

# Implementing the Water Framework Directive (WFD) method to evaluate the ecological health status of the Normandy coastal waters (France) regarding phytoplankton and supporting physico-chemical quality elements



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**SAMPLING, ANALYSES AND WFD-INDICATORS:** Seawater samples were collected from 25 stations (Figure 1) on a monthly to bi-monthly basis for chlorophyll-a, phytoplankton, in situ physico-chemical parameters (temperature, salinity, and dissolved oxygen), and nutrients data from 2000 to 2008 on 18 coastal and 4 transitional water masses. These parameters were determined following the methods described in Aminot A. and Kerouel R. (2004, 2007), recognised as reference methods for marine waters in France.

In order to optimise the cost and effectiveness of the RHLN, the representativeness of sampling stations relative to each water-mass to be evaluated for the WFD was studied in 2004, thanks to hydrodynamics modelling with 6 regional bi-dimensional models along

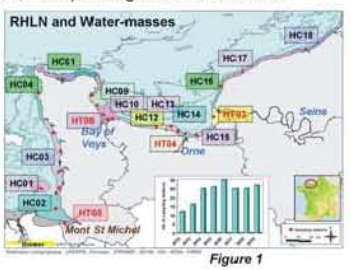


Figure 1

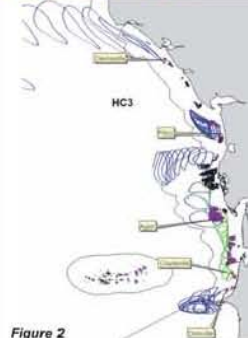
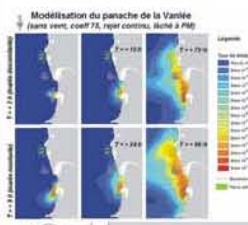


Figure 2

the Normandy coastline (Figure 2). Data collected are analysed on a yearly-basis to characterise the nutrients cycle and the productivity (biomass, abundance and composition) at each sampling station, in order to evaluate the risk of eutrophication. Then, the WFD-validated indicators for biomass (i.e. chlorophyll-a concentration percentile 90), for phytoplankton abundance (i.e. blooms of more than 100,000 cells per litre for species > 20 µm), and dissolved oxygen at the bottom were calculated. The indicator for phytoplankton composition as firstly defined as blooms of harmful species of more than 1.000.000 cells per litre, is currently being discussed by the EU inter-calibration group, therefore it won't be discussed here. The WFD indicators are calculated using only one result per month whereas the RHLN allowed collected more than monthly data for some sampling stations. The classification given by the indicators were therefore compared between the "WFD rules" and "All RHLN data" on a 6-year period (here 2003-2008), and considering the worst classification obtained between the Chlorophyll-a indicator and the Abundance index to evaluate the phytoplankton quality element.

**OBJECTIVES:** The Normandy hydrological coastal monitoring network is a project running for almost 10 years with two main goals: 1) to assess the quality and the potential eutrophication status of coastal water masses, and 2) to help implementing the Water Framework Directive (WFD) surveillance programme in the region, regarding the biological (here phytoplankton) and physico-chemical quality elements. The data collected since 2000-2001 allowed testing the newly developed indicators and assessing their relevance regarding the classification given and field observations.

**CONTRASTING WESTERN vs. ESTERN ECOSYSTEMS IN NORMANDY WATERS:** Data showed clear contrast between oligotrophic-type systems in the western and eastern side of the Cotentin peninsula, and heterotrophic-type systems in the bay of Seine influenced by nutrients inputs from 4 water-basins including the Seine (70.000 sq km). Nutrients winter-stocks along the Normandy coastline revealed a pronounced increase in concentrations from the most western stations (HC01 to HC61) (excluding those in or surrounding the HT05 water-mass) where stocks approached those of the Channel waters, to the most eastern stations (HC09 to HC18) clearly influenced by inputs from the Bay of Veys (HT06), the Orne estuary (HT04) and the Seine estuary (HT03) (Figure 3). Likewise, molar ratios confirm this trend particularly for the DIN/P ratio increasing eastward, while the Si/P ratio tends to remain stable except in estuarine water-masses (HT) where resuspension may increase silicate concentrations, and at two stations in the HC03 where phosphate concentrations are rather low (Figure 3). Molar ratios therefore confirm the excess in nitrogen in the eastern ecosystems influenced directly or indirectly by the Seine inputs.

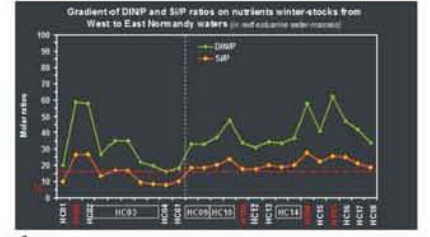
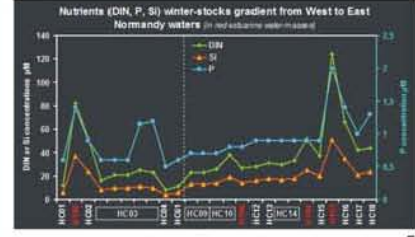


Figure 3

Regarding phytoplankton (> 20 µm) blooms, data showed consistency with nutrients data as the number of blooms increased substantially in 2008 approaching the bay of Seine (Figure 4). Species most commonly encountered in Normandy coastal waters were *Chaetoceros* sp., *Rhizosolenia* sp., *Skeletonema costatum*, *Leptocylindrus* sp., *Nitzschia* sp., and occasionally *Phaeocystis*. Moreover harmful algal species such as *Pseudo-nitzschia* sp. and *Dinophysis* sp. are regularly observed in the bay of Seine, producing toxins accumulating in seashells. Considering the fact that bottom dissolved oxygen data showed good oxygenation of bottom waters in all the water-masses monitored (except in HC15 showing few suboxic conditions since 2000), the risk of eutrophication in Normandy coastal waters is considered as low.

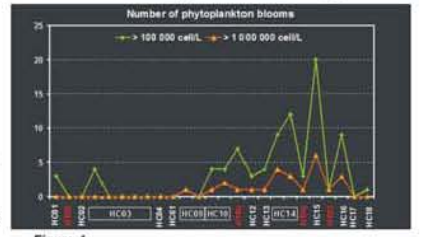


Figure 4

PHYTOPLANKTON QUALITY ELEMENT		Units	Very Good	Good	Moderate	Poor	Very Poor
Indicator	Matrix	Units	Very Good	Good	Moderate	Poor	Very Poor
Sub-carbon chlorophyll-a	Percentile 90	µg L <sup>-1</sup>	< 1	1-10	10-20	20-40	> 40
Abundance Index	Number of blooms exceeding the threshold of 100,000 cells L <sup>-1</sup> for a 20 µm species	%	< 20	20-40	40-70	70-90	> 90

PHYSICO-CHEMICAL CONDITIONS		Units	Very Good	Good	Moderate	Poor	Very Poor
Indicator	Matrix	Units	Very Good	Good	Moderate	Poor	Very Poor
Bottom-dissolved oxygen	Percentile 10	mg L <sup>-1</sup>	> 1	0.5-1	0-0.5	0-0.2	< 0.2

Figure 5

Station	Sub-carbon chlorophyll-a (µg L <sup>-1</sup> )	Abundance Index (%)	Bottom-dissolved oxygen (mg L <sup>-1</sup> )
HC01	1.2	10	1.5
HC02	1.5	15	1.2
HC03	2.0	20	0.8
HC04	3.0	30	0.5
HC05	4.0	40	0.3
HC06	5.0	50	0.2
HC07	6.0	60	0.1
HC08	7.0	70	0.1
HC09	8.0	80	0.1
HC10	9.0	90	0.1
HC11	10.0	100	0.1
HC12	11.0	110	0.1
HC13	12.0	120	0.1
HC14	13.0	130	0.1
HC15	14.0	140	0.1
HC16	15.0	150	0.1
HC17	16.0	160	0.1
HC18	17.0	170	0.1

Figure 6

**THE WFD-INDICATORS AS TOOLS TO ASSESS NORMANDY COASTAL WATERS QUALITY:** Data were used to calculate the WFD-indicators as defined in Figure 5. The evaluation showed that using all the RHLN data did tend to increase the indicators' metrics and lead for 3 water masses (HC2, HC4 and HC18) to a degradation of their classification from "very good" to "good" status for the phytoplankton quality element, two of them because of the chlorophyll-a indicator, and one caused by the Abundance index (Figure 6). Data either using the WFD rules or all the RHLN data suggest a "very good" status regarding the bottom dissolved oxygen indicator (Figure 6). This observation is consistent with field observations where suboxic conditions are scarce or brief so that the sampling strategy can not highlight these events.

The WFD water quality evaluation therefore confirms the interpretation given above, i.e. the "good health" status of the western coastal water-masses of Normandy where terrestrial nutrients inputs are low hence allowing a classical biological development, and the "moderate health" status of the eastern water-masses influenced by major nutrients inputs mainly from the Seine estuary (Figure 7). Despite observations of important chlorophyll-a concentrations and phytoplankton abundance leading to few green algae beaching and periodic harmful algal blooms, the Normandy coastal waters remain little impacted by the consequences of eutrophication as confirmed by the WFD evaluation.



Figure 7

**CONCLUSIONS AND FUTURE PROSPECTS:**

- " A clear contrast between oligotrophic-type systems in the western and eastern side of the Cotentin peninsula, and heterotrophic-type systems in the bay of Seine influenced by nutrients inputs from 4 water-basins including the Seine (70.000 sq km). In most water-masses, disequilibrium in favour of nitrogen was observed and increasing while approaching the Seine estuary.
- " The phytoplankton community in all the water-masses is mainly dominated by diatoms, and periodic harmful algal blooms can be observed.
- " The WFD indicators confirmed the interpretation despite probably under-estimating the phenomena in some water-masses as observed when using all the data available. However, considering the complexity and the time required to acquire these data, the methodology used by the WFD is probably a good compromise to assess the quality of water-masses, and gives consistent results in the Normandy waters.
- " The WFD is an interesting "exercice" at implementing indicators and working on sampling strategies to evaluate coastal water-masses quality. This experience will be useful while the scientific community is working on the new European Marine Strategy extending miles from the coast ...

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