

Protocol

1A4c: CO₂, N₂O and CH₄, by Fisheries

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Foreword

Under the Kyoto Protocol, the Netherlands is required to set up and maintain a national system to monitor its greenhouse gas emissions. One of the elements of this system is a transparent and verifiable description of the methods and processes used in this monitoring system. These methods must meet international guideline criteria, which have been defined by the United Nations (UN) and the European Union (EU).

The Netherlands meets the aforementioned requirement, for example, by defining a series of Monitoring Protocols, which describe the methods and work processes used to determine greenhouse gas emissions and the amounts of carbon sinks available. Protocols have been written for about 40 greenhouse gas sources or sinks. This document describes the protocol for one of these sources or sinks.

The protocols have been compiled in close collaboration with experts from various sectors of society in the Netherlands, particularly experts from the Emissions Registration (ER). The ER is a collaborative group that includes institutions such as CBS, WUR, RIVM and PBL. Until 31 December 2009 this was coordinated by PBL (Planbureau for the Leefomgeving, or the Netherlands Environmental Assessment Agency), but on 1 January 2010 this coordination task was taken over by RIVM (the Netherlands institute for public health and the environment). Other institutions that have contributed to the protocols include NL Agency; Ministry of Agriculture, Nature and Food Quality; and the Ministry of VROM (Housing, Spatial Planning and the Environment).

1 Scope and significance of emission sources/activities

1.1 Scope and definition

The emissions are related to SBI code 0311 (sea and coastal fishing). This category includes the fuel used in sea and coastal fishing in the ocean around the Netherlands (IPCC-code 1A4c).

Diesel engines are generally used to propel fishing boats and to generate electrical power on board these vessels. These diesel engines can run on either diesel oil (a distilled product) or residual fuel oil (a residue from the refining process). The combustion processes that occur in these diesel engines cause emissions of particles that pollute the air. This protocol includes only carbon dioxide, laughing gas and methane because it mainly focuses on the immediate greenhouse gases.

Emissions from fisheries are calculated based on IPCC Tier 2 methodologies. The fuel use data from LEI is combined with country-specific emission factors for CO₂ and IPCC default emission factors for N₂O and CH₄.

1.2 Significance and influences

1.2.1 Contribution to total national emissions

The CO₂ emissions by sea and coastal fishing contribute about 1% to the Netherlands annual greenhouse gas emissions. The emissions of CH₄ and N₂O by sea and coastal fishing, each contribute less than 0.1% to the Netherlands annual greenhouse gas emissions.

1.2.2 Major developments that influence emissions

There are currently no known measures that would have a direct influence on the fuel consumption and greenhouse gas emissions of fishing boats. However, the fishing quotas set for each Member States (at EU level) do have a considerable influence on these figures. A certain amount of autonomous reduction in specific fuel consumption is also caused by the continuing increased efficiency of these diesel engines. The international standards under the IMO (International Maritime Organisation) and MARPOL (maritime pollution convention) framework (which are not further discussed here) are also important for the emission of NO_x and SO₂ particles.

2 Method, emission factors and activity data

2.1 Calculation method

The calculation method is taken from the decision diagram as shown in Figure 2.6 of the 'Good Practice Guidance' (GPG, IPCC, 2001).

Emissions are calculated separately for each type of fuel (i.e. residual fuel oil and diesel oil). It is assumed that diesel oil is used in four-stroke engines, and residual fuel oil in two-stroke engines. IPCC standard emission factors are used to calculate emissions of CO₂, CH₄ and N₂O, with the exception of the CO₂ emission factor for diesel, which is country-specific. When calculating CO₂ emissions, these are split between diesel oil and residual fuel oil.

Calculations of CO₂ can be seen in Box 2 of the GPG (Good Practice Guidelines); calculations for N₂O and CH₄ are shown in Box 1 of the GPG (IPCC, 2001).

The annual emission calculation are shown in the following formula:

$$\text{Emission} = \sum_b (\text{fuel consumption}_b \times \text{heating value}_b \times \text{emission factor}_b)$$

Where:

Emission	(ton/year)
Fuel consumption	(ton/year)
Heating value	(TJ/ton)
Emission factor	(ton/TJ fuel)
b	= type of fuel (diesel oil or residual fuel oil)

The background figures used to calculate CO₂, N₂O and CH₄ emissions from the fishing sector are published annually and updated in a *set of tables* that accompany the methodology report for calculating the emissions by mobile sources in the Netherlands [Klein et al.]. Each table in the set states which source is used for the figures. The methodology report itself contains a detailed description of the way in which emission factors and emissions are calculated.

Table 3.1 of the *set of tables* shows the fuel consumption by the fishing vessels, both the Netherlands and foreign deep-sea trawlers, split into diesel oil and fuel oil. Table 3.2 shows the emission factors used for CO₂, N₂O and CH₄.

Determining these figures using statistical data

Since the sale of fuels to the fishing industry in the Netherlands cannot be differentiated from the sale of bunker fuels (as registered by CBS), calculations are based on shipping movements. This information was supplied by the LEI (Agricultural Economic Institute), and is based on the four groups of ships for which it has gathered fuel consumption data (see Table 1).

Table 1 Types of fishing vessels and methods of gathering fuel data

Type of ship/fishing method	Fuel type	Included/excluded from climate convention	Method/source
Fishing cutters NL	Diesel	Included	Fishing (in figures)
Deep-sea trawlers in NL	Diesel+Residual fuel oil	Included	Using VIRIS (described below)
NL Deep-sea trawlers in other countries	Diesel+Residual fuel oil	Excluded	Using VIRIS (described below)
Foreign fishing vessels in NL	Diesel	Included	Using VIRIS (described below)

The diesel consumption of Dutch fishing cutters is determined based on the company information network (BIN), which is gathered and published by the LEI in its annual ‘Visserij in cijfers’ (Fishing in figures, Taal, et al., 2003). The data collection and processing methods for the other types of fishing vessels in the aforementioned table are described further in the following section because, to date, this has never been published.

A very popular method of determining fuel consumption in the fishing industry, and which is also used here for the various ‘types of ship/fishing method’ shown in Table 1, consists of the following:

Fuel purchased per fishing method = the sum of hp-days ₁ x fuel consumption per hp per day per ship
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This method is also used in other countries; see, for example, the publication ‘Energy consumed by North Atlantic Fisheries’ (Tyedmers, 2000). The above method is also used for fishing cutters, as published in ‘Fishing in figures’.

Dutch deep-sea trawlers (in the Netherlands and other countries)

In 2002 the Dutch fishing fleet of deep-sea trawlers consisted of 17 vessels. The LEI has gathered company-economic data on these vessels, including costing data for the fuel purchased. However, the amounts of fuel purchased are not known. The data from VIRIS (Ministry of Agriculture, Nature and Food Quality (LNV), 2004) are therefore used to determine both the departure and arrival ports for each ship, per fishing trip, plus the number of days at sea in each fishing area.

When determining the location of the fuel purchase it is assumed that fuel was purchased in the Netherlands after each fishing trip where the vessel departed or arrived at a Dutch port. In all other cases it is assumed that the ships purchased fuel outside the Netherlands. The main assumption is that these ships always refuelled after each fishing trip.

Using the data gathered from previous research for the shipping companies operating deep-sea trawlers, the LEI has been able to determine the fuel consumption per ship, per sea-day, for the year 2000. These consumption figures have also been applied to determine 2002 fuel purchases, using the number of sea-days for the relevant ships in 2002.

This calculation has produced a good estimate of the fuel purchased (in the Netherlands) and the fuel consumption per ship.

Foreign fishing vessels that supply the Netherlands

The foreign fishing vessels that supply the Netherlands can be split into four groups:

- a) 'co-flaggers', i.e. deep-sea trawlers sailing under foreign flags, but with a Dutch interest;
- b) 'real' foreign deep-sea trawlers, comparable to their Dutch counterparts;
- c) 'co-flaggers', i.e. cutters sailing under foreign flags but with a Dutch interest;
- d) 'real' foreign cutters, often comparable to their Dutch counterparts.

Description of the calculation method used for all the aforementioned groups

Both the departure and arrival ports, plus the number of sea-days, were first determined (per ship, per fishing trip) using the data available in VIRIS.

When determining the location of the fuel purchase it is assumed that fuel was purchased in the Netherlands after each fishing trip if the departure and arrival ports were located in the Netherlands. In all other cases it is assumed that the ship took on fuel outside Dutch borders. The main assumption is that ships always refuel after each fishing trip.

In 2002 the main engine capacities of all ships supplying the Netherlands (both 'co-flaggers' and 'real' foreign vessels) were established using the previously known data gathered by LEI on foreign vessels from the VIRIS or the Guide to Fishing Vessels (LNV, unknown), but also complemented with data from the www.ShipData.nl website (ShipData, 2004). This allowed the engine capacity of the foreign ships to be determined or, where necessary, an estimate to be made.

The average consumption figures per sea-day of the various main engines, as installed on the Dutch deep-sea trawlers, were used as a guideline when estimating the fuel purchases of the (reasonably) comparable co-flagged or foreign deep-sea trawlers. This allowed a fairly accurate estimate to be made of the fuel consumption per ship, and thus the fuel purchased per ship, in the Netherlands.

Time period: 1990 - today

At this point in time data are not available for a complete time period, because the data for 1990 are only estimated, and the data for 2002 were gathered by the LEI using the aforementioned method. However, data concerning Dutch cutter fishing were available over a complete time period.

Table 2 *Types of fishing vessels and fuel data in 2002*

Type of ship/fishing method	Diesel (kton)	Residual fuel oil (kton)
Fishing cutters NL	238	0
Deep-sea trawlers in NL	5.7	43.8
NL Deep-sea trawlers in other countries	5.0	38.0
Foreign fishing vessels in NL	68.7	0
Total IPCC	312.4	43.8

Table 3 *Types of fishing vessels and fuel data in 1990*

Type of ship/fishing method	Diesel (kton)	Residual fuel oil (kton)
Fishing cutters NL	279	0
Deep-sea trawlers in NL	8.5	42.7
NL Deep-sea trawlers in other countries	0.5	45.0
Foreign fishing vessels in NL	61.8	0
Total IPCC	349.3	42.7

Until recently the Emissions Registration has only taken account of the fuel used by Dutch fishing cutters. The fuel consumption of deep-sea trawlers and foreign fishing vessels are now added to this figure. This means that the total amount of fuel has been increase per year by 118 kton (in 2002: 5.7+43, 8+68.7) and 113 kton (in 1990: 8.5+42.7+61.8) respectively. Fuel purchased in other countries by Dutch deep-sea trawlers is not included, as per the definition in Chapter 1 of the IPCC guidelines.

Since it became necessary in 2004 to produce figures for a complete time period and for want of data, an estimate has been made of fuel consumption from 1990 through 2003. Only the first column of Table 4 and the first line (1990, plus penultimate line (2002)) refer to actual registrations.

Table 4 *Preliminary estimate of fuel consumption by fishing vessels (kton)*

Base year	Fishing cutters NL Diesel	Deep-sea trawlers Diesel	Foreign vessels Diesel	Fishing Total Diesel	Deep-sea trawlers Residual fuel oil
1990	279 ¹	8,5 ³	61,8 ³	349	42,7 ³
1991	256 ¹	8,3 ⁴	62,4 ⁴	327	42,8 ⁴
1992	271 ¹	8,0 ⁴	63,0 ⁴	342	42,9 ⁴
1993	297 ¹	7,8 ⁴	63,5 ⁴	368	43,0 ⁴
1994	310 ¹	7,6 ⁴	64,1 ⁴	382	43,1 ⁴
1995	309 ¹	7,3 ⁴	64,7 ⁴	381	43,2 ⁴
1996	279 ¹	7,1 ⁴	65,3 ⁴	351	43,3 ⁴
1997	279 ¹	6,9 ⁴	68,1 ⁵	354	43,3 ⁴
1998	260 ¹	6,6 ⁴	70,6 ⁵	337	43,4 ⁴
1999	268 ¹	6,4 ⁴	79,6 ⁵	354	43,5 ⁴
2000	270 ¹	6,2 ⁴	77,7 ⁵	353	43,6 ⁴
2001	257 ¹	5,9 ⁴	81,5 ⁵	345	43,7 ⁴
2002	238 ¹	5,7 ³	68,7 ³	312	43,8 ³
2003	238 ²	5,5 ⁴	69,3 ⁴	312	43,9 ⁴

1 From "Fishing in figures" (annual publication)

2 Assumed constant

3 Method described in Hulskotte, 2004

4 Interpolated/extrapolated

5 Estimated based on fish supplied by foreign ships (euro)

Annual definition

Henceforth the annual determination of the fuel turnover using the aforementioned methodology is implemented by the LEI, based on the data from VIRIS.

This activity therefore has been included in the contract between RIVM (Dutch National Institute of Public Health and the Environment) and LEI, with respect to supplying data for the emissions reports. Sources for obtaining periodic updates include the annual publication 'Fishing in figures' and an annual processing of the data in the VIRIS information system at LEI. The fuel consumption figures reported by the LEI after 2002, plus the added estimates concerning the years before 2002, can be found in Table 3.1 of the *set of tables* accompanying the methodology report for calculating the emissions by mobile sources in the Netherlands [Klein et al.].

2.2 Emission factors

Table 5 shows the proposed emission factors to be applied when calculating emissions by fishing vessels.

Table 5 Emission factors and heating values per fuel (gram/MJ fuel)

Fuel	Heating value MJ/kg	CO ₂ gram/MJ	N ₂ O gram/MJ	CH ₄ gram/MJ
Diesel	42.7 ¹⁾	74.3 ²⁾	0.0006 ¹⁾	0.005 ¹⁾
Residual fuel oil	41.0 ¹⁾	77.4 ¹⁾	0.0006 ¹⁾	0.005 ¹⁾

¹⁾ IPCC, 1997

²⁾ Vreuls, 2006

Table 3.2 of the aforementioned *set of tables*, that accompany the methodology report for calculating the emissions by mobile sources in the Netherlands [Klein e.a.], shows the emission factors used for CO₂, N₂O and CH₄, in grams per kilogram of fuel.

Annual definition

In theory, the aforementioned emission factors are defined for a long period of time.

Whenever any new IPCC guidelines are published, emission factors may need to be adjusted accordingly.

2.3 Activity data

Sources available for periodic updating include the annual publication 'Fishing in figures' and an annual processing of the data in the VIRIS information system at LEI.

3 Working processes

Process for estimating (t-1)

The ER produces annual preliminary emission figures for the previous year (T-1). These preliminary data are calculated by extrapolating the figures from the previous year, based on the development prognoses for the most important activity data (derived from CBS and other statistics).

Process for final determination of (t-2)

The final emission figures (as described in this protocol) are calculated using the following process.

INPUT	PROCESS STEP	OUTPUT	BY WHOM
LEI figures ¹⁾ on fuel consumption . (A) Emission factors (g/kg) (B) ²⁾	(A) x (B_{CO2}) (A) x (B_{N2O}) (A) x (B_{CH4})	CO ₂ , N ₂ O, and CH ₄ emissions by fisheries (C) Final data	Statistics Netherlands
Final data Work package leader (t-2)	Include (t-2) data in ER database	ER-db with (t-2) data	Work package leader
ER-db with (t-2) data	Check, and trend analysis of air emissions: explain deviations or modify figures	Final defined emission figures (t-2)	Task forces and PBL experts

¹⁾ LEI = Dutch Agricultural Economics Research Institute (Wageningen University).

²⁾ IPCC factors (see Chapter 7).

4 Uncertainty and quality

4.1 Estimating uncertainties

A Tier-1 uncertainty analysis is implemented every year before the NIR is submitted by the ER, based on the greenhouse gas inventory and in compliance with IPCC guidelines. The assumptions used and the results thereof are described in a background report to the NIR. In addition to this, where included in the QA/QC programme for the relevant period, extra analyses are implemented regularly in specific situations, which include any updating of the Tier-2 uncertainty analyses.

The Tier-2 uncertainty assessment was last updated in 2006. This assessment showed that a Tier-1 uncertainty assessment is sufficiently reliable and that Tier-2 uncertainty assessments need only be implemented at periodic intervals of around 5 years, unless a major change in an important source is sufficient to require earlier reassessment.

- Source-specific uncertainty

The uncertainty estimate-totaal concerns the root of the sum of uncertainty in the data sources used (AD_{onz}) in the square and the uncertainty of the emission factor (EF_{onz}) in the square. The extent of the total uncertainty is here primarily determined by the greatest AD or EF uncertainty.

$$\text{Uncertainty estimate}_{\text{total}} = \sqrt{EF_{onz.}^2 + AD_{onz.}^2}$$

The uncertainty estimates concerning the data sources (AD) and emission factors (EF) used, and the total uncertainty estimate, are listed in the following table.

IPCC	Category	Gas	AD _{onz.}	EF _{onz.}	Uncertainty estimates _{tot}
1A4c	Stationary combustion : Other Sectors, Agriculture/Forestry/Fisheries, gases	CO ₂	10	1	10
1A4c	Stationary combustion : Other Sectors, Agriculture/Forestry/Fisheries, liquids	CO ₂	20	2	20
1A	Emissies door stationaire verbranding: niet-CO ₂	CH ₄	3	50	50
1A	Emissies door stationaire verbranding: niet-CO ₂	N ₂ O	3	50	50

With respect to CO₂ emissions, an uncertainty of 10% and 20% is assumed for respectively gases and liquid fuel use in 'Off-road Machinery and Fisheries', and in the other categories under 1A4 [Olivier et al, 2009].

The energy consumption data on the total category 1A4 'Other sectors', is much more accurate than the data on the subsectors. In particular, energy consumption in the commercial subsector, and - to a lesser extent - the agricultural subsector, was less accurately monitored than in the residential sector. Therefore, trend conclusions for these subcategories should be treated with some caution. The uncertainty for the 1A4 category as a whole was estimated to be 10% in annual emissions of CO₂, the uncertainty in CH₄ and N₂O emissions was estimated to be much larger (about 50% and 100%, respectively) [Olivier et al, 2009].

4.2 Quality assurance and quality control (QA/QC)

The ER work package leaders check that:

1. the basic data are well documented and adopted (check for typing errors, use of the correct unit sizes and correct conversion);
2. the calculations have been implemented correctly;
3. assumptions are consistent, also whether specific parameters (e.g. activity data) are used consistently;
4. complete and consistent data sets have been supplied.

Any actions that result from these checks are noted on an 'action list'. Before defining the data, supervisors check whether the relevant actions on this list, plus the QC checks, have all been completed. Defining the data is carried out by the WEM (working group on emissions monitoring), and confirmed in writing via an e-mail from the institute representatives to the ER project leader at PBL.

The work package leaders fill out a new documentation sheet when adding new data. For reasons of efficiency a minimum level has been set for obligatory documentation, i.e. 5% changes at target group level, and 0.5% at levels concerning the national total. These documentation sheets form part of the trend analysis, as well as the eventual definition of the data set.

The ER work package leaders communicate by e-mail regarding these QC checks, results and actions. They send a printed copy to the ER secretary, who keeps a logbook and compiles these e-mails into an 'action list'. This shows explicitly that the required checks and corrections have been carried out.

4.3 Verification

In order to check the quality of the emission figures for the sources in this protocol, general QA/QC procedures have been followed that are in line with the IPCC guidelines. These are described further in the QA/QC programme used by the National System, and the annual working plans published by the ER.

- Sector-specific QC

No additional specific verification procedures are implemented for the sources defined in this protocol.

4.4 Possibilities for improvement compared to the current calculation method

4.4.1 History

Emission figures: 2002

Using the fuel consumption defined in Table 2 and the emission factors shown in Table 4, Table 6 shows the emissions for 2002.

Table 6 Emissions by fishing vessels, conform IPCC in 2002

Fuel	CO ₂ (kton)	N ₂ O (ton)	CH ₄ (ton)
Diesel	991	8	67
Residual fuel oil	139	1	9
Total	1130	9	76

Emissions since 1990

Using the fuel consumption figures in Table 3 and the emission factors from Table 4, Table 7 shows the emissions for 1990.

Table 7 Emissions by fishing vessels, conform IPCC in 1990

Fuel	CO ₂ (kton)	N ₂ O (ton)	CH ₄ (ton)
Diesel	1108	9	75
Residual fuel oil	136	1	9
Total	1244	10	83

Differences in methodology

The most important difference in the methodology which is currently performed (as compared to previous calculations), is that the fuel consumption by deep-sea trawlers and foreign fishing vessels are now included in the Dutch fuel purchased. This was not the case in the past.

Differences in figures

Since, until recently, the definition of emissions by fishing vessels such as these did not comply with the IPCC definition, these emissions were not included in the UNFCCC statistics. These emissions, which are derived from fuel purchased by fishing vessels, are implicitly included in the NIR reports, via the memo item for 'bunkers'. The increase in the Dutch emissions, according to the IPCC definition, is therefore equal to over 1 Mton in CO₂ equivalents. Table 8 shows the increase in emissions in CO₂ equivalents.

Table 8 Difference in emissions in de NIR reports (kton CO₂ equivalents)

Fuel	CO ₂	N ₂ O	CH ₄	Total
1990	1244	3	2	1249
2002	1130	3	2	1135

4.4.2 Future

As soon as better emission factors for methane and laughing gas become available, these will need to be included in the IPCC guidelines. It may be advisable to bring the excessively high emission factor for methane to the attention of the IPCC.

5 Remaining aspects

5.1 Point source criteria

Not applicable

5.2 Component profiles

Not applicable

5.3 Regionalisation

Not applicable

5.4 Time-based variations in source strength

Not applicable

6 References and additional information

6.1 References

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6.2 Additional information

Not applicable