

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

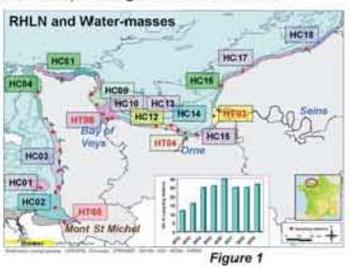


Figure 1

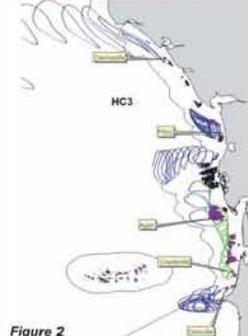
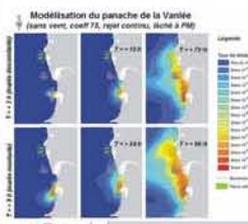


Figure 2

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.

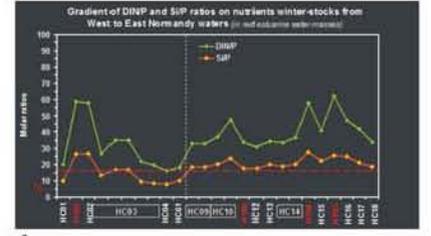
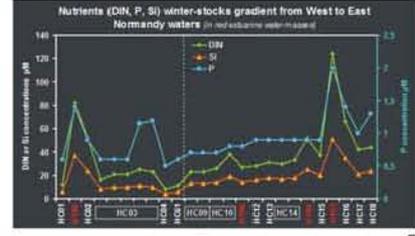


Figure 3

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.

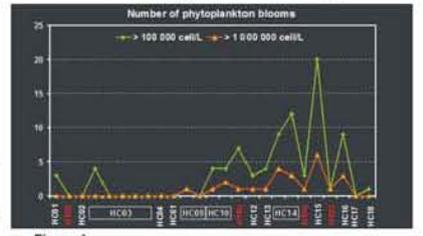


Figure 4

PHYTOPLANKTON QUALITY ELEMENT		Units	Very Good	Good	Moderate	Poor	Very Poor
Indicator	Matrix	Units					
Sub-carbonate chlorophyll-a	Percentile 90	µg L ⁻¹	< 1	1-10	10-20	20-40	> 40
Abundance Index	Number of blooms exceeding the threshold of 100,000 cells L ⁻¹ for a 20 µm species	%	< 25	26-40	41-70	71-90	> 90

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

Figure 5

Year	Station	Sub-carbonate chlorophyll-a (µg L ⁻¹)	Abundance Index (%)	Bottom-dissolved oxygen (mg L ⁻¹)
2003	HC01	1	10	1.5
2003	HC02	2	15	1.2
2003	HC03	3	20	1.0
2003	HC04	4	25	0.8
2003	HC05	5	30	0.6
2003	HC06	6	35	0.4
2003	HC07	7	40	0.2
2003	HC08	8	45	0.1
2003	HC09	9	50	0.1
2003	HC10	10	55	0.1
2003	HC11	11	60	0.1
2003	HC12	12	65	0.1
2003	HC13	13	70	0.1
2003	HC14	14	75	0.1
2003	HC15	15	80	0.1
2003	HC16	16	85	0.1
2003	HC17	17	90	0.1
2003	HC18	18	95	0.1
2003	HT01	19	98	0.1
2003	HT02	20	99	0.1
2003	HT03	21	100	0.1
2003	HT04	22	100	0.1
2003	HT05	23	100	0.1
2003	HT06	24	100	0.1
2004	HC01	2	15	1.2
2004	HC02	3	20	1.0
2004	HC03	4	25	0.8
2004	HC04	5	30	0.6
2004	HC05	6	35	0.4
2004	HC06	7	40	0.2
2004	HC07	8	45	0.1
2004	HC08	9	50	0.1
2004	HC09	10	55	0.1
2004	HC10	11	60	0.1
2004	HC11	12	65	0.1
2004	HC12	13	70	0.1
2004	HC13	14	75	0.1
2004	HC14	15	80	0.1
2004	HC15	16	85	0.1
2004	HC16	17	90	0.1
2004	HC17	18	95	0.1
2004	HC18	19	100	0.1
2004	HT01	20	100	0.1
2004	HT02	21	100	0.1
2004	HT03	22	100	0.1
2004	HT04	23	100	0.1
2004	HT05	24	100	0.1
2004	HT06	25	100	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.

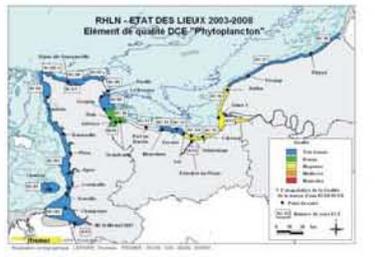


Figure 7

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 ...

REFERENCES:
 Directive n°2000/60/EC "establishing a framework for Community action in the field of water policy" (WFD).
 WFD CIS Guidance Document No. 13, 2005. Overall approach to the classification of ecological status and ecological potential.
 Arrêté du 25 janvier 2010 établissant le programme de surveillance de l'état des eaux en application de l'article R. 212-22 du code de l'environnement.
 Arrêté du 25 janvier 2010 relatif aux méthodes et critères d'évaluation de l'état écologique, de l'état chimique et du potentiel écologique des eaux de surface pris en application des articles R. 212-10, R. 212-11 et R. 212-18 du code de l'environnement.
 Nédélec Florence, Lamont Luis, Riou Philippe (2010). Réseau Hydrologique Littoral Normand (RHLN) - Suivi 2008. <http://archimer.ifremer.fr/doc/00006/11730/>