchment area

Accurate catchment area data is needed for river discharge calculations. This is because the discharge is often not measured on the same location as the sampling sites for water quality (i.e., concentrations). Discharge is therefore scaled to the sampling point as the ratio between the two drainage areas.

TEOTIL use Regine-field units, and for convenience, catchment areas for sampling points is changed so that they comply with the limits for their specific Regine field. This means that there is a full conformity between the various land use categories used in TEOTIL and in discharge calculations from the rivers.

In addition we have used the same drainage basin size throughout the entire period; in earlier reporting the sizes have varied.

2.5 Discharge in the 10 main rivers

The Hydrological Department at NVE is constantly improving their water discharge measurements, for example by improving procedures for correction of ice-reduction. The drainage area has also been adjusted over the years with improved map sources available. In addition, use of different water flow stations (changed, closed down, new) throughout the life-time of the RID program has also occurred. This will of course also affect the historical trends.

In this project, updated discharge data from NVE for the time period 1990-2007 was downloaded and the same water discharge stations was then used for each river over the entire study period.

3. Riverine inputs

3.1 Calculation of loads in 10 main rivers

It is important to note that campaign sampling during flooding period in particular years will create challenges in the trend analysis. This is due to the fact that the selected load calculation method in the RID program is sensitive to flood samples, especially the substances where the concentrations are positively correlated with water discharge. At the same time it is worthwhile to stress that extra sampling during flooding episodes are very important to be able to capture the annual inputs.

In this project a minor adjustment to the calculation method of loads in relation to what was done for the years 1990-2007 was implemented. Earlier reporting of annual loads has been based on calculation of a flow-weighted annual concentration multiplied by the total annual discharge (i.e., total annual water volume) in accordance with the OSPAR JAMP Guidelines. For various reasons, the sampling frequency is not always conducted at regular time steps and in some cases also monthly data are missing. Thus, it is necessary to weight each sample – in addition to water discharge- also by the time period the sample represents. The time periods are defined by the midpoints between the samples. Note the formula is used only within each year, i.e., the time period for a sample is never extended into another year. The modified load calculation formula is shown below.

$$Load = Qr \frac{\sum_{1}^{n} q_i \bullet c_i \bullet t_i}{\sum_{1}^{n} q_i \bullet t_i}$$

where Q_i represent the water discharge at the day of sampling;
C_i the concentrations at day i;
T_i the time periods by the midpoints between the samples, i.e., the half number of days between the previous and next sampling;
Q_r is the annual water volume.

If samples are taken at regular intervals within the year, the modified formula will give almost the same result as the original method. Minor differences occur because the actual period between samples is usually not an exact division of the year. However, for rivers with irregular sampling frequency, the difference can be quite large, especially when extra samples are taken during flood episodes. In those cases, the original method 'overestimates' the annual load. With the original method, each sample was given equal weight, and if several flood samples were taken during a short time period, the sampling frequency would per se influence the load calculation. The modified method handles irregular sampling frequency in a better way and allows flood samples to be included in the annual load calculations.

Some examples of flood samples include:

- Four additional samples during the snowmelt in May and June in Glomma and Drammenselva
- Additional samples during the high floods in the Drammenselva and Numedalslågen summer 2007
- Daily sampling in June 1995 in Glomma, and in the Drammenselva during the extreme spring flood in late 1995; the differences between calculation methods in River Drammenselva is illustrated in Figure 2.

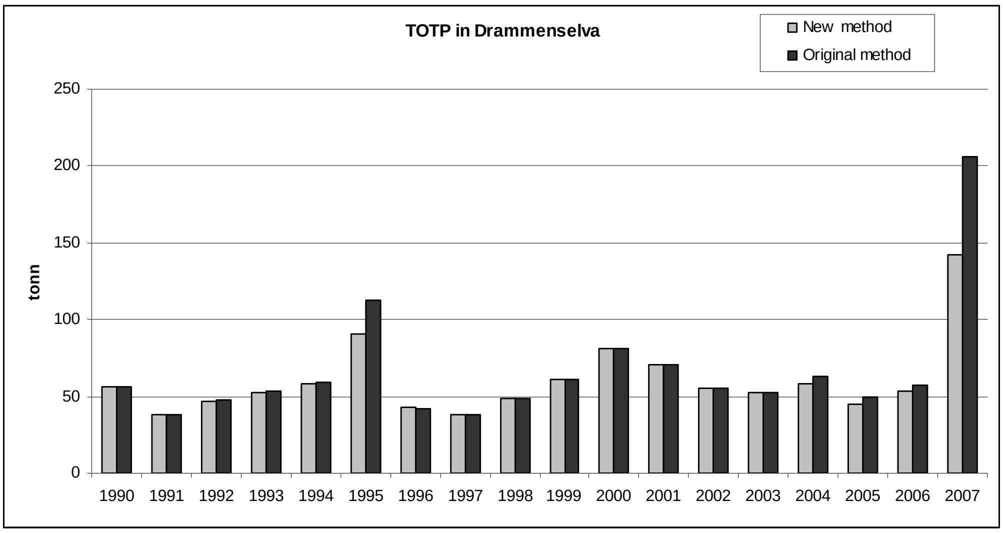

Figure 2. Calculated annual loads for total phosphorus in Drammenselva.

In addition to the modified load calculation methodology, it was also necessary to include the new and more precise estimates of catchment areas (as described above), which triggered the need for updated river input figures for the period 1990-2007.

3.2 Calculation of loads in 36 tributaries

For the 36 rivers sampled quarterly since 2004, the methodology for estimating water discharge has been different. Some examples:
In the period 1990-2003, the water discharge the specific year was estimated by the following simple method:

- The long-term average of water discharge in the normal period 1961-1990 was multiplied by the ratio between annual precipitation divided by long-term means of precipitation (1961-1990). This number was then multiplied by the concentration of the sample (which before 2004 thus consisted of a single sample per year).

After 2004, when the sampling frequency for these rivers rose to 4 times per year, the water discharge was obtained from a model (Beldring et al.; 2003; and given in detail in e.g., Skarbøvik et al. 2008).

In this project, we have for consistency used modelled water discharge for the entire time period for the 36 tributaries.

It should be noted that a modified sampling frequency, from 1 time per year to 4 times per year, will remain a challenge for the trend analyses. The sampling strategy for these tributaries (four times per year) deliberately includes samples during snowmelt and the autumn rain episodes, and has proven to provide considerably more variable concentrations compared to previous years. Thus, a trend analysis from 1990 to present will give a slightly false impression of increased loads in these 36 rivers. However, a simple solution to this problem does not exist, and it is therefore recommended that these apparent 'trends' should be explained each time when reporting and for external usage of the data.

3.3 Calculation of loads in 109 tributary rivers

Using the same reasoning as for the 36 tributaries, the water discharge in the 109 tributary in 1990-2003 was replaced with modelled water discharge. The discharge in 2004-2007 was also re-calculated, because the discharge model has been continuously improved since 2004.

Programming of functions in a database (RESA) for estimating of loads in these 109 rivers has been completed. This also includes the automatic calculation procedure for estimating of values in years without sampling (the same method as for industrial and water treatment plants; see chapter 3.4). This is a change compared to the reporting of 2004-2007 data which used a long-term average concentration derived from earlier data.

In addition, the adjustments of the catchment areas triggered a new reporting of discharge and input figures for 2004-2007.

3.4 The RESA-database and general methods and assumptions

Values missing in the time series in the period 1990 to 2007 from industrial sources, sewage and scattered dwellings, and partly in the water quality database are interpolated and extrapolated according to the following:

A. All interpolated and extrapolated estimates are based on a "Kendall-Theil Robust Slope estimate". This nonparametric fitted trend line is based on medians, and is not affected by single outliers. The estimation is performed on annual averages. Missing data in certain years are interpolated with the estimated trend-line. To avoid the risk of extrapolating trends, missing values before the first measured year, and after the last measured year, are given the value on the estimated line for the first or last measured year, respectively, i.e., we assume that the slope is zero outside the period with reported/measured data.
Exceptions from these interpolation and extrapolation rules are in cases when there are less than 5 measurements (annual data). In such case the median value is used. Another rule is that the extrapolated values cannot be lower than the LOD-value for a particular year and are in such cases set to the LOD-value for that particular year,

B. For industrial and sewage treatment plants we interpolate between the first and last observed values, but do not perform any extrapolation backward or forward assuming that the first reported value is when the plant started and similarly that the plants has been closed down after the final reported year. Noteworthy is that the data in the database about real closing year is incomplete in the original database used; see chapter 4 and 5.

For aquaculture plants, we set inputs to zero for any year without reporting, assuming that the plant has been closed down (permanently or temporary). A data report implemented in RESA gives information on which values have been calculated.

C. For water quality data, two different sets of complete time series are constructed, i.e., one for the "upper" estimates where the detection limit is used for values below the detection limit, and one for the "lower" estimates where all values below the detection limit is interpreted as zero. The routines are designed to handle future changes in the sampling programme, i.e., slopes and estimates can easily be recalculated when new data becomes available. Compared to earlier reporting we have no also included upper and lower estimates for de 109 rivers. Noteworthy is that no separate lower and upper estimates are given for industrial sources, aquaculture, or sewage and scattered dwellings.

Estimated inputs are stored in the RESA database system along with drainage areas, chemical raw-data from rivers and discharge data from NVE (observed for the main rivers and modelled for the tributaries). The database is a standard normalized (Oracle 11g) database, and most procedures are written as stored procedures in PL/SQL. The database is linked directly to NIVA's laboratory system, and data are transferred automatically as soon as the analyses are ready. User interface and reporting routines are currently a combination of a legacy VB6 application, .net code and VBA code in Excel.

The interpolation and extrapolation routines mentioned have been implemented as functions in the RESA-database. In addition, the following routines have been included in the RESA-database:

1. A quality check of incoming data – i.e., to identify extremes/outliers:
   Water quality data are subject to continuous control, mainly by visual inspection of time series plots. For input to TEOTIL the system generates an Excel report, in which values differing by a factor of 100 from an estimated value for a given year and constituent, is tagged. These tagged values are then checked manually.
2. File-export and import to the TEOTIL model:
   The TEOTIL model needs input from five "data types" for each year: Observed data, industry, sewage treatment plants, scattered dwellings, aquaculture and coefficients for diffuse losses. Routines have been designed that generate text files which can be used directly as input to TEOTIL. Output from the model is returned into the database for further processing and generation of reports.
3. The results of the annual calculations are stored in the database, and tables can be generated directly from the database for use in reports. Routines for export to the newly implemented OSPAR RID-Centre database have been made (Bioforsk is hosting this database on a contract with OSPAR).

4 Sewage treatment plants and scattered dwellings

Data from Norwegian sewage treatment plants (> 50 pe) is reported through the KOSTRA system, which is coordinated by Statistics Norway (SSB). SSB carry out the quality assurance of data, and is also in dialogue with plant owners on such issues. The data quality is improved gradually in recent years, but there is still need for further improvements.

When calculating inputs, it is important that the individual discharges are located to the correct recipient (river, lake, sea).

In the present project, NIVA has in dialogue with SSB identified the coordinates for all facilities that were missing or obviously incorrect (e.g., located in the open sea or in another country). It was fairly common that a digit was missing or that the UTM zone was set incorrectly. Some errors in coordinates still remain but are believed to be insignificant. More specifically, the accuracy now seems to be sufficient for this project[1], and plants included is now also spatially located to a corresponding watercourse.

Changes in coordinates for 192 sewage treatment plants have been performed, and coordinates for in total 2285 treatment plants are now included in the data base.

Data on nutrients and metals for the period 2002-2007 is available in KOSTRA. For previous years data came from the SESAM system (SSB-avløp), but SSB did not have resources to systematize older data for use in this project. Hence, we have therefore based the calculations on the following data and methods/assumptions:

- Nutrients 1993-2001:
  NIVA's own data from TEOTIL (originally reported from SESAM, SSB-avløp)
- Nutrients 1990-1992:
  Extrapolated from the available data (1993->).
- Metals 1990-2001:
  Extrapolated from the 2002-2007-period when other measures were not included in the existing data-set at NIVA.
- When data were missing for certain years, these have been replaced using the method described in chapter 3.4.
- It is indicated when plants are shut down, but not when they have started. We have chosen to interpret the first year of data as the initial year.

Emissions from scattered dwellings and household not connected to public sewerage systems are reported as an aggregated value for each municipality downstream the RID river sampling sites and unmonitored areas. For the scattered dwellings only nitrogen and phosphorus inputs are estimated but not for metals.

[1] Local use of these data in e.g. action plans in accordance with the Water Framework Directive would benefit from knowing the exact discharge point in river, lake or sea, but such a detailed approach was not the task of the present project.

5 Industry

Emissions from industry are as a standard procedure reported to the SFT's database system "Forurensning" ("Pollution", successor of the system "Inkosys"). NIVA has received data from industrial plants from 1990-2007. "Pollution" comprises data from approximately 8500 enterprises.

The industries that have reported relevant constituents in a RID-context more than once (764 companies in total) were undertaken a comprehensive and time-consuming review of the geographical location (coordinates). Errors and deficiencies have been corrected for 167 companies that had obvious erroneous coordinates.

After corrected coordinates were added to the list, they were further verified (i.e., through a check of whether the coordinates were in the right county according to specified address). This in turn led to further corrections.

It must be pointed out that it was not always straightforward to find good coordinates for the industry location, but it is believed that the location is sufficiently precise and accurate for the RID program's purpose (i.e., Norway report inputs into four sea-areas). For use in more detailed studies of single recipients like the requirements in the Water Framework Directive (WFD), it is important to know the point of emission with much more spatial accuracy.

Information is available on when a company has been closed down, but similar information about when it started does not exist. It has therefore been assumed that the first year of data equals the year of establishment.

6 Aquaculture

The aquaculture industry does not calculate their emissions (i.e., direct monitoring of inputs/emissions is lacking). Instead they report production-related data on a monthly basis that can be used to estimate the emissions. The fish production (calculated from standing biomass, slaughter, death, escapes, transfers) and use of fish feed is included in the calculation of inputs of nutrients to water.[2]

The Directorate of Fisheries has delivered production data to the TEOTIL project since 2002 (i.e., information recorded in ALTINN); with spatial resolution on production site at a monthly temporal resolution. From 1995 until 2002 production data was reported annually through the SFT system SESAM, and for the first years' estimates of nutrient discharges based on sold amount of fish was established. Data from the SESAM system was never transferred to ALTINN, and is now only available through data prepared for the TEOTIL. The nutrient emissions for all years have been calculated as part of the TEOTIL-project and data has been grouped on hydrological statistical areas, which was the smallest unit area in the TEOTIL model until recently (2006).

It was not possible to establish a historical overview of which facility that had been in operation each year throughout 1990-2002. The Directorate of Fisheries' registry has records for when various licenses have been issued (there are usually multiple licenses per locality). A list of operation duration for the plants could hence be established, with the assumption that the plants started the same year as permission was given. The operation of a plant might periodically lie fallow, and it is therefore not possible to routinely fill in missing data series.

The year 1991 was a difficult year for Norwegian fish farmers. Many enterprises went bankrupt. The Fishery Directorate and Statistics Norway indicate that figures on production this year are too uncertain to be reported. However, it was in this project decided to use the routine for filling gaps in the data series (see 3.4 above), in order to obtain a conservative estimate rather than an un-realistic null-input reporting for year 1991.

For the years prior to 2002, a simpler approach was used to obtain the geographic distribution of the discharges of nitrogen and phosphorus from the fish farms. The nutrient discharge is allocated to the most downstream hydrological statistical area in each river basin. However, this distribution of nutrient discharges is regarded as sufficient for the purpose of the RID project.

Copper is the proofing compound in antifouling paint for the net cages. Annually updated figures for sale of antifouling paint for the past few years are available for the whole of Norway. SFT estimates that 85 % of the copper content in the paint is lost to the surroundings. In order to give the inputs of copper a geographic distribution, we have assumed that the emissions of copper are correlated to plant size and production. Based on this, we have used a coefficient of discharge of copper per tons of nitrogen emissions (proportional to production), to distribute the copper emission onto all locations.

Through this approach, a time series for nitrogen, phosphorus and copper from aquaculture, has been established, covering the entire RID period of 1990 to 2007.

[2] The calculation is based on a mass balance approach, were the loss to water equals the difference between the amount nutrients supplied with the fish-feed and the proportion deposited in the fish produced (OSPAR HARP Guideline 2).

7 Conclusions

The assessment of the Norwegian RID data for the period 1990-2007 revealed that a number of revisions needed to be done to ensure a consistent database. These changes were carried out during 2008 and 2009 and have resulted in a revised and improved dataset for the RID-programme.

The list below gives an overview of the revisions and improvements done during the project period:

Riverine loads for the 155 rivers

1. Revision and correction of riverine concentration by checking the existing database content against what was reported in the original reports
2. Identification of unusual river concentration values, or so-called 'outliers' and in some few cases also removal of these data from the data-base.
3. Use of a standard catchment area sizes for water discharge and water quality stations,
4. Updating and more consistent use of more comparable water discharge data (mainly the 145 tributary rivers).
5. Implementation for extrapolation and interpolation routines in cases of missing years with data (for the 145 tributary rivers)

Industry

1. Conduction of a comprehensive review of the geographical location (coordinates). Errors and deficiencies have been corrected for 167 companies that had obvious erroneous coordinates.
2. Implementation for extrapolation and interpolation routines in cases of missing years with data

Sewage effluents and scattered dwellings

1. Identification of the coordinates for all facilities that were missing or obviously incorrect (e.g., located in the open sea or in another country).
2. Implementation for extrapolation and interpolation routines in cases of missing years with data

Aquaculture

1. Update of the methodology for emission estimates and implement it consistently for the entire time period
2. Updated figures for e.g. sale of antifouling paint
3. Calculation of emissions for the entire time period (previously only reported since 1999)

Methodological changes and data-base routines

1. Preparation of a database for easier input and output and quality assurance of data, and implement data base functions for automatic input calculations.

As stated above, the result is a new dataset for the RID Programme in Norway for the period 1990-2007. It is recommended that this revised set of data should be reported to the OSPAR Secretariat and should replace the Norwegian RID database for the period 1990-2007.

8 References

Beldring, S., Engeland, K., Roald, L.A., Sælthun, N.R., Voksø, A. 2003. Estimation of parameters in a distributed precipitation-runoff model for Norway. Hydrology and Earth System Sciences, 7, 304-316.

Borgvang, S.A., Stålnacke, P.G., Johansen, S.W., Skarbøvik, E., Beldring, S., Selvik, J.R., Tjomsland, T., and Harsten, S. 2007. Riverine inputs and direct discharges to Norwegian coastal waters – 2005. Norwegian Pollution Control Authority TA-2245/2007; NIVA Report 5380/2007. 152 pp.

OSPAR Harp Guideline 2. www.ospar.org

Skarbøvik, E. Stålnacke, P.G., Kaste, Ø., Selvik, J.R., Tjomsland, T., Høgåsen, T., Pengerud; A., Aakerøy, P.A., Fjeld, E. and Beldring, S. 2008. Riverine inputs and direct discharges to Norwegian coastal waters – 2007. OSPAR Commission. Norwegian Pollution Control Authority TA-2452/2008; 89 pp.

Wiederborg, M., Arctander Vik, E., Thoresen, H., Stang, P., Kelley, A. & Nedland, K.T. 2001. OSPAR Commission. Annual report on direct and riverine inputs to Norwegian coastal waters during the year 1999. A: Principles, results and discussions. Norwegian Pollution Control Authority. Aquateam Report number: 00-052. 41 pp.

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Tittel - norsk og engelsk
Revision and assessment of Norwegian RID data 1990-2007

Sammendrag – summary
Data from the Norwegian RID program is reported to OSPAR annually. The goal of this project was to make a complete assessment and review of the historical data and conduct new calculations to get better and more reliable estimates of inputs to the Norwegian coastal areas; and revise the Norwegian national RID-figures in the OSPAR database.
This report documents this review of historical figures and the reconstruction process.

4 emneord	4 subject words
Elvetilførsler. Direkte tilførsler. Norske kystområder. Overvåking	Riverine inputs. Direct discharges. Norwegian coastal waters. Monitoring