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**Hans-Marten Paulsen**
**Uwe Volkgenannt**
**Ewald Schnug**


# Contribution of organic farming to marine environmental protection

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# Contribution of organic farming to marine environmental protection[1]

Hans Marten Paulsen[2], Uwe Volkgenannt[3] and Ewald Schnug[4]

## Summary

In Europe organic farming is directed by the EU-Regulation 2092/91. The main differences between organic and conventional farming systems are significant restrictions for the use of fertilisers and pesticides on organic farms. Additionally, import of fertilisers, fodder, manure, pharmaceuticals, cleansing agents and stocking densities are limited. Thus it is concluded that organic farming has a high potential to contribute to marine environmental protection and is in accordance to the HELCOM Annex III on 'Prevention of pollution from agriculture'.

Organic farms are operating at a significantly lower yield level than conventional farming systems. Recent literature shows that conventional farms would have to set aside 50 % of their arable land to reach the lower level of nitrate leaching of organic farms. Vice versa organic farms would realise 25 % more yield at the same level of nitrate leaching.

The presented literature based survey shows that today's organic farming rate is not very important for the reduction of nutrient and pesticide loads into the drainage basin of the Baltic sea (2.3 % N, 1.8 % P; 0.8 % herbicides, 0.3 % insecticides, 0.6 % plant growth regulators). But considering the geographic distribution of the arable land in the countries forming the drainage basin and its conversion rates to organic farming it is obvious that the best efficiency to reduce effluxes can be expected when organic farming is legally regulated in countries with high input of fertilisers and pesticides and in countries covering large areas of special drainage basins, respectively.

*Key words: Baltic sea, marine environmental protection, pollution, organic farming, nutrient loads, pesticides, legislation*

**Beitrag des ökologischen Landbaus zum Meeresumweltschutz**

## Zusammenfassung

Ökologische Landwirtschaft wird in Europa durch die EU-Verordnung 2092/91 geregelt.

Hauptunterschiede zwischen ökologischer und konventioneller Landwirtschaft liegen in signifikanten Restriktionen beim Einsatz von synthetischen Düngemitteln und Pestiziden in ökologisch wirtschaftenden Betrieben. Weitere Limitierungen sind für ökologische Betriebe beim Import von Futtermitteln- und Wirtschaftsdüngern, bei der Anwendung von Medikamenten und Reinigungsmitteln sowie bei den Tierbesatzdichten gegeben.

Daher trägt ökologische Landwirtschaft eindeutig zum Meeresumweltschutz bei und entspricht bereits in vielen Punkten dem HELCOM Annex III 'Prevention of pollution from agriculture'.

Ökologisch wirtschaftende Betriebe erzielen im Ackerbau ein geringeres Ertragsniveau als konventionelle Betriebe. Basierend auf den Angaben der verfügbaren Literatur müssten konventionelle Betriebe 50% ihrer Ackerfläche aus der Produktion nehmen, um den geringeren Nitrataustrag zu realisieren, den ökologische Betriebe aufweisen. Umgekehrt könnten ökologische Betriebe bei gleichem Nitrataustrag 25 % höhere Erträge erzielen.

Die vorliegende Literaturauswertung zeigt, dass der heutige Prozentanteil ökologisch bewirtschafteter Flächen im Wassereinzugsgebiet der Ostsee hinsichtlich der Minderung des Eintrags von Nährstoffen und Pestiziden nicht sehr bedeutend ist (2,3 % N, 1,8 % P; 0,8 % Herbizide, 0,3 % Insektizide, 0,6 % Wachstumsregler). Wird der Flächenanteil der landwirtschaftlichen Nutzfläche und deren geographische Verteilung im Wassereinzugsgebiet der Ostsee betrachtet, zeigt sich, dass die höchsten Effekte zur Minderung von Nähr- und Schadstoffabflüssen durch die Einführung von ökologischem Landbau dann zu erwarten sind, wenn diese Form der Landnutzung in Ländern gestärkt wird, die einen hohen Dünger- bzw. Pestizidverbrauch haben oder die große Flächenanteile im Wassereinzugsgebiet aufweisen.

*Schlüsselworte: Ostsee, Meeresumweltschutz, ökologischer Landbau, Nährstofffrachten, Pestizide, Gesetzgebung*

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[2] Institute of Organic Farming (FAL), D-23847 Westerau, Germany, E-mail: oel@fal.de

[3] Federal Environmental Agency (UBA), Bismarkplatz 1, D-14193 Berlin, Germany, E-mail: uwe.volkgenannt@uba.de

[4] Institute of Plant Nutrition and Soil Science (FAL), Bundesallee 50, D-38116 Braunschweig, Germany, E-mail: pb@fal.de

## 1 Introduction

Since the beginning of the 1980s the work of the Helsinki Commission (HELCOM) aims at improving the quality in the Baltic marine environment. HELCOM is the governing body of the 'Convention on the Protection of the Marine Environment of the Baltic Sea Area' - more usually known as the Helsinki Convention. The commission takes administrative or other relevant measures to prevent and eliminate pollution in order to promote the ecological restoration of the Baltic Sea Area and the preservation of its ecological balance (Schnug et al., 2001). The contracting parties shall apply the precautionary principle (HELCOM, 1998 a-c).

The role of organic farming in reducing detrimental effects on the environment is discussed controversial in literature. Especially the high percentage of legumes in the crop rotations of this farming system is regarded as a potential source of uncontrolled N-effluxes (Cramer, 2001). But organic farming systems are characterized by factors that are reducing the potential for nitrate leaching i.e. soil cover during winter, intercrops, underseeds and fallow. So overall balances of organic farms show, that this way of farm management can reduce nutrient losses to the environment (Stolze et. al., 2000; Haas 2001). Therefore conversion to organic farming is seen as potential force to reduce environmental effects from agriculture (Köpke, 2002).

Aim of the study presented here is to evaluate, if a widespread introduction of organic farming can contribute to marine environmental protection. The literature based evaluation gives basic estimations with a special view to the introduction of organic farming in the Baltic sea region and was presented at the seminar prior to HELCOM in March 2002.

## 2 Organic farming, legislation and its effect on marine environment protection

The organic farming movement was originally initiated by Sir Albert Howard (1873-1947) and the anthroposophic agricultural lectures of Rudolf Steiner in the early 1920's (Barton, 2001; Haneklaus et al., 2002; Steiner, 1924). In the thirties and forties organic agriculture was developed in Switzerland by Hans Müller and in Japan by Masanobu Fukuoka (Willer and Yussefi, 2000). Since then organic farming has grown in different streams. Farming practices have been developed and controlled by private associations of the different countries.

The International Federation of Organic Agriculture Movements (IFOAM, 2002) gives the following description of organic farming:

*Organic agriculture includes all agricultural systems that promote the environmentally, socially and economically sound production of food and fibres. These systems take local soil fertility as a key to successful production. By respecting the natural capacity of plants, animals and the landscape, it aims to optimise quality of all aspects of agriculture and the environment. Organic agriculture dramatically reduces external inputs by refraining from the use of chemo-synthetic fertilisers, pesticides, and pharmaceuticals. Instead it allows the powerful laws of nature to increase both agricultural yields and disease resistance. Organic agriculture adheres to globally accepted principles, which are implemented within local social-economic, geo-climatic and cultural settings.*

Today organic farming is directed in Europe by the EU-Regulation 2092/91 which is the minimum standard for organic farming systems. According to this regulation inspection bodies have to make a full physical inspection, at least once a year to check if the farm is working in accordance to the regulation. This controlled production is totally different from the settings given to conventional farming that is working through rules of good agricultural practice (GAP). Legislation defining the GAP is build up by different laws. Therefore GAP codes of different countries may be different and never unique. Compared to GAP codes, legislation for organic farming through EU-guidelines is relatively homogeneous. This makes definition and control of agricultural practices much more transparent. It is easier for consumers and state authorities to understand farm production and to get an own opinion for example on environmental impacts. Consumer decisions and controlling are therefore more easier.

Out of the guidelines given by EU-Regulation 2092/91 different effects on issues of water protection can be anticipated (Table 1).

Even if considering that legume based systems can be a significant source for nitrate losses, the limitations in stocking densities, the use of synthetic N-fertilisers and in the import of fodder and manure given to organic farming systems give raise to expectations of lower overall nitrate-losses than in conventional systems (Table 1).

Renunciation of the use of highly soluble P-fertilisers, lower overall erosion risks resulting from the fact that intercrops and green fallows are immanent in organic farming (Stolze et al., 2001) and the limited availability of manure in organic farms due to limited stocking densities lead to a lower risk of P-losses from organic farms which again contributes to the protection of water bodies.

Pesticides are mostly banned and other xenobiotica are strictly limited in organic farming. The input of such substances to aquatic systems from organic farms can therefore be neglected.

Table 1
Effect of organic farming on water protection issues

| | Nitrate | Phosphorous | Xenobiotica |
|---|---|---|---|
| Organic farming | limited stocking densities | no highly soluble fertilisers allowed | synthetic pesticides are banned strict limits on pharmaceuticals for livestock |
| | no synthetic N-fertilisers limited import of fodder and manure | reduced erosion | no growth promoters environmentally friendly cleansing agents |
| Effect on water quality | + | + | + |

Table 2
Examples for N, P, K balances comparing organic and conventional farms from different European countries (Stolze et. al. 2001)

| | N balance [kg ha$^{-1}$] | | P balance [kg ha$^{-1}$] | | K balance [kg ha$^{-1}$] | |
|---|---|---|---|---|---|---|
| | Organic | Conventional | Organic | Conventional | Organic | Conventional |
| Sweden[1] | -15 | +44 | -12 | +37 | -4 | +39 |
| Netherlands[2] | | | | | | |
| - Cash crop farm | +98 | +154 | +18 | +23 | +31 | +25 |
| - Horticulture | +106 | +112 | +32 | +60 | +119 | +110 |
| - Dairy farm | +136 | +364 | +8 | +31 | na | na |
| Germany[3] | +42 | +118 | -4 | +13 | -27 | +31 |

[1] Granstedt, 1990: 3 organic farms, 4 conventional farms
[2] IKC, 1997: 1 organic farm, 1 conventional LEI farm (representative model farms), NL
[3] Hülsbergen et al., 1996: 1 farm - pre- and post conversion

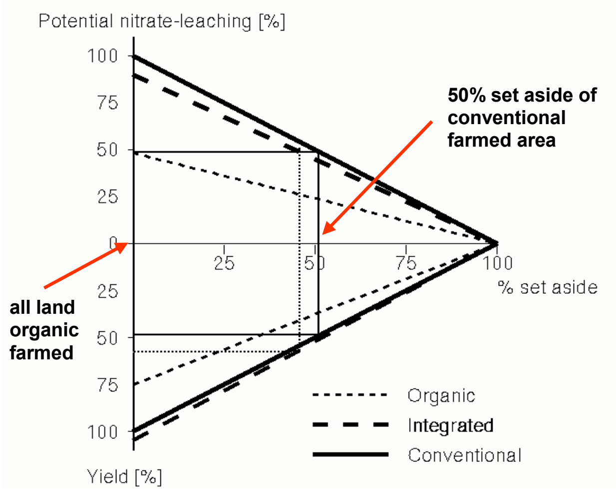
## 3 Nutrient balances of organic farms

Literature data summarized by Stolze et al. 2001 (Table 2) and the communications from Alföldi et al. (2001), Beste and Hampl (1999) and Cramer (2001) reveal generally lower nutrient surpluses in organic compared to conventional farming.

A detailed study on N balances of different farming systems in a water protection area conducted by Haas et. al (2001) showed that conventional farms have to set aside 50 % of their arable land or to reduce N-input by 50 % to reach equal nitrate losses as organic farms have. But in such a scenario organic farms would still gain 25 % higher yields (Figure 1). This approach visualizes the complexity of the problem. Because it needs also to be considered that organic farming systems require 30 % more area to obtain the same production level (Figure 1).

Most comparisons between the different farming systems reveal that clover based systems have higher amplitudes in nitrate leaching during the year. The reasons are different annual developments of legumes under varying growth conditions, the timing of ploughing and the rainfall distribution during the winter (Piorr and Werner, 1990). Thus conventional nutrient budgets seem to be more stable and easier to correct (Cramer, 2001).

But as mentioned before, the overall N-surplus of organic crop rotations is lower in organic farms than in




**Percentages of set aside, $NO_3$-leaching and yield level of different farming systems**

| [%] | Set aside | $NO_3$-leaching | Yield |
|---|---|---|---|
| org. | 0 | 50 | 75 |
| int. | 42 | 50 | 61 |
| conv. | 50 | 50 | 50 |

Fig. 1
Relationship between potential nitrate-leaching, set aside and yield for different farming systems (according to Haas et al., 2001)

Table 3
Land under organic management and total agricultural area in the catchment area of the Baltic sea

| | Organically farmed area | | Total agricultural area | Share of arable land in BSDB | Fertiliser use per hectare (N/P) |
|---|---|---|---|---|---|
| | [%] | [1000 ha] | [1000 ha] | [%] | [kg] |
| Poland | 0.12 | 22 | 18,72 | 41 | 47/16 |
| Russian Federation | 0.01 | 0.5 | 4,802 | 11 | 11/2 |
| Belarus | * | * | 4,082 | 9 | 27/10 |
| Lithuania | 0.13 | 4.5 | 3,467 | 8 | 26/11 |
| Sweden | 5.2 | 158 | 3,302 | 7 | 61/13 |
| Latvia | 0.79 | 20 | 2,541 | 6 | 13/4 |
| Finland | 6.73 | 167 | 2,483 | 5 | 86/26 |
| Denmark | 6.2 | 133 | 2,151 | 5 | 101/16 |
| Germany | 3.2 | 56 | 1,761 | 4 | 122/25 |
| Estonia | 0.69 | 9.6 | 1,400 | 3 | 14/3 |
| Ukraine | * | * | 788 | <2 | * |
| Czech Republic | 3.86 | 13 | 330 | <1 | 55/11 |
| Slovakia | 2.45 | 1.8 | 74 | < | 30/7 |
| Norway | 2.01 | 0.9 | 46 | < | 106/30 |

* no data available / Data: Willer and Yuseffi 2002, Sweitzer et al. 1996, HELCOM 1998a

conventional systems (Table 2). Forage systems show advantages compared to arable systems (Eltun, 1995). This effect is reasonable in the lower total nitrogen supply on organic farms. Practical advices given to conventional farmers end up in the conclusion that the fertiliser use could be reduced without yield losses (Cramer, 2001). Obviously those high productive farming systems can only exist at the upper nutrient level and need some reserves to secure high yields and cover expected yield progresses in future.

In organic farms, the certainty to handle farm-adopted yields instead of fertiliser adopted yields due to limited nutrients imports make organic systems insensitive to yield demands and consequently insensitive to fertiliser demands.

Altogether these facts justify linking nutrient surpluses directly to fertiliser consumption for estimating the effects of the introduction of organic farming on total nutrient budgets in water catchment areas.

## 4 Fertiliser use in the drainage basin of the Baltic Sea (BSDB) and reduction potential of organic farming

Table 3 gives an overview of the percentages of land under organic management in the drainage basin of the Baltic Sea (BSDB) and the share of total arable land of the different countries in that region.

Poland and the Russian Federation share the highest parts of arable land in the BSDB, but the organic farmed area is small. The West-European countries are offering almost 80 % of the organic farmed area which is still only a fraction of the total agricultural land.

The N-budget for Europe (excluding the former Soviet Union) indicates that the three principal driving forces of the acceleration of the European N-cycle are fertiliser production ($14 * 10^6$ $t \cdot y^{-1}$ N), fossil fuel combustion and industry ($3.3 * 10^6$ $t \cdot y^{-1}$ N) and import of N in various products ($7.6 * 10^6$ $t \cdot y^{-1}$ N) (Egmont et al., 2002).

Organic farms usually have low external N-fertiliser input and organic farmers are only allowed to use raw phosphates instead of soluble phosphates and are lower in total P-fertiliser input. So looking at the fertiliser use, organic farming can be expected to cause lower risk in N- and P-leaching. Considering that and looking at the average N- and P- fertiliser consumption per hectare of arable land in those countries - estimated by the total fertiliser consumption (FAO, 1998) and the actual agricultural area in the drainage basin (Table 3) - it is obvious that an increase of one percent in organic farming area will have much higher effects on the total fertiliser use in the BSDB in states sharing large parts of arable land than in countries sharing lower parts (Figure 2).

Altogether 1.1 million t N and 36000 t phosphorous are discharged to the Baltic Sea annually (Table 4). 20 % of the N-load and 35 % of the P-load is transported by rivers from agricultural land. The main part of the N-and P load is assigned to other sources. The percentage of gaseous N-emissions from agriculture in the Baltic Sea region can not be quantified exactly, but is included in the numbers given for the load via atmospheric deposition.

Looking at possible reductions of nutrient loads an introduction of organic farming will have effects on the nutrient efflux from soils. If the approach that nutrient effluxes are directly linked to the use of mineral fertilisers is used, today's organic farming area in the BSDB (Table 3) would reduce the nutrient input in the region by 2.3 % for N and 1.8 % for P (Table 5).

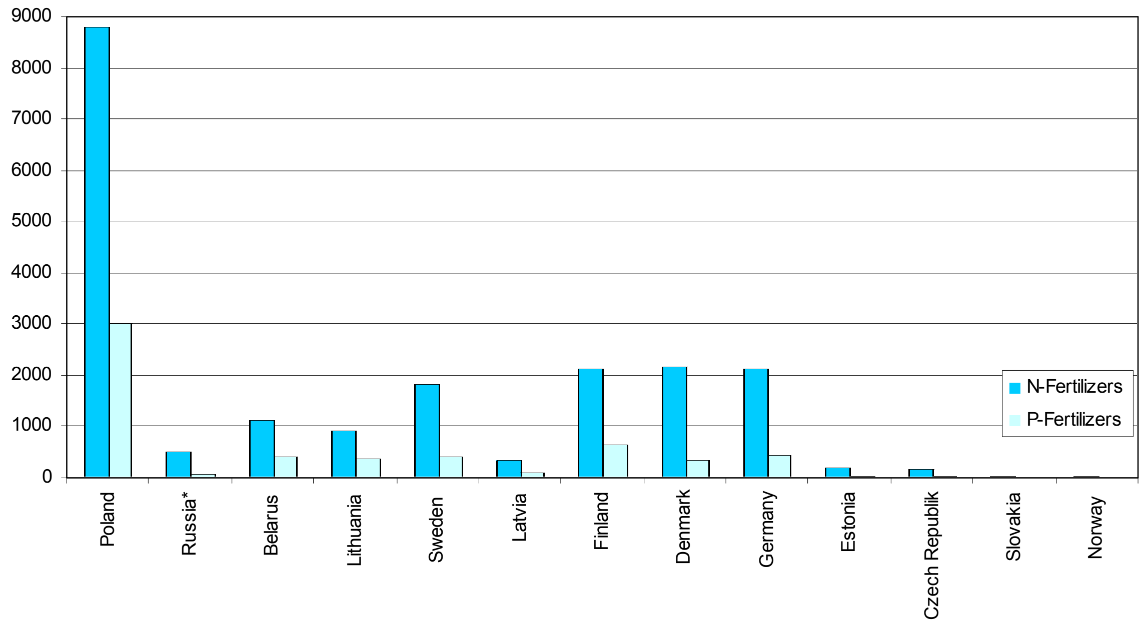



Fig. 2
Estimated reduction in the consumption of N- and soluble P-fertilisers for each percent of agricultural land converted to organic farming in the drainage basin of the Baltic Sea [t year$^{-1}$] (data source FAO (1998)) (blanc columns: no data available)

Considering the aspects determining the P-balance of farms, the risk of nutrient overflow is not only based on pure mass balances, because P is not easily leached from soils. The main factors of P-losses in adequately managed farming systems are rather erosion and surface runoff (Finck, 1992).

Important features influencing these factors in organic farms are given in Table 6. One of the main factors reducing erosion risk on a long term view is soil cover during winter. Growing intercrops, catch crops and green manure is characteristic for organic farms because of the essential need for closed nutrient cycles and the need to satisfy the N-supply by growing legumes (Neuerburg and Padel, 1992).

Some short term factors such as the need of a more frequent soil disturbance for weed control however may slightly increase erosion risk and the risk of P-losses from organic farms. These factors are dependant on climate and management on the farms.

Table 4
N- and P-loads to the Baltic sea [t year$^{-1}$] (source: Gren, Söderquist and Wulff, 1997)

| Source | Agricultural non point sources | Other non point sources | Direct discharge from land and sea based point sources | Atmospheric deposition over sea | Total |
|---|---|---|---|---|---|
| N | 219,100 | 516,000 | 104,800 | 255,500 | 1,095,400 |
| P | 12,800 | 14,200 | 9,200 | - | 36,200 |

Table 5
N- and P-fertiliser use and nutrient loads to the drainage basin of the Baltic Sea and its reduction by today's organic farming area

| | Fertiliser and nutrient use in BSDB [t] | | Reduction by today's organic farming area [t]* | | Reduction due to organic farming [%]* |
|---|---|---|---|---|---|
| | Fertiliser | Nutrient | Fertiliser | N/P load** | |
| N-fertiliser | 2,039,646 | 509,911 | 46,722 | 11,681 | 2.3 |
| Soluble P-fertiliser | 591,066 | 147,767 | 10,709 | 2,677 | 1.8 |

* calculated with percentages of organic farming area of each country
** assuming 25 % nutrient in fertilisers

Table 6
Contribution of organic farming to reduce soil erosion risk (Stolze et al., 2001)

| Effect | Long term factors | Short term factors |
|---|---|---|
| + | Diverse crop rotations with high percentage of fodder legumes<br>High percentage of soil cover<br>Better soil structure by intensive use of stable manure | Fewer row crops |
| - | Higher land use per production-unit<br>Direct or mulch drilling systems | Frequent soil disturbance by mechanical tillage<br>Wider row distances when seeding cereals<br>Slower juvenile development of crops<br>Premature breakdown of crops due to diseases |

The long term factors (Table 6) enhancing erosion risk are not directly bound to organic farming. Conventional farms can reduce soil erosion risk by conservation tillage. Although this strategy is highly effective in preventing soil erosion it requires a higher input of herbicides (Kahnt, 1995). At the same time conservation tillage is more difficult to realise on organic farms. Concerning P-losses organic farming has advantages in terms of water-protection because of smaller P-surpluses (Table 2), lower P-fertiliser input and -solubility and long term soil management parameters with a lower erosion risk (Table 6).

## 5 Pesticide use in the drainage basin of the Baltic Sea and reduction potential of organic farming

Synthetic pesticides and plant growth regulators are generally not allowed in organic farming (EU-Regulation 2092/91). Only in organic horticulture, vine- and potato production copper, natural pyrethroids and special slug poisons can be used with special permission of the inspection bodies so that most of organic farmed area will not be in contact with those substances. Therefore the potential of reducing pesticide inputs in the BSDB by enforced introduction of organic farming can be calculated on basis of the total annual pesticide consumption. In the different countries of the BSDB between 26 - 4499 t year$^{-1}$ herbicides, 1 - 662 t year$^{-1}$ insecticides and 4-483 t year$^{-1}$ are used. Variations refer to different regions (FAO, 1998). In figure 3 the estimated effect of the conversion of one percent agricultural land to organic farming on the pesticide input is illustrated.

The existing organic farming enterprises in the BSDB safe about 350 t year$^{-1}$ herbicides (0,8 %), 14 t year$^{-1}$ insecticides (0,3 %) and 31 t year$^{-1}$ plant growth regulators (0,6 %).

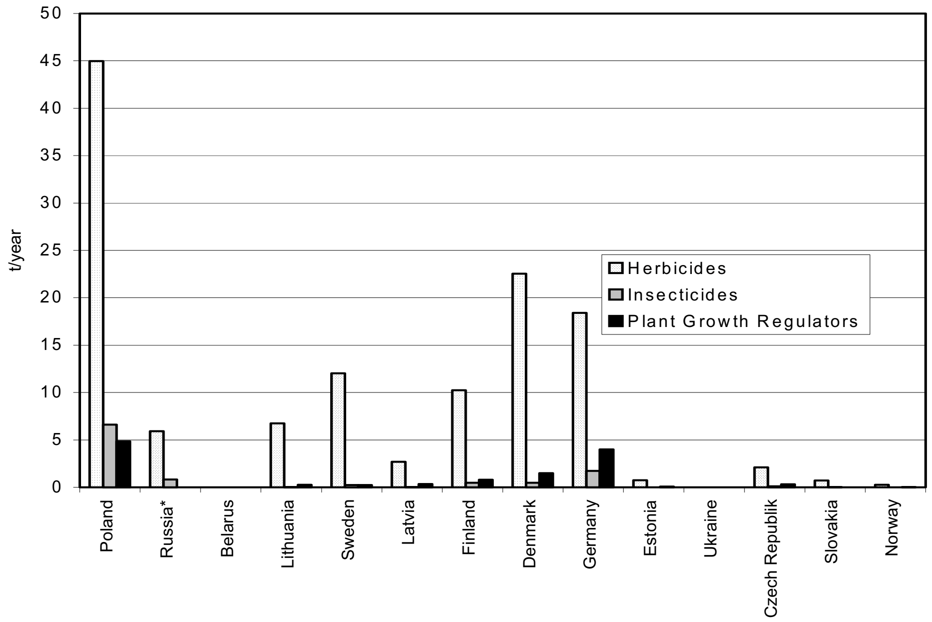



Fig. 3
Estimated reduction in the consumption herbicides, insecticides and plant growth regulators for each percent of agricultural land converted to organic farming in the drainage basin of the Baltic Sea [t year$^{-1}$] (data source FAO (1998)) (blanc columns: no data available)

Table 7
Basic principles to prevent pollution from agriculture in Annex III of the HELCOM convention (HELCOM, 1998c), the EU directive 2092/91 for organic farming and GAP codes for conventional farming

| Annex III of Helsinki Convention<br>Prevention of pollution from agriculture | Organic farming<br>EU Council Regulation 2092/91 | Conventional farming<br>Good agricultural practice (GAP) |
|---|---|---|
| - Regulation 2; Plant nutrients | legume based system with restricted fertiliser import | import of fertilisers possible |
| - 1. Animal density | limited stocking densities (max. 170 kg ha-1 N from manure) | GAP |
| - 2. Manure storage | minimum storage capacity | not regulated in all HELCOM member states |
| - 3. Agricultural waste water | legal restrictions, GAP | |
| - 4. Application of organic manures | legal restrictions, GAP | |
| - 5. Application rates for nutrients | legal restrictions, GAP | |
| - 6. Winter crop cover | required | not required |
| - 7. Water protection measures and nutrient reduction areas | legal restrictions, GAP | |
| - Regulation 3; Plant protection products | mostly forbidden | widespread |

## 6 Recommendations to marine environmental protection and farming practices and their validity in agricultural production

In Annex III of the HELCOM Convention basic principles to prevent pollution from agriculture are given (Schnug et al., 2001). All member states of HELCOM are obliged to transfer these guidelines in national legislation, programs and regulations (HELCOM, 1998 a-c). The regulations are covering aspects of plant nutrient management and pesticide use. Table 7 compares the rules for organic farming with the GAP codes required by the HELCOM member states. The outcome of Table 7 is that the regulations for organic farming are in full compliance with the Annex III of the HELCOM convention.

Organic farming has clear regulations for fertiliser use and import. Even if the N-management has to be done by legume management with possible imbalances due to climate and tillage practices the overall N-balance in organic farms has lower surpluses. Also nutrient balances of P and K have lower surpluses (Table 2) due to the limited stocking densities and the low nutrient availability of the permitted fertilisers on organic farms.

EU legislation for organic farming has defined minimum storage capacities for manure. Legislation on storage capacities is so far not existing in all HELCOM states. The use of winter crop covers is essential for organic farming. In conventional farming intercropping is only done if economically profitable.

Thus any enlargement of the organic farmed area in the BSDB is a strong argument for efficiently reducing nutrient and pesticide discharges.

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