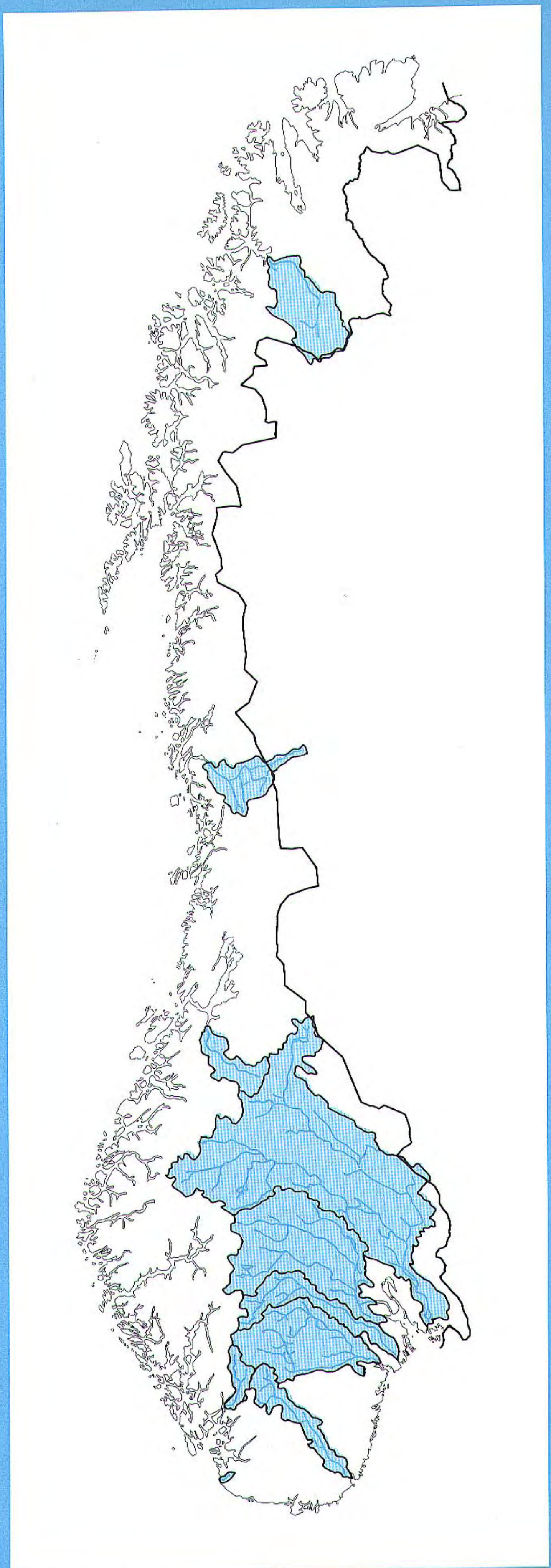


SFT State Pollution Control Authority

Contractor	SFT Norway
Performing institute	NIVA

Report 452A/91

Paris Convention

Annual report on direct and riverine inputs to Norwegian coastal waters during the year 1990

A Principles, results and discussions

TA 755A/1991

Norwegian Institute for Water Research NIVA

NIVA – REPORT

Norwegian Institute for Water Research NIVA

Main Office
P.O.Box 69, Korsvoll
N-0808 Oslo 8
Norway
Phone (47 2) 23 52 80
Telefax (47 2) 39 41 89

Regional Office, Sørlandet
Televeien 1
N-4890 Grimstad
Norway
Phone (47 41) 43 033
Telefax (47 41) 43 033

Regional Office, Østlandet
Rute 866
N-2312 Ottestad
Norway
Phone (47 65) 76 752
Telefax (47 65) 78 402

Regional Office, Vestlandet
Breiviken 5
N-5035 Bergen-Sandviken
Norway
Phone (47 5) 95 17 00
Telefax (47 5) 25 78 90

Report No.:	0-90001
Sub-No.:	
Serial No.:	2582
Limited distribution:	

Report Title:
Paris Convention.
Annual report on direct and riverine inputs to Norwegian coastal waters during the year 1990.
A. Principles, results and discussion.

Date: 25/6-1991

Author (s):
Gjertrud Holtan
Dag Berge
Hans Holtan
Terje Hopen

Topic group:

Geographical area: Norway

Number of pages (incl. app.): 43

Contractor:
The Norwegian State Pollution Control Authorities (SFT).

Contractors ref. (or NTNF-No)

Abstract:

Riverine inputs to Norwegian coastal waters from 10 main and 145 tributary rivers have been monitored during 1990. The loading from rivers not monitored as well as direct discharges to marine waters along the coast from Sweden to Soviet Union have been estimated.

According to the results, total annual nutrient load to coastal waters from landbased sources, is approximately 3.990 tons of phosphorus and 101.000 tons of nitrogen. About 50 per cent of the phosphorus and 60 per cent of the nitrogen are inputs from the monitored rivers and tributaties. Discharges of heavy metals and micropollutants are also included in the investigation. Most inputs of these substances are low, especially the riverine inputs of Cd, Pb and Hg. Most values of these substances are below the detection limits of the specific analysis, which also is the case for the different congeners of PCBs. The herbicide lindane is detected in most analyses in small amounts. Total load of this compound is estimated to about 530 kg. The largest yields from heavy metals comprise copper and zinc, with input estimates of 630 and 1.670 tons, respectively.

Retention in the fjords is not included in the above mentioned values, which in several cases would reduce the actual load to open marine waters considerably.

4 keywords, Norwegian
1. Forurensningstilførsler
2. Norske kystområder
3. Elvetilførsler
4. Direkte tilførsler

4 keywords, English
1. Pollution inputs
2. Norwegian coastal waters
3. Riverine inputs
4. Direct discharges

Project leader

Hans Holtan

For the Administration

Dag Berge

ISBN 82-577-1899-8

The National Environmental
Monitoring Programme

Paris Convention

Annual report on direct and riverine inputs
to Norwegian coastal waters during the year
1990

A Principles, results and discussion

Oslo, June 1991

Project manager:	Hans Holtan
Project coordinator:	Gjertrud Holtan
Co-workers:	Dag Berge
	Terje Hopen

Norwegian Institute for Water Research NIVA

PREFACE

The report presents the data from the 1990 monitoring of waterborne pollutants, both riverine and direct discharges, to the Norwegian coastal waters. The study is part of a joint monitoring programme under the "Paris Convention for the prevention of Marine Pollution from Landbased Sources". The Norwegian contribution is administered by the Norwegian State Pollution Control Authority (SFT) which has contracted the Norwegian Institute for Water Research to perform the actual investigations.

The 1990-investigation lasted from January till December. This report is the Norwegian part of the 1990-study, divided into two parts:

A: Principles - Results and Discussion
B: Data Report.

The Programme Committee has consisted of Jon Lasse Bratli (SFT), Dag Berge and Hans Holtan. The practical investigation is coordinated, and performed by Gjertrud Holtan. The calculations of all data has been performed by Terje Hopen. The names of all participants at NIVA and the local sampling persons are given in paragraph 5.

We would like to express our gratitude to all participants of the investigation, especially to the local fieldworkers for the collection and transport of the samples. The contact persons at the County Environmental Agencies and at the Municipalities of Oslo and Bærum are acknowledged for continous support and goodwill. The contact persons at the Norwegian Water Resources and Energy Administration (NVE) and The Norwegian Meteorological Institute (DNMI), Per Lofsberg and Stein Kristiansen, are acknowledged for their kind cooperation.

CONTENTS

		Page:
PREFACE		2
SUMMARY AND CONCLUSIONS		4
1.	INTRODUCTION	6
2.	RIVERSYSTEMS INCLUDED IN THE STUDY	7
2.1	General aspects	7
2.2	Monitored riversystems	8
2.3	Other riversystems included (tributaries)	11
3.	METHODOLOGY	11
3.1	**Methodology for assessing riverine inputs**	11
3.1.1	Objective	11
3.1.2	Site selection	11
3.1.3.	Sampling strategy and frequency	12
3.2	**Monitoring parameters and analytical methods**	14
3.2.1	Chemical parameters, detection limits and analytical methods	14
3.2.2	Method used to estimate flow rate	16
3.2.3	Calculation of annual load	19
3.3	**Methodology for assessing direct discharges to marine waters**	22
3.3.1	Sewage effluents	22
3.3.2	Industrial effluents	23
3.3.3	Other inputs	24
4.	RESULTS AND DISCUSSION	24
4.1	Pollutants	24
4.2	1990-results and discussion	25
4.3	Mean annual runoff (1930-60) and "mean load"	30
4.4	Nutrients retention in fjords	32
5.	REFERENCES	34
5.1	Project personnel	34
5.2	References	34
6.	APPENDIX I: TABLES I and I.I- I.IV	39

SUMMARY AND CONCLUSIONS

At the tenth meeting of the Paris Commission (Lisbon, June 1988) the principles for the comprehensive study on riverine inputs were accepted. It was then decided to commence the study with measurements carried out in 1990 (PARCOM, 10/3/2-E).

The purpose is to provide the Commission, in accordance with Article 17(B) of the Paris Convention, with an assessment of the waterborne inputs to Convention waters. Another objective of the programme is to control the fulfillment of The Ministerial Declaration of the North Sea which aims at 50% reduction of nutrients and and 50-70 %of selected micropollutants within 1995. Besides riverine inputs, the information sought also relates to direct discharges.

In 1987, the countries bordering the North Sea committed themselves to reducing inputs of nutrients in the order of 50 per cent into areas of the North Sea where these inputs are likely, directly or indirectly, to cause pollution. This area was in February 1990 decided to be from the Swedish border to Lindesnes. Further, discharges of selected micropollutants to the whole North Sea area are to be reduced by 50 - 70 % depending on the micropollutant in question.

In the rest of the country, the goals set by SFT, are to reduce phosphorus and nitrogen discharges to vulnerable watercources to the extent necessary to reduce local environmental impact to an acceptable level. SFT has also an additional objective to reduce discharges of erosion particles and suspended and dissolved organic material by 35 %.

In this report the results (1990) are given for riverine inputs of 10 main rivers and 145 tributaries. Thus the active monitoring programme covers drainage from 75 per cent of the main land areas. For discharges entering directly into marine recipients, i.e. sewage and industrial effluents, estimates are based on numbers from effluent control programmes. Area runoff of Total phosphorus and Total nitrogen from these coastal zones are estimated by use of area specific runoff coefficients.

Greatest emphasis with regard to accuracy has been given to the input estimate of the Skagerrak region, as this is considered the most susceptible part of the North Sea. The Skagerrak reception of Norways total loads are 30 per cent of the phosphorus and 36 per cent of the nitrogen yield. In this region where 90 per cent of the area is river-monitored, about 80 per cent of the load is found in the riverine inputs.

According to the results from the 1990 investigation total annual nutrient load to coastal waters from landbased Norwegian sources is approximately 3985 tons of phosphorus and 101178 tons of nitrogen. About 52 and 63 per cent respectively of the grand total inputs of phosphorus and nitrogen are monitored in the main and tributary rivers. Riverine inputs of metals and micropollutants are low. Most observations of these substances are in fact lower than the detection limit given for the specific analysis. Therefore, two quantities have been estimated: one assuming that the true concentration is zero and the other assuming that the true concentration is the limit of detection. This provides maximum and minimum concentrations within which range the true estimate will fall. When evaluating inputs these data provide upper and lower boundaries of the estimate.

Inputs of cadmium are in this way measured/calculated to be between 7 and 42 tons, lead between 75 and 167 tons, mercury between 627 and 1089 kg. This also applies for the inputs of PCBs which are measured to be between 74 and 890 kg. The herbicide lindane was found in most analyses, but in small amounts. Assumably lindane contamination in Norwegian rivers are mostly due to long range air pollution. Total load is estimated to about 530 kg. The largest yields of heavy metals comprise copper and zinc, with input estimates of 627 and 1670 tons, of which 85 and 95 % respectively, is river-monitored.

Retention in Norways many treshold fjords is not included in the above given values. This would in several cases reduce the actual load to open marin waters considerably.

For most Norwegian rivers the load to the sea, show large annual variations due to differences in water discharge. In order to use the data as a control of the fulfillment of the the Ministerial Declaration of the North Sea, the chemical data from 1990 are "normalized", i.e. 1990 chemical concentrations in river water have been multiplied with normal annual runoff (1930-1960). Even though the concentrations depend on water discharge to some extent, the transport values give an impression of possible year-to-year variations when compared to the "unnormalized" 1990-values. Both values will also be worked out the following years.

Data from 1985 has not yet been prepared, but will be given in the annual report 1991.

1. INTRODUCTION

At the eighth meeting of the Paris Commission (Madrid, June 1986) it was decided to carry out a pilot project to test methods for estimating transport of pollutants from rivers to marine areas. The Norwegian part of the pilot study comprised the two rivers Glomma and Skienselva (Fig. 1). The project was carried out from August 1986 till August 1987, and reported in October 1987 (Lingsten, 1987).

At the tenth meeting of the Paris Commission (Lisbon, June 1988) the principles for the comprehensive study on riverine inputs were accepted. It was then decided to commence the study with measurements carried out in 1990 (PARCOM, 10/3/2-E).

The purpose is to provide the Commission, in accordance with Article 17(B) of the Paris Convention, with an assessment of the waterborne inputs to Convention waters. Besides riverine inputs, the information sought therefore also relates to direct discharges.

The objectives of this study are the following:

1.1 To give a quantitative assessment, as accurately as possible, of all riverborne and direct inputs of selected pollutants to Convention waters on an annual basis.

1.2 To report these data annually to the Paris Commission and review them periodically with regard to determining trends.

1.3 For each country, to aim at monitoring on a regular basis 90% of the inputs of each selected pollutant.

2. To control if the objectives of the Ministerial Declaration at reducing the loads of heavy metals, organic micropollutions and nutrients to the North Sea in the order of 50 per cent, between 1985 and 1995, are fulfilled.*

*In 1987, the countries bordering the North Sea committed themselves to reducing inputs of nutrients in the order of 50 per cent into areas of the North Sea when these inputs are likely, directly or indirectly, to cause pollution. This area was in February 1990 decided to be from the Swedish border to Lindesnes (Fig. 1 and Fig. I.I. Appendix I, Report B). Further, discharges of prioritied micropollutants to the whole North Sea area, are to be reduced by 50 - 70 %, depending on the micropollutant in question.

In the rest of the country, the goals set by SFT, are to reduce phosphorus and nitrogen discharges to vulnerable watercources to the extent necessary to reduce local environmental impact to an acceptable level. SFT has also an additional objective to reduce discharges of erosion particles and suspended and dissolved organic material by 35 %.

The study is to be completed for each calender year and submitted to PARCOM by June following the year to which the data relate.

2. RIVERSYSTEMS INCLUDED IN THE STUDY

2.1 General aspects

The length of the Norwegian mainland coast line including fjords and bays is 21347 km, as the length of the islands' coast line is 35662 km. (Table 1). Because of the length of the coast line, the great numbers of rivers, and the fjords acting as sedimentary basins, in- and out-washing areas, monitoring of riverborne pollutants in Norway faces quite a few problems with respect to assessing their impact on coastal waters. Further, to measure 90 % of the load from the Norwegian rivers, a great number of rivers would have to be included, which would be extremely expensive. It was therefore decided that 8 of the major load bearing rivers should be monitored in accordance with the objectives of the comprehensive study. Further it was decided that 2 "unpolluted" rivers should be monitored at a reduced, but appropriate frequency. In these 10 rivers a number of investigations have been carried out during many years, and they have all been included in the National Monitoring Programme of Watercourses (SFT, 1980 - 1990).

These investigations mainly concentrate on nutrients. Therefore there are relatively good data on the load of the nutrients, while the data on heavy metals and organic micropollutants are rather insufficient. In addition to the ten rivers it was decided to estimate the load of 145 other rivers (tributaries) based on other 1990-monitoring programmes, and existing knowledge of the river systems concerned, supplemented with random samples taken in 1990.

The total drainage area of these monitored rivers is 229152 km^2, while the total area of mainland Norway is 323878 km^2 (Table 1). Totally is 306747 km^2 of the drainage area included in the investigation, of which 75 per cent is river monitored (Tables 5 and I.IV (Appendix I)). It was of special importance to estimate the major loads to Skagerrak. In this region the monitored rivers and tributaries cover 94, and the main rivers alone 80 per cent of the total area.

The coastline is divided into subareas/-regions, first between the drainage basins of the ten main rivers with tributaries, as shown in Fig. 1, and then after which surrounding seas the actual coastline belongs to (Fig. 1 and I.I-I.IV (Appendix I, Report B)). For this purpose, the surrounding seas with discharge areas are divided as follows (see also Table 5):

Barents Sea : From the Russian border (about 70°30''N, 70°30''E), to about 70°30''N, 21°E

Norwegian Sea: Southwards of 70°30''N, to about 62° N

North Sea : Southwards of 62° N, to the Swedish border
Skagerrak : From Lindesnes (the southernmost point of Norway), about 57°44''N to Sweden about 58°58''N, 11°E.

Some key informations about Norway and the adjacent oceans are given in Table 1.

Table 1. Norway: Population, areas and length of coastline

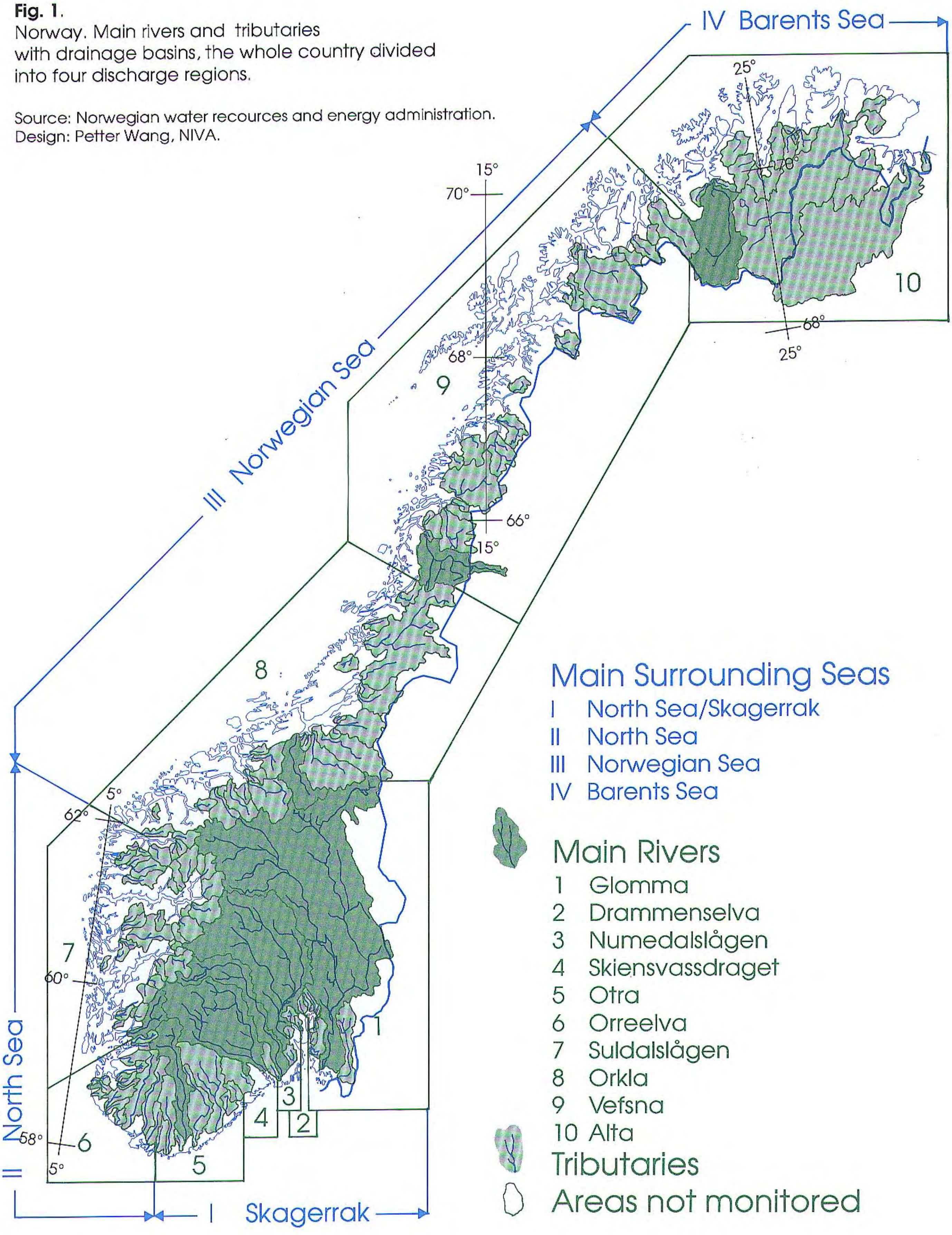
Population	4.2 million
Area:	
- Mainland Norway	323878 km^2
- The whole country incl. Svalbard and Jan Mayen	386958 km^2
Coastline:	
- Length of the continental coastline	21347 km
- Not including fjords and bays	2650 km
- Length of the islands' coastline	35662 km

2.2 Monitored riversystems

The rivers chosen for the comprehensive study are presented in Table 2 and Fig. 1. The rivers marked 1 to 5, are of the major load bearing rivers in Norway. As mentioned in chapter 2.1 it was of special importance to estimate the major loads to Skagerrak (Fig. I.I, Appendix I, Report B) which is an important part of the North Sea, and heavily loaded with polluting elements. The five rivers (No 1 to 5) are draining to the Skagerrak area. River Suldalslågen (No 7) and river Alta (No 10) are "unpolluted" river systems where actual measurements have been carried out at a reduced frequency.

Fig. 1.
Norway. Main rivers and tributaries with drainage basins, the whole country divided into four discharge regions.

Source: Norwegian water recources and energy administration.
Design: Petter Wang, NIVA.



In addition, all ten water courses are representing typical river systems in different parts of the country. As such they are very useful when estimating loads of comparable rivers, i.e corrections and adjustments in the tributary estimates which are based on fewer data.

Table 2. The main rivers with catchment areas and mean annual flow (1930-60)

No	River	Catchment area, km^2	Annual flow, mill.m^3
1	Glomma	41.918	21.600
2	Drammenselva	17.034	10.100
3	Numedalslågen	5.577	3.720
4	Skienselva	10.772	9.100
5	Otra	3.738	4.900
6	Orreelva	105	155
8	Orkla	3.053	2.040
9	Vefsna	4.122	6.000
7	Suldalslågen	1.457	3.260
10	Alta	7.373	2.570
Total		86.319	63.445

River Glomma (No 1), the largest and Drammenselva (No 2), the second largest rivers in Norway, are draining highlands, forested land and farmland, as well as villages, towns and cities (near/at outlet). This is also the case for river Numedalslågen (No 3), Skienselva (No 4) and Otra (No 5). By the standards of Norway these five "Skagerrak rivers" with adjacent fjords are located in areas with concentrations of many different kinds of industrial activities. There are lots of conflicting interests regarding the use of the rivers. For instance are villages, industry and agriculture using the rivers both as water sources, recreation activities and as recipient for waste water. They are therefore all exposed to agriculture runoff and waste water from sewage and industrial activities.

Orreelva (No 6) is draining the most intensive farming area in Norway especially concerning domestic animals (milk and meat production). Discharges from manure stores and silos together with areal runoff from heavily manured field are causing great problems (eutrophication, including toxic algae blooms) both in Orreelva and in the other water bodies in this area.

Orkla (No 8) is also draining farmland, but the farming in this part of the country is rather extensive compared to the Orre area. More important here is the abandoned mines even if situated in the upper part of the watercourse. Several other rivers in this area are also receiving waste water from abandoned mines (heavy metals).

Vefsna (No 9) is a watercourse where the runoff in periods is carrying quite a lot of suspended solids and as such is comparable with other rivers in this part of the country.

Suldalslågen (No 7) and Alta (No 10) are the two "unpolluted" rivers representing comparable rivers in the Western and the Northern Norway.

All watercourses except Orreelva are regulated for hydroelectric power production.

2.3 Other riversystems included (tributaries)

In additon to the ten main rivers, it was determined to assess the inputs from 145 river systems (Fig. 1) using "best estimates" of concentrations and flows. In total all Norwegian rivers with catchment areas larger than 500 km^2, and also several of the minor rivers (streams) are then included in the study. Some informations about these rivers are shown in Tables 8.1-8.10 (Appendix VIII, Report B).

3. METHODOLOGY

3.1 Methodology for assessing riverine inputs

3.1.1 Objective

The objective was "to obtain as precise an estimate as possible of the input load to Norwegian Coastal waters in terms of tonnes per annum". In order to obtain the objective, both sampling sites, sampling strategy and sampling frequency necessarily would have to be the best possible. The instructions given in PARCOM (10/3/2-E) are followed carefully and are outlined in paragraph 3.1.2 and 3.1.3.

3.1.2 Site selection

The measurement sites have been in regions of unidirectional flow. The sites chosen, have also been areas where the water is well mixed (such as, at or immediately downstream a weir, in water-falls, rapids or in channels in connection with hydroelectric power stations) and hence of uniform quality. That means well mixed both horisontally and vertically and that the rate of flow is sufficiently well estimated. Only one sampling station and one depth has been used in each of the rivers.

The working group of the Paris Commission also has recommended that the sampling is performed as close to the freshwater limit as possible. That means a site just upstream the marked increase in salinity at high tide and in a period of low freshwater flow.

With the choice of sampling sites according to the definition of the Paris Commission, several of the most significant discharges from the industry and the municipal waste are located downstream the sampling sites. Accordingly these supplies will not be included in the riverine inputs, but are given in the direct discharge estimates (Table I (Appendix I) and Appendix II and III, Report B).

3.1.3 Sampling strategy and frequency

The sampling regimes have been designed on the basis of historical records. Although it should aim at covering the whole cycle, it has been concentrated on periods of expected high river flow. Past experience has shown that there is a positive correlation between periods of high river flow and high input load, especially for heavy metals, suspended solids and nitrates (PARCOM 10/3/2-E).

Most monitoring effort has been directed towards the river with the highest input load (Glomma), and the rivers where the load to the sea show large seasonal and annual variations due to differences in water drainage (Orreelva and Vefsna).

In the main rivers (No 2 to 5 and No 8), it has been taken 12 samples at regularly monthly intervals during the sampling period from January till December 1990 as prescribed in PARCOM 10/3/2/E. In river Glomma (No 1), the largest watercourse of Norway, there also has been taken monthly samples, but in addition every second week during expected flood periods (16 data sets).

In the rivers Orreelva (No 6) and Vefsna (No 9) the samples have been taken at a frequency which appropriately reflects expected flow patterns, that means more intensive during periods of high flow (weekly) and less intensive during the rest of the year (19 data sets from Orre, 20 from Vefsna).

For the "unpolluted" rivers Suldalslågen (No 7) and Alta (No 10) where, on the basis of existing knowledge, the concentration levels are very low, the requirement of 12 data sets per annum was found too stringent. It was from these rivers taken 4 samples per annum. Being scarse, it should, however, be sufficient enough to obtain a reliable estimate of the pollution load.

For the other rivers (tributaries), the concentrations partly are from samples taken at the "standard" frequency (12, i.e. monthly, or more data sets per annum), which is the case in the Glomma, Oslo and Drammenselva areas. This is also the case for some of the rivers up North in the Alta area. As for the rest of the rivers the concentrations are based on sampling with measurements taken at random (at least twice) and compared with measurements from the last decade.

For all main rivers except Suldalslågen and Alta the parameters lindane and PCBs have been monitored four times in 1990, in Suldalslågen and Alta, twice. For the other rivers these parameters have been analysed once in samples from the tributaries draining to the Skagerrak and to the North Sea region. For the rest of the rivers the concentrations of lindane and PCBs are estimated on the basis of knowledge about the activity in the different drainage areas and the findings from the main rivers.

The sample frequency for the main rivers is shown in Table 3.

Table 3. Sampling sites and frequency of the main rivers

River/Location	J	F	M	A	M	J	J	A	S	O	N	D
Glomma at Sarpsfoss	x	x	x	x x	x x	x x	x x	x	x	x	x	x
Drammense. upstr.outl.	x	x	x	x	x	x	x	x	x	x	x	x
Numedalsl.at Bommestad	x	x	x	x	x	x	x	x	x	x	x	x
Skiense.at Klosterfoss	x	x	x	x	x	x	x	x	x	x	x	x
Otra upstream outlet	x	x	x	x	x	x	x	x	x	x	x	x
Orre upstream outlet	x		xxxx	x	x	x	x	x	x	xxxxx	xx	x
Orkla at Vormstad	x	x	x	x	x	x	x	x	x	x	x	x
Vefsna upstr. Mosjøen	x		x	xx	xxxx	xxx	x	x	x	xxxxxx		
Suldalsl. upstr. outl.		x				x		x		x		
Alta upstr. Alta			x			x		x		x		

The water samples were taken by local persons who in advance were instructed carefully. The samples were then sent to the laboratory at NIVA immediately. They usually reached NIVA within 24 to 36 hours after sampling.

3.2 Monitoring parameters and analytical methods

3.2.1 Chemical parameters - detection limits and analytical methods

According to PARCOM (10/3/2-E) it was necessary to choose an analytical method which would give at least 70 % of positive findings (i.e. above the detection limit). The following are the recommended detection limits from PARCOM:

gamma-HCH	:	1 ng/l
PCBs (for each selected congener)	:	1 ng/l
Hg and Cd	:	10 ng/l
Cu and Pb	:	0.1 µg/l
Zn	:	0.5 µg/l

We have had problems getting representative values of heavy metals, especially mercury, cadmium and lead, which during most of the investigation period were below the detection limit. This was also the case with PCBs. The detection limit of the parameters which is obtainable at the NIVA laboratory is presented in Table 4.

As will be seen from Table 4, the detection limits of the parameters Cd and Pb at the NIVA laboratory are above those given from PARCOM. As for the parameters Hg and PCBs the detection limits at the NIVA laboratory are within the "PARCOM-limits", but most of the measured concentrations were extremely low (Table I.III (Appendix I) and Appendix VII - VIII, Report B).

However, we assume that these difficulties do not affect the main results and conclusions of the study. In those cases were the results recorded were less than the limits of detection, two load quantities have been estimated, one assuming that the true concentration is zero and the other assuming that the true concentration is the limit of detection. This provides maximum and minimum concentrations within which the true estimate will fall. When used to evaluate inputs these data have then provided upper and lower boundaries for the estimate.

Table 4. Parameters monitored on a mandatory basis, limits of detection and analytical methods

Parameter		Unit	Limits of detection	Analytical methods NS = Norwegian Standard
Conductivity,		mS/m	0.02 mS/m	NS 4721
Susp. part. matter		mg/l	0.1 mg/l	*
Ortho-P	(PO_4-P),	µg/l	0.5 µg/l	NS 4724 Automated molybdate method
Total P	(Tot-P),	µg/l	1.0 µg/l	NS 4725 Peroxodisulphate oxidation method
Nitrates	(NO_3-N),	µg/l	1.0 µg/l	NS 4745 Automated cadmium reduction method
Total N	(Tot-N),	µg/l	2.0 µg/l	NS 4743 Peroxodisulphate oxidation method
Mercury	(Hg),	ng/l	2.0 ng/l	**
Copper	(Cu),	µg/l	0.5 µg/l	NS 4780 Graphite furnace atomabs.
Zinc	(Zn),	µg/l	0.05 µg/l	NS 4770 Graphite furnace atomabs.
Cadmium	(Cd),	µg/l	0.1 µg/l	NS 4780 Graphite furnace atomabs.
Lead	(Pb),	µg/l	0.5 µg/l	***
PCBs	(x)	ng/l	0.5 ng/l	****
Lindane	(γ-HCH),	ng/l	0.5 ng/l	****

(x) for the following congeners (****)

* Suspended particulate matter: The samples (100 - 300 ml) were filtrated through Nuclepore filters (0.4 µm with 47 diameter). The filters were weighted after drying (40°C) (Sartorius microbalance).

** Mercury: The samples were carried in glass bottles (250 ml). The mercury of 50 ml subsample was preconcentrated on a gold trap (Bloom and Crecelius, 1983).

*** Heavy metals: The samples taken for copper, zinc, cadmium and lead analyses were filtrated through a Nuclepore filter 0.4 µm with 25 mm diameter. A Millipore Swinnex-holder was used. The samples were carried in acid washed flasks (60 ml), and preserved with nitric acid.

**** PCBs and lindane: The samples were carried in glassbottles (10 l). PCB 53 was added to the water samples as an internal standard. After extraction with cyclohexan, the extract was dried and reduced in volum. After treatment with sulfuric acid, the extraxt was injected spitless on GC/ECD.

Lindane and the PCB-congeners 28, 52, 101, 118, 138, 153 and 180 were determined.

As for nutrients (P and N) and conductivity tests, these samples were carried in plastic bottles (high density polyeten).

3.2.2 Method used to estimate flow rate

Runoff is recorded at special discharge gauging stations. Discharge is measured in the number of m^3 or litres of water that pass the gauging station every second (m^3/s, l/s). Runoff is expressed as depth of water in mm per time unit (mm/year). Specific runoff is a measure of the number of litres of water that drain from a certain unit area per second ($l/s\ km^2$).

For the period 1930-60 the annual specific runoff from the total area of Norway is estimated at 42.9 $l/s\ km^2$. Expressed in volumetric units this amounts to 438 km^3 water, which distributed over the whole country equals a mean runoff of 1350 mm. Mean annual runoff in Norway for the period 1930-60 is shown in Fig. 2, for the subregions also in Table 5. Mean annual precipitation for the same period is shown in Fig. 3.

Table 5. Mean annual runoff (1930-1960) from the subregions to the main surrounding seas (Fig. 1 and Appendix I, Report B).

Subregions	Main Seas	Drainage area km^2	Runoff mill.m^3
The Swedish border - Lindesnes	Skagerrak	98699	57934.47
The Swedish border - Stad	North Sea	138902	164875.88
Stad - the border of Finnmark	Norwegian Sea	94704	231928.67
Finnmark-the border of Sovjet	Barents Sea	73141	41462.90
Total		306747*	438267.45

* The difference between the total area and the area given in Table 1 is due to rivers which are draining into the neighbouring countries.

At a given place the runoff will change from one year to another and throughout the year. In natural river basins the seasonal variations will depend mostly on the distance from the coast, the altitude and the latitude. The mean discharge is determined both by the precipitation and the catchment area. Along the coast of Southern and Western Norway the summer low flows are usually dominant together with high runoff in autumn and winter. Thus although Western Norway has much more precipitation than Eastern Norway, its smaller catchment areas lead to much less absolute discharge in western rivers. In the central part of Southern Norway and in the Northern part of the

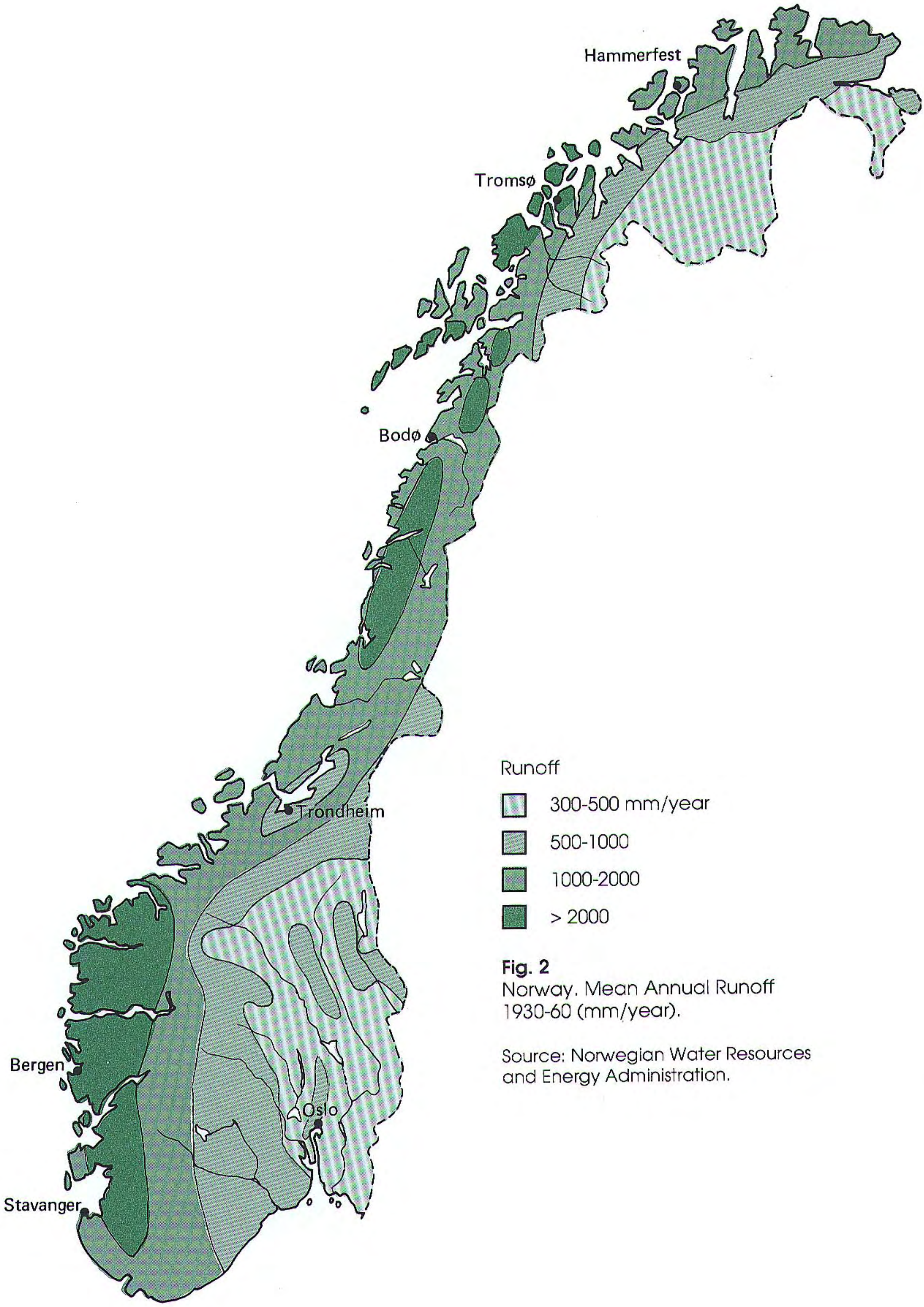


Fig. 2
Norway. Mean Annual Runoff 1930-60 (mm/year).

Source: Norwegian Water Resources and Energy Administration.

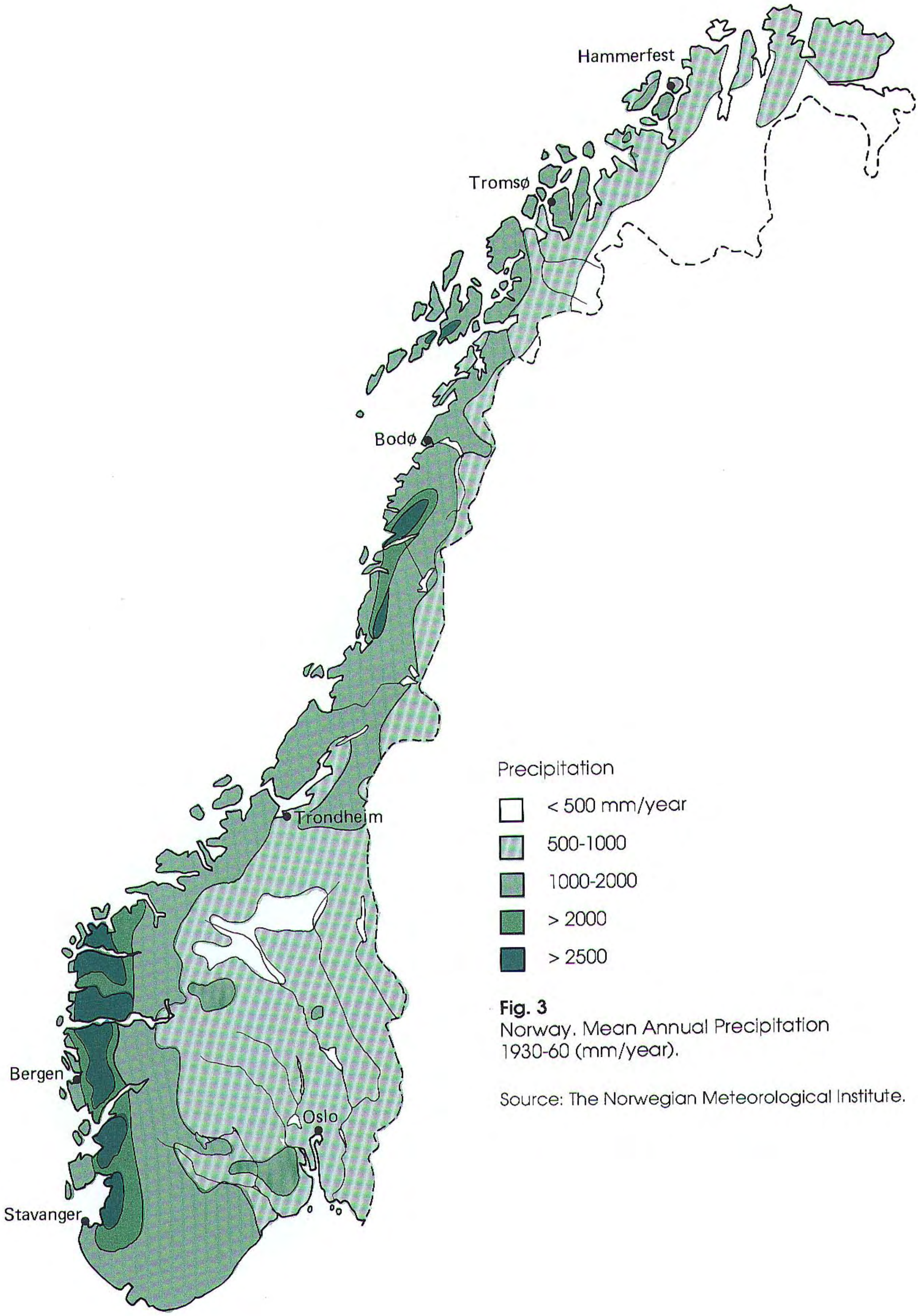


Fig. 3
Norway. Mean Annual Precipitation 1930-60 (mm/year).

Source: The Norwegian Meteorological Institute.

country low water flows are typical both in summer and winter, whereas periods of higher runoff will appear during the snow melting period (spring and early summer). In late summer and in autumn the flow depends on the precipitation and may therefore vary considerably.

In all main rivers except Orreelva continous observationes of the rate of flow are gauged. For most rivers these stations are located upstream the sampling stations (NVE, 1990). The additional water supplied is estimated using measured rainfall data from the local catchment areas (DNMI, 1990). For the river Orre, the flow rate is estimated by using flow observations from the neighbouring river, Hå (page 62, App. VIII, Report B) and measured rainfall data in 1990.

For 8 of the main rivers, seasonal changes in runoff in the period 1930-60, together with mean runoff in 1990, are shown in Fig. 4. In Fig. 5 monthly precipitation for the same period together with mean precipitation in 1990, are shown.

For the other rivers (tributaries) the runoff data partly are from continous observations as the case is for most rivers in the Skagerrak area, and also for many of the rivers draining to the remaining North Sea. For the rest of the rivers mean runoff data (1930-60) and measured rainfall data (1990) are used.

3.2.3 Calculation of annual load

The estimation of annual load of the main rivers is expressed in the following formula:

$$L = \frac{\sum_{i=1}^{n} (Ci \cdot Qi)}{\sum_{i=1}^{n} (Qi)} \cdot Qa$$

L : annual load
Qa : annual flow
Ci : the concentration measured in sample i
Qi : the corresponding flow for sample i
n : the number of samples taken in the sampling period

In those cases where insufficient information is available to use the above formula, the pollutant load has been estimated by taking the average of the product of flow and concentration for a series of measurements, as expressed in the following formula:

$$L = \frac{\sum_{i=1}^{n} (Ci \cdot Qi)}{n} \cdot T$$

T : time

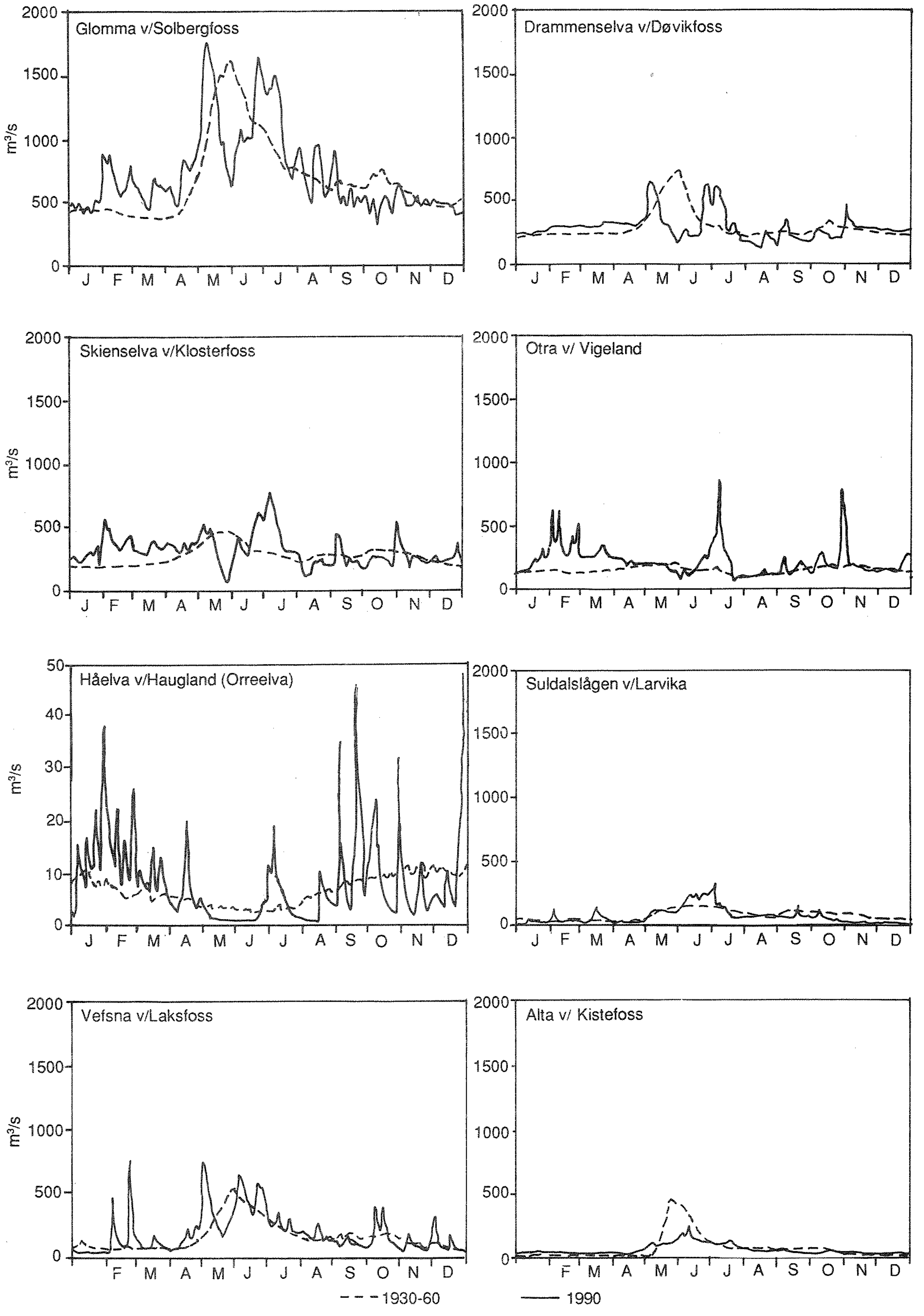


Fig. 4 Seasonal Changes in Daily Runoff (m^3/s)

Source: Norwegian Water Resources and Energy Administration

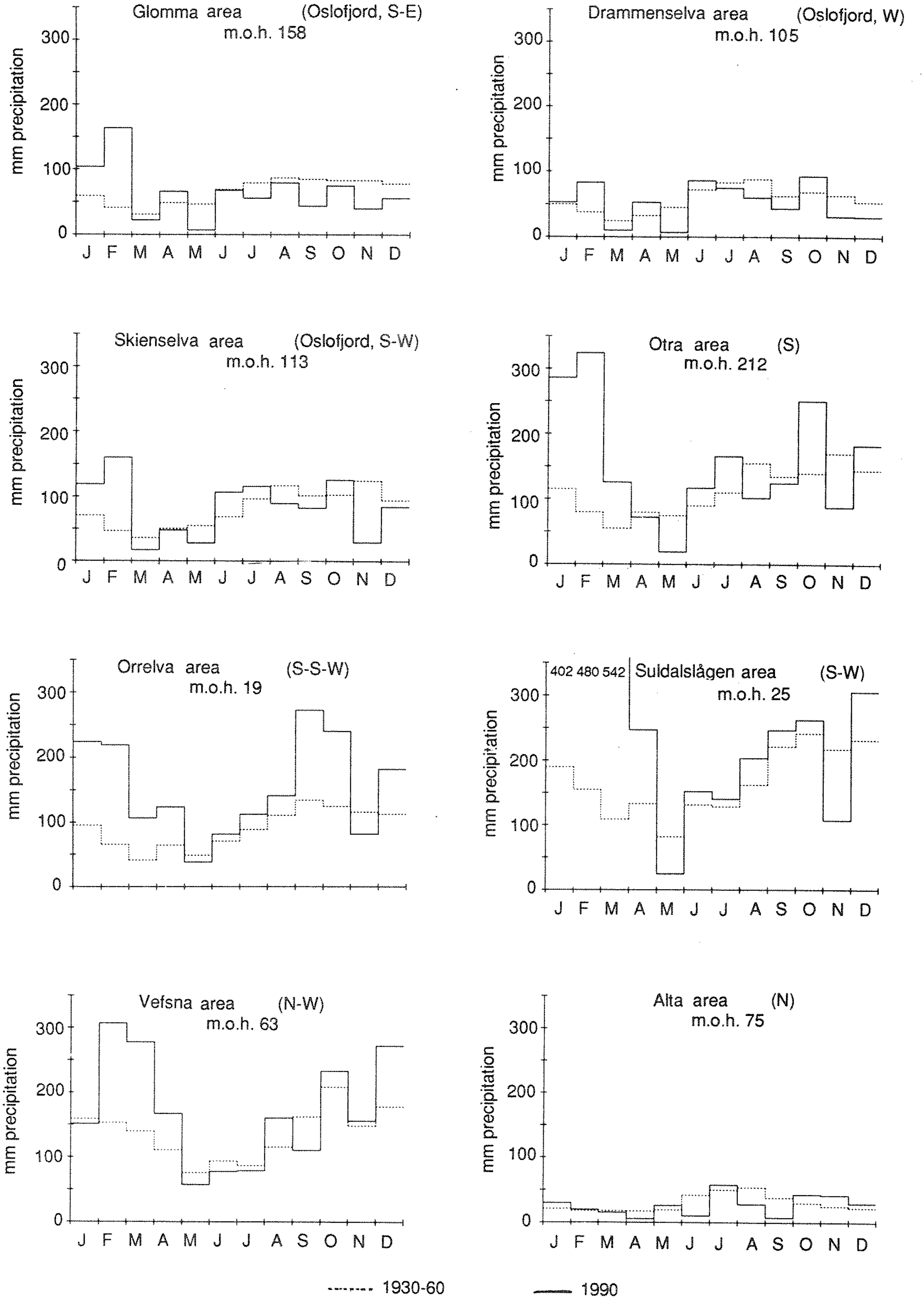


Fig. 5 Monthly Changes in Precipitation (mm/month)
(m.o.h. = meters above sea level)

Source: The Norwegian Meteorological Institute

For the other rivers, which only have been monitored twice, the best available estimates of flow (catchment area multiplied by specific runoff adjusted for deviations from normal precipitation) and flowweighted concentrations have been used to estimate contaminant loads.

Drainage basins to the different areas and regions (km^2 and per cent) is shown in Table IV (Appendix I).

3.3 Methododology for assessing direct discharges to marine waters

In conjunction with the project "Measure Analysis North Sea" (Ibrekk, Holtan and Tjomsland, 1990) NIVA has developed a computer model (TEOTIL) for estimation of the nutrient loadings to Norwegian coastal waters. The model includes anthropogenic and natural sources (Tjomsland, 1990). The tool to link riverine inputs and down stream discharges, has been developed by NIVA (T. Hopen) as well as the computer-programme for calculation of other effluents (organic substances, heavy metals and micropollutants).

The model uses statistical data from censuses of Agriculture and Forestry, Population and Housing from the Central Bureau of Statistics of Norway (SSB, 1979, 1980). The sensus data are available on small geographical units. As a whole, Norway is divided into more than 1500 geographical units. Each census unit is further assigned to drainage basins (NVE, 1990). By combining census data and drainage basins a comprehensive data base is developed. The data base includes the following set of data: number of people, houses, farms, agricultural land, forest land, wetland, upland areas and so forth. Nutrient data on each sewage treatment plant (1990) and nutrient inputs from industry (1990) are also included.

3.3.1 Sewage effluents

Where possible, the annual loads have been estimated as the product of annual flow and flowweighted concentrations, which is the case in the Oslo part of the Glomma area. For the rest of the municipal wastewater, the loading was estimated by multiplying number of people with the coefficients mentioned below.

For crude (untreated) sewage discharges, PARCOM (10/3/2-E) has recommended the following derived per capita loads to be used for nutrients:

	PARCOM:	NORWAY:*
BOD	0.063 kg O/person/day	0.046 kg O/person/day
COD		0.094 kg O/person/day
SPM	0.063 kg /person/day	0.042 kg /person/day
Total N	0.009 kg N/person/day	0.012 kg N/person/day
Total P	0.0027 kg P/person/day	0.0017 kg/P/person/day

* Based on recent studies of Norwegian sewerage districts. These data are also used to calculate pollutional loads from the different treatment plants, reduced by the removal efficiency of the treatment plants. Municipal sewage also includes a portion of industrial effluents. The fraction of the total personequivalents (p.e.) is proportioned between sewage and industrial wastewater according to the number of persons and the size of industrial effluents connected to each treatment plant.

For metals in sewage discharges the loads have been calculated from monitoring and flow measurements in the Oslo part of the Glomma area. Metal inputs from the rest of the country are estimated from local knowledge (*) as follow:

Substance	Cu	Zn	Cd	Pb	Hg
mg/person-equivalent/day (p.e.)	56	86	0.5	8.0	0.7

* Sources: Knutzen and Øren (1983), Myhrstad (1985), VEAS (1991), OVA (1991).

Measured and estimated loads from sewage are shown in Appendix II, Report B.

3.3.2 Industrial effluents

Sampling of industrial wastewater varies in frequency from weekly mixed samples to samples taken at random, but at least twice a year. Measured and estimated loads from industrial activities in the different areas are shown in Appendix III, Report B. According to SFT about 90 per cent of the industrial discharges (i.e. of the substances in question) are included in the total, and probably more for Total-P and Total N.

3.3.3 Other inputs (nutrients in areal runoff from "Down Stream areas" of main and tributary rivers and rivers not monitor

The pollution loading model calculates the loading from each pollution source by using loading coefficients and areas (in square kilometres) of different types of land and number of people (Holtan and Åstebøl 1990). The coefficients used are prepared according to precipitation, climate, vegetation and soil in the different areas.

To estimate loading from agricultural land area runoff coefficients in the range of 50 - 200 kg Total-P and 2000 - 6500 kg Total-N km^2/year depending on point sources, location of the agricultural land in relation to major tributaries, and agricultural production intensity, are used. Loading from upland (remote unpolluted) areas were estimated by using export coefficients in the range of 4 - 6 kg Total-P and 200-600 kg Total-N km^2/year. The highest values were used in areas most susceptible to long range pollution (acid rain) along the Southern and Western coast. The coefficients are based on mean annual water runoff of a period of thirty years (1930-60, Fig. 2).

Total direct nutrient discharges (Down stream areas) are shown in Table I (Appendix I), in the different subareas (1-10) in Appendix VI, Report B. Direct discharge areas (km^2) are shown in Table I.IV (Appendix I).

4. RESULTS AND DISCUSSION

4.1 Pollutants

Norwegian watercourses, coastal fjords and sea areas are recipients of various substances discharged from many different sources. The discharges may have widely different impacts of varying severity. SFT (1990) considers that the most serious problems are connected to eutrophication (nutrient effluents and runoff), discharges of micropollutants and acidification of water and soil.

In this investigation riverine and direct inputs of nutrients (P- and N-compounds), heavy metals, lindane and PCBs are measured or estimated. In addition to these problems the water is polluted by dissolved organic matter, especially from the pulp and paper industry and from municipal sewage, which also has been taken into account in this investigation.

SFT (1990) has given first priority to eliminating the effluents of 13 of the substances classified as micropollutants, which are in use in Norway, as quickly as possible. Most of this pollution comes from industry, but other sources are the municipal sewerage network, landfill leachate, and pesticide residues from agriculture. Long-range transboundary air pollution is another source of pollution by heavy metals and organic micropollutants.

Pollution by heavy metals is either due to discharges from industry, discharges from existing and abandoned mines, leaching from landfills polluted ground or atmospheric fallout. The municipal sewerage network is the source of several heavy metals.

Polychlorinated biphenyls (PCBs) are present in different industrial effluents and also released from discarded electrical equipment containing PCBs (e.g. transformer oil), when such equipment is unsatisfactorily stored or destroyed by incineration. There is no enterprise in Norway discharging PCBs regularly.

Major sources of phosphorus and nitrogen pollution are considered to be municipal sewage, agriculture and to a certain degree, industry.

4.2 1990-results and discussion

The results given for riverine inputs (main rivers and tributaries) and discharges entering directly into marine recipients, are mainly based on monitoring data. (paragraph 3.3).

Measured concentrations of the chemical parameters of the ten main rivers (1990), mean values, standard deviation and range are listed in Appendix VII, Report B. In the case of Cd, Pb, Hg and the different congeners of PCBs, where most of the rivers had concentrations below the respective detection limits, the concentrations are statistically treated as "limit-values". Mean annual concentrations (1990) of the chemical parameters and the rate of flow for the main rivers are also listed in Table I.III (Appendix I). Total annual loads of the main rivers 1990 are shown in Table I.IA (Appendix I) and in Appendix IV, Report B. Annual loads of nutrients and S.P.M. are also presented in Fig. 6. Total annual loads of the tributaries are shown in Table I.IIA (Appendix I) and Appendix V, Report B. For the whole country, total annual loads (Direct discharges and Riverine inputs are shown in Table I (Appendix I) and for the four subregions in Appendix I, Report B, nutrients and S.P.M. also in Fig. 7.

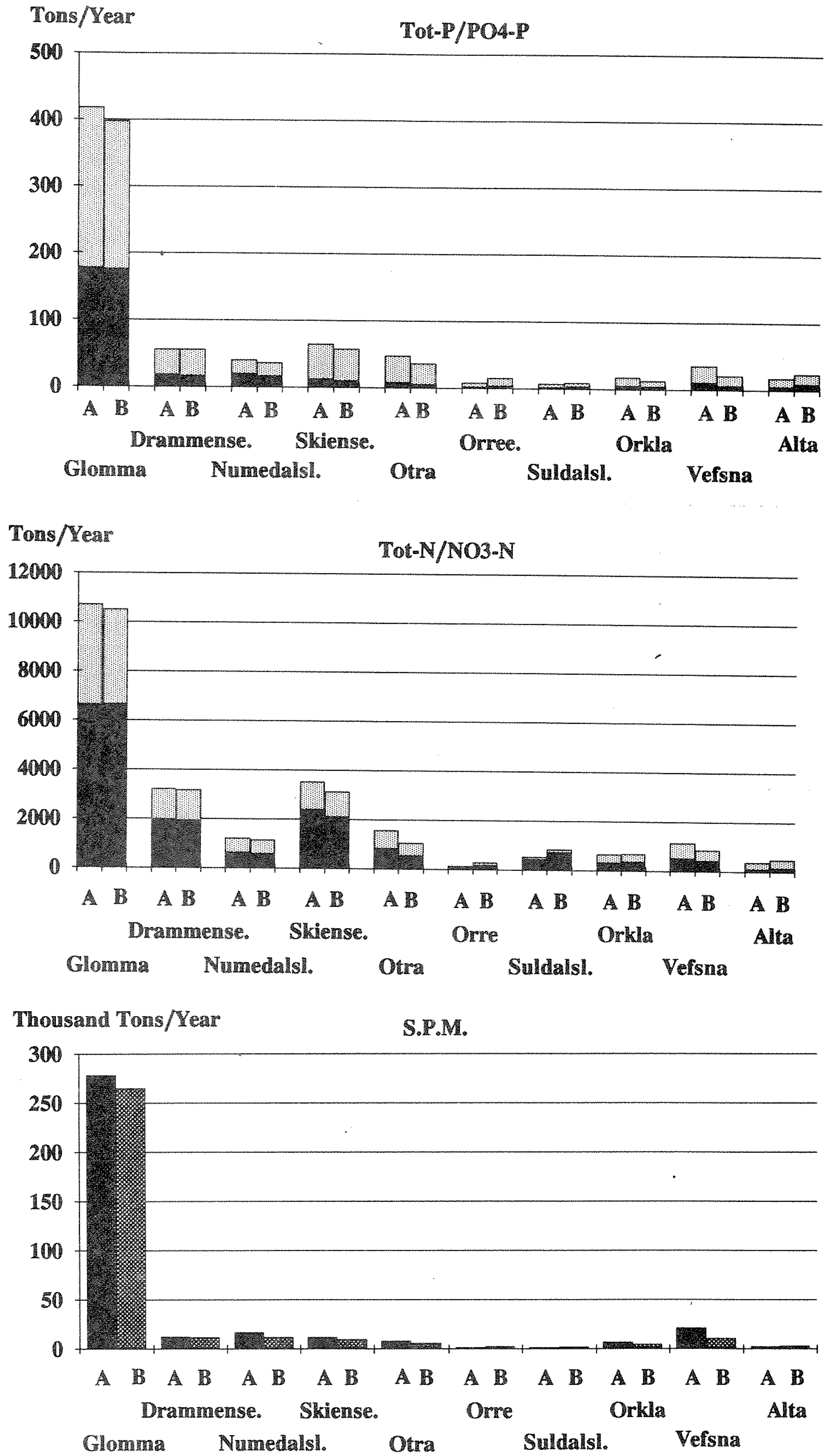


Fig. 6 Main rivers. Nutrients and S.P.M. Total loads 1990(A) and Total normalized loads (B) in the different rivers

Filled column = Total P / N / S.P.M.
Dark hatching = Phosphates / Nitrates

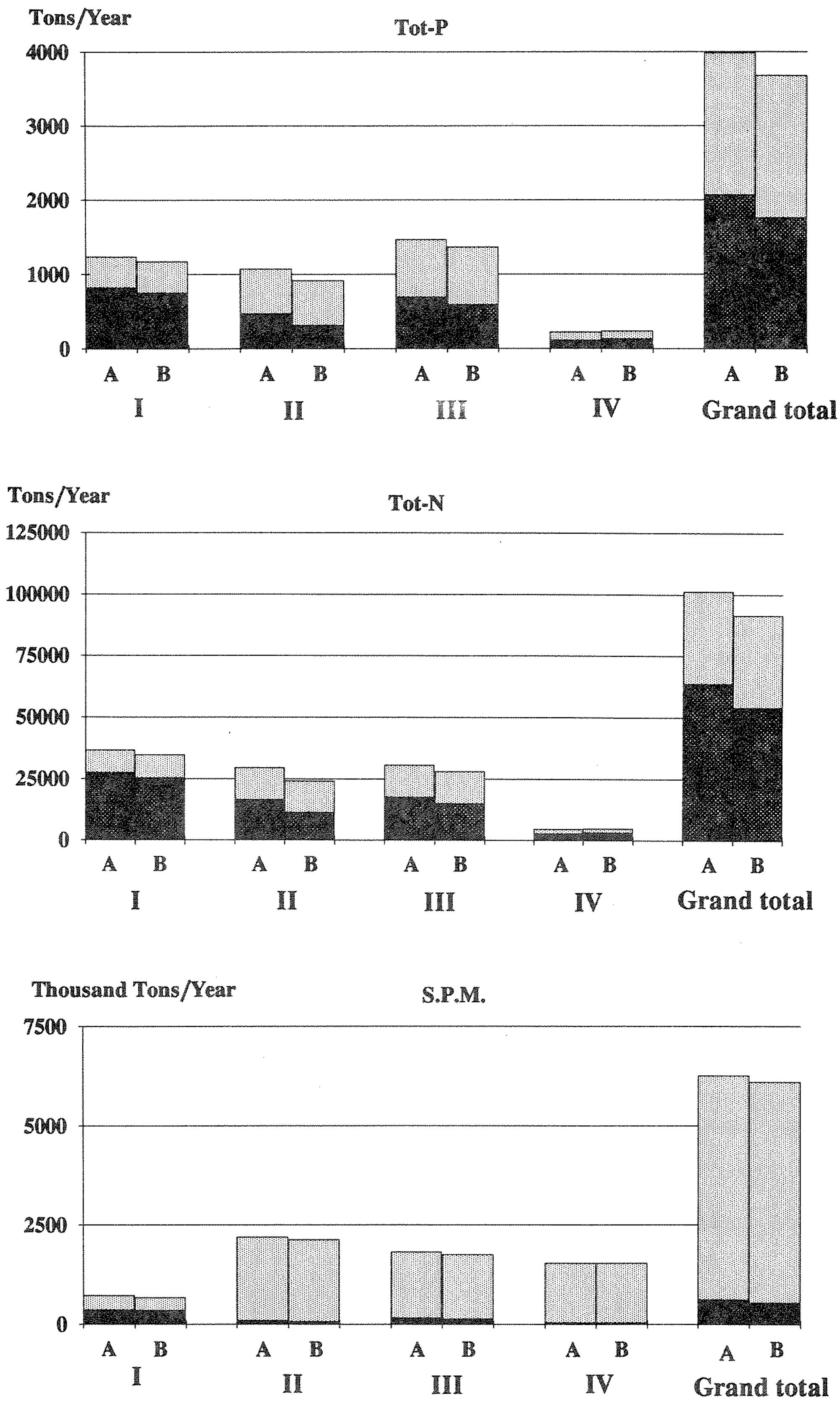


Fig. 7 Nutrients and S.P.M. Total and river discharges 1990 (A) and Total normalized loads (B) from mainland Norway to convention waters and the four subregions: I: Skagerrak, II: The remaining North Sea, III: The Norwegian Sea, IV: The Barents Sea

Filled column = Grand total
Light hatching = Direct discharges
Dark hatching = Main and tributary rivers

Greatest emphasis with regard to accuracy has been given to the input estimate of the Skagerrak region, as this is considered the most susceptible part of the North Sea. The Skagerrak reception of total loads are 30 per cent of the phosphorus and 36 per cent of the nitrogen yield. In this region where 94 per cent of the area is river-monitored, about 80 per cent is found to be riverine inputs of these substances.

According to the results from the 1990 investigation total annual nutrient load to coastal waters from landbased Norwegian sources is approximately 3985 tons of phosphorus and 101178 tons of nitrogen (Fig. 7). About 52 per cent of the phosphorus and 63 per cent of the nitrogen yield were inputs from the monitored rivers and tributaries. The largest inputs of heavy metals were of copper and zinc, which amounted to about 627 and 1670 tons, of which 85 and 95 per cent respectively, are river monitored (Fig. 8).

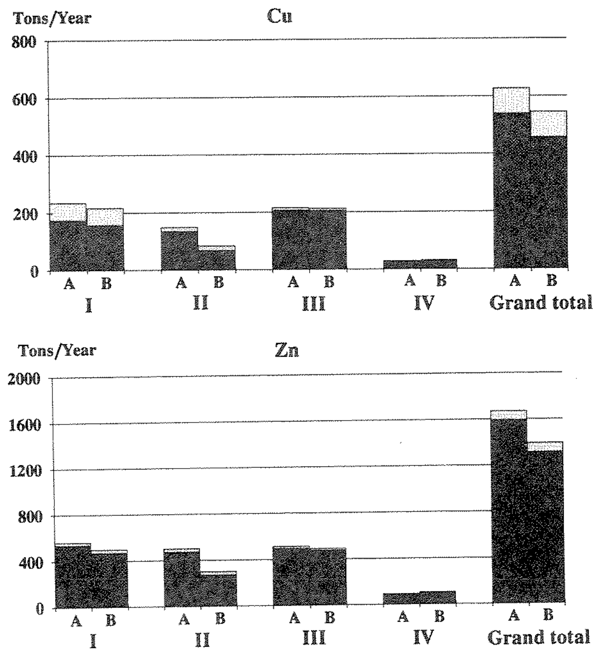


Fig. 8 Cu and Zn. Total and river discharges 1990 (A) and Total normalized loads (B) from mainland Norway to convention waters and the four subregions: I: Skagerrak, II: The remaining North Sea, III: The Norwegian Sea, IV The Barents Sea

Filled column = Grand total
Light hatching = Direct discharges
Dark hatching = Main and tributary rivers

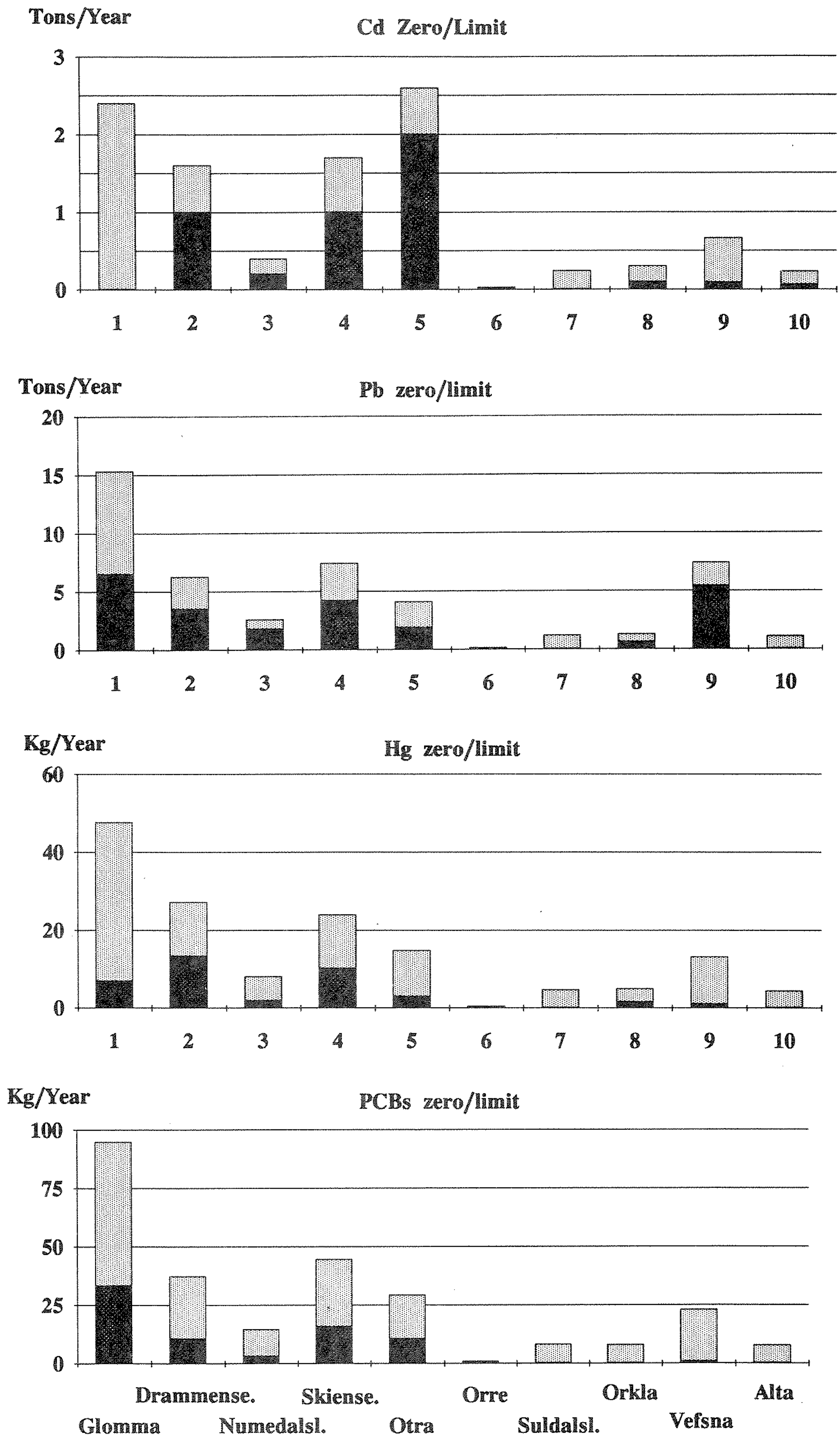


Fig. 9 Main rivers. Cd, Pb, Hg and PCBs. Total loads of the different rivers 1990 (lower and upper boundaries for the estimates)

Filled column = upper boundary for the estimate
Dark hatching = lower boundary for the estimate

Inputs of other metals and micropollutants are low. Most observations of these substances are in fact lower than the detection limit given for the specific analysis. Therefore two quantities have been estimated, one assuming that the true concentration is zero and the other assuming that the true concentration is the limit of detection. This provides maximum and minimum concentrations within which the true estimate will fall. When evaluating inputs these data provide upper and lower boundaries of the estimate.

Inputs of cadmium are measured/calculated to be between 7 and 42 tons, lead between 75 and 167 tons, mercury between 627 and 1089 kg. This also applies for the inputs of PCBs which are measured to be between 74 and 890 kg. In Fig. 9 the lower and upper loads of these substances in the ten main rivers are presented. The herbicide lindane was found in most analyses, but in small amounts. The findings of this substance in Norwegian rivers are likely due to long range air pollution, as we often find lindane in runoff from areas where the compound has never been used (Olav Lodhe, State Plant Protection Agency, pers. comm.). Total load is estimated to about 530 kg.

4.3 Mean annual runoff (1930-60) and "mean load"

Compared to the "Pilot Study of Riverine Inputs to Marine Waters (Lingsten, 1987, which comprised the river Glomma and Skienselva), the concentrations including total flow and calculated loads for Glomma, are lower in this investigation than in the former study, whereas for Skienselva, most values are higher, also total flow.

The variations between the two periods are to a certain extent due to differences in total flow, which would have to be taken into consideration when the transport values are evaluated from one year to another.

Both annual variations in runoff, erosion and seasonal activities of man in the drainage basins, strongly influence the mass transport of the watercourses. The transport values might vary considerably from one year to another. These variations are complicating the estimation of "normal transport values" i.e. mass transport in a "normal" year.

In order to adjust the 1990 transport values to a "normal year", approximation have been made by multiplying weighted mean concentrations by mean runoff (1930-60). (To normalize the concentrations is not possible.)

"Mean-values" (normals) for the ten main rivers and tributaries are given in Tables I.I.B - I.II.B (Appendix I) and Appendix X, Report B. Fig. 10 is showing annual (1990) and mean runoff (1930-60) for the ten main rivers. In Table IB (Appendix I) "normalized" total discharges from mainland Norway to the convention waters are given, and in Appendix X, Report B, total discharges to the sub regions are shown. In Fig. 6 - 7 the "normalized" nutrient transport values are compared with 1990-values.

Even though the concentrations depend on runoff to some extent, the figures give an impression of possible year-to-year variations.

From experience we have learned that the product of weighted concentrations and mean runoff (1930-60) gives a good estimate of the mass-transport in rivers, especially for the large rivers, and those not considerably exposed to erosion-material. Though special weather conditions in winter 1990, the over all annual water discharge in watercourses in Eastern and Northern Norway were close to "normal". We therefore consider the transport-values of most rivers in this part of the country to be representative or "normal"-values. As for rivers in the South-Western and Western part of Norway, annual runoff 1990 was higher than normal, and accordingly also the mass-transport. The river Suldalslågen is recently regulated and has now considerably less annual water discharge than in the normal period (1930-60).

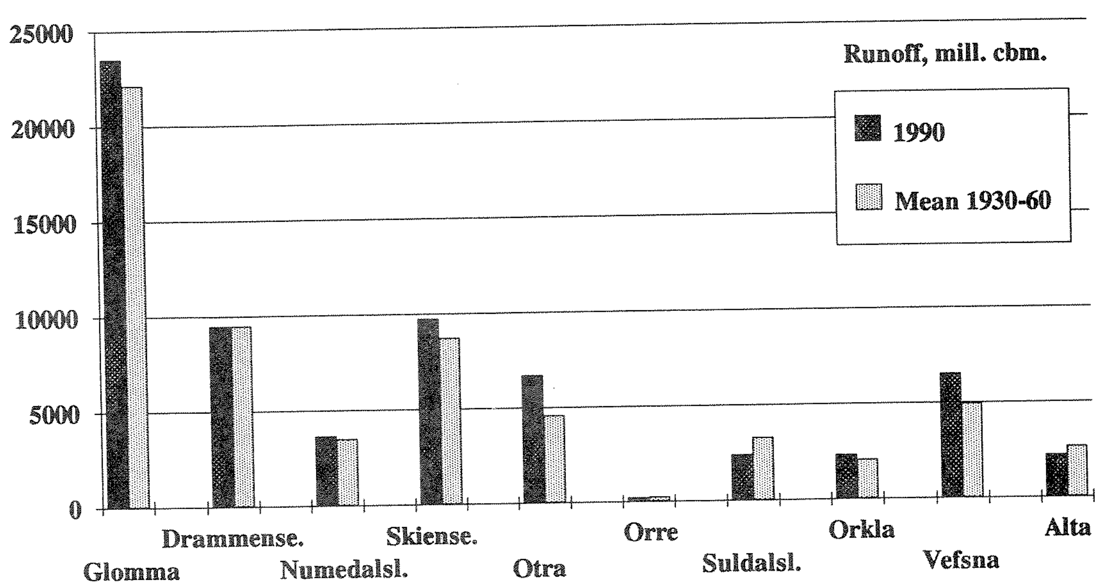


Fig. 10 Main rivers. Annual 1990 and normal runoff (Mean 1930 -60)

However, by monthly sampling, short periods with deviating concentrations caused by high or low precipitation/runoff, will not be caught in the measurements. This might be the case for Glomma in 1990, which in lower parts is exposed to erosion, and where rainfalls caused increased sediment transport in winter and early spring (monthly sampling). Further more, the spring- and early summer high flow (programmed for bi-weekly sampling) did not occur at expected time (Fig. 4). The local monitoring programme, with frequent spring sampling, measured higher concentrations and accordingly higher transport-values than measured/ calculated in this investigation. In winter and spring 1991 bi-weekly samples have been taken the whole period.

4.4 Nutrients retention in fjords

Both phosphorus and nitrogen retention in watercourses is taken into account in the calculation of the Norwegian contribution to marine pollution, but in a conservative way. However, no corrections are so far made for retention in fjords.

Considering the nutrient input to the open marine waters, one should also take into account retention in fjords, at least in well defined treshold fjords. As a result of high salinity compared to freshwater, marine waters have better conditions for sedimentation than lakes. For example clay settles very poorly in lakes, but very efficient in fjords. In addition to temperature stratification, fjords also show salinity stratification, with light brackish water on top of heavier, saline waters. Thus the over all stratification in fjords is in most cases stronger than in lakes. This implies that particulate pollutants lost to deep waters by sedimentation have less chance to be brought back to the plankton producing layer than in lakes.

In addition, stronger stratification implies greater chance for oxygen depletion in deep waters, which in fact is seen in many sheltered Norwegian fjords. Theoretically this will improve the conditions for denitrification. However, this greater stability is often reduced by rougher physical conditions in fjords compared to lakes.

Retention in Norwegian fjords is very poorly studied by direct budget measurements. In the Drammensfjord Magnusson and Næss (1986) found that about 60% of the incoming phosphorus was retained in the fjord, while for nitrogen the retention was only about 15%. In the silled Inner Oslofjord preliminary calculations indicate that nitrogen retention is in the order of 30-50% (Kjell Baalsrud, NIVA, in press.).

Thus, nutrient retention in treshold fjords seems to be of the similar magnitude as we find in lakes, and it is likely to believe that retention can be estimated from the same type of models that applies for lakes. The general lack of calibration data on retention models in fjords implies that we find it to early, at this stage of knowlege, to include these correction in the Norwegian discharge budget. It should be kept in mind, however, that a significant part of the particulate pollutants, and pollutants with particle affinity, end up in fjord sediments and thus are prevented from reaching the coastal waters.

5 REFERENCES

5.1 Project Personnel:

At NIVA:

Dag Berge : Member of the Programme Committee
Hans Holtan : Member of the Programme Committee/project manager
Gjertrud Holtan : Coordinator of the practical investigation

Contact with field workers/field work: G. Holtan, B. Hals, H. Holtan, M. Mjelde, T. Oredalen.

Care of equipment, shipment of samples etc.: E. Bjerknes, B. Hals.

Analysis of PCBs and Lindane: L. Berglind, G. Sigernes, T. Tellefsen.

Analysis of Hg and Heavy Metals: H. Hovind, B. Lauritzen, L.B. Skancke R. Beba, L. Bryn.

Other chemical analyses: NIVAs Analytical Chemical Laboratory.

Data Collection/evaluation: G. Holtan, M. Grande, R. Gulbrandsen, S. W. Johansen.

EDP/calculations/registrations: T. Hopen, L. Henriksen, G. Holtan, A. Lauritzen, T. Tjomsland.

Reporting work: G. Holtan, D. Berge, H. Holtan.

FIELD WORKERS:

(1) GLOMMA : E. Skaane. Fylkeslaboratoriet i Østfold. Moss.
(2) DRAMMENSELVA : E. Iversen, NIVA. Oslo.
(3) NUMEDALSLÅGEN : E. Løve. Næringsmiddeltilsynet. Larvik kommune.
(4) SKIENSVASSDRAGET: A. Andersen. Vannlaboratoriet i Telemark. Skien
(5) OTRA : M. Aadnevik. Ingeniørvesenet. Kr.-sand kommune.
(6) ORREELVA : G. Undheim. Landbrukskontoret. Time kommune.
(7) SULDALSLÅGEN : Ø. Vårvik. Suldal Elveeigarlag. Suldalsosen.
(8) ORKLA : O. Lien. Rennebu.
(9) VEFSNA : B. Hauan. Teknisk etat. Vefsn kommune. Mosjøen.
(10) ALTA : P. Nilsen. Finnmarksforskning. Alta.

5.2 References

Baalsrud, K. og B. Bjerkeng, 1991: Tiltaksanalyse for Indre Oslofjord. Brukerkrav. Siktedyp og oksygen i dypvannet. En enkel lineær modell. NIVA-rapport 0-90131 (l.nr. 2524), 79 s.

Bloom, N.S. and E.A. Crecelius, 1983: Determination of Mercury in Sea-water at sub-nanogram per liter levels. Marine Chem. 14, pp. 49- 59.

Brandrud. T.E. og M. Mjelde, 1991: Tilgroing av makrovegetasjon i terskelbasseng. Undersøkelse i Ekså, Skjomen og Hallingdalselva. NIVA-rapport 0-90136 (in prep.).

Brettum, P. og E.-A. Lindstrøm, 1983: Vassdrag i Vest-Agder. Vurdering av vannkvalitet på grunnlag av fysisk-kjemiske og biologiske ana-lyseresultater 1981-82. NIVA-rapport 0-82082 (L.nr. 1493), 146 s.

Brun, P.F. og T. Haugen, 1990: Overvaking av fjordar og vassdrag i Møre og Romsdal 1986-88. Fylkesmannen i Møre og Romsdal. Rapport nr. 2/90, 101 s.

Bærum kommune, 1991: Data fra Sandvikselva. Bærum (unpublished).

Central Bureau of Statistics of Norway, 1979, 1980, 1990: Statistical Yearbooks. SSB. Oslo.

Faafeng, B., Prettum, P. og T.J. Oredalen, 1990: Overvåking av Gjersjøen 1990. NIVA-rapport 0-70006 (in press).

Fagernes, K.E. og K. Vaaje, 1990: Vassdragsundersøkelser i Buskerud 1989. Fylkesmannen i Buskerud. Miljøvernavdelingen, 25 s.

Grande, M. og R. Romstad, 1991: Tiltaksorientert overvåking i Orkla, 1990. Overvåkingsrapport nr. /91. NIVA-rapport 0-800210, 58 s. (in press).

Hamarsland, A. og K. Nagy, 1989: Vassdragsovervåking i Nordland 1988. Hovedrapport. Fylkesmannen i Nordland. Miljøvernavdelingen. Rap-port nr. 7A-89, 119 s.

Hamarsland, A. og K. Nagy, 1989: Vassdragsoveråking i Nordland 1988. Vedleggsrapport. Fylkesmannen i Nordland. Miljøvernavdelingen. Rapport nr. 7B-89, 297 s.

Hamarsland, A. og K. Nagy, 1990: Vassdragsovervåking i Nordland 1989. Fylkesmannen i Nordland. Miljøvernavdelingen. Rapport nr. 5-90, 172 s.

Hessen, D., Lindstrøm, E.-A. og M. Mjelde, 1991: Vassdragsovervåking i forbindelse med Stor-Glomfjordreguleringen. Undersøkelser av vannkjemi og vegetasjon. Årsrapport 1990. NIVA-rapport 0-901234, 14 s.

Hindar, A., 1990: Vannkvaliteten i Topdalselva (nedre del av Tovdalsvassdraget) i 1987-1988. NIVA-rapport 0-89136 (L.nr. 2369), 24 s.

Hindar, A., 1990: Arealavrenning av nitrogen og fosfor til vassdrag i Aust-Agder. NIVA-rapport 0-89171 (L.nr. 2375), 51 s.

Holtan, G. og T. Hopen, 1990: Modell for teoretisk beregning av forurensningstilførsler (P, N og organisk stoff) fra ulike kilder til vassdrag og fjorder. NIVA-rapport E-86607 (in prep.).

Holtan, H. (red.), 1986: Norsk Vassdragsleksikon (utkast). Rapport fra Norsk Hydrologisk Komité, Oslo, 32 s. + vedlegg.

Holtan, H., 1988: Befaring og undersøkelse av tilløpsvassdrag til Hornindalsvatnet. NIVA-rapport 0-87127 (L.nr. 2186), 30 s.

Holtan, H. (red.), 1989: Vannkvalitetskriterier for ferskvann. Rapport TA-630 fra Statens forurensningstilsyn.

Holtan, H., Berge, D. and J. Molvær, 1990: Retention of nutrients in lakes and rivers with comments on retention in fjords. Paper prepared for PARCOM. NIVA-document 0-90145. 14 s. (unpublished).

Holtan, H. og S.O. Åstebøl, 1990: Håndbok i innsamling av data om forurensningstilførsler til vassdrag og fjorder. Revidert utgave. NIVA-Jordforsk 0-89043/0-892301 (L.nr.2501), 53 s.

Holtan, H., 1991: Forurensningene i Glomma 1989-1990. Forurensningsbudsjett, forurensningsgrad, vurderinger og prognoser. NIVA-rapport 0-90083/90156 (L.nr. 2546), 65 s.

Ibrekk, H.O., Holtan, H., Berge, D., Gulbrandsen, R., Tjomsland, T. og Øren, K., 1991: Nordsjøplan. Vassdrag. NIVA-rapport 0-90230 (in prep.).

Iversen, E. R., 1990: Vannforurensninger fra nedlagte gruver. Del III. NIVA-rapport 0-90138 (L.nr. 2531), 20 s.

Knutzen, J. og K. Øren, 1983: Miljøgifter i kommunalt avløpsvann - vurdering av effekter ved utslipp i sjøvann. Vann-3-83. pp. 292-305.

Lingsten, L., 1987: Pilot Study on Riverine Inputs to Marine Waters. NIVA- report 0-86201. 37 s. (unpublished).

Magnusson, J. og K. Næs, 1986: Basisundersøkelser i Drammensfjorden 1982-84: Delrapport 6: Hydrografi, vannkvalitet og vannutskiftning. Overvåkingsrapport nr. 243/86. NIVA-rapport 8000315 (L.nr. 1892), 77 s.

Molværsmyr, Å., Sanni, S. og T. Tyvold, 1989: Basisundersøkelse av Figgjovassdraget 1984-1987. Rapport fra Rogalandsforskning (nr. RF-21989), 79/52 s.

Molværsmyr, Å., Aabel, J.P., Sanni, S., Bergheim, A. og P.T. Haaland, 1990: Samlerapport: Forurensningsundersøkelser i vassdrag og sjøområder i Rogaland. Rapport fra Rogalandsforskning (nr. RF-132/90), 136 s.

Molvær, J. og A. Stigebrandt, 1991: Undersøkelse av eutrofiering i Grenlandsfjordene 1988-89. Delrapport 3. Vannutskiftning i fjordene. Overvåkingsrapport nr. 450/91. NIVA-rapport 0-8000372, 45 s. (in press).

Myhrstad, A., 1985: Miljøgifter. Utslipp via kommunale anlegg. Rapport fra Elliot Strømme A.S. 13 s. + vedlegg.

Norwegian Water Resources and Energy Administration, 1987: Avrenningskart over Norge. NVE. Oslo. 8 kartblad.

Norwegian Water Resources and Energy Administration, 1990: Vassdragsregisterets kartbok. V 24. NVE. Oslo.

Norwegian Water Resources and Energy Administration, 1991: Vannføringsdata fra 1990. NVE. Oslo (unpublished).

Oslo kommune, Vann- og avløpsverket (OVA), 1991: Data fra vassdrag og renseanlegg i Oslo kommune. OVA. Oslo (unpublished).

Rensvik, H. (red.), 1990: Vårt felles miljø. Oslo, SFT-rapport, 95 s.

Riibe, S.M., 1983: Resipientundersøkelse i Lundevatn 1981-1982. Rapport fra Rogalandsforskning (nr. T 23/83), 99 s.

Rosland, D. og S. Stene-Johansen, 1989: Analyse av forurensningstilførsler til indre Oslofjord. NIVA-rapport 0-87160 (L.nr. 2288), 85 s.

SFT, 1980-1990: The National Monitoring Programme of Water Courses. Monitoring Results. Annual Reports; TA-1980, 1981: TA-580, 1982: TA-588, 1983: TA-597, 1984: TA-607, 1985: TA-622, 1986: TA-628, 1987: TA-639, 1988: TA-629/1989, 1989: TA-711/1990.

Paris Commission, 1986: Eighth Meeting of the Paris Commission. Annex 4-6. Madrid 2-4 June 1986.

Paris Commission, 1987: Tenth Meeting of the Paris Commission. PARCOM 10/3/2-E. Lisbon 15-17 June 1988.

The County Environmental Agencies: Østfold, Oslo and Akershus, Buskerud, Vestfold, Telemark, Aust-Agder, Vest-Agder, Rogaland, Hordaland, Sogn og Fjordane, Møre og Romsdal, Sør-Trøndelag, Nord-Trøndelag, Nordland, Troms, Finnmark: Chemical data from monitored rivers in 1990 and/or monitored the last decade (mostly unpublished) and also information about treatment plants in the different counties.

The Norwegian Meteorological Institute, 1987: Nedbørnormaler 1930-60. DNMI. Oslo, 14 s.

The Norwegian Meteorological Institute, 1991: Nedbørdata fra 1990. DNMI. Oslo (unpublished).

Tjomsland, T., 1991: TEOTIL. Modul for teoretisk beregning av fosfor- og nitrogentilførsler i Norge. NIVA-rapport 0-902301 (in press).

Traaen, T., Lindstrøm, E.-A. og H. Huru, 1990: Overvåking av Tanavassdraget. Fremdriftsrapport for 1988-1989. NIVA-rapport 0-88192/ 0-89152 (L. 2515), 57 s.

Traaen, T., 1991: Overvåking av Grense Jacobselva og Pasvikelva 1990. NIVA-rapport 0-89187 (in prep.).

VEAS, 1991: Årsmelding 1990. Rapport fra Vestfjordens Avløpsselskap, 20 s.

7 APPENDIX I: TABLES AND FIGURES

		Page:
Table IA	Total discharges from Norway to convention waters 1990	40
Table IB	"Mean" total discharges from Norway to convention waters	40
Table I.IA	Main rivers. Total load 1990	41
Table I.IB	Main rivers. "Mean" total load	41
Table I.IIA	Tributary rivers. Total load 1990	42
Table I.IIB	Tributary rivers. "Mean" total load 1990	42
Table I.III	Main rivers. Mean concentrations of monitored parameters 1990	43
Table I.IV	Drainage areas of monitored main and tributary rivers and Down stream areas (km^2 and per cent monitored in each sub-area and subregion)	43

Table IA Total discharges from Mainland Norway to convention waters 1990

Substance:	Area runoff	Direct Discharges	Tributary Inputs		Main Riverine Inputs		Grand Total	
Cadmium		0.8	2.1	*	4.4	*	7.3	tonnes
Cadmium			31.3	**	10.2	**	42.2	tonnes
Mercury		579	10	*	38	*	627	kg
Mercury			361	**	149	**	1089	kg
Copper		89	344		194		627	tonnes
Zinc		82	1106		482		1670	tonnes
Lead		11.9	39.2	*	24.0	*	75.1	tonnes
Lead			108.3	**	46.9	**	167.0	tonnes
PCBs ***			0.2	*	73.9	*	74.1	kg
PCBs			621.0	**	268.5	**	889.5	kg
gamma-HCH			371		160		531	kg
NO3-N			20582		13802		34385	tonnes
PO4-P			305		258		563	tonnes
Total N	23442	14195	40442		23098		101178	tonnes
Total P	715	1209	1347		714		3985	tonnes
S.P.M.		5067443	238790		358160		5664394	tonnes
TOC		555			81040		81595	tonnes
COD		280407					280407	tonnes
BOD		38128					38128	tonnes

Table IB "Mean" total discharges from mainland Norway to convention waters (Mean runoff 1930-60)

Substance:	Area runoff	Direct Discharges	Tributary Inputs		Main Riverine Inputs		Grand Total	
Cadmium		0.8	1.7	*	3.7	*	6.2	tonnes
Cadmium			23.1	**	7.0	**	30.9	tonnes
Mercury		579	7	*	37	*	623	kg
Mercury			280	**	124	**	983	kg
Copper		89	278		178		546	tonnes
Zinc		82	873		435		1390	tonnes
Lead		11.9	31.0	*	15.1	*	58.0	tonnes
Lead			84.9	**	32.4	**	129.2	tonnes
PCBs ***			0.2	*	66.3	*	66.6	kg
PCBs			483.4	**	229.6	**	713.0	kg
gamma-HCH			266		134		400	kg
NO3-N			15520		13559		29079	tonnes
PO4-P			251		247		498	tonnes
Total N	23442	14195	31729		22184		91551	tonnes
Total P	715	1209	1089		664		3677	tonnes
S.P.M.		5067443	190105		324516		5582065	tonnes
TOC		555					555	tonnes
COD		280407					280407	tonnes
BOD		38128					38128	tonnes

Measurements below detection limits are treated in two ways :

*) Detection limit = Zero

**) Detection limit = Limit

*** the following congeners: IUPAC Nos. 28,52,101,118,153,138,180

Table I.IA Main rivers. Total load 1990.

Main surrounding seas		<---- North Sea ----> <---- Skagerrak ----							Norwegian Sea		Barents Sea
NO Rivers / Substance	Total	1 Glomma	2 Drammenselva	3 Numedalslågen	4 Skienselva	5 Otra	6 Orreelva	7 Suldalslågen	8 Orkla	9 Vefsna	10 Alta
Tot-P, t	714	418	56	40	65	48	7.8	7.56	18	35.3	18.02
PO_4-P, t	258	177	18	19	12	7	1.5	1.58	5	10.8	4.71
Tot-N, t	23099	10708	3217	1218	3514	1571	139	524	672	1153	373
NO_3-N, t	13802	6628	1960	621	2370	826	69	425	313	505	86
Cu, t	193.9	68.8	12.4	6.2	42.8	9.4	0.16	2.93	31.3	16.33	3.64
Zn, t	482.1	146.3	40.7	23.1	118.0	49.1	0.44	7.32	57.0	33.59	6.62
Cd*, t	4.4	0.0	1.0	0.2	1.0	2.0	0.01	0.0	0.1	0.09	0.06
Cd**, t	10.2	2.4	1.6	0.4	1.7	2.6	0.03	0.24	0.3	0.66	0.23
Pb*, t	24.0	6.5	3.5	1.8	4.2	1.9	0.06	0.0	0.6	5.42	0.0
Pb**, t	46.9	15.3	6.3	2.6	7.4	4.1	0.14	1.18	1.3	7.42	1.10
Hg*, kg	37.5	6.9	13.2	1.8	10.1	2.9	0.07	0.02	1.6	0.94	0.0
Hg**, kg	149.0	47.6	27.1	8.1	23.9	14.8	0.41	4.72	4.9	13.12	4.39
Lindane, kg	160.0	54.2	23.1	8.6	28.4	25.5	0.22	8.92	1.7	7.46	2.01
PCBs*, kg	73.9	33.3	10.5	2.9	15.7	10.5	0.24	0.0	0.0	0.74	0.0
PCBs**, kg	268.5	94.8	37.3	14.7	44.6	29.3	0.88	8.27	8.1	23.02	7.68
SPM, t	358160	278050	11950	16500	11628	7557	998	1246	6689	21176	2365
TOC, t		80448					581		11		

* Detection limit = zero. ** Detection limit = limit.

Table I.IB Main rivers. "Mean load" (Mean concentrations 1990 multiplied with mean runoff, 1930-60)

Main surrounding seas		<---- North Sea ----> <---- Skagerrak ----							Norwegian Sea		Barents Sea
NO Rivers / Substance	Total	1 Glomma	2 Drammenselva	3 Numedalslågen	4 Skienselva	5 Otra	6 Orreelva	7 Suldalslågen	8 Orkla	9 Vefsna	10 Alta
Runoff, $l/s\ km^2$		17.0	17.6	19.9	26.6	38.8	66.6	70.4	24.3	38.0	11.3
" , m^3/s		700	300	110	275	145	7.0	103	65.0	156	83.0
Tot-P, t	665	398	56	36	57	36	15	9	13	21	24
PO_4-P, t	247	175	16	16	10	5	3	3	4	6	9
Tot-N, t	22185	10518	3176	1142	3137	1063	296	844	678	848	483
NO_3-N, t	13559	6651	1909	574	2100	529	148	718	359	429	142
Cu, t	178	62	12	7	37	6	0.4	5	33	12	4
Zn, t	435	130	41	22	105	34	1.0	10	62	24	6
Cd*, t	3.9	0	1.0	0.4	0.9	1.4	0	0	0.2	0	0
Cd**, t	7.2	2.2	1.0	0.4	0.9	1.4	0	0.3	0.2	0.5	0.3
Pb*, t	15.1	0	4.7	2.1	5.2	0	0.1	0	0	3.0	0
Pb**, t	32.3	11	4.7	2.1	5.2	2.3	0.1	1.6	1.0	3.0	1.3
Hg*, kg	37	0	20	0	17	0	0	0	0	0	0
Hg**, kg	123	44	20	6.9	17	9.1	0.4	6.5	4.1	9.9	5.3
Lindane, kg	135	47	21	8.7	25	16	0.7	10	1.4	3.5	2.1
PCBs*, kg	66	15	14	5.5	19	6.9	0.2	0	0	4.9	0
PCBs**, kg	229	82	33	14	37	18	0.8	11	7.2	17	9.2
SPM, t	322153	265170	11340	11760	9670	5710	1960	1620	4310	10350	2630

* Detection limit = zero. ** Detection limit = limit.

Table I.IIA Tributary rivers. Total load 1990.

Main surrounding seas		<-- North Sea -->; <-- Skagerrak -->								Norwegian Sea		Barents Sea
NO Subareas / Substance	Total	1 Glomma	1 Inner Oslo-fiord	2 Dram-mens-elva	3 Nume-dals-lågen	4 Skiens-elva	5 Otra	6 Orre-elva	7 Suldals-lågen	8 Orkla	9 Vefsna	10 Alta
Tot-P, t	1349	34	33	5	23	4	85	228	206	349	292	90
PO_4-P, t	305.4	4.5	7.8	0.7	4.0	0.9	16.2	49.3	39.7	88.9	76.9	16.5
Tot-N, t	40442	1211	567	120	757	363	3923	8524	6953	10022	5689	2313
NO_3-N, t	20581	575	302	97	580	203	2139	5665	4226	4592	1795	407
Cu, t	384.4	1.6	4.3	0.2	1.2	10.1	15.6	40.6	60.2	102.7	83.1	23.8
Zn, t	1106	4.6	10.1	1.2	5.3	18.9	116.1	212.7	200.2	275.8	175.5	85.6
Cd^*, t	2.11	0	0.09	0	0	0	0	0	0.4	0.31	1.31	0
Cd^{**}, t	31.3	0.11	0.09	0.01	0.06	0.09	1.28	2.42	11.69	10.48	3.47	1.59
Pb^*, t	39.2	0	1.6	0	0.1	0	2.2	18.4	4.9	0	0.9	11.1
Pb^{**}, t	108.4	0.5	1.6	0.1	0.4	0.5	6.8	21.8	23.3	21.6	17.7	14.1
Hg^*, kg	9.9	0	0	0	0	0	0	0	9.9	0	0	0
Hg^{**}, kg	361.1	2.2	0.5	0.2	1.3	1.9	25.6	48.4	93.4	86.4	69.3	31.9
Lindane, kg	371	3.0	1.1	0.3	1.2	2.8	40.8	83.7	140.7	46.1	26.6	24.7
$PCBs^*$, kg	0.2	0	0	0.2	0	0	0	0	0	0	0	0
$PCBs^{**}$, kg	621.1	3.8	1.6	0.5	2.2	3.3	44.8	84.7	151.9	151.2	121.3	55.8
SPM, t	238791	2867	2964	338	2274	1684	12855	39211	34416	81074	45818	15290

* Detection limit = zero. ** Detection limit = limit.

Table I.IIB Tributary rivers. "Mean load" (Mean concentrations 1990 multiplied with mean runoff, 1930-60)

Main surrounding seas		<-- North Sea -->; <-- Skagerrak -->								Norwegian Sea		Barents Sea
NO Subareas / Substance	Total	1 Glomma	1 Inner Oslo-fiord	2 Dram-mens-elva	3 Nume-dals-lågen	4 Skiens-elva	5 Otra	6 Orre-elva	7 Suldals-lågen	8 Orkla	9 Vefsna	10 Alta
Tot-P, t	1091	33	34	6	21	4	64	148	129	303	249	100
PO_4-P, t	251.2	4.3	7.7	0.9	3.9	1.0	12.2	32.3	26.3	78.4	66,0	18.2
Tot-N, t	31728	1199	601	154	704	388	2990	5416	4435	8578	4705	2558
NO_3-N, t	15520	572	322	126	536	217	1610	3597	2686	3927	1485	442
Cu, t	278.4	1.6	5.3	0.2	1.2	10.8	11.8	25.3	37.2	87.4	71.3	26.3
Zn, t	873.5	4.6	12.6	1.6	5.1	20.2	89.9	129.8	127.1	238.9	148.4	95.3
Cd^*, t	1.7	0	0.09	0	0	0	0	0	0.28	0.30	1.03	0
Cd^{**}, t	23.12	0.11	0.10	0.02	0.06	0.10	0.98	1.49	7.10	8.52	2.88	1.76
Pb^*, t	31.0	0	1.7	0	0.1	0	1.6	11.3	3.1	0	0.9	12.3
Pb^{**}, t	84.9	0.5	1.7	0.1	0.3	0.5	5.2	13.4	14.6	18.2	14.8	15.6
Hg^*, kg	7.0	0	0	0	0	0	0	0	7.0	0	0	0
Hg^{**}, kg	280.4	2.2	0.6	0.3	1.2	2.0	19.6	29.9	59.0	72.8	57.7	35.1
Lindane, kg	265.9	3.0	1.2	0.4	1.2	3.0	31.1	51.4	89.3	35.7	22.2	27.4
$PCBs^*$, kg	0.3	0	0	0.3	0	0	0	0	0	0	0	0
$PCBs^{**}$, kg	483.9	3.8	1.7	0.6	2.1	3.5	34.3	52.3	95.2	128	101	61.4
SPM, t	190106	2847	3233	437	2204	1799	10033	24118	21480	68949	38019	16987

* Detection limit = zero. ** Detection limit = limit.

Table I.III Main rivers. Mean concentrations of monitored parameters 1990.

Main surrounding seas	<------ North Sea ------> <--- Skagerrak --->							Norwegian Sea		Barents Sea
NO Rivers / Parameters	1 Glomma	2 Drammenselva	3 Numedalslågen	4 Skienselva	5 Otra	6 Orreelva	7 Suldalslågen	8 Orkla	9 Vefsna	10 Alta
Runoff, m^3/s	741	300	116	308	211	5.8	74.9	73.0	206	69.6
Kond., mS/m	4.39	3.10	2.90	2.15	2.47	17.43	2.20	5.99	5.13	12.3
Tot-P, µg P/l	18.0	5.90	10.4	6.5	7.8	67.6	2.8	6.4	4.3	9.1
PO_4-P, µg P/l	7.9	1.7	4.5	1.2	1.1	14.6	0.8	1.9	1.3	3.9
Tot-N, µg N/l	476	336	330	360	233	1343	261	330	172	184
NO_3-N, µg N/l	301	202	166	241	116	669	222	175	87	54
Cu, µg/l	2.8	1.3	1.9	4.3	1.3	1.6	1.5	16.1	2.4	1.6
Zn, µg/l	5.9	4.3	6.4	12.1	7.5	3.7	3.0	30.8	4.9	2.4
Cd*, µg/l	0.0	0.09	0.04	0.09	0.23	0.04	0.0	0.06	0.01	0.03
Cd**,	0.10	0.80	0.12	0.17	0.33	0.14	0.10	0.13	0.1	0.11
Pb*, µg/l	0.22	0.38	0.51	0.42	0.26	0.63	0.0	0.21	0.44	0.0
Pb**, µg/l	0.63	0.67	0.72	0.75	0.59	0.84	0.50	0.58	0.81	0.50
Hg*, ng/l	0.28	1.33	0.58	1.17	0.33	0.70	0.0	0.58	0.23	0.0
Hg**, ng/l	2.03	3.7	2.25	2.50	2.17	2.28	2.0	2.08	2.03	2.00
Lindane, ng/l	2.13	2.15	2.53	2.90	3.35	3.20	3.05	0.77	0.75	0.90
PCBs*, ng/l	0.17	0.18	0.28	0.25	0.25	0.26	0.0	0.0	0.09	0.0
PCBs**, ng/l	0.57	0.57	0.69	0.71	0.71	0.64	0.50	0.50	0.54	0.50
SPM, mg O/l	11.96	1.22	3.99	1.11	1.25	8.89	0.45	2.13	2.12	
TOC, mg O/l	3.27					5.93		4.37		

* Detection limit = zero. ** Detection limit = limit.

Table I.IV. Drainage areas of monitored main and tributary rivers and Down Stream areas (km^2 and per cent monitored in each subarea and subregion). (Fig. 1, Figs. I.I - I.V).

Sub-regions	Sub-areas	Drainage area of monitored rivers km^2 Main	Tributary	Down Stream areas km^2	Total km^2	Monitored %
Skagerrak	No 1: Glomma	41218	2389	2416	46023	94,8
	" 1: Inner Oslofiord		959	342	1301	73.7
	No 2: Drammenselva	17028	226	320	17614	98.2
	No 3: Numedalslågen	5513	1043	631	7187	91.2
	No 4: Skienselva	10348	1200	1283	12831	90.0
	No 5: Otra	3730	9109	904	13743	93.4
Total		77837	14966	5896	98699	94.0
The remaining North Sea	No 6: Orre	105	7233	2513	9851	74.5
	No 7: Suldalslågen	1466	16205	12681	30352	58.2
Total		1571	23438	15194	40203	62.2
The Norwegian Sea	No 8: Orkla	2680	28118	17036	47834	64.4
	No 9: Vefsna	4113	23907	18850	46870	59.8
Total		6793	52025	35886	94704	62.1
The Barents Sea	No 10:Alta	7367	45155	20619	73141	71.8
Total		93568	135584	77595	306747	74.7