The Convention for the Protection of the Marine Environment of the North-East Atlantic (the "OSPAR Convention") was opened for signature at the Ministerial Meeting of the former Oslo and Paris Commissions in Paris on 22 September 1992. The Convention entered into force on 25 March 1998. It has been ratified by Belgium, Denmark, Finland, France, Germany, Iceland, Ireland, Luxembourg, Netherlands, Norway, Portugal, Sweden, Switzerland and the United Kingdom and approved by the European Community and Spain.

La Convention pour la protection du milieu marin de l'Atlantique du Nord-Est, dite Convention OSPAR, a été ouverte à la signature à la réunion ministérielle des anciennes Commissions d'Oslo et de Paris, à Paris le 22 septembre 1992. La Convention est entrée en vigueur le 25 mars 1998. La Convention a été ratifiée par l'Allemagne, la Belgique, le Danemark, la Finlande, la France, l'Irlande, l'Islande, le Luxembourg, la Norvège, les Pays-Bas, le Portugal, le Royaume-Uni de Grande Bretagne et d'Irlande du Nord, la Suède et la Suisse et approuvée par l'Espagne et la Communauté européenne.

ISBN 0 946955 99 9

OSPAR Commission
2000

Nutrient Discharges from Fish Farming in the OSPAR Convention Area

Contents

EXECUTIVE SUMMARY

Over the last few years there has been a significant increase in the use of intensive forms of aquaculture, such as the mass production of salmon in net cages. As a result, there is increasing concern as to its environmental impact. The release of excreta, faeces and unconverted feed has led to an increase in nutrient concentrations and to local pollution of the marine and freshwater environment. Possible consequences include eutrophication, oxygen depletion and silting in rivers, lakes and coastal zones.

OSPAR agreed that Germany should take the lead on an assessment of nutrient discharges from aquaculture and should prepare an emission inventory for the OSPAR Convention Area, based on a questionnaire campaign. Belgium, Denmark, Germany, Iceland, the Netherlands, Norway, Portugal, Sweden and the UK supplied information in response to the questionnaire. Finland and Switzerland provided information on a voluntary basis. France, Ireland and Spain did not respond to the questionnaire despite several requests. The gaps in information resulting from the incomplete response were partially compensated for by reference to information from other sources, such as the International Council for the Exploration of the Sea (ICES) and the United Nations Food and Agriculture Organization (FAO).

Total production by OSPAR countries was approximately one million tonnes in 1995 and comprised the farming of over sixty species or taxa. The largest producer was Norway at 282 471 t, corresponding to about 28% of the total production. The next largest producers were France (280 257 t) and Spain (138 260 t). Other major producers were Denmark, Germany and the UK.

Nutrient discharges to the maritime area were estimated at 20 000 – 36 000 t N/yr and 2000 – 6000 t P/yr. Estimated discharges to the freshwater environment were considerably lower at 2000 – 6000 t N/yr and 60 – 900 t P/yr. However, it is likely that the actual quantities discharged are considerably higher than the estimates calculated.

Only a proportion of the aquaculture by OSPAR countries occurs in the eutrophication problem areas as currently identified. Discharges within these areas are estimated at > 6000 t N/yr and > 800 t P/yr. However, these estimates do not include discharges by France (due to the lack of response to the questionnaire) which would undoubtedly have increased these estimates.

Comparing nutrient discharges from aquaculture with nutrient inputs from other relevant sectors (agriculture, industry, detergents, municipal wastewater treatment and atmospheric emissions) indicates those from aquaculture to be of less importance. Nevertheless at a regional and local (i.e. farm) level this is not the case. For Norway nutrient discharges from marine aquaculture are of greater significance.

For certain regional and/or maritime areas it seems advisable to reduce further the nutrient discharges from aquaculture as eutrophication problems have already occurred. This would also reduce the overall nutrient load and improve the quality of the maritime area in general. This could include the development of BAT/BEP requirements for aquaculture. A number of practical and technical proposals for such a document are outlined in this report.

Recommendations

An exchange of data concerning aquaculture production is required, with special regard to nutrient discharges. This should take place via the Harmonised Reporting Procedure for Nutrients (HARP).

An investigation should be undertaken into the possibility of developing a background document on a BAT/BEP for aquaculture, integrating work by the OSPAR Working Group on Diffuse Sources (DIFF) with PARCOM Recommendation 94/6 on Best Environmental Practice (BEP) for the Reduction of Inputs of Potentially Toxic Chemicals from Aquaculture Use (OSPAR, 1994).

RECAPITULATIF

Ces quelques dernières années, l'on a constaté un développement significatif des formes intensives d'aquaculture, telles que la production en masse de saumons dans des cages en treillis. De ce fait même, l'aquaculture suscite des inquiétudes croissantes. Les excrétions, les fèces et les aliments non transformés ont abouti à une augmentation des teneurs en nutriments, ainsi qu'à une pollution localisée du milieu marin et des eaux douces. Les conséquences de cet état de choses peuvent se manifester par une eutrophisation, une raréfaction de l'oxygène ainsi qu'un envasement des cours d'eau, des lacs et des zones côtières.

OSPAR est convenue que l'Allemagne assurerait le pilotage d'une évaluation des rejets de nutriments provenant de l'aquaculture, et qu'elle dresserait un inventaire des émissions dans la zone de la Convention OSPAR, ceci sur la base d'un questionnaire diffusé à cet effet. La Belgique, le Danemark, l'Allemagne, l'Islande, les Pays-Bas, la Norvège, le Portugal, la Suède et le Royaume-Uni ont communiqué des renseignements en répondant au questionnaire. La Finlande et la Suisse ont volontairement remis des informations. En dépit de plusieurs demandes, la France, l'Irlande et l'Espagne n'ont pas répondu au questionnaire. Les lacunes de l'information, dues au fait que les réponses étaient incomplètes, ont été en partie compensées par des renseignements provenant d'autres sources, telles que le Conseil International pour l'Exploration de la Mer (CIEM) et l'Organisation des Nations Unies pour l'alimentation et l'agriculture (FAO).

En 1995, au total, la production des pays du périmètre OSPAR était de l'ordre de un million de tonnes, et englobait l'élevage de plus de soixante espèces. Le plus gros producteur était la Norvège, avec 282 471 t, soit environ 28 % de l'ensemble de la production. La Norvège était suivie par la France (280 257 t) et par l'Espagne (138 260 t). Les autres gros producteurs étaient le Danemark, l'Allemagne et le Royaume-Uni.

Les rejets de nutriments dans la zone maritime se situaient entre 20 000 et 36 000 t N/an et entre 2 000 et 6 000 t P/an. Les estimations des rejets dans les eaux douces étaient considérablement moindres, puisqu'ils étaient de 2 000 à 6 000 t N/an et de 60 à 900 t P/an. Toutefois, il est probable que les quantités effectivement rejetées sont considérablement plus élevées que les estimations issues des calculs.

Seule une partie de l'aquaculture pratiquée par les pays OSPAR a lieu dans des zones à problème d'eutrophisation, telles qu'elles sont reconnues à l'heure actuelle. Dans ces zones, les rejets sont estimés à plus de 6 000 t N/an et à plus de 800 t P/an. Cependant, ces estimations ne tiennent pas compte des rejets de la France (celle-ci n'ayant pas répondu au questionnaire), rejets qui sans aucun doute auraient fait monter les estimations.

Si l'on compare les rejets de nutriments de l'aquaculture aux apports de nutriments des autres secteurs concernés (agriculture, industrie, détergents, épuration des eaux usées urbaines et émissions atmosphériques), l'on constate que ceux de l'agriculture sont de moins grande ampleur. Néanmoins, à un niveau régional et local (autrement dit, au niveau de l'élevage), la situation est inversée. Dans le cas de la Norvège, les rejets de nutriments dus à l'aquaculture dans l'eau de mer présentent une importance plus grande.

Dans certaines zones régionales et/ou maritimes, il semblerait judicieux de réduire plus avant les rejets de nutriments de l'aquaculture, car des problèmes d'eutrophisation se sont déjà posés. Ceci permettrait aussi de réduire la charge globale en nutriments, et d'améliorer la qualité de la zone maritime en général. Une telle mesure serait assortie de l'élaboration de normes de BAT/BEP applicables à l'aquaculture. Plusieurs propositions pratiques et techniques portant sur des normes de ce type sont esquissées dans le présent rapport.

Recommandations

Un échange de données sur la production de l'aquaculture s'impose, l'accent devant être particulièrement mis sur les rejets de nutriments. Cet échange pourrait avoir lieu dans le contexte de la procédure harmonisée de notification des nutriments (HARP).

Il conviendrait en outre d'étudier la possibilité de créer un document de fond sur la BAT/BEP dans l'aquaculture, en l'intégrant aux travaux que le Groupe de travail OSPAR sources diffuses (DIFF) effectue sur la Recommandation PARCOM 94/6, sur la meilleure pratique environnementale (BEP) en vue de la réduction des apports de produits chimiques potentiellement toxiques provenant de l'aquaculture (OSPAR, 1994).

INTRODUCTION

Background

While fishery yields are no longer increasing owing to the over-exploitation of a large proportion of the world's fish stocks, there is increasing growth in the production of marine and freshwater organisms by aquaculture. According to the United Nations Food and Agriculture Organization global fish production increased by 3 x 10^6 t between 1994 and 1995 to a total of 112 x 10^6 t and this increase was almost entirely due to aquaculture. Production is currently around 22 x 10^6 t; this represents around 20% of world fish production. As a consequence concern is developing regarding the environmental impact of aquaculture. Environmental problems are associated with the use of chemicals to fight disease and the release of feed and excreta. Such activities may result in local pollution. Many recent studies have addressed these issues and are reflected in this report, for example: Hering and Köhn (1999), Hilge (1997), ICES (1996), Norges Forskningsrad/DNV (1994), Rennert (1993), Rennert *et al*. (1996), Rosenthal *et al*. (1993; 1994) and von Lukowicz (1994).

Environmental problems associated with aquaculture are currently being addressed by various international organisations. For example:

- the European Inland Fisheries Advisory Commission (EIFAC) (by its Working Party on Fish Farm Effluents);
- the FAO (by its Working Group on the Environmental Impacts of Coastal Aquaculture);
- ICES (by its Working Group on Environmental Interactions of Mariculture); and
- the Helsinki Commission (HELCOM).

In 1994 OSPAR agreed Germany should take the lead, via its Working Group on Nutrients, on an investigation of 'nutrients discharged from aquaculture' and should prepare an emission inventory for the entire Convention Area.

This report is based on replies to a questionnaire concerning nutrient discharges from fish and shellfish farming supplied by Contracting Parties to the OSPAR Convention. The questionnaire was developed by the Umweltbundesamt (UBA, the German Federal Environmental Agency) in collaboration with aquaculture expert Prof Rosenthal from the Institut für Meereskunde at Kiel University (Appendix 1).

Replies to the questionnaire were received from Belgium, Denmark, Germany, Iceland, Luxembourg, Netherlands, Norway, Portugal, Sweden and the UK. Additional information was supplied by Finland (on nutrient discharges from fish farms draining into the maritime area) and Switzerland (on freshwater aquaculture). According to the FAO (1997a) aquaculture in Finland and Switzerland is of limited significance with regard to the OSPAR maritime area.

Despite several requests France, Ireland and Spain did not respond to the questionnaire.

Thanks are expressed to Andreas Bauer (UBA) for organising and drafting the report (including the German contribution; Bauer, 1997) and to the other experts involved in its preparation, including Harry Dooley and Susanne Reimert (ICES), Uwe Barg (FAO), Timo Mäkinen (Finnish Game and Research Unit) and Grant Lawrence (European Commission, EC).

Data Quality and Availability

Some of the gaps resulting from the incomplete response to the questionnaire were filled using information from other sources, for example the EC and the FAO. However, such data are generally estimates and their accuracy varies considerably from country to country (FAO 1995a). Even the working groups previously referred to have been unable to produce complete and reliable datasets on production and nutrient discharges from aquaculture. Difficulties during the present study resulted from:

- missing or incomplete responses to the questionnaire;
- a lack of detail in the response (e.g. no distinction between marine and freshwater production and the respective feed used);
- little or no distinction between the total production of a particular country, production within the OSPAR Convention Area and/or production within 'eutrophication problem areas';
- differences in the quality and accuracy of the data supplied, owing to variability in the calculation procedures and assessment methods used; and
- data supplied for different years.

The wide range of aquaculture systems in use imposes a further limitation. Factors crucial to an assessment of this type are not reported statistically due to the large number of farms and species farmed. Variability in the technical equipment used (e.g. cleaning and filtration systems) and types of farm-specific feed and feeding techniques are also important, as well as temperature which affects the conversion of nutrients. Consequently, the results presented in this report illustrate scale and trends, rather than precise quantitative data.

It is likely that the actual quantities of nutrients discharged are higher than the quantities calculated here. However the FAO recommends that the absence of adequate scientific information should not be used as a reason for postponing or failing to take conservation and management measures (FAO, 1995a).

PRODUCTION IN THE OSPAR CONVENTION AREA

Annual Production and Taxa Farmed

Total production by the OSPAR countries in 1995 was 1 054 489 t (FAO, 1997a). This was based on country-specific data and so included data for areas falling outside the OSPAR Convention Area, such as the Baltic Sea (Denmark, Germany, Finland and Sweden) and the Mediterranean Sea (France and Spain) (see also Appendix 2). Since most of the country-specific data do not include stock production, higher total production can be assumed. For the purposes of this report total aquaculture production in the OSPAR Convention Area was taken as 1 x 10^6 t/yr (i.e. around 5% of world production).

This estimate was based on the cultivation of more than sixty species or taxa; approximately fifty-three with an annual production of > 10 t. These included sixteen species of freshwater fish (3% of production), nine diadromous and marine fish species (54% of production), three species of freshwater crustacean (< 1% of production), two species of marine crustacean (< 1% of production) and thirteen species of marine mollusc (43% of production). Other species were produced in smaller quantities.

1995 production figures for the commercially important species are shown in Figures 1 to 3. In quantitative terms the most important were salmon (*Salmo salar*; 363 107 t), mussel (*Mytilus edulis*; 261 773 t), rainbow trout (*Oncorhynchus mykiss*; 191 342 t) and Pacific oyster (*Crassostrea gigas*; 133 475 t). The most important freshwater fish species was carp (*Cyprinus carpio*; 19 148 t). Production of freshwater and marine crustaceans was of less importance, totalling < 2500 t. Salmon and rainbow trout can be farmed in both the freshwater and marine environment. As it is often unclear from the statistics where they were farmed, they have been classed as anadromous and brackish-water species. Salmon were mainly farmed in the marine environment, while the location varied from country to country for rainbow trout.

The taxa produced differ between countries and this is illustrated in Figure 4. In 1995 the largest producers were Norway (282 471 t, representing 28% of the production by OSPAR countries), France (280 257 t; 28%) and Spain (138 260 t; 14%).

According to an assessment of the effects of fisheries directed at gastropods and bivalves presented by Sweden to the OSPAR Working Group on Impacts on the Marine Environment (OSPAR, 1998), physical disturbance by fishing gear may alter the chemical exchange process between the sediment and water. In sediments that normally release nutrients there is an immediate increase in nutrient release followed by a period of lower flux until the original nutrient profile of the sediment is restored.

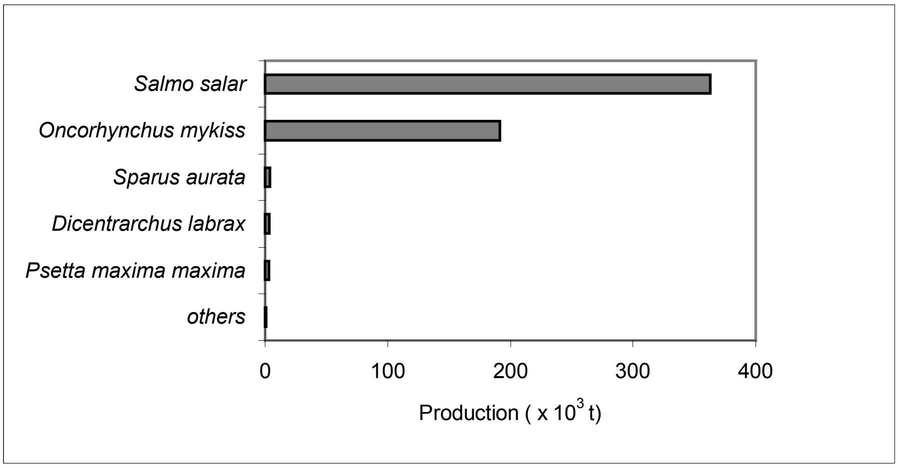

Figure 1 Production of marine, anadromous and brackish-water fish (including rainbow trout) and crustaceans in 1995

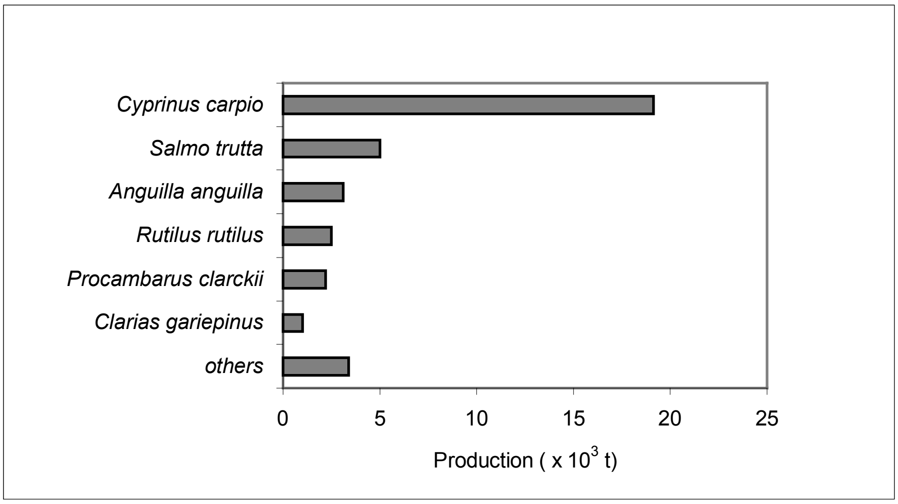

Figure 2 Production of freshwater fish (excluding rainbow trout) and crustaceans in 1995

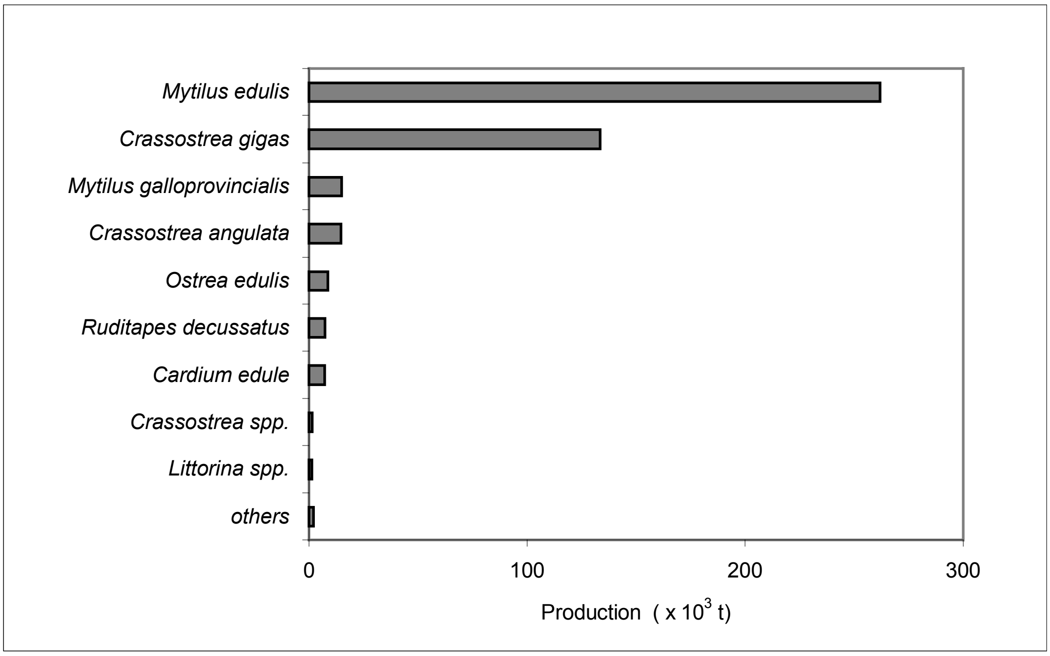

Figure 3 Production of marine molluscs in 1995

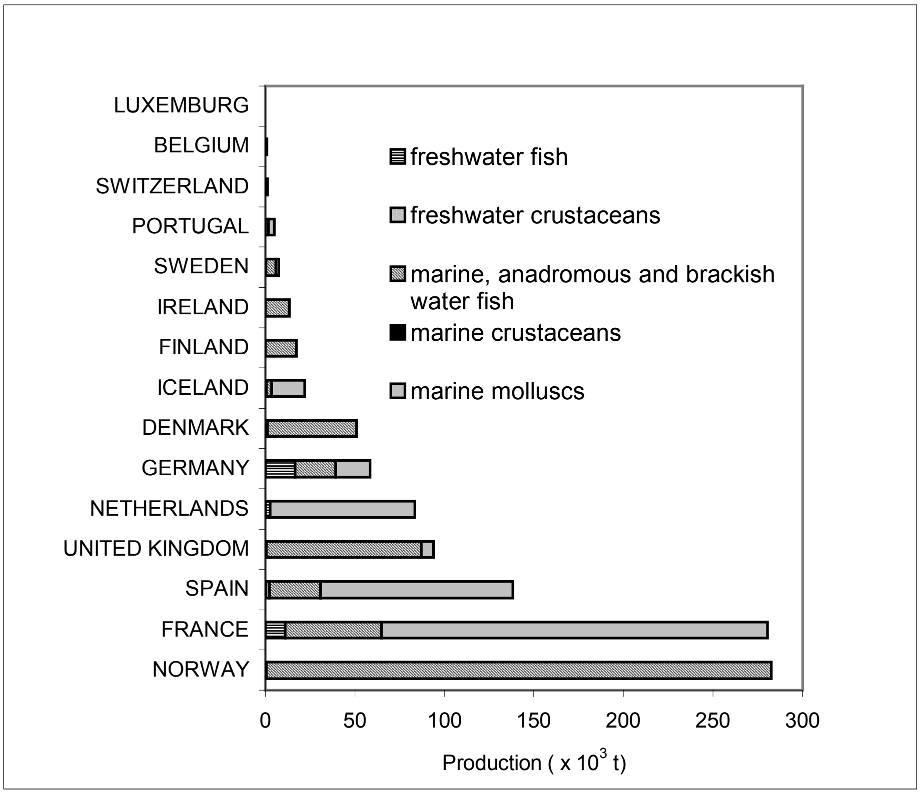

Figure 4 Production by country in 1995. Source: FAO (1997b)

As shellfish production does not require commercial feeds and its influence on the marine nutrient balance is unclear, nutrient discharges from the cultivation of marine molluscs are not considered in this report. Excluding marine molluscs then the largest producers during 1995 become Norway, the UK, France, Denmark, Germany and Spain (see Appendix 2 for a detailed breakdown of production).

Types of Cultivation and Number of Farms

Methods of production within the OSPAR Convention area are of three main types: extensive, semi-intensive and intensive. Extensive systems include inland ponds for cyprinid production. Additional feeding does not occur at these sites, or is only undertaken to a limited extent using grain for example. Other pond farms use semi-intensive production methods. High-quality feed is added at these sites and they are used primarily for salmonid production, although their use for species such as acipenserids is increasing. Intensive production methods include the cultivation of fish in basins, silos, flowing water channels, net cages and closed (warm water) circulation systems. Intensive farming occurs in inland waters and on the coast. Species which command high ‘per kilo’ prices, such as eels and salmon are produced using intensive methods.

Production methods tend to be country-specific as they must correspond to the prevailing climatic and geographical conditions. Table 1 shows the systems used by the six largest producers and highlights the dominance of net cages for the production of salmon. Owing to a lack of information it was not possible to determine the total number of marine and freshwater farms in the Convention Area.

Almost all the farms located in coastal areas use net cages and, of these, by far the most occur in Norway (Table 2). Net cages lack filtration and cleaning systems.

Different types of pond system predominate in the freshwater sector. The majority are German pond farms for the farming of carp and salmonids (Table 3). Most use settlement ponds as cleaning systems; filtration and purification systems are rare.

NUTRIENT DISCHARGES

The release of nutrients and organic matter to the aquatic environment can cause adverse effects, including eutrophication, oxygen depletion and silting. The extent of the impact depends on the type of receiving water (small river, big river, lake, ocean) and the nutrient release must be assessed within the context of the local conditions. For example, although net cages in inland waters have a significant effect on nutrient loading, recirculating systems with filter systems and small water usage do not (FAO, 1997c).

Nutrients discharged from production sites originate from the feed delivered to the fish. Improvements can be made in feeding techniques and in the development of new feeds, for example high-energy extruded feeds (FAO, 1997c). The following calculations do not include shellfish farming because feed is not used by this sector.

Nutrients in feed (N_{feed}) are converted to fish biomass (N_{fish}) or released into the water as unconverted nutrients (N_{rel}). Thus:

$$N_{feed} = N_{fish} + N_{rel}$$

Unconverted nutrients (N_{rel}) may occur as:

- uneaten feed, sedimented feed and inedible constituents. This represents approximately 1 – 5% of dry feed and 70 – 95% of wet feed (UBA, 1996);
- faeces and indigestible feed; and
- excreta (i.e. branchial and renal release). Approximately 50% of the nutrients excreted are precipitated/lost through the gills and in the urine.

According to UBA (1996) approximately 25% of the nutrients in feed are converted into biomass, with the remaining 75% discharged to the environment (Table 4). Handy and Poxton (1993) estimated that 52 – 95% of the nitrogen added to aquaculture systems as feed will ultimately enter the environment.

Table 1 Farming systems and production by the six largest producers in 1995

	System	Location	Production	Other systems	Other species
DENMARK	ponds, raceways (on shore)	marine and freshwater	32 800 t, mainly rainbow trout*	net cages in Baltic Sea and Faroe Islands	rainbow trout, eel and others
FRANCE†	ni	ni	ni	ni	ni
GERMANY	ponds, basins	freshwater	7 540 t carp, 5 740 t rainbow trout	none	eel and others
NORWAY	net cages	marine	330 160 t salmon	none	rainbow trout and others
SPAIN†	ni	ni	ni	ni	ni
UK	net cages	marine	76 043 t salmon	none	rainbow trout and others

* Plus 8600 t in Faroe Islands, mainly salmon; † no information as no response to the questionnaire at Appendix 1.

Of the nutrients which are not taken up as fish biomass the amount released to the water depends on factors such as the use of cleaning, filtration and settlement techniques to trap feed residue and faeces. Recent studies demonstrate that certain carp pond systems act as nutrient traps (Knösche *et al*., 1997); the biological cycle results in nutrient uptake from the pond water so creating a negative nutrient balance. This is not true of the more intensive farming methods; cleaning, filtration and settlement systems are not used at marine net cage farms which produce (and so pollute) on a large scale.

The large number and diversity of production sites makes it impossible to determine the overall extent of nutrient reduction. Nutrients discharged to receiving waters by fish farms are taken-up biologically within a few hundred metres to a few kilometres of the point of release, to the extent that an increase in concentration is no longer detected. However, a powerful dilution effect must be assumed in large areas of water. A further reduction results from the binding of phosphorus to sediment (Table 4) and a proportion of the phosphorous precipitated remains bound in the sediment for some time.

There are thus several possibilities for nutrient reduction:

- cleaning, filtration and settlement systems;
- biological conversion within the fish farming system itself (as in certain carp pond farms);
- biological conversion within the receiving water; and
- phosphate fixation in sediments.

Table 2 Marine aquaculture farms

	Cage farms		Onshore farms			Floating tanks and basins, ponds	
	licensed sites	no. net cages	no. farms	with waste water treatment	with sludge removal	floating tanks/ basins near shore	tanks, basins, ponds discharging directly
BELGIUM	-	-	-	-	-	-	-
DENMARK	-	-	10	ni	ni	-	-
FINLAND[*]	0	0	0	0	0	0	0
FRANCE[†]	ni	ni	ni	ni	ni	ni	ni
GERMANY	-	-	-	-	-	-	-
ICELAND[‡]	ni	ni	ni	ni	ni	ni	ni
IRELAND[†]	ni	ni	ni	ni	ni	ni	ni
LUXEMBOURG[§]	0	0	0	0	0	0	0
NETHERLANDS	1	1	1	1	-	-	-
NORWAY[‖]	1847	ni	6	ni	ni	3	3
PORTUGAL	1	ni	389[¶]	ni	ni	-	-
SPAIN[†]	ni	ni	ni	ni	ni	ni	ni
SWEDEN[**]	19[††]	ni	-	-	-	-	-
UK	364	ni	5	ni	ni	5	5

Information based on responses to the questionnaire at Appendix 1, except for Denmark which includes information presented at PRAM 1999.

[*] no aquaculture farms in the OSPAR catchment area; [†] no information as no response to questionnaire at Appendix 1; [‡] total number of marine and freshwater farms 135, no other information available; [§] no marine aquaculture; [‖] plus 311 hatcheries; [¶] settled on old earth salt pans; [**] plus 16 hatcheries; [††] situation unclear; -: production negligible; ni: no information available.

Table 3 Freshwater aquaculture farms

	Ponds	Raceways	Cages in lakes/ reservoirs	Indoor hatcheries	Unspecified hatcheries	Total no. farms	Waste water treatment facilities	Sludge removal
BELGIUM	15	50	0	5	0	70	< 5	< 5
DENMARK	350	ni	0	ni	ni	350 – 400	ni	100%
FINLAND[*]	~ 35	0	0	0	0	~ 35	0	> 90%
FRANCE[†]	ni	ni	ni	ni	ni	ni	ni	ni
GERMANY	4818	111	43	ni	328	5056[‡]	> 50%[§]	> 90%
ICELAND[‖]	ni	ni	ni	ni	ni	ni	ni	ni
IRELAND[†]	ni	ni	ni	ni	ni	ni	ni	ni
LUXEMBOURG	0	0	0	1	0	1	ni	ni
NETHERLANDS	3	?[¶]	0	37	0	40[¶]	0	100%
NORWAY	0	63	0	ni	37	100	0	0
PORTUGAL	20[**]		2	ni	ni	22	ni	ni
SPAIN[†]	ni	ni	ni	ni	ni	ni	ni	ni
SWEDEN[††]								
SWITZERLAND	35[**]		0	0	0	35	25%	100%
UK	ni	127	83	24	0	234	> 50%	0

Information based on responses to the questionnaire at Appendix 1, except for Denmark which includes information presented at PRAM 1999.

[*] approximate figures because situation varies; [†] no information as no response to questionnaire at Appendix 1; [‡] some farms have more than one type of production; [§] only settlement ponds; [‖] total number of marine and freshwater farms 135, no other information available; [¶] situation unclear although Vollenbroek (1993) indicates 65 farms (with recycling systems); [**] combined figure for ponds and raceway farms; [††] exact data not available; ni: no information available.

Table 4 Percentage distribution of nutrients at fish farms. Source: UBA (1996)

	Feed	Sedimentation	Excretion	Fish
Nitrogen	100	13	62	25
Phosphorus	100	66	11	23

Assessment of Nutrients Discharged

Effluents from aquaculture are not reported routinely. Thus it is necessary to estimate nutrient discharges to the environment using various calculation methods; estimates may be derived from the feed used or from production data.

Both methods are based on statistical surveys that exclude the impact of particular local circumstances such as the effects of purification and filtration systems, the species farmed and their age distribution, whether open or closed systems are used and the type of feeding techniques. Thus the estimates derived can only indicate scale.

It is likely that the actual quantity of nutrients discharged is higher than the estimates calculated. Thus, more than one calculation method should be used when determining the extent of nutrients discharged. The following calculations do not include shellfish production because commercial feed is not used by this sector.

Assessment based on feed used

A range of feed is used in aquaculture. According to the FAO (1995a) 70% of feed for most carnivorous fish consists of other fishery products. The feed used is determined by:

- the species of fish farmed;
- the type of farming (i.e. farm type, marine/freshwater, seasonal and climatic conditions, fish density);
- the age of the fish (i.e. fry, adult); and
- the production objective (i.e. for food or as stock).

Table 5 summarises the questionnaire responses on the types and quantities of feed used. Dry feed with a dry organic matter (DOM) content of > 90% is the main type used in all countries. Feed with a DOM of < 90%, as well as other types of feed, are also used but to a lesser extent. These other types include grain in cyprinid production and (to an extremely limited extent) wet feed in salmonid production.

The composition of the most frequently used feed is given in Table 6. These data are based on the questionnaire responses and on the open literature. The composition of the most frequently used feed (i.e. with a DOM of > 90%) is identical in the marine and freshwater sectors.

Table 5 Quantities of feed used (t/yr)

	Marine			Freshwater			TOTAL
	dry feed (> 90% DOM)	dry feed (< 90% DOM)	others	dry feed (> 90% DOM)	dry feed (< 90% DOM)	others	
BELGIUM*	-	-	-	-	-	-	-
DENMARK	822	0	0	32 800	0	0	33 622
FINLAND	0	0	0	260	0	0	260
GERMANY	0	0	0	5 715	5 660	4 399	15 774
ICELAND	3 400	0	0	880	0	0	4 280
LUXEMBOURG*	-	-	-	-	-	-	-
NETHERLANDS	40	0	0	3 000	0	0	3 040
NORWAY	380 206	1 370	0	279	0	0	381 855
PORTUGAL	10 000	4 000	ni	4 500	ni	ni	> 18 500
SWEDEN	420	0	0	0	0	0	420
UK	85 000	0	0	4 500	0	0	89 500
TOTAL	479 888	5 370	ni	51 934	5 660	4 399	> 547 171

Information based on responses to the questionnaire at Appendix 1.

DOM: dry organic matter; * no data available; ni: no information.

Table 6 Composition of frequently used feed

	Mixed feed		Others	
	salmonids/intensive production	cyprinids	wet feed for salmonids	grain for cyprinids
Dry organic matter (%)	> 85 – 90	90	25	90
Nitrogen (g/kg DOM)	64 – 80	48	35	21
Phosphorus (g/kg DOM)	10 – 13	7	6	4
Crude protein content (g/kg DOM)	400 – 550	300	220	130
Energy content (kJ/g)	16 – 24	19	10	16.5

DOM: dry organic matter.

Example calculation: the Netherlands

Feed used
The feed used comprises 90% DOM (see Table 5)

Marine

dry feed > 90% DOM	= 40 t/yr

Freshwater

dry feed > 90% DOM	= 3000 t/yr

Nutrient content of feed
The DOM is 90% of the feed by weight. The nutrient content of the feed is 64 – 80 g N/kg DOM and 10 – 13 g P/kg DOM (see Table 6).

Marine

90% of 40 t feed/yr	= 36 t DOM/yr
64 – 80 g N/kg DOM for 36 t DOM/yr	= 2 – 3 t N/yr
10 – 13 g P/kg DOM for 36 t DOM/yr	= 0 t P/yr

Freshwater

90% of 3000 t DOM/yr	= 2700 t DOM/yr
64 – 80 g N/kg DOM for 2700 t DOM/yr	= 173 – 216 t N/yr
10 – 13 g P/kg DOM for 2700 t DOM/yr	= 27 – 35 t P/yr

Nutrients released
According to Table 4 only 25% of the nitrogen and 23% of the phosphorous in fish feed are converted into fish biomass. As marine farms have no retention or filtration systems the remaining percentages are released directly to the environment (see Table 7). Freshwater farms have settlement basins and/or similar systems that retain some of the sedimented nutrients (see Table 8).

Marine

75% of 2 – 3 t N/yr	= 2 t N/yr
77% of 0 t P/yr	= 0 t P/yr

Freshwater

62% of 173 – 216 t N/yr	= 107 – 133 t N/yr
11% of 27 – 35 t P/yr	= 3 – 4 t P/yr

Assessment based on production

Nutrient discharges can also be calculated using production data. Approximate discharges can be calculated from the non-converted nutrients per tonne of fish produced. According to various producers approximately 40 – 70 kg N and 4 – 11 kg P per tonne of fish produced are not converted when using dry feed with a DOM of > 90%.

Assessments based on production data are inexact because production-specific information such as aquaculture type, feeding method, the species farmed and its age structure, losses through mortality and the import/export of stock are not included in the calculation.

Table 7 Nutrient content of feed and nutrients released from marine aquaculture (t/yr)

	Nutrient content of feed				Nutrients released	
	dry feed (> 90% DOM)		dry feed (< 90% DOM)			
	N	P	N	P	N	P
DENMARK	47 – 59	7 – 10	0	0	36 – 45	6 – 7
ICELAND	218 – 272	34 – 43	0	0	164 – 204	26 – 33
NETHERLANDS	2 – 3	0	0	0	2	0
NORWAY	21 900 – 27 375	3 422 – 4 448	70 – 88	14	16 478 – 20 597	2 646 – 3 436
PORTUGAL	576 – 720	90 – 117	1	0	403 – 505	69 – 90
SWEDEN	24 – 30	4 – 5	0	0	18 – 23	3 – 4
UK	4 896 – 6 120	765 – 995	0	0	3 672 – 4 590	589 – 766
TOTAL					20 773 – 25 966	3 339 – 4 336

Information based on responses to the questionnaire at Appendix 1, the percentage distribution of nutrients at fish farms (Table 4), the feed used in the OSPAR Convention Area (Table 5) and the composition of frequently used feed (Table 6). As the farms referred to in this table have no retention or filtration installations the nutrients are released directly into the environment.

Table 8 Nutrient content of feed and nutrients potentially released from freshwater aquaculture (t/yr)

	Nutrient content of feed						Nutrients released	
	dry feed (> 90% DOM)		dry feed (< 90% DOM)		others			
	N	P	N	P	N	P	N	P
BELGIUM*	-	-	-	-	-	-	-	-
DENMARK	1888 – 2362	299 – 386	0	0	0	0	1171 – 1464	33 – 43
FINLAND	14 – 19	2 – 3	0	0	0	0	9 – 12	< 1
GERMANY	329 – 411	51 – 67	290 – 362	45 – 59	153	17	479 – 574	12 – 16
ICELAND	56 – 70	9 – 11	0	0	0	0	35 – 43	1
NETHERLANDS	173 – 216	27 – 35	0	0	0	0	107 – 133	3 – 4
NORWAY	16 – 20	3	0	0	0	0	10 – 12	< 1
PORTUGAL	259 – 324	41 – 53	0	0	0	0	161 – 201	5 – 6
SWEDEN	0	0	0	0	0	0	0	0
UK	259 – 324	41 – 53	0	0	0	0	161 – 201	5 – 6
TOTAL							2133 – 2640	61 – 78

Information based on responses to the questionnaire at Appendix 1, the percentage distribution of nutrients at fish farms (Table 4), the feed used in the OSPAR Convention Area (Table 5) and the composition of frequently used feed (Table 6). The farms have settlement basins and/or similar systems which retain some of the sedimented nutrients. Nutrients are retained in extensive carp pond farms.

* no data available.

Production data are available for Germany, Iceland, the Netherlands, Norway, Sweden and the UK for 1995 and for Belgium and Portugal for 1996. FAO data were used for the other countries (which thus included areas of the Baltic and Mediterranean Seas). It is worth noting that in response to the questionnaire Norway reported a considerably higher production in 1995 (330 160 t) than that published by the FAO (281 730 t).

Example calculation: Sweden

According to Table 9 freshwater production is 2350 t/yr. There are no Swedish data for marine fish production.

Nitrogen
A ratio of 40 – 70 kg N released per tonne of fish produced equates to a discharge of 94 – 165 t N/yr for an annual freshwater production of 2350 tonnes fish.

Phosphorus
A ratio of 4 – 11 kg P released per tonne of fish produced equates to a discharge of 9 – 26 t P/yr for an annual freshwater production of 2350 tonnes fish.

Table 9 Aquaculture production and nutrients released in 1995/1996 (t/yr)

	Marine			Freshwater		
	production	nutrients released		production	nutrients released	
		N	P		N	P
BELGIUM	0	0	0	2 125	85 – 149	9 – 23
DENMARK	667	27 – 47	3 – 7	32 800	1 312 – 2 297	132 – 360
(Faroe Islands)	(8 600)	(348 – 606)	(39 – 90)	(0)	(0)	(0)
FINLAND	0	0	0	200	8 – 14	1 – 2
FRANCE	54 252*	2 170 – 3 798	217 – 597	10 927	437 – 765	44 – 120
GERMANY	0	0	0	25 000†	1 700 – 2 150	170 – 275
ICELAND	3 004*	120 – 210	12 – 33	481	19 – 34	2 – 5
IRELAND	13 284*	531 – 930	53 – 146	0	0	0
NETHERLANDS	0	0	0	2 710	108 – 190	11 – 30
NORWAY	330 160*	13 206 – 23 111	1 321 – 3 632	ni	ni	ni
PORTUGAL	2 694*	108 – 189	11 – 30	83	3 – 6	< 1
SPAIN	28 359*	1 134 – 1 985	113 – 311	2 227	89 – 156	9 – 24
SWEDEN	ni‡	ni‡	ni‡	2 350	94 – 165	9 – 26
SWITZERLAND	0	0	0	1 161§	46 – 81§	5 – 13§
UK	76 244*	3 050 – 5 337	305 – 839	ni	ni	ni
TOTAL	517 264	20 694 – 36 213	2 074 – 5 685	80 064	3 901 – 6 007	393 – 879

FAO data used for France, Iceland, Ireland, Spain, Switzerland and the Faroe Islands (FAO, 1997a,b). The data therefore concern each country as a whole.

* includes data for all rainbow trout (even when produced in freshwater); † includes hatchery production; ‡ situation unclear; § refers to the whole of Switzerland (of which ~ 88% occurs within the North Sea catchment area); ni: no information.

Assessment based on national information and other sources

Germany, the Netherlands, Norway, Sweden and the UK have produced national assessments of nutrients discharged and these are given in Table 10. The data presented in Table 10 concern the marine and freshwater sectors, with the exception of Germany which has no marine production within the OSPAR Convention Area. Approximately half the aquaculture production in the OSPAR Convention Area is covered in Table 10.

Table 10 Nutrients discharged (t/yr) according to national calculations

	N	P	Method
BELGIUM	-	-	no calculation presented
DENMARK	1 320	102	calculation based on 1995 production
FINLAND	13	2	calculation based on 1995 production
GERMANY	1 925	198	calculation based on 1995 production
ICELAND	-	-	no calculation presented
IRELAND	500	60	calculation based on production*
NETHERLANDS	-	-	no calculation presented
NORWAY	14 870	2 403	calculation based on 1995 production
PORTUGAL	-	-	no calculation presented
SWEDEN	20	2	calculation based on 1994 production
UK	4 300	950	calculation based on 1995 production
TOTAL	22 948	3 717	

* Information from Warrer-Hansen (1993) was used to calculate discharges for Ireland.

Conclusions

1. The quantities of nutrients discharged from aquaculture can be calculated on the basis of feed used and production data. Since the values obtained are estimates and are likely to be lower than the actual discharges, such data can only provide an indication of the scale of nutrient release. Also, variability in the production processes used at a local level will affect the nutrient loading.

2. The data presented in this report mainly concern aquaculture within the OSPAR Convention Area. However, a proportion of the data for some countries concern activities within the Baltic and Mediterranean Seas, while data for a few countries are missing completely.

3. Nutrient discharges should be calculated separately for the various types of aquaculture; the main distinctions being between marine and brackish-water net cage farming, intensive farming in ponds, basins and channels, and extensive carp pond farming. However, the data available are not sufficient to

enable such distinctions.

4. Table 11 compares the results of applying the three methods for estimating discharges and shows that the scale of the results is more or less similar. Marine discharges are 20 000 – 36 000 t N/yr and 2000 – 6000 t P/yr. Discharges from the freshwater sector are considerably lower at approximately 2000 – 6000 t N/yr and 60 – 900 t P/yr. Discharges cannot be determined more precisely for the reasons given under points 1 – 3. The actual discharges are likely to be higher than the estimates calculated.

Table 11 Comparison of the methods for calculating the discharges of nitrogen and phosphorus (t/yr)

Method	Nitrogen			Phosphorus		
	marine	freshwater	total	marine	freshwater	total
Feed consumption	20 773 – 25 966	2 133 – 2 640	22 906 – 28 606	3 339 – 4 336	61 – 78	3 400 – 4 414
Fish production	20 694 – 36 213	3 901 – 6 007	24 595 – 42 220	2 074 – 5 685	393 – 879	2 467 – 6 564
Questionnaire	-	-	22 948*	-	-	3 717*

* total incomplete as no response to the questionnaire by France and Spain and data unavailable for the Faroe Islands.

5. Of particular importance when evaluating the ecological impact of aquaculture, apart from the type of production process used, are the characteristics of the receiving environment. In this context distinctions should be made between marine and brackish waters, Scottish lochs, major lakes, carp ponds of various sizes and flowing water, as well as major and minor watercourses.

6. Incomplete and missing data were the main factors preventing a complete assessment of nutrient discharges from aquaculture within the OSPAR Convention Area.

ENVIRONMENTAL LEGISLATION RELEVANT TO THE ESTABLISHMENT AND OPERATION OF FISH FARMS

The information concerning environmental legislation relevant to aquaculture supplied by Contracting Parties in response to the questionnaire is insufficient. Additional (but less current) information is available from the European Commission (EC, 1995).

Licensing Procedures

The environmental impact resulting from the nutrient discharges must be evaluated within a local context. Freshwater aquaculture mainly affects minor watercourses, particularly in terms of silting and oxygen depletion. Discharges from marine farms and installations in lakes can cause eutrophication. Environmental obligations must therefore focus on the impacts likely in each individual case. Careful choice of locations for aquaculture facilities is vital to avoid environmental impact.

Belgium

According to Belpaire *et al*. (1992) licensing procedures in Belgium differ between Flanders and Wallonia. In Flanders the government licensing policy for environmental protection (drawn up by the Ministry of the Flemish Community) was, for many years, fragmented, complex and involved many different procedures. To address the complexity and to incorporate EC Directives the Flemish Environmental Licensing Regulation (VLAREM) was established; its responsibilities include exploitation and effluent discharge permits. Nevertheless, aquaculture legislation is either unknown or mostly non-existent. Other Flemish authorities concerned with aquaculture legislation are those dealing with area planning, import/export permits and quality control of consumer goods investment subsidies. In Wallonia there are no specific regulations concerning the discharge of effluents from fish farms. If an effluent discharge licence is required it is obtained from the regional administration on the basis of a form filled out by the farmer (Belpaire *et al*., 1992).

Denmark

Marine fish farming is regulated by Statutory Order No. 640 17 September 1990 which contains the necessary power to regulate site selection and discharges etc. For the freshwater environment the Danish Order on Fresh Water Fish Farms exists. The Order stipulates a set of measures and requirements for administrative purposes. The headings of the measures are given in Chapter 6 of the OSPAR report on 'Nutrients in the Convention Area' (OSPAR, 1995).

Finland

Each fish farm requires a permit. Farms with low production (~ 5000 –10 000 kg fish/yr) obtain this from the local authority, bigger farms obtain their permits from the water court. The permits specify factors such as farm size, feed used, nutrient discharges and monitoring activities.

France

No response to the questionnaire.

Germany

The legal basis for licensing fish farms is specified in the *Wasserhaushaltsgesetz* (WHG, the German Federal Water Act) and the *Bundesnaturschutzgesetz* (the *BNatSchG*, the Federal Nature Conservation Act). The *29 Allgemeine Verwaltungsvorschrift über Mindestanforderungen an das Einleiten von Abwasser in Gewässer* (*Fischintensivhaltung*) (the *29 AbwasserVwV*, the 29th General Administrative Regulation on Minimum Requirements for the

Discharge of Waste Water into Watercourses (intensive fish farming)) is applied in conjunction with the WHG. The *29 AbwasserVwV* only applies to wastewater originating from fish farming installations, not to fish farming in natural waters. It sets emission limit values for various substances; sedimenting substances must not exceed 0.3 ml/l, a 2 hr mixed sample for chemical oxygen demand (COD) must not exceed 30 mg/l and a 2 hr mixed sample for biological oxygen demand (BOD) must not exceed 10 mg/l. This regulation is currently being revised and is planned to include requirements for nitrogen and phosphorus.

If polluted water is discharged directly into a water body, the *Abwasserabgabengesetz* (the *AbwAG*, the German Waste Water Charges Act) is applied. Charges are determined on the basis of the quantity and harmfulness of the constituents discharged. The act sets very ambitious threshold values for individual classes of substances.

The licensing authorities for the establishment and operation of fish farms are the regional water authorities, which abide by the provisions of *Landeswassergesetz* (the Water Acts of Federal States) in setting conditions. The result is different licensing regulations for the setting up and operation of aquaculture installations in individual Federal States. The *Landeswassergesetz* is particularly concerned with the drawing off and reintroduction of water. Operating permits are subject to time limits. The keeping of operating records of production data, and regular inspection may be imposed on producers. Water inspection covers: temperature, pH, oxygen consumption (BOD_5, COD), nitrogen (NH_4-N, NO_3-N), phosphorus (PO_4-P, P_{total}) and substances which can be filtered off.

Iceland

The legal basis for the licensing of aquaculture installations is the 1994 decree on pollution control. Permits for setting up and operating aquaculture installations are dependent on size and are granted either by local health authorities or by the central Icelandic environment and food authority. Production quotas, effluent limits and conditions for the treatment of wastewater may be set.

Ireland

No response to the questionnaire.

Luxembourg

No information presented.

The Netherlands

Environmental obligations cover potential changes to water quality. The licensing procedure includes requirements for BOD, COD, phosphate, nitrogen (N-KJELDAHL: 10 – 15 mg/l; NO_2-N/NO_3-N: 200 mg/l), chloride and suspended particles. Additional requirements concern the quantity of water which may be drawn off and specific water cleaning procedures.

Norway

As part of the licensing process the installation operator must demonstrate that no negative environmental effects are expected from the operation of the installation and that waste disposal is ensured. Licences are granted for those areas where there is no risk of eutrophication, where there is no sedimentation and where there is sufficient oxygen. This is the case for areas with a sufficient exchange of water. Ninety-five percent of Norwegian aquaculture installations are therefore located north of Stavanger. Also, no installation may be established near rivers containing wild salmon stocks. There are also regulations governing installation capacity and fish density.

Portugal

The environmental authorities undertake the licensing process in accordance with Law 74/90, Law 261/89 and Decree 980-A89.

Spain

No response to the questionnaire.

Sweden

Individual licences for setting up systems are granted in accordance with the laws governing fisheries and the environment.

Switzerland

Fish farms need a licence according to the fisheries legislation; the other environmental authorities also contribute to the licensing process.

United Kingdom

All information for the UK refers to Scotland and originates from the Scottish Environmental Protection Agency (SEPA), which undertakes a range of licensing and regulatory activities for the regions West, East and North.

SEPA West: According to the ADRIS Report, in future, location and water quality should be criteria in the licensing of net cage systems. Planning consent is required for stationary systems. Licensing takes place in accordance with relevant EC Directives. Furthermore, there must be no significant worsening of water quality, compatibility with all other current and potential usage options must be guaranteed and the freedom of movement of wild fish must not be hindered. Water quality is subject to specific requirements: BOD may not increase to more than 2 mg/l, or the proportion of suspended particles may not fall to 5 mg/l and the oxygen content must not be reduced by more than 10%. There are maximum levels of 0.5 mg/l for ammonium and 0.05 mg/l for phosphate. The concentration of oils must not exceed

5 mg/l and there must be no visible film of oil on the water. Overall environmental impact must be kept to a level which is so low that there is no discernible growth of algae and fungi which can be traced to the discharge of wastewater.

Environmental Obligations for the Operation of Fish Farms

Belgium

In Flanders levies are imposed where water is polluted. Intensive fish farms are required to obtain an effluent discharge licence. They are required to pay levies on the amount of pollution these effluents cause. The levies can be calculated by different methods (Belpaire *et al*., 1992). Normally, the Flemish Environmental Company measures the effluent once a year, continuously for three nights. In Wallonia there are no specific regulations or levies concerning fish farm effluents. Some methods of calculating levies are under consideration.

Denmark

Statutory Order No. 640 17 September gives the power to the regional authorities to monitor and supervise fish farms. In accordance with the Order freshwater fish farms must also submit to the county authorities once a year information on annual production and feed consumption, as well on the internal control of discharge limits (as a minimum two samples a year and in many cases six samples a year). The fish farms are also required to keep an operation record. The county authorities are obliged to undertake control visits at the farms at least once a year and to undertake an impact survey at the discharge site. They are also required to undertake an extended investigation of loading at at least 10% of the farms each year, this being partly based on the results of the internal control. The county authorities use the internal control data and the results of the loading investigations to calculate organic matter, nitrogen and phosphorus loading from the farms. This information is submitted to the Danish EPA for incorporation into the annual report on the Nation-wide Monitoring Programme. As far as possible the submission of these data is coordinated with the submission of other data relating to the Statutory Order.

Finland

Requirements are included in the permit. Farms are required to maintain records and to undertake monitoring activities. The information obtained must be sent to the local authority each year. Farms which do not fulfil their obligations may be taken to court.

France

No response to the questionnaire.

Germany

The regional water authority sets environmental obligations in conjunction with the granting of an operating permit. In setting its provisions, the authority is guided by the water legislation of each Federal State. Environmental obligations are usually controlled by public authorities but may also take the form of self-regulatory measures, such as the keeping of operating records. These logs provide information about day-to-day production operations, as well as the results of water tests conducted by the operator itself.

Iceland

Regulatory visits and monitoring are carried out in addition to inspection of the farms' records.

Ireland

No response to the questionnaire.

Luxembourg

No information presented.

The Netherlands

The environmental obligations laid down in the licence are subject to self-regulation and are monitored by official checks.

Norway

Self-regulation takes place in the form of an annual report containing data on fish stocks, mortality, escaped fish, waste treatment, feed and chemical usage. The environmental authorities make regulatory visits. The veterinary and fishery authorities also provide further regulatory systems.

Portugal

A monitoring programme, regulatory visits and various other requirements are undertaken in accordance with regulation no. 74/90 of 7 March 1990.

Spain

No response to the questionnaire.

Sweden

All farms with an annual production of > 10 t must produce annual reports. Environmental monitoring is also carried out at such farms. Regulatory visits are made by representatives of the authorities.

Switzerland

No information presented.

United Kingdom

SEPA West: Monitoring is based on the recommendations of the ADRIS Reports. At net cage farms, farm records are kept and official inspections take place. Self-regulation takes place at larger farms and farms in sensitive areas. The volume of feed per net cage has an upper limit. Stationary systems are monitored by SEPA. Discharge water is analysed four times a year. Measurements are taken for temperature, turbidity, BOD, pH, ammonium, conductivity, oxidised nitrogen, total phosphate and phosphate-phosphorus. Four times a year, all the parameters given above (excluding total phosphate and oxygen content, alkalinity, overall hardness, nitrites, nitrates and chloride) are measured upstream and downstream of the farm. Biological monitoring encompasses benthic invertebrates and the growth of algae and fungi. However, no operating records are kept on the use of chemicals and feed.

SEPA North: Marine net cages are subject to self-regulation. This includes the use of video monitoring of the seabed, chemical and biological monitoring, monitoring stocks of drugs, and the keeping of operating records on production, mortality, and the number and location of cages.

SEPA East: In bodies of flowing water there is both chemical monitoring, which records suspended particles, BOD, ammonium and toxic substances, and biological monitoring, which records trophic and toxic indications in macroinvertebrates. Discharge water may also be tested. Problems arise in particular with silting. However, static water is threatened by eutrophication, and therefore particularly sensitive to inorganic substances discharged by aquaculture. Water and sediment near the cages are checked once a year, and trophic parameters such as chlorophyll-a are measured at the outflow of lochs.

RESEARCH ON POSSIBLE ENVIRONMENTAL EFFECTS

State of Research within OSPAR Countries

Belgium

Exact data on fish production are not known. This is the first requirement for further research. A ‘Code of good practice in aquaculture’ is currently being prepared. Several research groups are active in the different fields of aquaculture, e.g. larviculture, the production of non-commercial species for restocking and reintroduction, nutrition, genetics and disease.

Denmark

No further measures or research are reported.

Finland

Eutrophication is investigated by monitoring programmes.

France

No response to the questionnaire.

Germany

Measures concern the reduction of the nutrient and environmental load, and licensing procedures. Possible measures may include:

- the improvement and harmonisation of the official licensing procedures (permits, obligations);
- the improvement and harmonisation of official monitoring activities; and
- the reduction of the nutrient and environment load by:
  - improving the quality of feed (a target N content of 7.5% and a target P content of 1%);
  - feeding techniques; and
  - filtration technology and systems.

There are only a few research projects which concentrate on the effects of intensive farming, cleaning of wastewater and improving feed quality. Research subjects and required research named by individual Federal States include:

a. the effects of intensive farming:
   - ecological effects on different areas of flowing water, on wild fish stocks and on the benthos;
   - assessment of nutrient discharge and load from certain types of fish farms;

b. the cleaning of wastewater:
   - cleaning capacity of settlement systems and micro-sieves;
   - studies on the use of sieve drum filters in channel systems;
   - studies on the use of collection pans under net cages;

c. improving feed quality:
   - influence of the feed on the compactness of fish faeces;
   - reduction of N and P loads by improving the amino-acid composition in feed;

- limiting the protein-saving effect of fat supplements with reference to growth and meat quality; and
- reduction of P load through the substitution of fish meal with other protein components.

Iceland

No further measures or research are reported.

Ireland

No response to the questionnaire.

Luxembourg

No further measures or research are reported.

The Netherlands

No further measures or research are reported.

Norway

Environmental quality standards are currently being determined and monitoring procedures developed. Computer models relating to nutrient discharges and environmental effects are being developed.

Portugal

No further measures or research are reported.

Spain

No response to the questionnaire.

Sweden

No further measures or research are reported.

Switzerland

No further measures or research are reported.

United Kingdom

No further measures or research are reported.

Conclusions regarding Eutrophication Problem Areas and a BAT/BEP Document

Nutrient Discharges in Eutrophication Problem Areas

Only a proportion of the aquaculture undertaken by Contracting Parties occurs in the eutrophication problem areas identified in the OSPAR report 'Nutrients in the Convention Area' (OSPAR, 1995). Aquaculture is undertaken in eutrophication problem areas by Belgium, Denmark, the Netherlands, Germany (on its North Sea coast – *c.* 16 000 t), France (on parts of the North Sea coast), Sweden (the western part – *c.* 200 t) and Norway (the southern part – *c.* 16 500 t). France did not respond to the questionnaire so further specification of the estimated data might be necessary.

At present aquaculture data for Finland, Iceland, Portugal, Spain and the UK do not concern the eutrophication problem areas as currently defined. In 1997 OSPAR adopted a Common Procedure for the Identification of the Eutrophication Status of the Maritime Area (OSPAR 1997). The purpose of this procedure is to characterise the maritime area in terms of problem areas, potential problem areas and non-problem areas with regard to eutrophication. The results of applying this procedure may identify new problem areas, and potential problem areas, in which aquaculture is currently taking place. These results are expected to become available in 2002 and will be presented to OSPAR 2003.

According to Table 12 nutrient discharges from aquaculture currently exceed 5000 t N/yr and 780 t P/yr within the eutrophication problem areas as currently defined.

Table 12 Nutrient discharges from aquaculture (t/yr) within Eutrophication Problem Areas

	Marine			Freshwater		
	production	discharge		production	discharge	
		N	P		N	P
BELGIUM	0	0	0	2 125	85 – 149	9 – 23
DENMARK	667	27 – 47	3 – 7	ni	ni	ni
FRANCE*	ni	ni	ni	ni	ni	ni
GERMANY	0	0	0	16 670†	1 133 – 1 433	113 – 183
NETHERLANDS	0	0	0	2 710	108 – 190	11 – 30
NORWAY	16 508‡	1 981 – 3 467	198 – 545	ni	ni	ni
SWEDEN	200§	8 – 14	1 – 2	ni	ni	ni

The data in this table are based on calculations using production data (see Table 9).

* no response to the questionnaire at Appendix 1; † approximately two-thirds of German production takes place within Eutrophication Problem Areas; ‡ 5% of Norwegian production takes place within Eutrophication Problem Areas; § 200 t of Swedish production occurs within Eutrophication Problem Areas; ni: no information available.

Estimated Nutrient Inputs to the OSPAR Convention Area

Tables 13 and 14 present an overview of estimated nutrient inputs from the major sources to the OSPAR Convention Area. These tables highlight the relative importance of the aquaculture sector compared to the other relevant sectors: agriculture, municipal wastewater treatment, detergents, industry and atmospheric emissions.

For most Contracting Parties the nutrient discharges from aquaculture are lower than for the other sectors. Nevertheless on a regional level, and especially at the farm level, these discharges may be relatively significant. For Denmark and Norway discharges from marine aquaculture are of greater significance; in Denmark discharges from aquaculture correspond to 4 – 6% of the total N and 13 – 29% of the total P discharges, while in Norway these correspond to 40 – 54% and 65 – 83%, respectively. Although the aquaculture sector is particularly important in the UK, comparable figures were not available due to insufficient data.

Recommendations for a BAT/BEP Document

In recent years concern about the environmental impact of aquaculture has become a major issue (FAO 1995a), for example in relation to the development of eutrophication in sensitive areas. Eutrophication problems may result from high waste loads and nutrient effluents from fish farms. The main effects associated with eutrophication are:

- nutrient enrichment;
- organic enrichment (silting and sedimentation);
- oxygen depletion in the water column, and within and above the sediments; and
- changes in benthic biomass and community structure.

There are very few published estimates of nutrient release from fish culture and their associated environmental effects. Those that do exist concern salmonids; principally trout in freshwater and salmon in coastal water (FAO, 1995a; Handy and Poxton, 1993, Saroglia and Poxton, 1995).

Waste loads and nutrient discharges can be reduced using different approaches. Stellwagen and Kelly (1994) compared waste loads from Scottish and Danish farms and found that high feed use and the nutrient content of feed were the main factors responsible for high waste loads. They found water treatment using settlement ponds to be inadequate, since these installations appeared to encourage nutrient release after material had been allowed to accumulate for a relatively short period. Their findings suggest that waste treatment should be site-specific rather than region-specific. Handy and Poxton (1993) proposed three methods for reducing nitrogen inputs via feed: by minimising the time food spent in the water (by maximising the appetite of the fish and using an efficient dispersion method), by improving the stability of the feed and by using feed appropriate to the feeding behaviour of the species farmed (e.g. extruded pellets – floating, compressed pellets – sinking).

There is an urgent need for a further exchange of information, due to:

- little information on the subject (see for example FAO, 1995a; Saroglia and Poxton, 1995);
- requests for information on discharges from aquaculture in relation to PARCOM Recommendation 94/6 (OSPAR, 1994); and
- data gaps resulting from missing responses to the questionnaire.

Table 13 Estimated nitrogen emissions (tonnes) in the OSPAR Convention Area for 1995

Sector	BELGIUM	DENMARK	FRANCE	GERMANY	NETHERLANDS	NORWAY	SWEDEN	SWITZERLAND	UK
Agriculture	< 35 350	50 000	180 000*	270 000†	116 000*	9 827‡	15 000	8 700*	ni
Municipal Treatment Plants	28 200	2 700	ni	148 500†	31 500	8 160	5 500	17 000§	ni
Detergents	-	-	ni	-	-	-	-	-	-
Industry	18 000	1 200	ni	40 500†	8 500	1 500‡	800	< 1 000	ni
Aquaculture:									
Estimate based on production‖									
marine	n	375 – 653	2 170 – 3 798	n	n	13 206 – 23 111	ni	n	3 050 – 5 337
freshwater	85 – 149	1 312 – 2 297	437 – 765	1 700 – 2 150	108 – 190	ni	94 – 165	46 – 81¶	n
Estimate based on feed**									
marine	ni	36 – 45	ni	ni	2	16 478 – 20 597	18 – 23	ni	3 672 – 4 590
freshwater	ni	1 171 – 1 464	ni	479 – 574	107 – 133	10 – 12	ni	ni	161 – 201
Estimate by OSPAR (1995)	n	1 270	ni	n	n	12 100††	25‡‡	n	ni
TOTAL§§	81 635 – 81 699	55 587 – 56 850	182 607 – 184 563	460 700 – 461 150	156 110 – 156 192	32 709 – 42 618	21 412 – 21 488	26 746 – 26 781	353 211 – 355 538
Atmospheric emissions	192 700	162 000	462 300‖‖	1 395 000	274 000	101 136	94 400	83 300	860 000¶¶

* provisional estimate; † data for the original federal states only; ‡ data for problem areas only; § 1989 data; ‖ unpublished data for 1996 produced by UBA; ¶ refers to the whole of Switzerland (of which ~ 88% occurs within the North Sea catchment area); ** based on data supplied by Belgium, Denmark, Germany, Netherlands, Norway, Sweden and the UK, and on FAO data for France and Switzerland (FAO 1997a,b); †† 1991 data; ‡‡ 1985–87 data; §§ total based on estimated inputs from aquaculture using production data; ‖‖ 1992 data; ¶¶ ammonia inputs from agriculture not included; ni: no information; n: negligible.

Table 14 Estimated phosphorus emissions (tonnes) in the OSPAR Convention Area for 1995

Sector	BELGIUM	DENMARK	FRANCE	GERMANY	NETHERLANDS	NORWAY	SWEDEN	SWITZERLAND	UK
Agriculture	< 1 680	530	21 000*	13 500†	6 400*	202‡	270	305*	ni
Municipal Treatment Plants	4 800	700	ni	9 900†	3 700	408	130	< 1 000§	ni
Detergents	n	n	24 557‖	n	n	n	n	n	n
Industry	3 400	120	ni	4 500†	6 800	113‖	50	< 30	ni
Aquaculture:									
Estimate based on production¶									
marine	n	42 – 97	217 – 597	n	n	1 321 – 3 632	ni	n	305 – 839
freshwater	9 – 23	132 – 360	44 – 120	170 – 275	11 – 30	ni	9 – 26	5 – 13**	n
Estimate based on feed††									
marine	ni	6 – 7	ni	ni	n	2 646 – 3 436	3 – 4	ni	589 – 766
freshwater	ni	33 – 43	ni	12 – 16	3 – 4	< 1	ni	ni	5 – 6
Estimate by OSPAR (1995)	n	108	ni	n	n	1 600‡‡	3§§	n	ni
TOTAL‖‖	9 889 – 9 903	1 524 – 1 807	45 818 – 46 274	28 070 – 28 175	16 911 – 16 930	2 045 – 4 356	462 – 480	1 340 – 1 348	28 310 – 28 845
Atmospheric emissions	ni	ni	ni	ni	ni	ni	ni	ni	ni

* provisional estimate; † data for the original federal states only; ‡ data for problem areas only; § 1989 data; ‖ 1994 data; ¶ unpublished data for 1996 produced by UBA; ** refers to the whole of Switzerland (of which ~ 88% occurs within the North Sea catchment area); †† based on data supplied by Belgium, Denmark, Germany, Netherlands, Norway, Sweden and the UK, and on FAO data for France and Switzerland (FAO 1997a,b); ‡‡ 1991 data; §§ 1985–87 data; ‖‖ total based on estimated inputs from aquaculture using production data; ni: no information; n: negligible.

Despite the work of several international organisations on this topic (e.g. EIFAC, FAO, HELCOM and ICES) a complete and reliable dataset on nutrient discharges from aquaculture is not yet available. An exchange of data concerning aquaculture production is required, especially in relation to the associated nutrient discharges from this sector. This should take place under the umbrella of the Harmonised Reporting Procedure for Nutrients (HARP).

A BAT/BEP[1] background document for the consideration of environmental assessments of fish farming, with special regard to eutrophication problem areas, is currently being prepared by Germany.

With regard to 'Nutrients in the Convention Area – Overview of Implementation of PARCOM Recommendation 88/2' (OSPAR, 1995) (which shows the current eutrophication problem areas within the OSPAR Convention Area) and 'PARCOM Recommendation 94/6 on Best Environmental Practice (BEP) for the Reduction of Inputs of Potentially Toxic Chemicals from Aquaculture Use' (OSPAR, 1994), the following subjects should be included in the BAT/BEP:

1. A list of the possible environmental effects of fish farming.
2. The scale of the environmental effects.
3. Nutrient discharges from fish farms.
3.1 A description of existing fish farm systems, with particular regard to nutrient release, for example land-based farms, water-based farms, species farmed, filtration techniques used.
3.2 The establishment of possible emission standards, in relation to farming systems and location.
3.3 Measures to reduce impacts on water and environmental quality, such as optimising feed composition, feeding technique, food conversion rate, site selection, filtration techniques and fish density limits.
3.4 The implementation of certain licensing procedures/legislation.
3.5 The monitoring of environmental effects, for example nitrogen and phosphorus concentrations at and near fish farming sites.

Possible measures to reduce the environmental impact of aquaculture in eutrophication problem areas, as a part of a possible BAT/BEP document, are summarised in Table 15. These are grouped according to measures to improve aquaculture activities, recommendations for their management and the monitoring of environmental impact at production sites.

---

[1] BAT: Best Available Technology; BEP: Best Environmental Practice.

Table 15 Measures to improve aquaculture activities, in relation to the development of BAT/BEP to reduce nitrogen and phosphorus discharges from aquaculture in eutrophication problem areas

MEASURE	AIM
1. Changes to operating procedures	
Production site:	The production systems used should be appropriate to their location. Aquaculture should not take place in sensitive areas.
Species farmed:	The species farmed should be appropriate to their location in terms of food conversion rates, excretion rates and the age of fish.
Fish density:	Fish density should be restricted according to the aquaculture system used and the production site (e.g. in terms of distance between groups of cages).
Quantities produced:	Restrictions should be imposed concerning the total size of a farm, production sites per locality and total quantity of fish produced. These will depend on the production site and the environmental effects of particular aquaculture systems.
Wastewater treatment/filtration type:	Wastewater treatment types (e.g. mechanical, gravitational, chemical and biological) should be established for particular aquaculture systems.
Suspended solids:	Suspended solids should be removed within production systems.
Feed waste:	Feed waste should be minimised (e.g. by the establishment of a ratio for: used feed/feed waste.
Quantity of feed:	Restrictions should be imposed on the quantity of feed used according to the production site, the quantities and type of species farmed, and the aquaculture system and wastewater treatment used.
Feed:	Improvements should be made concerning food conversion by: decreasing the concentration of indigestible components, increasing the digestibility of nutrients, increasing the dietary digestible energy content and optimising the: dietary digestible protein : digestible energy ratio; and optimising the dietary balance of indispensable nutrients.
Feeding technique:	The feeding techniques should be optimised according to the species farmed and aquaculture system used in order to reduce feed waste.
2. Recommendations for Management	
Emission standards for nutrient release:	Emission standards should be established according to farm type.
Reporting scheme:	Consecutive actualisation of data concerning measures listed under points 1 and 3.
Legislation and licensing procedure:	Legislation and licensing procedures should be standardised.
3. Monitoring of Environmental Impacts at Production Sites	
Overview of all discharges:	As there are few data on the environmental impacts of particular production systems, research data should be reported to OSPAR. Data from authorities and farmers could be a supplementary source of useful information.
Changes in nitrogen levels:	Monitoring of environmental impacts.
Changes in phosphorus levels:	Monitoring of environmental impacts.
Dissolved oxygen:	Monitoring of environmental impacts.
Biological Oxygen Demand:	Monitoring of environmental impacts.
Chemical Oxygen Demand:	Monitoring of environmental impacts.
Estimation of organic waste:	Monitoring of environmental impacts.
Silting:	Monitoring of environmental impacts.
Other possible effects of eutrophication, e.g. algal blooms:	Monitoring of environmental impacts.

Other material of possible relevance to the development of a BAT/BEP document on aquaculture, is being prepared (FAO, 1997d):

- 'Guidelines for the development and management of inland fisheries';
- 'Guidelines and criteria for responsible enhancement measures for culture-based fisheries';
- 'Technical guidelines for good aquaculture feed manufacturing practice'; and
- 'Guidelines on the integration of agriculture, forestry and fisheries into coastal management'.

Several articles of the FAO Code of Conduct for Responsible Fisheries (FAO, 1995b; FAO, 1997d) are of relevance to aquaculture:

> Article 9.1.5: 'States should establish effective procedures specific to aquaculture to undertake appropriate environmental assessment and monitoring with the aim of minimising adverse ecological changes and related economic and social consequences resulting from water extraction, land use, discharge of effluents, use of drugs and chemicals, and other aquaculture activities.'
>
> Article 9.2.4: 'States should establish appropriate mechanisms, such as databases and information networks to collect, share and disseminate data related to their aquaculture activities to facilitate cooperation on planning for aquaculture development at the national, subregional, regional and global level.'
>
> Article 9.4.3: 'States should promote efforts which improve selection and use of appropriate feeds, feed additives and fertilisers, including manure.'

REFERENCES

Bauer, A. 1997. Bilanzierung der Nährstoffeinträge aus Aquakulturanlagen der Bundesrepublik Deutschland. Unpubl. Umweltbundesamt. Berlin.

Belpaire, C., Denayer, B. and Gerard, P. 1992. Aquaculture production and regulation of fish farm effluents in Belgium.

EC, 1995. *Aquaculture and the environment in the European Community*. European Commission, Directorate-General for Fisheries. Brussels. 89 pp.

FAO, 1995a. Review of the state of world fishery resources: aquaculture. *FAO Fisheries Circular No. 886*. United Nations, Food and Agriculture Organisation. Rome.

FAO, 1995b. *Code of conduct for responsible fisheries*. United Nations, Food and Agriculture Organisation. Rome.

FAO, 1997a. *Aquaculture Production Statistics 1986–1995*. United Nations, Food and Agriculture Organisation. Rome.

FAO, 1997b. *FAO Yearbook. Fishery Statistics. Catches and landings 1995. vol. 80*. United Nations, Food and Agriculture Organisation. Rome.

FAO, 1997c. Reports on the symposium on social, economic and management aspects of recreational fisheries and the intersessional working parties` meetings. *FAO*

Fisheries Report No. 541, *Suppl*. United Nations, Food and Agriculture Organisation. Rome.

FAO, 1997d. Aquaculture development. *FAO technical guidelines for responsible fisheries 5*. United Nations, Food and Agriculture Organisation. Rome.

Handy, R.D. and Poxton, M.G. 1993. Nitrogen pollution in mariculture: toxicity and excretion of nitrogenous compounds by marine fish. *Reviews in Fish Biology and Fisheries*, 3: 205–41.

Hering, G. and Köhn, J. 1999. Die Auswirkungen von mariner Fischmast in Netzkäfigen auf Meeresorganismen und marine Lebensgemeinschaften. Study for the Bundesamt für Naturschutz. Bon-Bad Godesburg.

Hilge, V. 1997. A contribution to the role and importance of inland fisheries in Germany. *Fortschr*. *Fischwiss*. 13: 11–18.

ICES, 1996. Report of the working group on environmental interactions of mariculture. International Council for the Exploration of the Sea. Copenhagen.

Knösche, R., Schreckenbach, K., Pfeifer, M. and Weißenbach, H. 1997. Phosphor- und Stickstoffbilanzen von Karpfenteichen. *Fischer*. *Teichwirt*. 7: 290–3.

Lukowicz, M. von 1994. Site selection and regulation issues for trout and carp farming in Germany. *J*. *Appl*. *Ichthyol*. 10: 312–18.

Norges Forskningsrad/DNV, 1994. Environmental issues of marine salmon and trout farming. A position paper. Veritas Miljøplan. Oslo.

OSPAR, 1994. PARCOM Recommendation 94/6 on Best Environmental Practice (BEP) for the Reduction of Inputs of Potentially Toxic Chemicals from Aquaculture Use. Oslo and Paris Commissions, London.

OSPAR, 1995. *Nutrients in the Convention Area*. Overview of Implementation of PARCOM Recommendation 88/2. Oslo and Paris Commissions, London.

OSPAR, 1997. Common procedure for the identification of the eutrophication status of the maritime area. Oslo and Paris Commissions, London. Internal meeting document, OSPAR 97/15/1 Annex 24.

OSPAR, 1998. The extent and impact of fisheries directed at gastropods and bivalves. OSPAR Commission, London. Internal meeting document, IMPACT 98/04/01.

Rennert, B. 1993. Untersuchungen zur Gewässerbelastung durch Fischzuchtanlagen. *Fortschr*. *Fischwiss*. 11: 83–90.

Rennert, B., Steffens, W., Hack, H., Tillack, A. and Kunow, M. 1996. Die Nährstoffdynamik in der modernen Aquakultur am Beispiel der Zucht von Regenbogenforellen (*Oncorhynchus mykiss*). Annual report 1994/95. Institut für Gewässerökologie und Binnenfischerei. Berlin-Friedrichshagen.

Rosenthal, H., Hilge, V. and Kamstra, A. (Eds.) 1993. Report of the workshop on fish farm effluents and their control in EC countries. Kiel.

Rosenthal, H., Schnack, D. and Hilge, V. (Eds.) 1994. Proc. workshop on fish farm effluents. *J*. *Appl*. *Ichthyol*. 10(4): 215–390. Special issue.

Saroglia, M. and Poxton, M. 1995. Effects of feeding strategies on the internal and external water quality impacts of extensive aquaculture. Report within the EEC Research Programme in the Fisheries Sector. Contract No. AQ-2-580.

Stellwagen, J. and Kelly, L. 1994. Summary of a confidential report within the EEC Research Programme in the Fisheries Sector. Contract No. AQ-2-431.

UBA, 1996. Die Einflüsse der Fischerei und Aquakultur auf die marine Umwelt. UBA-Texte 46-96. Umweltbundesamt, Berlin.

Vollenbroek, F.A. 1993. Control of fish farm effluents in the Netherlands. In: Report on the workshop on fish farm effluents and their control in EC countries. Ed. by H. Rosenthal, V. Hilge and A. Kamstra, Kiel.

Warrer-Hansen 1993. Federation Européenne de la Salmoniculture – position paper on fish farm effluents and their control in EC countries. In: Report on the workshop on fish farm effluents and their control in EC countries. Ed. by H. Rosenthal, V. Hilge and A. Kamstra, Kiel.

Appendix 1 Questionnaire on nutrient discharges from fish and shellfish farming

If total freshwater production is included this will lead to an overestimation of the total nutrient discharges to the receiving waters, particularly coastal habitats. This is because a large proportion of freshwater production takes place in stillwater ponds (particularly for carp farming) where nutrients are recycled. A limited and seasonal water exchange may occur (e.g. pond cleaning or winter drainage). These scenarios may be re-evaluated at a later stage.

Each Contracting Party is asked to present information on the calculation methods used.

COUNTRY:

YEAR:

Sub-area: (for coastal activities if available)

1. Species cultivated and total annual production

a. species produced in grow-out facilities (t/yr)

Data to be given as produced biomass including losses (dead fish). If data are not available for individual species, then it should be supplied for species groups.

- salmonids in cages and raceways (optional: (a) net production (b) total production);
- cyprinids;
- shellfish;
- others.

b. species produced in hatcheries for stocking purposes (e.g. sport fishing, lake and river stocking, sea ranching) (t/yr)

- species;
- quantity (either numbers or on weight basis).

2. Number of fish and shellfish farms

a. marine systems:

- number of licensed cage farm sites;
- net cages (total number in the jurisdiction);
- number of licensed onshore farms;
- wastewater treatment facilities;
- number of fish farms which practice sludge removal;
- floating tanks/basins near shore;
- tanks/basins/ponds discharging directly to the sea.

b. freshwater systems:

- total number of farms;
- pond farms;
- raceway farms;
- indoor hatcheries;
- cages in lakes and reservoirs;
- wastewater treatment facilities;
- number of fish farms which practice sludge removal.

3. Total feed consumption

If possible according to the following categories:

a. marine systems:

- > 90% dry organic matter (t/yr dry feed);
- 80 – 90% dry organic matter (t/yr dry feed);
- 35 – 80% dry organic matter (t/yr semi-moist feed);
- < 35% dry organic matter (t/yr moist, fresh feed).

b. freshwater systems (excluding stillwater ponds):

- > 90% dry organic matter (t/yr dry feed);
- 80 – 90% dry organic matter (t/yr dry feed);
- 35 – 80% dry organic matter (t/yr semi-moist feed);
- < 35%dry organic matter (t/yr moist, fresh feed).

4. Nutrient and energy content of feed

a. marine systems:

- total nitrogen (g/kg dry matter);
- total phosphorus (g/kg dry matter);
- crude protein content (g/kg dry matter);
- energy content (kJ/g).

b. freshwater systems (excluding stillwater ponds):

- total nitrogen (g/kg dry matter);
- total phosphorus (g/kg dry matter);
- crude protein content (g/kg dry matter);
- energy content (kJ/g).

5. Discharge of nutrients

Information is required on the calculation method used, including whether the nutrient discharges are estimated, measured/monitored or calculated/modelled.

- cages ([total nutrients in feed] minus [total nutrients in net production] (total N; P/total net production));
- flow-through systems (raceways, ponds etc.) (based on monitoring effluent concentrations, e.g. twice a year, 24 hr mixed sample, 2 hr intervals, multiplied by flow).

6. Environmental regulations as part of the licensing procedure

Measures taken to assess the impact of fish farms on the aquatic environment and to set limits to maximum allowable discharges from fish farms as part of the authorisation process (e.g. site selection surveys, water quality models, environmental objectives, investigations, permit conditions and limit values).

7. Environmental regulations as part of the control and monitoring procedure

Measures taken to supervise discharges and environmental effects (e.g. monitoring programmes and obligations, fish farm operation records, control visits, use of models).

8. Further measures planned (e.g. BAT) and/or need for further measures, *inter alia* to harmonise regulations (e.g. within OSPAR)

9. Need for further research

Appendix 2 Production data by species and country for 1995 (t/yr). Source: FAO (1997)

	Belgium	Denmark	Finland	France	Germany	Iceland	Ireland	Netherlands	Norway	Portugal	Spain	Sweden	Switzerland	UK	TOTAL
Freshwater fish															
Cyprinus carpio	100	0	0	5 000	14 000	0	0	0	0	0	0	0	35	13	19 148
Anguilla anguilla	125	950	0	160	0	0	0	1 535	0	10	174	158	0	0	3 112
Salmo trutta	0	250	0	1 897	2 500	10	0	0	0	0	0	6	0	345	5 008
Rutilus rutilus	0	0	0	2 500	0	0	0	0	0	0	0	0	0	0	2 500
Clarias gariepinus	0	0	0	0	0	0	0	1 019	0	0	0	0	0	0	1 019
Salvelinus spp.	0	0	0	0	0	471	0	0	289	0	0	85	0	5	850
Esox lucius	0	0	0	500	0	0	0	0	0	0	0	0	0	0	500
Stizostedion lucioperca	0	0	0	400	0	0	0	0	0	0	0	0	0	0	400
Oreochromis/Tilapia	200	0	0	0	0	0	0	0	0	0	0	0	0	120	320
Silurus glanis	0	0	0	310	0	0	0	0	0	0	0	0	0	0	310
Tinca tinca	0	0	0	0	70	0	0	0	0	0	153	0	0	0	223
Acipenseridae	1	0	0	160	0	0	0	0	0	0	0	0	0	0	161
Hypophthalmichthys molitrix	0	0	0	0	76	0	0	0	0	0	0	0	0	0	76
Coregonus spp.	0	0	0	0	0	0	0	0	0	0	0	0	26	0	26
Aristichys nobilis	0	0	0	0	12	0	0	0	0	0	0	0	0	0	12
Ctenopharyngodon idella	0	0	0	0	10	0	0	0	0	0	0	0	0	0	10
Others	0	0	35	0	0	0	0	0	444	6	0	0	0	0	485
SUB-TOTAL	426	1 200	35	10 927	16 668	481	0	2 554	733	16	327	249	61	483	34 160
Freshwater crustaceans															
Procambarus clarckii	0	0	0	0	0	0	0	0	0	0	2 200	0	0	0	2 200
Astacus spp., *Cambarus* spp.	0	160	0	0	0	0	0	0	0	0	0	12	0	0	12
Pacifastacus leniusculus	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2
SUB-TOTAL	0	160	0	0	0	0	0	0	0	0	2 200	12	0	2	2 214
Anadromous and marine fish															
Salmo salar	0	8 539	41	894	0	2 591	11 811	0	268 195	0	695	19	0	70 322	363 107
Oncorhynchus mykiss	420	41 077	17 269	48 924	22 550	379	1 473	50	13 246	948	22 000	5 772	1 100	16 134	191 342
Sparus aurata	0	0	0	984	0	0	0	0	0	417	2 706	0	0	0	4 107
Dicentrarchus labrax	0	0	0	2 656	0	1	0	0	0	265	461	0	0	0	3 383
Psetta maxima maxima	0	0	0	694	0	0	0	0	0	82	2 174	0	0	0	2 950
Mugilidae	0	0	0	0	0	0	0	0	0	1	114	0	0	0	115
Solea vulgaris	0	0	0	0	0	0	0	0	0	5	25	0	0	0	30
Thunnus thynnus	0	0	0	0	0	0	0	0	0	0	15	0	0	0	15
Seriola dumerili	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
Gadus morhua	0	0	0	0	0	33	0	0	289	0	0	0	0	0	322
SUB-TOTAL	420	49 616	17 310	54 152	22 550	3 004	13 284	50	281 730	1 718	28 191	5 791	1 100	86 456	565 372

	Belgium	Denmark	Finland	France	Germany	Iceland	Ireland	Netherlands	Norway	Portugal	Spain	Sweden	Switzerland	UK	TOTAL
Marine crustaceans															
Palaemon serratus	0	0	0	0	0	0	0	0	0	0	110	0	0	0	110
Penaeus japonicus	0	0	0	13	0	0	0	0	0	0	58	0	0	0	71
SUB-TOTAL	0	0	0	13	0	0	0	0	0	0	168	0	0	0	181
Marine molluscs															
Mytilus edulis	0	0	0	49 194	17 782	15 556	0	79 281	8	380	92 250	1 521	0	5 801	261 773
Crassostrea gigas	0	0	0	130 328	73	2 539	0	0	0	0	0	0	0	535	133 475
Mytilus galloprovincialis	0	0	0	15 000	0	0	0	0	0	0	0	0	0	0	15 000
Crassostrea angulata	0	0	0	14 000	0	0	0	0	0	652	0	0	0	0	14 652
Ostrea edulis	0	0	0	2 662	0	397	0	100	0	0	5 213	0	0	189	8 561
Ruditapes decussatus	0	0	0	200	0	103	0	0	0	1 815	5 212	0	0	0	7 330
Cardium edule	0	0	0	2 403	0	0	0	0	0	0	4 594	0	0	5	7 002
Crassostrea spp.	0	0	0	0	0	0	0	1 300	0	0	0	0	0	268	1 568
Littorina spp.	0	0	0	1 137	0	0	0	0	0	0	0	0	0	0	1 137
Ruditapes philippinarum	0	0	0	197	0	0	0	0	0	0	0	0	0	17	214
Pecten maximus	0	0	0	44	0	28	0	0	0	0	100	0	0	36	208
Chlamys opercularis	0	0	0	0	0	0	0	0	0	0	0	0	0	46	46
Veneridae	0	0	0	0	0	0	0	0	0	0	5	0	0	0	5
Others	0	0	0	0	1 191	0	0	0	0	400	0	0	0	0	1 591
SUB-TOTAL	0	0	0	215 165	19 046	18 623	0	80 681	8	3 247	107 374	1 521	0	6 897	452 562
TOTAL	846	50 976	17 345	280 257	58 264	22 108	13 284	83 285	282 471	4 981	138 260	7 573	1 161	93 838	1 054 489

These data refer to production by the country as a whole. Thus production in areas external to the OSPAR Convention area, such as the Mediterranean and Baltic Seas, are also included.

For further information about the work and publications of the OSPAR Commission, or additional copies of this report, please contact:

Pour tout renseignement sur les activités et les publications de la Commission OSPAR, ou pour tout exemplaire supplémentaire de ce rapport veuillez contacter :

The Executive Secretary
OSPAR Commission
New Court
48 Carey Street
London WC2A 2JQ
United Kingdom
Tel: 00 44 (0) 20 7430 5200
Fax: 00 44 (0) 20 7430 5225
E-mail: secretariat@ospar.org
Website: http://www.ospar.org

Price: £7.00 including postage & packing
Prix franco de port : £7.00

ISBN 0 946955 99 9