Interreg Safeguard - Food safety mapping of mussels and oysters (Crassostrea gigas) in the Dutch Wadden Sea.

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Summary

The areal coverage and biomass of the invasive Pacific oyster has increased in both the Dutch and German part of the Wadden Sea area since its introduction in the late seventies. In the Dutch part of the Wadden Sea oyster beds have increased in areal coverage in the period 2003 – 2008. The Pacific oyster has relevance for commercial exploitation since 2009. This arises special interest for food safety aspects. A joint monitor program named 'Interreg Safeguard' has been set up with German partners to firstly identify oyster bed location and subsequently obtain insight in the temporal and areal variation in both the level of chemical contamination as well as contamination with pathogens. Measured levels were compared with legislation standards currently in force and it was also researched what the relation of pollution levels found in oysters were with those found in mussels collected in the near vicinity.

At eight locations covering the entire area of the Dutch Wadden Sea oysters and mussels were sampled in 2010 (once) and 2011 (in three periods around; March, May and September). The samples were analysed on Polycyclic Aromatic Hydrocarbons (PAH), PCB's (Polychorinated biphenyl), OCP's (organochlorine pesticides), metals, Dichloordifenyltrichloorethaan (DDT) and the microbiological pathogens Norovirus, E. Coli, Vibrio sp., Champylobacter, Salmonella and Clostridium.

No significant difference in the analysed metals, DDT and PCB's concentration could be found for period of sampling (data 2011) or between years. The temporal variation is therefore low based on these data. However, measured concentration of arsenic, cadmium, chrome, copper, nickel and lead in oyster are relative high in the most northern sample location (near Eems Dollard) pointing to spatial variation. No mussels were present at the Eems-Dollard sample location.

No significant difference in the analysed PCB's could be found between mussels and oysters, but for some PAH's and metals differences were found. Especially copper and zinc concentrations were much higher in oyster compared to levels found in mussels (factor 20 – 29). Also the PAH pyrene concentration in oysters were slightly but significant higher in oysters (factor 1.3). Chromium, nickel, lead and mercury were significant higher in mussels (factor 1.6 – 3.1). For the PAHs fluorene, fenantrene, benzo(a)pyrene, benzo(g,h,i)perylene, indeno(1,2,3-cd) pyrene significant higher concentrations were found in mussels compared to oysters (factor 1.4 – 2.6).
Measurements show that no consumption and environmental quality standards set were exceeded for the metals, OCP's and PAH's analysed. From the pathogens E. Coli cfu were always well below legislative standards. Both Vibrio parahaemolyticus and V. alginolyticus were found in mussels and oysters at some occasions. As (only) V. parahaemolyticus is associated with disease outbreaks its presence indicates a potential health risk when consuming raw oysters from the Wadden Sea.

This work was done in the framework of Interreg IV A Safeguard.

1. Introduction

The blue mussel (Mytilus edulis) is in ecological competition with the invasive Pacific Oyster (Crassostrea gigas) in the Lower Saxony and Dutch Wadden Sea since the past three decades. The recruitment of pacific oysters pose a challenge for the mussel industry because of the competition for space with respect to the blue mussel, and moreover create a chance for hand collection of pacific oysters for human consumption.

Whereas the primary production of classified blue mussel culture areas is regularly controlled by the Product Board of fish (in the Netherlands) according to the EC regulation (EC) 854/2004 (and previously other regulatory frameworks) since decades, the wild reefs of Pacific Oysters are under control of official control programmes for food safety aspects since 2010. This program is combined with the food safety monitoring of blue mussels and cockles. Moreover, since an increasing temptation of an uncontrolled collecting and marketing of pacific oysters in the Wadden sea has been observed, a risk assessment of microbial and chemical hazards in Pacific Oysters is of interest. The aim of
the Safe Guard Project "WP 3.5" is to elaborate actual data on the status of microbial, and chemical parameters, analysed in oysters and adjacent mussel beds for comparison. A sampling scheme was therefore designed which regards both spatial and seasonal distribution to attain a representative coverage. This was done in the German part of the Wadden Sea as well as the Dutch part. According to the characterized spatial distribution of oyster beds in the Dutch Wadden Sea 8 locations have been selected for mussel and oyster collection. The samples were analysed according to EU-Regulations for shellfish (e.g. 854/2004/EG) using standardized methods.

This report describes the results of the work carried within the Dutch part of the Wadden Sea and include; results of the mapping effort of oyster beds, concentrations of chemical and microbiological parameters in oyster and mussel tissue and the comparison of the contaminant levels found in oyster with those found in mussels.

2. Assignment

A joint monitoring programme within the Interreg IV Safeguard framework has been set up with Dutch and German parties in order to invest:

1. Determine the spatial and temporal variation in contaminant levels of contaminants and pathogens in oyster and oysters.
2. Determine the relationship of contaminant levels found in oyster tissue with those that are found in mussel tissue.

This report describes the results of the work carried within the Dutch part of the Wadden Sea and include; results of the mapping effort of oyster beds, concentrations of chemical and microbiological parameters in oyster and mussel tissue and the comparison of the contaminant levels found in oyster with those found in mussels.

3. Existing regulations for monitoring of live bivalve molluscs fishery

Kindly contributed by: Annelies van der Linden (Dutch Product Board of Fish – Mosselkantoor)

This chapter gives an overview of important regulations related to the control and monitoring of live bivalve molluscs from the Dutch Wadden Sea. The regulations involve ecological affairs and food hygiene mostly.

3.1 Fisheries Act 1963

Fishing in the Dutch Wadden Sea is only allowed with a permit based on the Fisheries Act 1963. This act states also when fishery activities are allowed to take place.

3.2 Nature Conservation Act 1998 and Natura 2000

The Dutch Wadden Sea is designated as a Natura 2000 area. For shellfish fishery a permit is needed of the Ministry of Economic Affairs, Agriculture & Innovation (now called Economic Affairs) based on the Nature Conservation Act 1998. Depending on the activity this permit can also be issued by the local authority (province). The Dutch Wadden Sea is part of the Natura 2000 site "North Sea, Wadden Sea and Delta" and is classified under the Bird Directive and the Habitat Directive. This involves mainly ecological impact in the area by fishery activities.

3.3 Food hygiene

The areas where fishing takes place on bivalve molluscs are monitored according to Regulation (EC) 853/2004 and 854/2004. In section 3.3 of the Hygiene of Foodstuffs (Commodities Act) the Minister for Public Health, Welfare and Sport designates the Dutch Fish Product Board as the competent authority, as referred to in Annex II, Chapter II of Regulation (EC) 854/2004. This is done through the 'Regulation production areas live bivalve molluscs 2006 of the Dutch Fish Product Board'. The Dutch Fish Product Board monitors the shellfish production areas, five designated areas are in the Dutch Wadden Sea: three areas in the westerly part of the Dutch Wadden Sea and two in the easterly part. A sixth area is proposed additionally, but since no monitoring takes place, the area is closed for the fishery on bivalve molluscs. It concerns the area of the Dutch Wadden Sea next to the German border, the area Eems/Dollard.

Monitoring
For the monitoring of the microbiological quality, sources of pollutions and natural circumstances as current patterns and tidal cycle are taken into consideration when possible. To establish the microbiological quality of faecal pollution of an area E.coli is used as an indicator. The product (bivalve molluscs) need the be purified when more than 230 colony-forming units (cfu) E.coli are found till less than 230 cfu E.coli are found in order to allow the product to be marketed.

The areas are also monitored for toxin-forming phytoplankton in the water, as an early warning system for biotoxins and the presence of biotoxins in bivalve molluscs. The various areas are monitored for ASP , PSP and DSP-complex -forming phytoplankton and biotoxins. Where possible current patterns, phytoplankton blooms and fishery activities in the area are taken into account. In the Netherlands the regulatory limits for ASP-forming phytoplankton are set on 500,000 cells/liter, for PSP-forming phytoplankton 1,000 cells/liter and for DSP-forming phytoplankton 100 cells/liter. In Europe no limits are set for phytoplankton. For biotoxins the European limits are used. The production areas are yearly sampled by the Dutch Fish Product Board for heavy metals and Polycyclic Aromatic Hydrocarbons (PAH's), the limits are listed in Regulation (EC) 1881/2006.

Mussel fishery is the main shellfish fishery in the western part of the Dutch Wadden Sea, in the eastern part the main shellfish fishery consists of cockle fishery by hand collection. From December 2009 there are a number of licences for hand collected oyster fishery, both in de western and the eastern part of the Dutch Wadden Sea. Therefore the monitoring in the western part of the Dutch Wadden Sea mostly takes place on mussels and, in the eastern part on cockles. Oysters are mainly monitored at the end of the year.

3.4 Water Framework Directive

Rijkswaterstaat (Ministry of Waterworks) conducts the research for the Shellfish Water Directive (schelpdierwater richtlijn) (2006/113/EC). Rijkswaterstaat is the executive arm of the Dutch Ministry of Infrastructure and the Environment and is managing the main water systems. In 2013 the directive is withdrawn by the Water Framework Directive (2000/60/EC).

3.5 Allocating bivalve molluscs

The movement of bivalve molluscs to the Dutch Wadden Sea (except the movement from the Danish and German part of the Wadden Sea) is not permitted according to the policy plan on movement of shellfish, 1997-2003 (Beleidslijn inzake het verplaatsen van schelpdieren, 1997-2003) (Snijdelaar & Greutink, 2003). Since early 2012 it is allowed to move mussels from the Oosterschelde to the Dutch Wadden Sea under strict conditions.

4. Materials and Methods

In this chapter the selection procedure to select the sample locations and the relevant parameters for chemical and microbiological analyses is described. The followed method for sample collection, chemical and biological analyses are described as well as the statistics used to analyse the data.

4.1 Choice of sample locations

4.1.1 Development and areal distribution of Crassostrea gigas

In the Netherlands imports of *Crassostrea gigas* started from 1964, mainly in the Oosterschelde region. Following the imports, the oysters reproduced and started expanding their habitat to the Wadden Sea. The success of natural recruitment and the rate of spread are different in specific regions and seem to depend on abiotic factors. In 2011 the estimated areal distribution of *Crassostrea gigas* in the Dutch Wadden Sea is 909 hectares of which 178 ha is estimated to exist of *Crassostrea gigas* and 731 ha of a mix of *Crassostrea gigas* and blue mussels (*Mytilus edulis*). The total areal accounts for a biomass of approximately 105 million kg (105.000 tons) fresh weight (van Stralen, 2012). These figures should be regarded carefully, since the data is estimated based on field data in combination with GIS reconstruction. These data need confirmation by field data.

IMARES performs annual surveys of littoral and sublittoral shellfish stocks. These data are used to map the oyster biomass and prevalence in the Wadden Sea. The surveys are performed according to the protocol "Handboek bestandsopnames en routinematige bemonsteringen van schelpdieren" (*Craeymeersch et al., 2004*). In the entire Wadden Sea oyster beds were measured using GPS devices. The littoral stock assessment is done by carrying out biomass sampling at low tide. This is done for a number of oyster beds in the entire area (not all beds). Oyster populations on and around dikes and dams have not been taken into consideration.

The measurement and mapping of littoral oyster beds in the Wadden Sea was performed at the same time and with the same methodology as the inventory of mussel beds (as described by van Zweeden, 2010). Prior to the inventory of the mussel beds an estimation of the approximate location of the oyster beds was done based on:

- surveys which were performed at an earlier stage,
- information from fishermen and governmental employees,
- photographs from the ministry of Waterworks, and Google Earth,
- exploratory surveys performed by aircraft in spring.

The areas with oyster beds have been visited at low tide. The contours and locations of these beds were measured using GSP-equipment (Garmin) according to a fixed procedure (Brinkman, 2003). The contours of the beds were mapped by walking around them, and registration in a hand-held GPS. If oyster beds were present, but no sampling or contour drawing could be done (eg. High tide), the beds were mapped as present.

During the field visits, the following data was gathered:

- Estimate of the coverage of the contours (%) with "humbs" and/or "patches" of the beds, and the occupation with oysters in the humps and patches (%);
- Areas with low densities (<50% coverage) are not indicated as oysters, but as "scattered" oysters. These are usually not mapped;
- The size class of oysters in the bed (small, medium sized, big or combined);
- A qualitative indication of the density of the oyster bed (thick, reasonable, moderate, thin, scattered);
- For each bed the percentage of dead and living oysters were estimated;
- Substrate of the bed (mud, shellfs, sand, etc.);
- Thickness of silt layer in cm;
- Height of the structures (cm);
- Other observations (presence of weed, etc.).

For the biomass assessment the method of the annual stock assessments of the littoral mussel beds was used. This method is extensively described by van Zweeden (2010). In brief a pre-designed stratum is used to collect samples of the littoral and sub littoral mussel (and oyster) beds. The shellfish are sampled using a special designed dredge (2.00m length, 0.2m wide and 0.1m deep). The sample is transported to an adapted rinse mill with a mesh size of 5mm. On board the sample (surface 0.4m^2) is sorted, and total counts, size and biomass of the species are recorded.
Based on the data derived from the Dutch shellfish stock assessments, the maps of oyster beds could be constructed using GIS. These maps were used to select easy access, and potential commercially used oyster beds for the Interreg Safeguard data. The data for mapping the oyster beds was derived from additional efforts on the 2009 survey data.

In 2011 a mapping exercise was performed by MarinX and IMARES (van Stralen, 2012). This exercise was done to reconstruct the development of oyster beds in the Wadden Sea. This was done using an additional field sampling strategy to map the oyster beds more adequate. These data show that the total amount of area of oyster beds in the period 2003-2008 has increases in the Wadden Sea. After 2008 a stabilisation of the growth can be observed (*Figure 1*), at this moment it is not known whether this is a temporary trend or a continuous development.

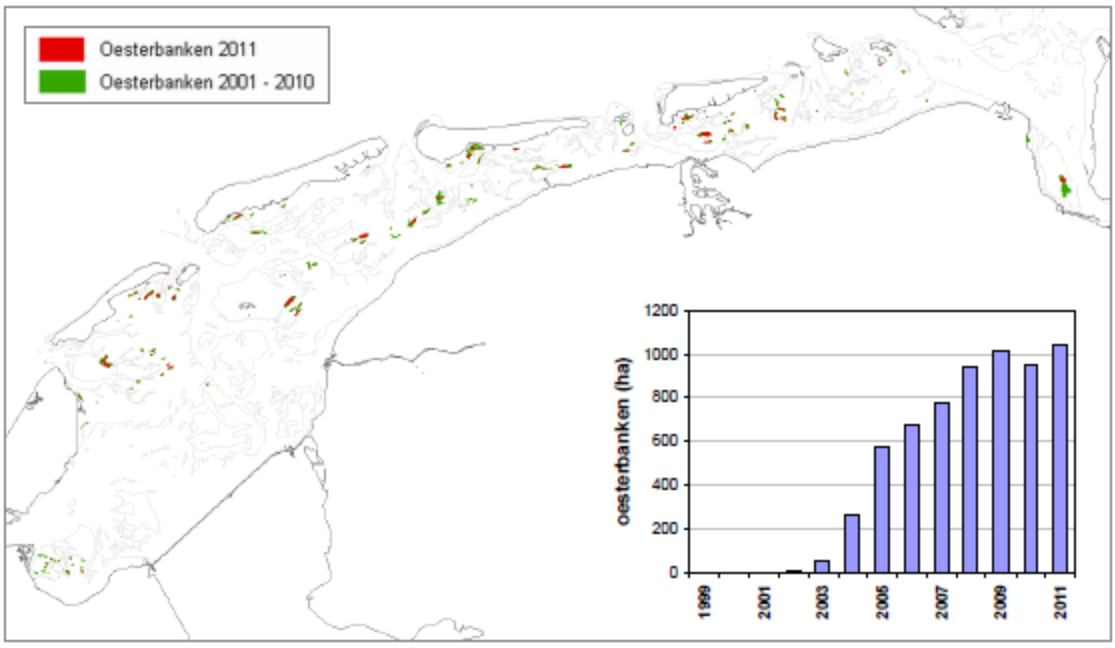

Figure 1. Map of the oyster beds as observed and reconstructed from data in 2011. In the right corner the development (van Stralen, 2012) the development of total areal of oyster beds is indicated.

Based on the development of the oyster- and mussel beds over time, an analysis is made on the development of the composition of the oyster beds. The first oyster beds have been mapped in 2001. The mussel bed areal in the Eastern part of the Wadden Sea is much larger than the areal of oyster beds in the Western part. Roughly halve of the oyster beds are situated in the eastern part and half in the western part. In the Eastern part the bulk of the oyster spat fall takes place in mussel beds. When the oysters are aging the oysters seem to be a suitable substrate for mussel spat to settle and grow. Therefore since 2008 many oyster beds have changed into oyster-mussel beds (Figure 2).

Van Stralen describes that the origination of the oyster beds in the Wadden Sea is not well documented. The main reason for that is that oyster beds have started forming in areas which were not primarily of interest for the general surveys. Therefore many of the oyster beds have been visited only in a stage in which they were large enough to be visible by plane. In those occasions oyster beds were found on locations with hard substrate, such as empty shells, and on locations with a sandy and silt bottom.

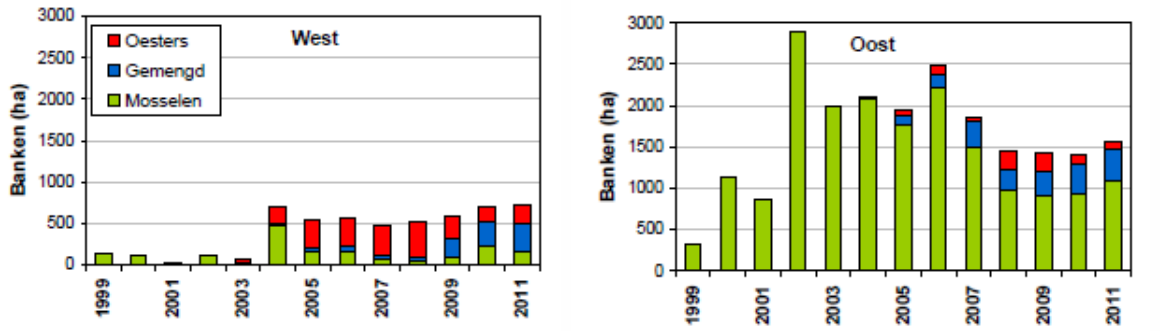

Figure 2. Development of the areal of mussel, oyster and mixed beds in the Eastern and Western part of the Wadden Sea, as described by van Stralen (van Stralen 2012).

4.1.2 Selection of sample locations

In 2009 the oyster beds were mapped using similar methods as the above mentioned. These maps were made to visualise the existing oyster beds, and to make choices on the beds to be visited during the surveys in the Interreg project. During the planning of the project no fixed commercial collection locations were available for monitoring purposes.

The maps were constructed using GIS, and all locations were mapped (*Figure 3*), these maps form the baseline for further elaboration.

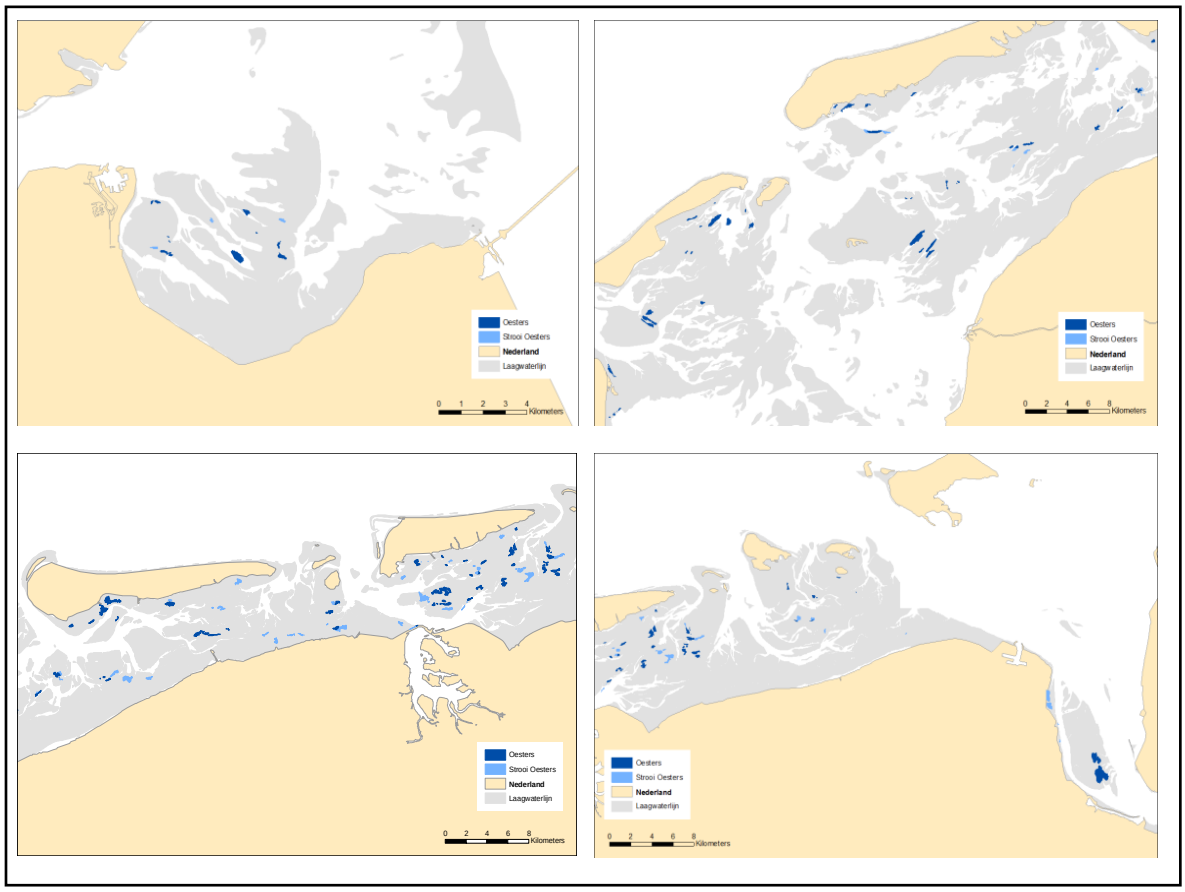

Figure 3. Maps of oyster beds in the Dutch part of the Wadden Sea. (Figure 4 shows the sample locations which were selected for monitoring purposes).

In 2009 effort has been made to map the spatial distribution of oyster beds in the Dutch Wadden Sea, the result is shown in *Figure 3*. Eight locations situated within the Wadden Sea were selected for mussel and oyster collection (SG 1 till SG 8 in *Figure 4*). These oyster beds are all (except for SG8) situated in the areas assigned as shellfish production areas. In the national monitoring program the locations are assigned in the production zones as shown in
Table 1.

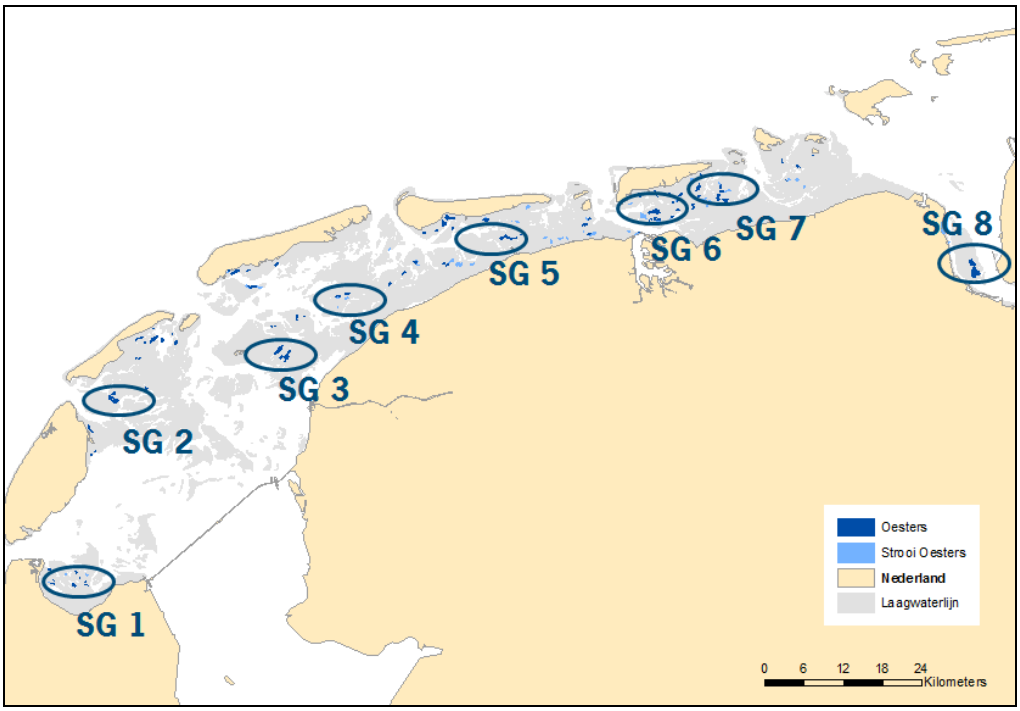

Figure 4. Location of oyster beds and sample locations (SG 1 to 8).

Table 1. Overview of Interreg monitoring programs, and the assignment of production zones in the national shellfish food safety monitoring program.

Location number	**Assigned Production area**
SG1	Western Wadden Sea Compartment South
SG2	Western Wadden Sea Compartment South
SG3	Western Wadden Sea Compartment Middle
SG4	Western Wadden Sea Compartment North
SG5	Friese Wad
SG6	Groninger Wad
SG7	Groninger Wad
SG8	Eems-Dollard

In order to invest both spatial and temporal variations in contaminant concentrations and to invest differences in accumulation between oysters and mussels, both oysters- and mussels were collected once in 2010 and multiple times in 2011. Based on accessibility, oyster prevalence and distribution in the Wadden Sea sample locations were selected.

In 2010 all eight locations (SG1 till SG8) were monitored once. Sampling took place in the months November and December. At locations SG1 till SG7 both oysters and mussels were collected, at location SG8 only oysters could be collected as mussel beds were absent.

In 2011 fewer locations were sampled but more frequently. Sampling took place in in three periods covering spring, summer and autumn.

Period 1 23th of March – 19th of April 2011
Period 2 20th of April – 31th July 2011
Period 3 1th of September – 31th of October 2011

Similar to 2010 mussel beds were absent at location SG8. An overview of the species collected at each location and period is given in *Table 2*.

Table 2. Mussel and oyster samples collected in 2011.

Period	Date	Location	Mussel	Oyster
1	23-mrt-11	SG1	x	x
	23-mrt-11	SG3	x	x
	5-apr-11	SG8		x
	15-apr-11	SG6	x	x
	19-apr-11	SG4	x	x
	19-apr-11	SG5	x	x
2	21-apr-11	SG2	x	x
	27-apr-11	SG1	x	x
	12-may-11	SG6	x	x
	10-may-11	SG7	x	x
	jul-11	SG8		x
3	sep/oct 2011	SG1	x	x
	sep/oct 2011	SG3	x	x
	sep/oct 2011	SG6	x	x
	sep/oct 2011	SG7	x	x

4.2 Collection of samples

All sites which were visited received the same instructions. Ships of the ministry of Waterworks, or Economic Affaires were used for the fieldwork (*Figure 5*). Sampling was performed according the same procedures (except labelling) as the procedures which are in place for the National food safety monitoring program for shellfish (IMARES procedure). In brief approximately 1 to 4 kg of both mussels and oysters were collected by hand and stored in plastic bags (according to the sampling program). In April and May samples were also collected during the shellfish stock assessments. During this period samples were collected using a dredge, and samples were sorted on board of the vessel. On board the samples were directly transferred to plastic bags and labelled. Samples kept cool during transportation to the laboratory. Samples were transported by courier in cool boxes, or if available by cooled transport. Transport was always performed overnight.
Samples taken for chemical analysis were stored in a freezer room immediately after arrival at the laboratory of IMARES (within 48 hours after sampling). Samples which were taken for microbiological analyses were transported (within 48 hours) to the laboratory immediately after arrival in the distribution laboratory.

Figure 5: Ships used to collect mussel and oyster samples.

4.3 Chemical analysis

Chemicals analysed and standards

The pollutions analysed within the project consisted of the following groups; metals, OCP, DDT, PAH and pathogens. Contaminants for which legislation is active (both consumption standards and environmental protection) and which have persistent, toxic and accumulative properties are included within the project, see also Chapter 2. An overview of pollutants for which legislation is active is given in Table 3.

Table 3. The European consumption standards and EQS (Environmental Quality Standards) set for bivalve molluscs.

Contaminant group	**Parameter**	**Consumption standards[1] (µg /kg product)**	**MKN biota standards[2] (µg /kg product)**
Metals	Cadmium	1000	-
	Lead	1500	-
	Mercury	500	-
OCP	HCB	-	10
PAH	Benzo(a)pyrene	10	10
	Benzo(b)fluorantene	-	10
	Benzo(k)fluorantene	-	10
	Benzo(g,h,i)perylene	-	10
	Indeno(1,2,3-cd)pyrene	-	10
Pathogens	Norovirus		-
	E. coli[3]	230 MPN or cfu/100 gram flesh	-
	Vibrio sp.	-	-
	Campylobacter	-	-
	Salmonella	Absent	-
	Clostridium	-	-

[1] COMMISSION REGULATION (EC) No. 420/2011 of 29 April 2011 amending Regulation (EC) No 1881/2006 setting maximum levels for certain contaminants foodstuffs (shellfish).
[2] EU directive 2011/0429 of 31 January 2012, amending Directives 2000/60/EC and 2008/105/EC as regards priority substances in the field of water policy.
[3] EU Directive No. 2073/2005 of 15 November 2005 on microbiological criteria for foodstuffs.

In Table 4 an overview is given of the pollutants that are analysed in mussels and oysters tissue collected in 2010 and 2011. PAH concentrations were analysed in 2010 only; PAH concentrations in 2010 showed that these did not exceed legislation standards and difference between mussel and oysters were relative small compared to metals. In 2011 PCB, pesticides/herbicides and DDT were analysed additionally.

Table 4: List of chemical and microbiological parameters for which mussel and oyster tissue was analysed.

Pollutant group	**Year**	**Parameter**	**Country of analyses**
Heavy metals	2010 & 2011	arsenic (As), cadmium (Cd), chromium (Cr), copper (Cu), nickel (Ni), lead (Pb), zinc (Zn) and mercury (Hg)	The Netherlands
PAH's	2010	acenafteen, fluorene, fenantreen, anthracene, fuoranteen, pyrene, benzo(a)anthracene, chryseen, benzo(b)fluorantene, benzo(k)fluorantene, benzo(a)pyrene, dibenzo(a,h)anthracene, benzo(g,h,i)perylene, indeno(1,2,3-cd)pyrene	*The Netherlands*
PCB's	2011	PCB 28, 52, 101, 138, 153, and 180	*Germany*
Pesticides	2011	dieldrin, a-HCH, b-HCH, lindane, cis-heptachlorepoxid, heptachlor, bromocyclen, trans-heptachlorepoxid, moschusxylol, moschusketon, a-chlordane, g-chlordane, oxichlordane, parlar 26, parlar 50, parlar 62, a-endosulfan, b-endosulfan, endosulfansulfat, endrin, endrinketon, p,p-DDE, o,p-DDE, p,p-DDT, o,p-DDT, p,p-DDD, o,p-DDD	*Germany*
Herbicide	2011	HCB	*Germany*
Viruses	2011	Norovirus	*Germany*
Bacteria	2010 & 2011	*Escherischia coli*	*The Netherlands*
	2011	*Virbio alginolyticus*	*The Netherlands*
	2011	*Vibrio parahaemolyticus*	*The Netherlands*
	2011	*Vibrio vulnificus*	*The Netherlands*
	2011	*Campylobacter sp.*	*The Netherlands*

Microbiological pathogens that are monitored are based on European legislation and known food safety concerns in bivalve mollusc. *E. coli* is one of the main parameters which are monitored based on the association with faecal contaminations. In the past faecal coliforms were used as an indicator species for faecal contaminations (sewage, birds, tourism). Since 2005 the legislation has been modified and primarily *E. coli* is used as indicator organism for faecal contamination. This indicator is used as second best, since the indicator does not have a clear relation with the true pathogen Norovirus (and other viruses), which is of main concern. According to EFSA (EFSA, 2012), adequate monitoring systems for Norovirus should be put into place, however at this moment adequate methods and approaches for routine monitoring are yet missing. Therefore, within the framework of monitoring purposes the project has monitored Norovirus as well as *E. coli* in order to be prepared for future adaptations of legislation.

In the Netherlands 7 occasions of Norovirus infections caused by shellfish were reported in 2010. In the same year one occasion of Salmonella infection caused by shellfish was reported. In the Dutch monitoring system Salmonella is only tested for in end product testing (by companies), on rewatering plots and in entrance controls of the companies. In the Netherlands the choice is made to leave the responsibility of Salmonella primarily to the companies, due to a lack of Salmonella detections in the production areas over de last 5 years.

During mapping and monitoring of the occurrence of infectious disease in the Netherlands no cases of *Campylobacter* or *Clostridium* infections were reported (RIVM, 2010). Previous field studies (2002-2005) indicate that *Campylobacter* was present in approximately 30-50% of the shellfish samples (mainly mussels). *Clostridium* has never been tested for. In the current study we monitor only for *Clostridium* in order to investigate the risk of the potential "new" consumption source of the Wadden Sea.
Previous surveys of Vibrio sp. in the Oosterschelde have indicated an absence of *Vibrio parahaemolyticus* and *V. vulnificus* in the summer of 2003. In this study *V. alginolyticus* was found in 8 out of 18 samples

(Aalberts, 2003). Vibrio has never been tested for in the Wadden Sea, therefore the current survey strives to map the occurrence of Vibrio sp.

4.3.2 Chemical analysis

Sample preparation
A number of oysters and mussels were pealed to obtain the required amount of 150 gram material (wet weight) for the chemical analysis. As only larger specimens are to be consumed, mussels between 48 and 57 mm (length class four) and oysters >100 mm (minimum size for consumption) were selected when available. Both average flesh weight as the shell length and weight were noted. Flesh of both oysters and mussels were homogenised using an Ultra Turrax with a plastic disposable head. Part of the material were kept in plastic bottles (for analysis on metals), and a second subsample in bottles made of glass (for analysis on PCB's/OCP's/PAH's). Bottles were stored in a freezer (<25 ^{o}C) prior to analysis. To prevent contamination with especially metals and PAH's, pealing and homogenisation work took place in a contaminant free room, supplied with filtered air.

Dry matter, ash and fat content
Determination of the dry matter has been done following the procedure according to ISW 2.10.3.011. A weighted sample is mixed with a substance that increases the surface after which the sample is dried in a stove (105 ^{o}C, 3 hours). After cooling in an exsiccator the sample is weighted again.
For determination of the ash weight the procedure according to ISW 2.10.3.018 has been followed. The weighted sample is slowly heated and dried at a cooking plate after which the sample is put in a muffle furnace for 22 hours (550 ± 15°C). After cooling in an exsiccator the sample is weighted again.
Determination of the fat content follows the procedure described in ISW 2.10.3.002. This method is and adjusted version of the Bligh and Dyer methods and based on cold chloroform-methanol extraction.

Heavy metals
All heavy metals, except mercury, have been analysed by TNO Triskelion, located at the Utrechtseweg 48, 3704 HE, Zeist. Protocol used for sample preparation is LSP/108. Part of the sample is digested with nitric acid and hydrogen peroxide. Metal content is determined using ICP-MS following procedure LSP/055. Quantifications takes place using external calibration standards, to correct for fluctuation in the apparatus an internal standard (rhodium) is used.

Mercury
Determination of the fat content follows the procedure described in ISW 2.10.3.025. The sample is dried and subsequently put in an oven to ash and release the mercury from the sample. With the help of oxygen, the released compounds are transported to a catalyst tube were oxidation takes place and halogen, nitrogen- and sulphur oxides are removed. Remaining compounds are converted to metallic mercury and quantified with atomic absorption spectroscopy using calibration standards.

PCB /OCP/DDT
PCB / OCP and DDT were analyses at LAVES- Niedersachsen Germany. Measurements were performed according to accredited methodology used in the German Sate Laboratory for official purposes. Analytics were done using Gas Chromatorgraphy and GC-MS. The description of the methodology is fully available in the report "Bioinvasion of the Pacific Oyster (Crassostrea gigas) in the Wadden Sea: microbial and chemical risks for the consumer " (LAVEX, in prep).

Polycyclic Aromatic Hydrocarbons (PAH)
Protocol used is ISW 2.10.3.005. Saponification of the sample takes place for several hours by heating and shaking of the sample with alcoholic soda. PAH are isolated from this solution using hexane. After cleaning of the extract PAH's are separated at a HPLC-column and detected with a fluorescent detector.

4.4 Microbiological analysis

Microbiological analyses were performed in the laboratory of SGS Belgium NV, Antwerp, Belgium.
E. coli was analysed using the Donovan-MPN method performed according to ISO 16649-3 (Anonymous, 2005). The procedure is summarised below as described by Mooijman (2007). The media used are described in ISO 16649-3.

Sixty ml of the primary homogenate was diluted in 140 ml PS to obtain a 10-1 dilution of the sample material in PS. This 10-1 dilution was used to prepare 10-2, 10-3, 10-4 and 10-5 dilutions.

Dilutions were inoculated in 5-fold as follows:

0: 10 ml 10-1 dilution in 10 ml double-strength enrichment medium Mineral Modified Glutamate Broth (MMGB);
10-1: 1 ml 10-1 dilution in 10 ml single-strength enrichment medium MMGB;
10-2: 1 ml 10-2 dilution in 10 ml single-strength enrichment medium MMGB;
10-3: 1 ml 10-3 dilution in 10 ml single-strength enrichment medium MMGB;
10-4: 1 ml 10-4 dilution in 10 ml single-strength enrichment medium MMGB;
10-5: 1 ml 10-5 dilution in 10 ml single-strength enrichment medium MMGB.

After incubation at (37 ± 1) ^{o}C for (24 ± 2) h, the MMGB tubes were examined for acid production (yellow coloration) and for lactose fermentation (gas production). From each tube showing acid production, a loopful of material was streaked on a plate containing Tryptone Bile Glucoronic agar (TBX). TBX plates were incubated at (44 ± 1) °C for (21 ± 3) h. The presence of characteristic blue colonies on TBX indicated the presence of Escherichia coli in the original MMGB tube. The number of positive tubes in each dilution resulted in an MPN code. From this MPN code the Most Probable Number of Escherichia coli was derived using the 5-fold MPN-tables (De Man, 1983).

E. coli in the national monitoring program was analysed using a plating method on Tryptone Bile Glucoronic agar TBX (ISO 16649-2), according to ISO 16649-2. The procedure is described in brief (after Mooijman, 2006). The media used are described in ISO 16649-2.

Sixty ml of the primary homogenate was diluted in 140 ml PS to obtain a 10-1 dilution of the sample material in PS. This 10-1 dilution was used to prepare 10-2, 10-3, 10-4 and 10-5 dilutions. Fifteen ml of the primary homogenate was distributed over 8 Petri dishes (each with a diameter of 9 cm). Subsequently, 15 ml of freshly prepared and molten TBX agar was added to each dish. Furthermore, duplicates of 1 ml of the 10-1, 10-2, 10-3, 10-4 and 10-5 dilutions were inoculated into Petri dishes and mixed with molten TBX agar. After solidification, TBX plates were resuscitated at (37 ± 1) oC for (4 ± 0.5) h, followed by incubation at (44 ± 1) °C for (18 ± 2) h. Typical blue (ß-glucuronidase-positive) colonies were counted and the number of *E. coli* in the original sample was calculated.

Vibrio sp. was analysed using the method described by ISO/TS 21872-1 and ISO/TS 21872-2, in a modified method.

Clostridium sp. was analysed using the standardized method ISO 7937. Samples are suspended and diluted according to a ISO 6887. Petri dishes are inoculated with a specific volume of dissolved sample. A selective medium is added, including an overlay of the medium. The petri dishes are incubated anaerobically at 37oC for 20h±2h. The characteristic formed colonies are enumerated. The number of Clostridium bacteria is calculated.

Norovirus and Hepatitus A

Norovirus and Hepatitus A were analysed at LAVES- Niedersachsen Germany. Measurements were performed according to accredited methodology used in the German Sate Laboratory for official purposes. Analytics were done using real time PCR, SOP-NRL Gas Chromatorgraphy and GC-MS. The description of the methodology is fully available in the report "Bioinvasion of the Pacific Oyster (Crassostrea gigas) in the Wadden Sea: microbial and chemical risks for the consumer " (LAVEX, in prep).

4.5 Statistical analysis

Variation in pollutant concentration was analysed with the use of a linear model. Significant differences are explored by a one-way ANOVA test. To correct for the uneven number of data points extra variation is added to the model. The statistical software package 'R' is used for the analyses. Concentrations are expressed on dry weight (metals) or on fat weight (PCB's, DDT's and PAH's) for the statistical analysis.

5. Results

5.1 Chemical contamination

The mussels an oysters collected in 2010 were analysed on heavy metals and PAH's. Mussels and oysters collected in 2011 were analysed on metal, PCB, DDT, pesticides and the herbicide (HCB) concentrations. Pesticide concentrations were below limits to report. Only the DDT; p,p-DDE, o,p-DDT and DDT u.s. metabolites exceeded limits of report and of the PCB's only PCB52, -101, -138, -153 and -180 were detected above the report limits. All metals analysed exceeded report limits and could be quantified.

In Appendix E (metals), F (DDT and PCB's) and G (PAH's) graphs depicting contaminant concentration in mussels and oysters collected in 2010 and 2011 are shown. Using the data of 2011 for both mussels and oysters two graphs are made; one in which concentrations are plotted per period and one were concentrations are plotted against sample location. Metal concentrations are expressed on basis of dry weight, DDT, PCB's and PAH's concentrations are expressed based on fat weight.

5.1.1 Temporal and geographical variation in contaminant levels

In 2011 oysters and mussels were collected in three time periods covering spring, summer and autumn (see also chapter 3.1.2). In order to investigate the occurrence of seasonal variation in contaminant levels, data of mussels and oysters collected at each of the time period in 2011 are statistically analysed. In *Table 5* the species, location and corresponding period is shown of the data used for this analysis.

Table 5: Data of mussel and oyster's collected in 2011 used for chemical and statistical analysis.

Period	Mussel	Oyster
1	SG; 1 3 5 6	SG; 1 3 5 6 8
2	SG; 1 2 6 7	SG; 1 2 6 7 8
3	SG; 1 3 6 7	SG; 1 3 6 7

First it is examined if there are differences in shell length and fat content within the groups defined by species and period. In Figure 6 the fat content of mussels and oysters collected in 2011 is shown. No significant differences could be found between the species or between the periods of collection ($p > 0.05$) except when the shell length of oysters are compared with those of mussels for obvious reasons ($p < 0.001$).

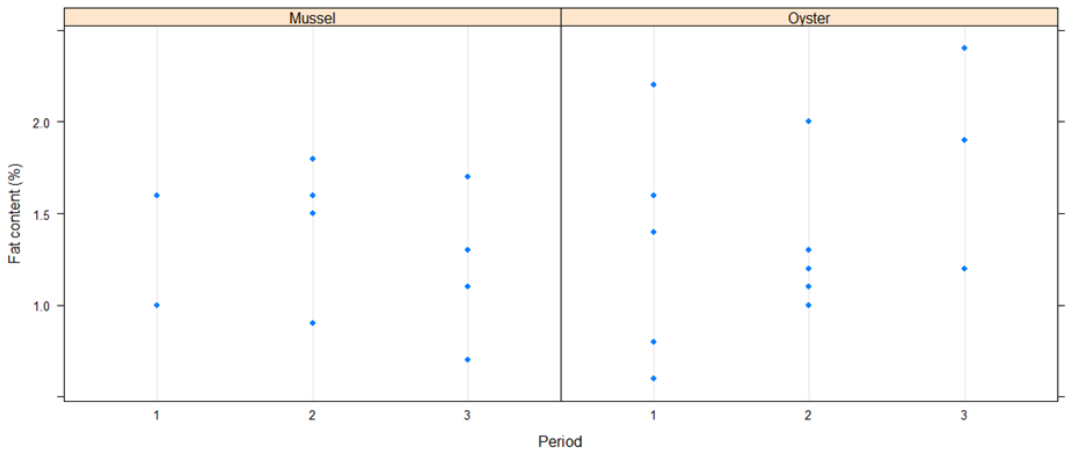

Figure 6: Fat content of both mussel and oyster collected in 2011 plotted per period.

No statistical analyses could be performed to test for differences between sample locations due to low number of replicated within the locations. However based upon Figure 7, fat content seem to be similar between the sample locations.

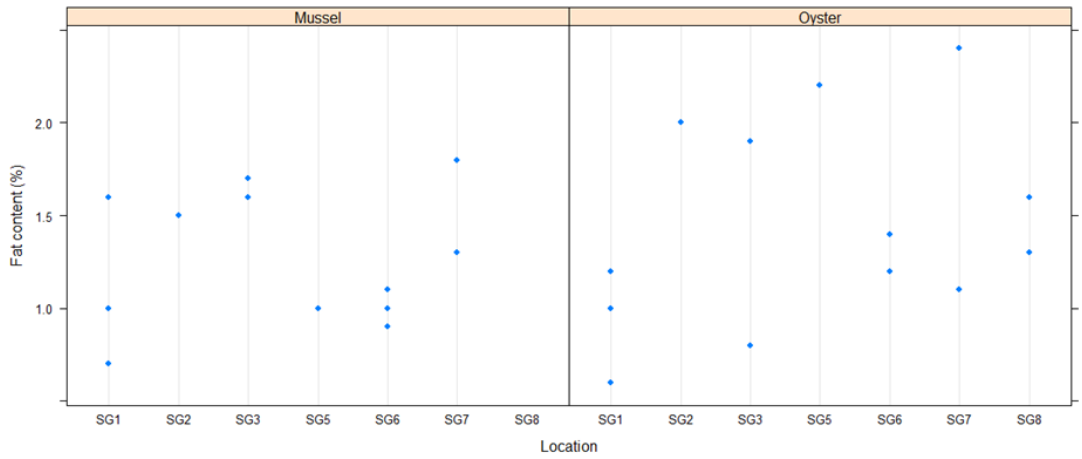

Figure 7: Fat content for both mussel and oyster collected in 2011 plotted per sample location.

5.1.2 Metals

No significant difference in metal concentration was found between the three period's oysters and mussels were collected (data of 2011). Furthermore, metal concentrations in oysters and mussels collected in 2011 are comparable with those collected in 2010, no significant difference could be found in concentration between the years.

Based upon plots included in appendix E there doesn't seem to be differences in sample location as well. However, metal content in oyster collect at location SG8 forms an exception on this observation. Concentrations of arsenic (As), cadmium (Cd), chrome (Cr), copper (Cu), nickel (Ni) and lead (Pb) are relative high compared to concentrations at sample location SG1 to 7. The zinc (Zn) and mercury (Hg) concentrations in oyster collected at sample location SG8 were not markedly elevated compared to oysters sampled at the other locations, see Figure 8 and the graphs in Appendix E. As mussels were absent at SG8 in both years, it could not be verified if this observations holds for mussels as well.

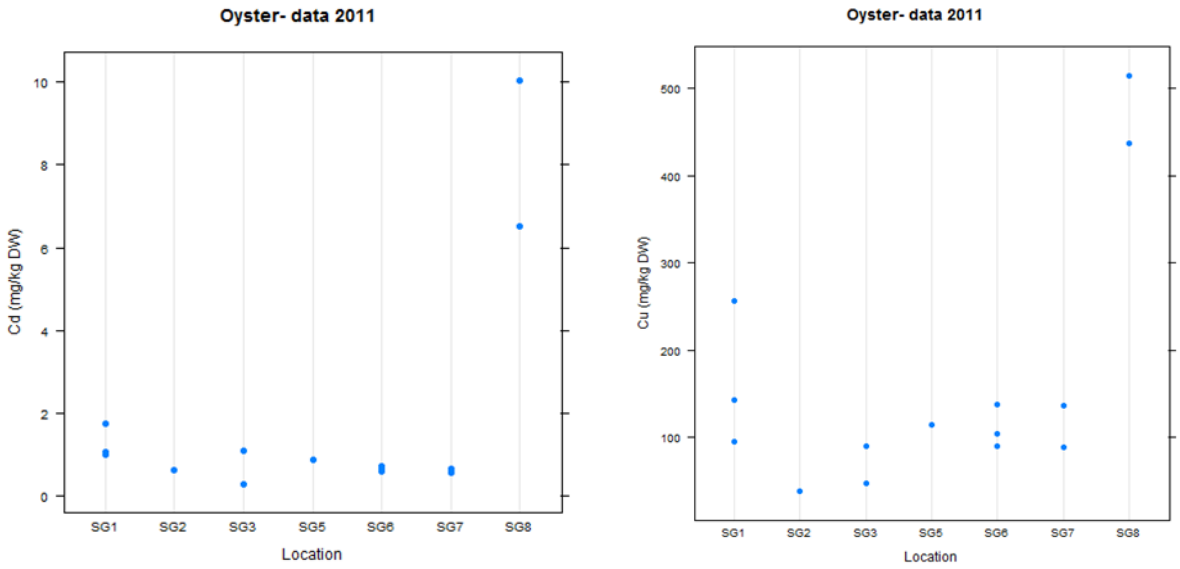

Figure 8. Concentration of cadmium and copper in oysters collected in 2011 as an example for elevated levels at sample location SG8. (The multiple points plotted for each of the sampled location resemble the sample period).

5.1.3 DDT and metabolites and PCBs

Dioxin (p,p-DDE and DDT u.s. metabolites) and PCB (52, 101, 138, 153 and 180) concentrations did not differ between the period of sampling (data 2011). For especially mussels, sample location SG1 is relative high in PCB 53, -101, -153 and -180 and for DDT metabolites compared to the other locations, see the graphs in Appendix F. This observation could not be tested statistically however. Whereas metal concentration in oysters collected at location SG8 were relative high, PCB concentrations were not markedly elevated compared to the other sample locations.

5.1.2 Variation between species

No significant difference in PCB's and DDT's concentration between mussels and oysters are found. However, there are significant differences found between species for some of the metals and PAH's analysed (Table 6 and Table 7).

Both in 2010 and 2011 chromium, nickel, lead and mercury concentrations are higher in mussels compared to oysters (factor between 1.6 and 3.1) and copper and zinc concentrations are higher in oysters (Table 6). Especially the copper and zinc concentration difference is markedly as concentration differs with a factor between 20.3 and 28.9.

Table 6: Average and difference in metal concentration (mg/kg dry matter) in mussels and oysters collected in 2010 and 2011. Concentration difference printed in bold are found significant.

Year	Species	n	Arsenic (As)	Cadmium (Cd)	Chromium (Cr)	Copper (Cu)	Nickel (Ni)	Lead (Pb)	Zinc (Zn)	Mercury (Hg)
2010	Mussel	7	11	0.7	1.4	7.3	2.3	2.2	97	0.25
	Oyster	8	13	1.9	0.5	184	1.0	1.0	2802	0.15
	M/O	-	*0.9*	*0.3*	***3.1***[2]	***0.04***[3]	***2.4***[3]	***2.2***[3]	***0.03***[3]	***1.6***[2]
	O/M	-	*1.2*	*2.9*	***0.3***[2]	***25.2***[3]	***0.4***[3]	***0.5***[3]	***28.9***[3]	***0.6***[2]
2011	Mussel	12	12	0.5	2.0	8.0	2.6	2.5	100	0.26
	Oyster	14	13	1.9	1.0	164	1.0	1.3	2210	0.16
	M/O	-	*0.9*	*0.3*	***2.1***[1]	***0.05***[2]	***2.7***[3]	***2.0***[2]	***0.05***[3]	***1.7***[1]
	O/M	-	*1.1*	*3.6*	***0.5***[1]	***20.3***[2]	***0.4***[3]	***0.5***[2]	***22.2***[3]	***0.6***[1]

Significance level: [1] = p<0.05, [2]= p<0.01 & [3]= p<0.001

The concentration of the PAH's; fluorene, fenantrene, pyrene, benzo(a)anthracene, benzo(a)pyrene, benzo(g,h,i)perylene and indeno(1,2,3-cd)pyrene, differ significant between the species (Table 7). Except for pyrene, PAH concentrations in mussels are higher compared to concentrations in oysters. PAH concentration differs with a factor between 1.3 and 2.6 and only benzo(g,h,i)perylene and indeno(1,2,3-cd)pyrene exceed a factor 2 (Table 7).

Table 7: Average and difference in PAH concentration (µg / kg fat) in mussels and oysters collected in 2010. Concentration difference printed in bold are found significant.

PAH	***Average concentration***		***Concentration difference***	
	Mussel	***Oyster***	***(M/O)***	***(O/M)***
Fat	1.3	1.7	0.8	1.3
Acenafteen	32	30	1.1	0.9
Fluorene	58	39	**1.5**[1]	**0.7**[1]
Fenantreen	227	159	**1.4**[3]	**0.7**[1]
Anthracene	17	9	2.0	0.5
Fuoranteen	277	316	0.9	1.1
Pyrene	178	232	**0.8**[1]	**1.3**[1]
Benzo(a)anthracene	51	35	1.5	0.7
Chryseen	67	73	0.9	1.1
Benzo(b)fluorantene	141	132	1.1	0.9
Benzo(k)fluorantene	57	52	1.1	0.9
Benzo(a)pyrene	42	25	**1.7**[1]	**0.6**[1]
Dibenzo(a,h)anthracene	4	4	1.0	1.0
Benzo(g,h,i)perylene	79	38	**2.1**[2]	**0.5**[2]
Indeno(1,2,3-cd)pyrene	52	20	**2.6**[3]	**0.4**[3]

Significance level: [1] = p<0.05, [2]= p<0.01 & [3]= p<0.001

4.1.3 Found concentrations related to legislative standards

Pollution levels measured within this project were always well below consumption and environmental standards currently in place, see also Appendix B till D.

4.1.4 Comparison Dutch MWTL shellfish monitor program

From data of 2010 and 2011 the average metal concentration found in mussels is compared with mussel concentrations found in 2010 within the Dutch MWTL shellfish (mussel) monitor program, see *Figure 9*. As can be seen, concentrations correspond.

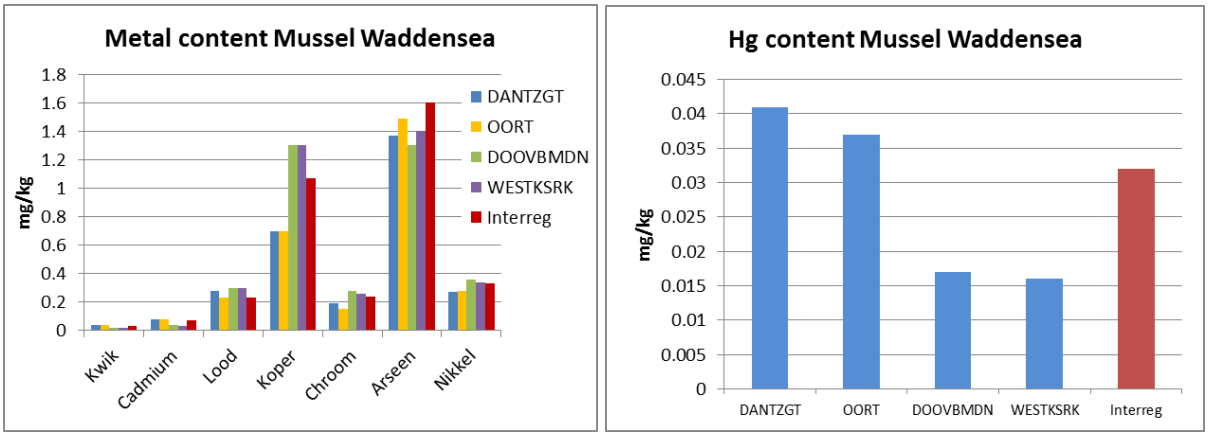

Figure 9. Metal concentrations in mussels as measured within Interreg program (average value of 2010 and 2011 measurements, n=19) (red bar) and within the Dutch shellfish monitor program.

In *Figure 10* the average PCB 138 + 163 and 153 concentration of mussels measured within Interreg (average value) and of Dutch MWTL shellfish (mussel) monitor program is shown. As can be seen PCB concentration correspond well. HCB concentrations found within Interreg were always below limits of report (<0.1 µg/kg).

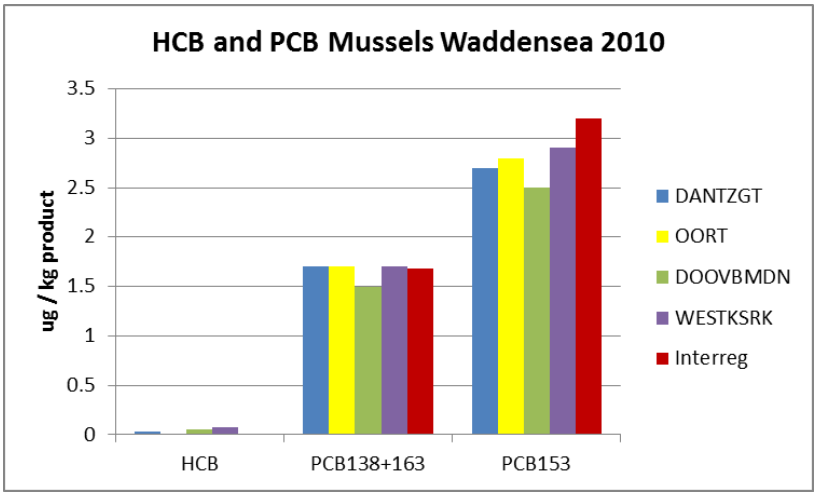

Figure 10. PCB concentrations in mussels as measured within Interreg program (average value of 2011 measurements, n=9) (red bar) and within the Dutch shellfish monitor program.

5.2 Microbiological contamination

5.2.1 Microbiological data overview

For microbiological sampling, all locations as specified in *Figure 4* were planned to be visited. The sampling could not be planned in the same period of time for all locations, due to logistic difficulties. Therefore samples were taken in different months of the year in some cases. Sampling time and vessel occupation could not be tuned to transport the samples to the laboratory within 24 hours after sampling, due to infrastructural challenges (week trips). This resulted in a second best monitoring program for microbiological monitoring.

In 2010 all locations were visited once in November. In some occasions the locations could not be visited (SG2, SG7 and SG8). The samples from these locations were analysed for *E. coli*. *Table 8* shows the samples taken for microbiological analyses in the Wadden Sea in 2011. These locations were analysed for *Vibrio alginolyticus* and *V. parahaemolyticus*, and *Clostridium sp.*

Since microbiological data of the National food safety monitoring program of the Wadden Sea demonstrates that microbiological loads (*E. coli*) are generally <230 cfu/100 grams of shellfish meat, the choice was made not to spent excessive expenses on sampling for microbiological criteria. Therefore the main focus was laid on contaminants.

Table 8. Sampling locations in November 2010. SG1 through 8 indicates the Safeguard sampling locations ranging from West (SG1) to East (SG8).

Location ID	Date	Matrix
SG1	17-11-2010	mussel
SG2		No data
SG3	17-11-2010	mussel
SG4	17-11-2010	mussel
SG5	30-11-2010	mussel
SG6	30-11-2010	mussel
SG7		No data
SG8		No data
SG1	17-11-2010	Oyster
SG1		No data
SG3	17-11-2010	Oyster
SG4	17-11-2010	Oyster
SG5	30-11-2010	Oyster
SG6	30-11-2010	Oyster
SG7		No data
SG8		No data

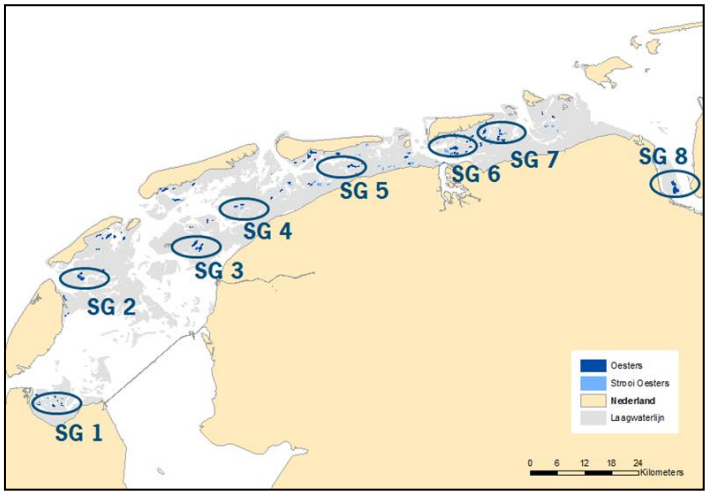

Table 9. Sampling locations 2011. SG1 through 8 indicates the Safeguard sampling locations ranging from West (SG1) to East (SG8).

Location	Date	Sample matrix
SG1	27-Apr-11	Mussel
SG1	27-Apr-11	Oyster
SG1	5-Oct-11	Mussel
SG1	5-Oct-11	Oyster
SG2	21-Apr-11	Mussel
SG2	21-Apr-11	Oyster
SG3	1-May-11	Mussel
SG3	1-May-11	Oyster
SG3	5-Oct-11	Mussel
SG3	5-Oct-11	Oyster
SG4	19-Apr-11	Mussel
SG4	19-Apr-11	Oyster
SG6	13-Okt-11	Mussel
SG6	13-Okt-11	Oyster
SG7	5-Oct-11	Mussel
SG7	5-Oct-11	Oyster
SG8	7-July-11	No mussels available
SG8	7-July-11	Oyster

Besides the monitoring data derived from the Interreg Safeguard sampling program, data from the National monitoring for Shellfish Food safety was used in the project. This data mainly focussed on mussel beds, cockle fisheries locations and in some occasions oyster beds. In 2010 mussel and oysters were collected from the Wadden Sea by commercial hand collectors. This was the start of the monitoring campaign for commercial harvesters in the Wadden Sea. In 2011 the Wadden Sea was entirely monitored by vessels from the ministry. The monitoring program is configured as shown in *Table 9*.

Table 10. Monitoring frequency and areas of the National monitoring program for shellfish Food safety. Red indicates monthly, Blue indicates fortnightly sampling.

	WWN Western Wadden Sea North	**WWM Western Wadden Sea Middel**	**WWZ Westelijke Wadden Sea Zuid**	**GW Eastern Wadden Sea Groninger Wad**	**FW Eastern Wadden Sea Friese Wad**
January	Monthly	Monthly	Monthly	Monthly	Monthly
February	Monthly	Monthly	Monthly	Monthly	Monthly
March	Monthly	Monthly	Monthly	Monthly	Monthly
April	Monthly	Monthly	Monthly	Monthly	Monthly
May	Monthly	Monthly	Monthly	Monthly	Monthly
June	fortnightly	fortnightly	fortnightly	Monthly	Monthly
July	fortnightly	fortnightly	fortnightly	Monthly	Monthly
August	fortnightly	fortnightly	fortnightly	Monthly	Monthly
September	fortnightly	fortnightly	fortnightly	fortnightly	fortnightly
October	fortnightly	fortnightly	fortnightly	fortnightly	fortnightly
November	Monthly	Fortnightly*	Fortnightly*	Fortnightly*	Fortnightly*
December	Monthly	Fortnightly*	Fortnightly*	Fortnightly*	Fortnightly*
*In week 44 and 48 oysters were sampled for commercial oyster hand collection activities					

5.2.2 Confirmation of low E. coli loads in the Dutch system

Since all production zones for shellfish production are intensively monitored for *E. coli*, it is known *that E. coli* loads in the production areas are generally low <200 fcu / 100 ml shellfish flesh- and moist. Monitoring is in general not performed on oyster samples, but mainly on cockle or mussel matrix. Therefore, a confirmatory test for compliance of oysters and mussels to low microbiological loads was performed. In the monitoring performed in October and November 2010, only levels of *E. coli* below detection limit (<20 fcu / 100 gram of flesh and moist) could be observed. *Figure 11* shows the results of this monitoring.

The results indicate that in the given sample period (October / November 2010) *E. coli* levels were very low. No relation between oyster and mussel matrix could be detected. Data in general show low levels of *E. coli*, and no specific trend in the presence of *E. coli* in the Dutch Wadden Sea. Therefore, in order to observe any trends in presents of *E. coli* between the organisms blue mussels, cockles and pacific oysters it was decided to rely on the data from the German project partners. In Germany an intensive monitoring program on *E. coli* loads and variations in time, space and organisms is performed during the project.

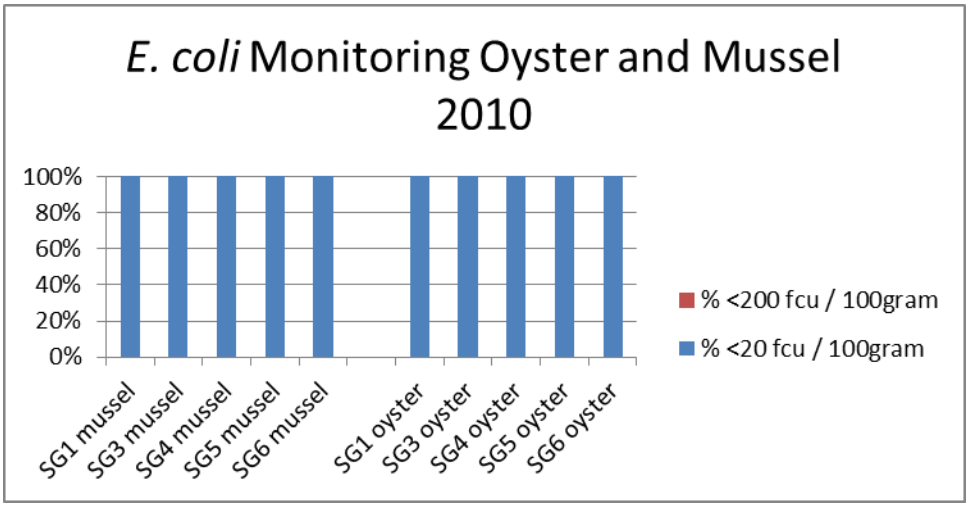

Figure 11. Results of the E. coli monitoring at different sides in the Wadden Sea. All sites were sampled for oyster and blue mussel matrix. At all sites 4 individual samples of 10 oysters each were sampled.

To support the microbiological data as found during the monitoring of Oysters and mussels, an analyses was made on the microbiological (*E. coli*) field data from the national food safety monitoring for shellfish. This data was provided by the Product Board of fish as general input for the project. The data demonstrated that the majority of the results show results < 20 or <200 fcu per 100 grams of flesh and moist. This indicates either results below detection limit (<20 fcu) or in low amounts, well below the legislative consumption standards (<200 cfu / 100gram). In the monitoring program no quantitative data below 200 cfu / 100 gram is reported. The absence or prevalence of *E. coli* in low amount indicates that relations between areas, locations and species is a very theoretical exercise. In order to make the data more practical an analysis was made of the trends in amount of samples which had low levels of *E. coli* (< 200 fcu) and values below detection limit (equivalent absent) (<20 cfu). The results of this analyses are shown in *Figure 12*.

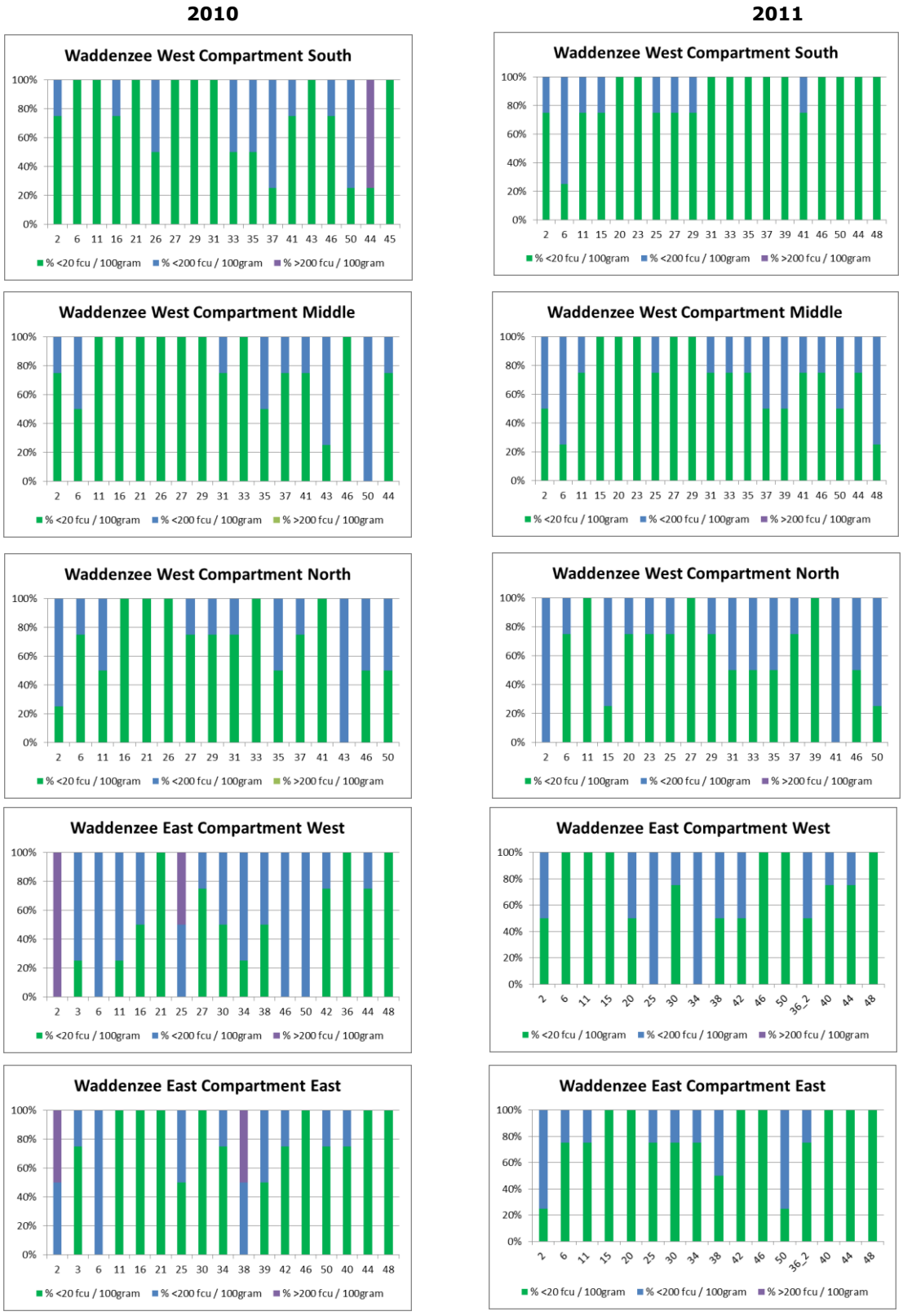

Figure 12. Results of the analyses of E. coli from the monitoring program for food safety of shellfish in the Netherlands of 2010 and 2011 (data source: Product Board of Fish)

The data from the national monitoring program shows that levels of *E. coli* in the Western part of the Wadden Sea were only higher than 200 fcu per 100 grams in one occasion. This was the case in week 44 in area Wadden Sea West Compartment south in 2010. The results were derived from the first oyster monitoring results in that year. This was a monitoring program which was set in place to intensify the monitoring for commercial oyster hand collecting activities. Due to unexplained reasons (most likely sampling methodology) the microbiological results indicated high prevalence of *E. coli* (840, 3.580, 1.620 cfu / 100 grams). Resampling to confirm these results (week 45) did not result in a confirmation. The sampling strategy was adapted based on these results.

Furthermore, it can be observed that the majority of the elevated microbiological loads (but still <200 fcu/100ml) are found in autumn and winter months. Only in the area Wadden Sea West Compartment South levels elevated levels of *E. coli* were found during the summer months.

All results of the Wadden Sea West production zone, except for one observation in oysters in week 44-2010 that was above threshold levels, indicate that the production area can be assigned as A classification, based on European and national legislation.

5.2.3 Vibrio and Clostridium Netherlands

Monitoring for presence of *Vibrio alginolyticus* and *Vibrio parahaemolyticus* was performed during the year 2011. Monitoring was performed at location SG1, SG2, SG3, SG4, SG6, SG7 and SG8. SG54 could not be visited due to logistic difficulties. All sampling stations were visited, however all sampling stations were not visited in the same months. SG1, SG3 were both visited in April-May and in October, SG6 and SG7 were sampled only in October. SG1, SG2, SG3, SG4 were visited in the same period (April-May) and could therefore be compared. The results of the *Vibrio sp,* and *Clostridium* monitoring are shown in *Table 11*.

In the locations SG1, SG2 and SG4 in all samples Vibrio *alginolyticus* or *V. alginolyticus* could be detected in April-May in both oysters and mussels. In location SG3 no *Vibrio alginolyticus* was found.
At location SG8 in July both *Vibrio parahaemolyticus* and *V. alginolyticus* were present.
In October *V. alginolyticus* was detected at locations SG1 and SG6 in both oysters and mussels. *V. alginolyticus* was found in mussels only at location SG7. At location SG3 *V. alginolyticus* could not be found in any of the samples in October.

The presence of *Vibrio alginolyticus* in different seasons and at different location in both oyster and mussel matrix demonstrates a wide spread prevalence of *V. alginolyticus*. *V. Alginolyticus* is however not associated with disease outbreaks.
There seems to be a geographic trend in the prevalence of *V. alginolyticus* since one location (SG3) is not affected in any of the cases.

Vibrio parahaemolyticus was found in mussels at location SG3, and was not detected in oysters in October 2011. In SG7 and SG8 *V. parahaemolyticus* was found in oysters and not in mussels. *Vibrio parahaemolyticus* was not found during the Spring sampling. The presence of *Vibrio parahaemolyticus* indicates a potential health risk when consuming raw oysters from the Wadden Sea.

Table 11. Monitoring results of microbiological parameters Vibrio sp. and Clostridium sp. in 2011.

Location	**Month**	**Matrix**	***Vibrio alginolyticus***	***Vibrio parahaemolyticus***
SG1	April-May	Mussel	Present	Absent
SG2	April-May	Mussel	Present	Absent
SG3	April-May	Mussel	Absent	Absent
SG4	April-May	Mussel	Present	Absent
SG1	April-May	Oyster	Present	Absent
SG2	April-May	Oyster	Present	Absent
SG3	April-May	Oyster	Absent	Absent
SG4	April-May	Oyster	Present	Absent
SG8	July	No mussel	-	-
SG8	July	Oyster	Present	Present
SG1	October	Mussel	Present	Absent
SG3	October	Mussel	Absent	Present
SG6	October	Mussel	Present	Absent
SG7	October	Mussel	Present	Absent
SG1	October	Oyster	Present	Absent
SG3	October	Oyster	Absent	Absent
SG6	October	Oyster	Present	Absent
SG7	October	Oyster	Absent	Present

Clostridium sp. could not be detected in any of the samples.

The results given in this report apply only to the samples analysed.

6. Discussion and Conclusions

6.1 Contamination with chemical residues

Of the PCB's, DDT's and OCP's analysed only PCB 52, -101, -138, -153, -180 and p.p-DDE and DDT u.s. metabolites were analysed above quantification limits while all metals and PAH's analysed could be quantified. Pollution levels do resemble concentrations found within the Dutch MWTL shellfish monitor program.

Temporal and spatial variation
No difference in fat content was discovered between the different years (data 2010) and between the periods of collection (2010 and 2011).

Based on metal and PCB/DDT concentrations no season effects could be discovered as well; contaminant levels were similar for the three different period's mussels and oysters were collected in 2011. Furthermore there was no significant difference in metal concentration in both mussels and oysters comparing sampling year 2011 with 2010.

Despite this could not be tested statistically, there seem to be some spatial differences in pollution levels. Metal concentrations were relative high at location SG8 (oysters only) compared to the other sample location. Contrarily, PCB and DDT concentrations seem to be relative high at SG1.

Variation between mussels and oysters
Fat, PCB and DDT concentration did not differ significant between mussels and oysters while for metals and PAH significant difference between the species was found. Six out of the 14 PAH analysed showed significant differences namely; fluorene, fenantreen, pyrene, benzo(a)pyrene, benzo(g,h,i)perylene and indeno(1,2,3-cd)pyrene. Except for pyrene, average PAH concentrations were higher in mussel tissue (factor 1.4 to 2.6). The average pyrene concentration was a factor 1.3 higher in oysters. Chromium, nickel, lead and mercury were higher in mussels in both years (factor between 1.7 and 3.1) while significant higher copper and zinc concentrations were found in oysters. Concentrations differed with a factor >20 (max 28.9).

6.2 Contamination with pathogens

Data of the National food safety monitoring program of the Wadden Sea demonstrates that microbiological loads (*E. Coli*) are generally < 230 cfu / 100 grams of shellfish meat. The Interreg monitoring in 2010 confirmed low cfu of *E. Coli*, well below legislative consumption standards. It was found during winter months *E. Coli* cfu were highest, but still below standards. The production area can be classified as 'A' based on European and national legislation.

As *Vibrio parahaemolyticus* has been detected and can cause a potential health risk when consuming raw oysters from the Wadden Sea. In the German situation similar results have been found.

6.3 Overall conclusion

Overall it can be concluded that temporal variation is very limited but that there are indications for spatial variation with higher contaminant levels at SG8, considering metals in oysters, and SG1 considering PCBs in both oysters and mussels. Overall contaminant levels seem to be slightly higher considering some PAH's and metals in mussels compared to oysters. More markedly, zinc and copper concentrations are with a factor >20 higher in oysters. However, as pollution levels measured within this monitoring program were always well below consumption standards and environmental quality standards currently in place and because levels seem to be similar compared to other monitor programs no urgent action seems required. The microbiological results for *Vibrio parahaemolyticus* as found in the German and Dutch Wadden Sea imply a potential food safety risk of a non-regulated contamination. Further study and risk assessment should indicate whether this is an urgent problem for the consumers of Wadden Sea oyster products.

7. Quality Assurance

IMARES utilises an ISO 9001:2008 certified quality management system (certificate number: 124296-2012-AQ-NLD-RvA). This certificate is valid until 15 December 2015. The organisation has been certified since 27 February 2001. The certification was issued by DNV Certification B.V. Furthermore, the chemical laboratory of the Fish Division has NEN-EN-ISO/IEC 17025:2005 accreditation for test laboratories with number L097. This accreditation is valid until 1th of April 2017 and was first issued on 27 March 1997. Accreditation was granted by the Council for Accreditation.

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Justification

Rapport: C104/14
Project Number: 430410091

The scientific quality of this report has been peer reviewed by the a colleague scientist and the head of the department of IMARES.

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Date: 8th July 2014

Appendix A. Mussel and oyster composition (Dutch Wadden Sea)

Table 1. Composition of mussel samples collected in 2010.

LIMS	Location	Moister (%)	ash (%)	fat (%)
2010/1627	SG1	92.4	2.0	0.5
2010/1629	SG2	80.3	2.1	2.5
2010/1631	SG3	84.8	1.9	1.7
2010/1633	SG4	88.6	2.1	1.0
2010/1635	SG5	88.9	2.5	1.0
2010/1637	SG6	86.3	2.4	1.3
2010/1639	SG7	86.2	2.2	1.3

Table 2. Composition of oyster samples collected in 2010.

LIMS	Location	Moister (%)	ash (%)	fat (%)
2010/1643	SG1	89.6	2.1	1.1
2010/1645	SG2	82.5	1.8	2.5
2010/1647	SG3	89.2	1.4	1.8
2010/1649	SG4	88.6	1.6	1.9
2010/1651	SG5	88.2	1.6	2.0
2010/1653	SG6	88.8	1.7	1.8
2010/1655	SG7	89.6	1.8	1.4
2010/1657	SG8	91.0	1.8	1.0

Table 3. Composition of mussel samples collected in 2011.

LIMS	Period	Location	Moister (%)	ash (%)	fat (%)	average shell lenght (mm)	average tissue weight (g)
2011/1608	1	SG1	87.6	2.5	1.0	54.9	4.6
2011/1612		SG3	83.6	2.6	1.6	51.9	5.1
2011/1616		SG5	86.3	3.6	1.0	47.3	2.5
2011/1618		SG6	87.1	2.9	1.0	52.2	4.5
2011/1624	2	SG1	83.5	2.9	1.6	49.4	2.5
2011/1626		SG2	84.3	3.1	1.5	48.5	3.1
2011/1634		SG6	88.5	2.8	0.9	51.9	4.9
2011/1636		SG7	82.3	NA	1.8	52.3	3.7
2011/1640	3	SG1	90.1	2.2	0.7	53.8	4.2
2011/1644		SG3	78.8	2.1	1.7	52.4	7.7
2011/1650		SG6	87.7	2.2	1.1	51.7	6.2
2011/1652		SG7	87.5	3.1	1.3	53.3	3.7

Table 4. Composition of oyster samples collected in 2011.

LIMS	Period	Location	Moister (%)	ash (%)	fat (%)	average shell lenght (mm)	average tissue weight (g)
2011/1609	1	SG1	91.0	2.4	0.6	110.3	21.4
2011/1613		SG3	90.2	2.3	0.8	130.3	49.2
2011/1623		SG8	91.8	2.3	1.6	118.7	15.4
2011/1619		SG6	85.8	2.3	1.4	106.1	27.0
2011/1617		SG5	83.2	2.6	2.2	83.6	4.4
2011/1627	2	SG2	84.9	2.4	2.0	79.5	13.8
2011/1625		SG1	88.5	2.2	1.0	93.3	20.4
2011/1635		SG6	88.3	2.3	1.2	114.9	43.5
2011/1637		SG7	85.8	NA	1.1	110.6	20.7
2011/1639		SG8	89.9	NA	1.3	132.6	18.3
2011/1641	3	SG1	88.2	2.1	1.2	91.8	13.2
2011/1645		SG3	82.4	2.0	1.9	128.6	44.0
2011/1651		SG6	87.5	2.2	1.2	130.4	59.5
2011/1653		SG7	83.4	2.5	2.4	127.9	21.0

Appendix B. Heavy metals (Dutch Wadden Sea)

In table 1 to 4 metal concentrations in oysters and mussels collected in 2010 tabulated and in table 5 to 8 metal concentrations of oysters and mussels collected in 2011. Metal content is expressed both on fresh- and dry weight basis.

Table 1. Concentration of heavy metals (mg/kg) in mussel samples collected in 2010 on basis of fresh weight.

LIMS	Location	As	Cd	Cr	Cu	Ni	Pb	Zn	Hg
2010/1627	SG1	1.08	0.100	0.17	0.70	0.24	0.21	8.0	0.037
2010/1629	SG2	1.88	0.046	0.15	1.40	0.24	0.29	17	0.024
2010/1631	SG3	1.10	0.047	0.15	1.10	0.26	0.20	13	0.023
2010/1633	SG4	1.31	0.091	0.23	0.90	0.32	0.31	13	0.040
2010/1635	SG5	1.35	0.073	0.18	0.80	0.30	0.28	10	0.030
2010/1637	SG6	1.25	0.083	0.14	0.80	0.29	0.25	11	0.0096
2010/1639	SG7	1.93	0.092	0.20	0.90	0.37	0.36	16	0.040
Consumption norm			*1.0*				*1.5*		*0.5*

Table 2. Concentration of heavy metals (mg/kg) in mussel samples collected in 2010 on basis of dry weight.

LIMS	Location	Moist (%)	As	Cd	Cr	Cu	Ni	Pb	Zn	Hg
2010/1627	SG1	92.4	14.21	1.316	2.237	9.2	3.158	2.763	105	0.487
2010/1629	SG2	80.3	9.54	0.234	0.761	7.1	1.218	1.472	86	0.122
2010/1631	SG3	84.8	7.24	0.309	0.987	7.2	1.711	1.316	86	0.151
2010/1633	SG4	88.6	11.49	0.798	2.018	7.9	2.807	2.719	114	0.351
2010/1635	SG5	88.9	12.16	0.658	1.622	7.2	2.703	2.523	90	0.270
2010/1637	SG6	86.3	9.12	0.606	1.022	5.8	2.117	1.825	80	0.070
2010/1639	SG7	86.2	13.99	0.667	1.449	6.5	2.681	2.609	116	0.290

Table 3. Concentration of heavy metals (mg/kg) in oyster samples collected in 2010 on basis of fresh weight.

LIMS	Location	As	Cd	Cr	Cu	Ni	Pb	Zn	Hg
2010/1643	SG1	1.14	0.130	0.04	15	0.08	0.12	349	0.021
2010/1645	SG2	2.83	0.084	0.05	5.8	0.08	0.14	226	0.025
2010/1647	SG3	1.28	0.071	0.03	11	0.07	0.08	224	0.013
2010/1649	SG4	1.55	0.120	0.05	17	0.09	0.12	345	0.018
2010/1651	SG5	1.35	0.088	0.03	11	0.07	0.08	246	0.014
2010/1653	SG6	1.60	0.110	0.04	19	0.08	0.10	368	0.017
2010/1655	SG7	1.34	0.078	0.02	10	0.08	0.10	234	0.015
2010/1657	SG8	1.08	0.830	0.13	62	0.27	0.15	454	0.017
Consumption norm			1.0				1.5		0.5

Table 4. Concentration of heavy metals (mg/kg) in oyster samples collected in 2010 on basis of dry weight.

LIMS	Location	As	Cd	Cr	Cu	Ni	Pb	Zn	Hg
2010/1643	SG1	1.14	0.130	0.04	15	0.08	0.12	349	0.021
2010/1645	SG2	2.83	0.084	0.05	5.8	0.08	0.14	226	0.025
2010/1647	SG3	1.28	0.071	0.03	11	0.07	0.08	224	0.013
2010/1649	SG4	1.55	0.120	0.05	17	0.09	0.12	345	0.018
2010/1651	SG5	1.35	0.088	0.03	11	0.07	0.08	246	0.014
2010/1653	SG6	1.60	0.110	0.04	19	0.08	0.10	368	0.017
2010/1655	SG7	1.34	0.078	0.02	10	0.08	0.10	234	0.015
2010/1657	SG8	1.08	0.830	0.13	62	0.27	0.15	454	0.017
Consumption norm			*1.0*				*1.5*		*0.5*

Table 5. Concentration of heavy metals (mg/kg) in mussel samples collected in 2011 on basis of fresh weight.

LIMS	Period	Location	As	Cd	Cr	Cu	Ni	Pb	Zn	Hg
2011/1608	1	SG1	1.3	0.053	0.39	1.5	0.38	0.37	13	0.022
2011/1612		SG3	1.9	0.058	0.25	1.3	0.34	0.28	17	0.023
2011/1616		SG5	1.9	0.10	0.48	1.6	0.51	0.51	19	0.039
2011/1618		SG6	2.0	0.077	0.20	1.2	0.37	0.36	16	0.040
2011/1624	2	SG1	2.1	0.13	0.42	1.5	0.49	0.53	16	0.070
2011/1626		SG2	2.7	0.064	0.31	1.1	0.35	0.49	19	0.028
2011/1634		SG6	1.3	0.062	0.21	0.75	0.35	0.26	11	0.024
2011/1636		SG7	1.8	0.069	0.30	0.89	0.48	0.40	13	0.037
2011/1640	3	SG1	1.2	0.094	0.25	0.77	0.28	0.26	9.3	0.052
2011/1644		SG3	1.4	0.035	0.14	1.4	0.20	0.16	11	0.022
2011/1650		SG6	1.2	0.050	0.14	0.87	0.22	0.21	10	0.030
2011/1652		SG7	1.6	0.068	0.28	0.84	0.38	0.41	14	0.041
	Consumption norm			*1.0*				*1.5*		*0.5*

Table 6. Concentration of heavy metals (mg/kg) in mussel samples collected in 2011 on basis of dry weight.

LIMS	Period	Location	Moist (%)	As	Cd	Cr	Cu	Ni	Pb	Zn	Hg
2011/1608	1	SG1	87.6	10.9	0.428	3.13	12.2	3.04	2.98	106	0.177
2011/1612		SG3	83.6	11.8	0.354	1.54	8.0	2.06	1.72	102	0.140
2011/1616		SG5	86.3	13.8	0.74	3.53	11.4	3.70	3.73	136	0.285
2011/1618		SG6	87.1	15.4	0.600	1.54	9.2	2.90	2.83	127	0.310
2011/1624	2	SG1	83.5	13.0	0.77	2.56	9.4	2.99	3.19	97	0.424
2011/1626		SG2	84.3	17.4	0.406	1.96	6.8	2.22	3.15	120	0.178
2011/1634		SG6	88.5	11.1	0.543	1.85	6.55	3.07	2.26	93	0.209
2011/1636		SG7	82.3	10.1	0.387	1.67	5.03	2.74	2.27	76	0.209
2011/1640	3	SG1	90.1	11.9	0.946	2.49	7.73	2.83	2.59	94	0.525
2011/1644		SG3	78.8	6.6	0.167	0.64	6.4	0.92	0.76	52	0.104
2011/1650		SG6	87.7	9.7	0.403	1.16	7.11	1.75	1.70	84	0.244
2011/1652		SG7	87.5	13.0	0.548	2.25	6.7	3.04	3.29	109	0.328

Table 7. Concentration of heavy metals (mg/kg) in oyster samples collected in 2011 on basis of fresh weight.

LIMS	Period	Location	As	Cd	Cr	Cu	Ni	Pb	Zn	Hg
2011/1609	1	SG1	1.0	0.16	0.16	23	0.12	0.15	291	0.011
2011/1613		SG3	1.4	0.11	0.036	8.8	0.057	0.071	168	0.011
2011/1617		SG5	2.0	0.15	0.10	19	0.11	0.21	271	0.022
2011/1619		SG6	1.8	0.094	0.066	13	0.085	0.14	265	0.021
2011/1623		SG8	1.8	0.82	0.44	36	0.38	0.34	248	0.019
2011/1625	2	SG1	1.4	0.11	0.094	11	0.082	0.16	291	0.023
2011/1627		SG2	2.2	0.092	0.048	5.7	0.070	0.15	167	0.020
2011/1635		SG6	1.4	0.083	0.035	12	0.055	0.08	200	0.014
2011/1637		SG7	2.1	0.094	0.11	12	0.11	0.21	276	0.030
2011/1639		SG8	1.2	0.66	0.068	52	0.088	0.095	400	0.019
2011/1641	3	SG1	1.2	0.13	0.083	17	0.082	0.15	332	0.027
2011/1645		SG3	1.5	0.048	0.059	8.2	0.055	0.11	167	0.016
2011/1651		SG6	1.2	0.074	0.069	17	0.068	0.10	233	0.014
2011/1653		SG7	2.2	0.095	0.084	23	0.10	0.20	433	0.030
	Consumption norm			*1.0*				*1.5*		*0.5*

Table 8. Concentration of heavy metals (mg/kg) in oyster samples collected in 2011 on basis of dry weight.

LIMS	Period	Location	Moist (%)	As	Cd	Cr	Cu	Ni	Pb	Zn	Hg
2011/1609	1	SG1	91.0	10.93	1.73	1.75	256	1.35	1.71	3236	0.122
2011/1613		SG3	90.2	14.0	1.08	0.367	90.0	0.58	0.73	1717	0.112
2011/1619		SG6	85.8	12.5	0.660	0.467	90	0.60	0.95	1864	0.148
2011/1617		SG5	83.2	12.1	0.87	0.62	114	0.68	1.23	1611	0.131
2011/1623		SG8	91.8	21.6	10.05	5.36	437	4.63	4.15	3021	0.232
2011/1625	2	SG1	88.5	12.1	0.99	0.818	95	0.72	1.39	2527	0.200
2011/1627		SG2	84.9	14.3	0.607	0.318	37.5	0.46	1.01	1109	0.132
2011/1635		SG6	88.3	11.8	0.711	0.300	104	0.47	0.72	1712	0.120
2011/1637		SG7	85.8	14.8	0.659	0.79	88	0.80	1.47	1946	0.211
2011/1639		SG8	89.9	12.3	6.51	0.675	515	0.87	0.94	3961	0.188
2011/1641	3	SG1	88.2	10.2	1.06	0.706	143	0.70	1.28	2812	0.229
2011/1645		SG3	82.4	8.5	0.272	0.335	46.8	0.31	0.61	951	0.091
2011/1651		SG6	87.5	9.6	0.589	0.550	138	0.54	0.83	1863	0.112
2011/1653		SG7	83.4	13.5	0.574	0.506	136	0.63	1.18	2608	0.181

Appendix C. PCBs, DDT, pesticides and herbicides (Dutch Wadden Sea)

Table 1. Concentration of PCB's and DDT (µg/kg) in mussel samples collected in 2011 on basis of fresh weight.

LIMS	Period	Location	PCB 28	PCB 52	PCB 101	PCB 138	PCB 153	PCB 180	p,p-DDE	o,p-DDE	p,p-DDT	o,p-DDT	p,p-DDD	o,p-DDD	DDT u. s. metaboliten
2011/1608	1	SG1	< 0,2	0.2	0.7	0.8	1.9	0.1	0.3	< 0,2	< 0,2	< 0,2	< 0,2	< 0,2	0.6
2011/1612		SG3	< 0,2	0.4	1.4	1.9	3.7	0.2	0.7	< 0,2	0.5	0.2	< 0,2	< 0,2	1.6
2011/1614		SG4	< 0,2	0.2	1.0	1.8	3.2	0.2	0.6	< 0,2	< 0,2	< 0,2	< 0,2	< 0,2	1.0
2011/1616		SG5	< 0,2	< 0,2	0.6	1.0	1.7	0.2	0.3	< 0,2	< 0,2	< 0,2	< 0,2	< 0,2	0.7
2011/1618		SG6	< 0,2	0.2	1.2	2.0	3.3	0.2	0.6	< 0,2	< 0,2	< 0,2	< 0,2	< 0,2	1.1
2011/1624	2	SG1	< 0,2	0.4	1.4	1.8	3.7	0.3	0.7	< 0,2	< 0,2	< 0,2	< 0,2	< 0,2	1.3
2011/1626		SG2	< 0,2	0.5	1.6	2.0	4.4	0.2	0.9	< 0,2	< 0,2	0.3	< 0,2	< 0,2	1.6
2011/1634		SG6	< 0,2	0.4	1.6	2.4	4.8	0.3	0.9	< 0,2	< 0,2	0.3	< 0,2	< 0,2	1.6
2011/1636		SG7	< 0,2	< 0,2	0.7	1.3	2.1	0.1	0.4	< 0,2	< 0,2	< 0,2	< 0,2	< 0,2	0.8
Consumption norm (NED)							100								

Table 2. Concentration of PCB's and DDT (µg/kg) in mussel samples collected in 2011 on basis of fat weight.

LIMS	Period	Location	Fat (%)	PCB 28	PCB 52	PCB 101	PCB 138	PCB 153	PCB 180	p,p-DDE	o,p-DDE	p,p-DDT	o,p-DDT	p,p-DDD	o,p-DDD	DDT u. s. metaboliten
2011/1608	1	SG1	1.3	<7.7	17.8	53.9	64.1	144.9	10.2	24.5	<7.7	<7.7	<7.7	<7.7	<7.7	47.7
2011/1612		SG3	3.4	<3.0	12.0	42.0	56.9	109.0	6.7	19.9	<3.0	14.7	6.1	<3.0	<3.0	47.4
2011/1614		SG4	2.1	<4.8	11.4	48.8	89.2	152.5	9.8	28.2	<4.8	<4.8	<4.8	<4.8	<4.8	49.5
2011/1616		SG5	1.9	<5.4	<5.4	31.4	54.8	88.5	8.0	15.7	<5.4	<5.4	<5.4	<5.4	<5.4	37.2
2011/1618		SG6	3.0	<3.3	8.3	40.3	66.9	111.0	6.3	20.7	<3.3	<3.3	<3.3	<3.3	<3.3	35.5
2011/1624	2	SG1	2.1	<4.8	19.3	68.3	86.9	178.4	13.1	34.6	<4.8	<4.8	<4.8	<4.8	<4.8	59.8
2011/1626		SG2	3.6	<2.8	13.5	44.2	55.2	121.5	6.8	26.2	<2.8	<2.8	7.2	<2.8	<2.8	44.9
2011/1634		SG6	3.5	<2.8	12.7	46.6	68.8	137.0	9.2	26.4	<2.8	<2.8	7.8	<2.8	<2.8	44.2
2011/1636		SG7	2.2	<4.6	<4.6	30.6	60.0	97.6	6.1	20.2	<4.6	<4.6	<4.6	<4.6	<4.6	36.0

Table 3. Concentration of pesticides and herbicides (µg/kg) in mussel samples collected in 2011 on basis of fresh weight.

LIMS	Period	Location	Dieldrin	a-HCH	b-HCH	Lindan	cis-Heptachlorepoxid	Heptachlor	Bromocyclen	trans-Heptachlorepoxid	Moschusxylol	Moschusketon	a-Chlordan	g-Chlordan	Oxichlordan	Parlar 26	Parlar 50	Parlar 62	a-Endosulfan	b-Endosulfan	Endosulfan sulfat	Endrin	Endrinketon	HCB
2011/1608	1	SG1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,2	< 0,1	< 0,1	< 0,2	< 0,2	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,2	< 0,2	< 0,2	< 0,2	< 0,2	< 0,2	< 0,1
2011/1612		SG3	< 0,1	< 0,1	0.1	< 0,1	< 0,1	< 0,2	< 0,1	< 0,1	< 0,2	< 0,2	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,2	< 0,2	< 0,2	< 0,2	< 0,2	< 0,2	< 0,1
2011/1614		SG4	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,2	< 0,1	< 0,1	< 0,2	< 0,2	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,2	< 0,2	< 0,2	< 0,2	< 0,2	< 0,2	< 0,1
2011/1616		SG5	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,2	< 0,1	< 0,1	< 0,2	< 0,2	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,2	< 0,2	< 0,2	< 0,2	< 0,2	< 0,2	< 0,1
2011/1618		SG6	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,2	< 0,1	< 0,1	< 0,2	< 0,2	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,2	< 0,2	< 0,2	< 0,2	< 0,2	< 0,2	< 0,1
2011/1624	2	SG1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,2	< 0,1	< 0,1	< 0,2	< 0,2	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,2	< 0,2	< 0,2	< 0,2	< 0,2	< 0,2	< 0,1
2011/1626		SG2	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,2	< 0,1	< 0,1	< 0,2	< 0,2	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,2	< 0,2	< 0,2	< 0,2	< 0,2	< 0,2	< 0,1
2011/1634		SG6	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,2	< 0,1	< 0,1	< 0,2	< 0,2	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,2	< 0,2	< 0,2	< 0,2	< 0,2	< 0,2	< 0,1
2011/1636		SG7	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,2	< 0,1	< 0,1	< 0,2	< 0,2	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,2	< 0,2	< 0,2	< 0,2	< 0,2	< 0,2	< 0,1

Table 4. Concentration of PCB and DDT (µg/kg) in oyster samples collected in 2011 on basis of fresh weight.

LIMS	Period	Location	PCB 28	PCB 52	PCB 101	PCB 138	PCB 153	PCB 180	p,p-DDE	o,p-DDE	p,p-DDT	o,p-DDT	p,p-DDD	o,p-DDD	DDT u. s. Metaboliten
2011/1609	1	SG1	< 0,2	0.3	1.3	2.0	3.6	0.3	0.5	< 0,2	< 0,2	< 0,2	< 0,2	< 0,2	0.9
2011/1613		SG3	< 0,2	0.3	1.1	2.1	3.6	0.2	0.6	< 0,2	< 0,2	< 0,2	< 0,2	< 0,2	0.9
2011/1615		SG4	< 0,2	0.3	1.3	1.6	3.6	0.2	0.8	< 0,2	< 0,2	0.2	< 0,2	< 0,2	1.2
2011/1619		SG6	< 0,2	0.4	1.4	2.0	3.9	0.2	0.8	< 0,2	< 0,2	0.2	< 0,2	< 0,2	1.2
2011/1623		SG8	< 0,2	0.2	0.8	1.4	2.7	0.2	0.6	< 0,2	< 0,2	< 0,2	< 0,2	< 0,2	1.0
2011/1625	2	SG1	< 0,2	0.2	0.8	1.3	2.1	0.1	0.4	< 0,2	0.2	< 0,2	< 0,2	< 0,2	1.0
2011/1627		SG2	< 0,2	0.3	1.1	1.9	3.3	0.2	0.6	< 0,2	< 0,2	< 0,2	< 0,2	< 0,2	1.1
2011/1635		SG6	< 0,2	0.3	1.1	1.7	3.3	0.2	0.7	0.5	< 0,2	0.2	< 0,2	< 0,2	1.7
2011/1637		SG7	< 0,2	< 0,2	0.7	1.3	2.1	0.1	0.4	< 0,2	< 0,2	< 0,2	< 0,2	< 0,2	0.7
Consumption norm (NED)							100								

Table 5. Concentration of PCB and DDT (µg/kg) in oyster samples collected in 2011 on basis of fat weight.

LIMS	Period	Location	Fat (%)	PCB 28	PCB 52	PCB 101	PCB 138	PCB 153	PCB 180	p,p-DDE	o,p-DDE	p,p-DDT	o,p-DDT	p,p-DDD	o,p-DDD	DDT u. s. Metaboliten
2011/1609	1	SG1	3.0	<3.3	11.2	43.8	67.4	118.3	8.3	17.1	<3.3	<3.3	<3.3	<3.3	<3.3	29.8
2011/1613		SG3	2.9	<3.4	9.0	38.6	71.2	122.2	8.1	19.5	<3.4	<3.4	<3.4	<3.4	<3.4	31.9
2011/1615		SG4	3.5	<2.8	9.4	35.7	44.0	100.6	4.9	21.6	<2.8	<2.8	5.8	<2.8	<2.8	34.9
2011/1619		SG6	3.2	<3.1	10.9	44.1	60.9	121.6	7.2	25.1	<3.1	<3.1	6.9	<3.1	<3.1	36.8
2011/1623		SG8	2.5	<3.9	8.0	33.3	56.3	107.2	8.8	23.9	<3.9	<3.9	<3.9	<3.9	<3.9	38.8
2011/1625	2	SG1	2.0	<5.0	11.4	41.1	65.0	105.7	7.4	19.1	<5.0	12.5	<5.0	<5.0	<5.0	48.0
2011/1627		SG2	2.0	<4.9	13.8	55.9	90.9	161.0	10.1	29.0	<4.9	<4.9	<4.9	<4.9	<4.9	55.6
2011/1635		SG6	2.5	<4.0	11.4	44.7	66.9	132.5	9.3	29.0	21.2	<4.0	9.0	<4.0	<4.0	68.4
2011/1637		SG7	3.9	<2.6	<2.6	17.0	34.0	53.6	3.5	9.3	<2.6	<2.6	<2.6	<2.6	<2.6	16.8

Table 6. Concentration of pesticides and herbicides (µg/kg) in oyster samples collected in 2011 on basis of fresh weight.

LIMS	Period	Location	Dieldrin	a-HCH	b-HCH	Lindan	cis-Heptachlorepoxid	Heptachlor	Bromocyclen	trans-Heptachlorepoxid	Moschusxylol	Moschusketon	a-Chlordan	g-Chlordan	Oxichlordan	Parlar 26	Parlar 50	Parlar 62	a-Endosulfan	b-Endosulfan	Endosulfan sulfat	Endrin	Endrinketon	HCB
2011/1609	1	SG1	< 0,1	< 0,1	0.1	< 0,1	< 0,1	< 0,2	< 0,1	< 0,1	< 0,2	< 0,2	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,2	< 0,2	< 0,2	< 0,2	< 0,2	< 0,2	< 0,1
2011/1613		SG3	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,2	< 0,1	< 0,1	< 0,2	< 0,2	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,2	< 0,2	< 0,2	< 0,2	< 0,2	< 0,2	< 0,1
2011/1615		SG4	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,2	< 0,1	< 0,1	< 0,2	< 0,2	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,2	< 0,2	< 0,2	< 0,2	< 0,2	< 0,2	< 0,1
2011/1619		SG6	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,2	< 0,1	< 0,1	< 0,2	< 0,2	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,2	< 0,2	< 0,2	< 0,2	< 0,2	< 0,2	< 0,1
2011/1623		SG8	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,2	< 0,1	< 0,1	< 0,2	< 0,2	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,2	< 0,2	< 0,2	< 0,2	< 0,2	< 0,2	< 0,1
2011/1625	2	SG1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,2	< 0,1	< 0,1	< 0,2	< 0,2	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,2	< 0,2	< 0,2	< 0,2	< 0,2	< 0,2	< 0,1
2011/1627		SG2	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,2	< 0,1	< 0,1	< 0,2	< 0,2	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,2	< 0,2	< 0,2	< 0,2	< 0,2	< 0,2	< 0,1
2011/1635		SG6	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,2	< 0,1	< 0,1	< 0,2	< 0,2	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,2	< 0,2	< 0,2	< 0,2	< 0,2	< 0,2	< 0,1
2011/1637		SG7	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,2	< 0,1	< 0,1	< 0,2	< 0,2	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,2	< 0,2	< 0,2	< 0,2	< 0,2	< 0,2	< 0,1

Appendix D. PAH's (Dutch Wadden Sea)

Table 1. Concentration of PAH's in (µg/kg) in oyster and mussel samples collected in 2010 on basis of fresh weight. Fat content in percentage (%).

LIMSnr.	Location	Species	Date of analysis	Fat B&D	Acenafteen	Fluoreen	Fenantreen	Anthraceen	Fuoranteen	Pyreen	Benzo(a) anthraceen	Chryseen	Benzo(b) fluoranteen	Benzo(k) fluoranteen	Benzo(a) pyreen	Dibenzo(a,h) anthraceen	Benzo(g,h,i) peryleen	Indeno(1,2,3-cd) pyreen
2010/1627	SG1	mussel	March 2011	0.5	0.1	<0.7	<4.3	0.1	2.7	1.2	0.5	0.6	1.0	0.4	0.4	0.03	0.6	0.4
2010/1629	SG2	mussel	March 2011	2.5	0.4	1.3	4.8	0.3	6.9	4.0	0.7	1.1	2.2	0.7	0.6	0.04	1.2	0.6
2010/1631	SG3	mussel	March 2011	1.7	0.4	0.8	2.9	0.2	3.8	2.4	0.6	0.8	1.9	0.7	0.5	0.04	0.8	0.7
2010/1633	SG4	mussel	March 2011	1.0	0.4	0.3	<4.3	0.2	1.8	1.4	0.6	0.7	1.5	0.6	0.5	0.06	0.9	0.6
2010/1635	SG5	mussel	March 2011	1.0	0.4	0.6	<4.2	0.2	2.3	1.6	0.5	0.6	1.5	0.7	0.4	0.04	0.8	0.6
2010/1637	SG6	mussel	March 2011	1.3	0.7	0.7	<4.2	0.3	2.8	2.5	0.5	0.8	1.9	0.8	0.5	0.05	1.1	0.6
2010/1639	SG7	mussel	March 2011	1.3	0.4	0.8	2.7	0.2	3.6	2.8	0.6	0.9	1.8	0.8	0.4	0.03	1.1	0.7
2010/1643	SG1	oyster	March 2011	1.1	0.4	0.4	<4.3	0.1	5.5	3.1	0.5	1.2	1.2	0.5	0.3	0.04	0.4	0.2
2010/1645	SG2	oyster	March 2011	2.5	0.8	1.2	4.8	0.2	8.9	5.9	0.8	2.0	2.7	1.1	0.5	0.10	0.7	0.4
2010/1647	SG3	oyster	March 2011	1.8	0.7	0.7	2.3	0.2	4.5	3.0	0.5	1.1	1.8	0.7	0.3	0.07	0.5	0.3
2010/1649	SG4	oyster	March 2011	1.9	0.7	0.6	<4.0	0.2	4.7	3.4	0.6	1.3	2.2	0.9	0.5	0.10	0.7	0.4
2010/1651	SG5	oyster	March 2011	2.0	0.4	0.7	3.0	0.2	4.9	3.5	0.5	1.1	1.9	0.7	0.3	0.07	0.5	0.3
2010/1653	SG6	oyster	March 2011	1.8	0.5	0.8	2.4	0.1	6.1	4.7	0.6	1.2	2.7	1.0	0.4	0.03	0.7	0.3
2010/1655	SG7	oyster	March 2011	1.4	0.3	0.6	<4.2	0.1	4.3	3.7	0.6	0.9	2.1	0.8	0.3	0.04	0.4	0.2
2010/1657	SG8	oyster	March 2011	1.0	0.3	<0.7	<4.3	0.1	2.8	2.9	0.4	0.8	2.3	0.9	0.5	0.06	0.8	0.4
Environmetntal quality standards													*10*	*10*	*10*		*10*	*10*

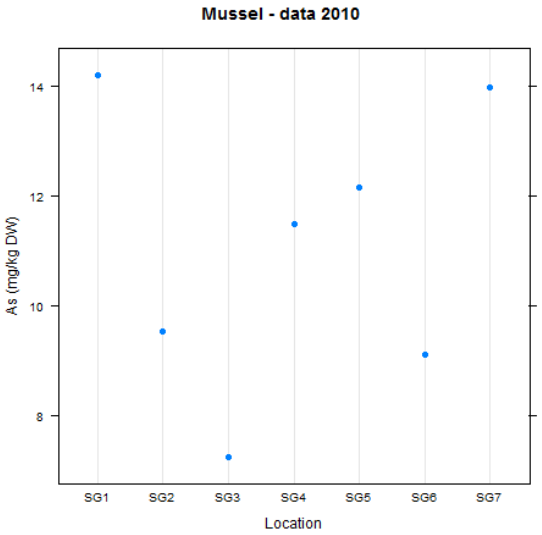
Table 2. Concentration of PAH's in (µg/kg) in oyster and mussel samples collected in 2010 on basis of fat weight. Fat content in percentage (%).

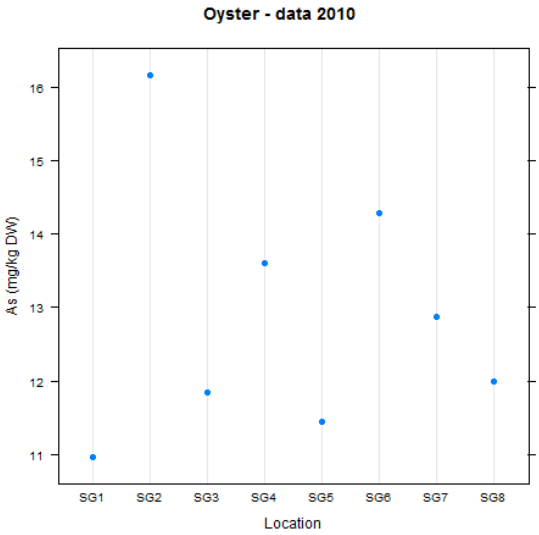
LIMSnr.	Location	Species	Date of analysis	Fat B&D	Acenafteen	Fluoreen	Fenantreen	Anthraceen	Fuoranteen	Pyreen	Benzo(a) anthraceen	Chryseen	Benzo(b) fluoranteen	Benzo(k) fluoranteen	Benzo(a) pyreen	Dibenzo(a,h) anthraceen	Benzo(g,h,i) peryleen	Indeno(1,2,3-cd) pyreen
2010/1627	SG1	mussel	March 2011	0.5	20	***70***	***430***	20	540	240	100	120	200	80	80	6.0	120	80
2010/1629	SG2	mussel	March 2011	2.5	16	52	192	12	276	160	28	44	88	28	24	1.6	48	24
2010/1631	SG3	mussel	March 2011	1.7	24	47	171	12	224	141	35	47	112	41	29	2.4	47	41
2010/1633	SG4	mussel	March 2011	1.0	40	30	***215***	20	180	140	60	70	150	60	50	6.0	90	60
2010/1635	SG5	mussel	March 2011	1.0	40	60	***210***	20	230	160	50	60	150	70	40	4.0	80	60
2010/1637	SG6	mussel	March 2011	1.3	54	54	***162***	23	215	192	38	62	146	62	38	3.8	85	46
2010/1639	SG7	mussel	March 2011	1.3	31	62	208	15	277	215	46	69	138	62	31	2.3	85	54
2010/1641	SG8	mussel	nvt	nb	nb	nb	nb	nb	nb	nb	nb	nb	nb	nb	nb	nb	nb	nb
2010/1643	SG1	oyster	March 2011	1.1	36	36	***195***	9	500	282	45	109	109	45	27	3.6	36	18
2010/1645	SG2	oyster	March 2011	2.5	32	48	192	8	356	236	32	80	108	44	20	4.0	28	16
2010/1647	SG3	oyster	March 2011	1.8	39	39	128	11	250	167	28	61	100	39	17	3.9	28	17
2010/1649	SG4	oyster	March 2011	1.9	37	32	***105***	11	247	179	32	68	116	47	26	5.3	37	21
2010/1651	SG5	oyster	March 2011	2.0	20	35	150	10	245	175	25	55	95	35	15	3.5	25	15
2010/1653	SG6	oyster	March 2011	1.8	28	44	133	6	339	261	33	67	150	56	22	1.7	39	17
2010/1655	SG7	oyster	March 2011	1.4	21	43	***150***	7	307	264	43	64	150	57	21	2.9	29	14
2010/1657	SG8	oyster	March 2011	1.0	30	***35***	***215***	10	280	290	40	80	230	90	50	6.0	80	40

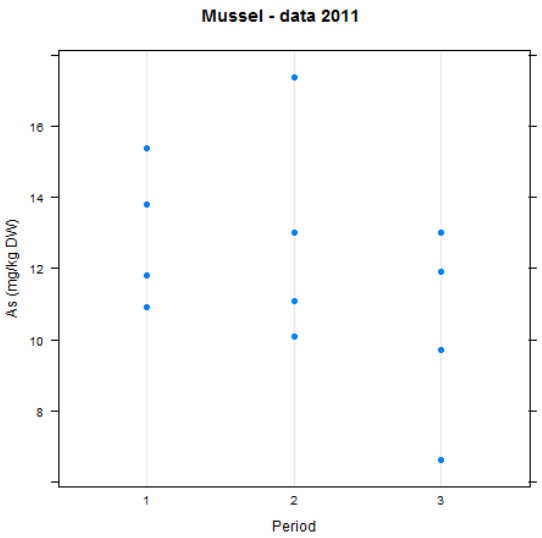
Values in bold are calculated using ½ of reporting limit.

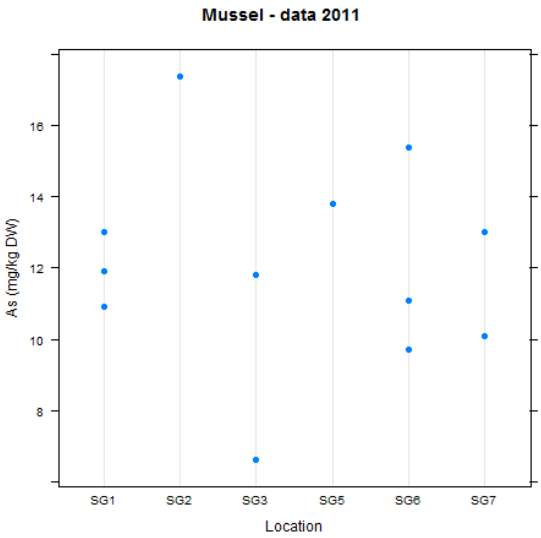
Appendix E. Plots concentrations of heavy metals in oyster and mussel tissue

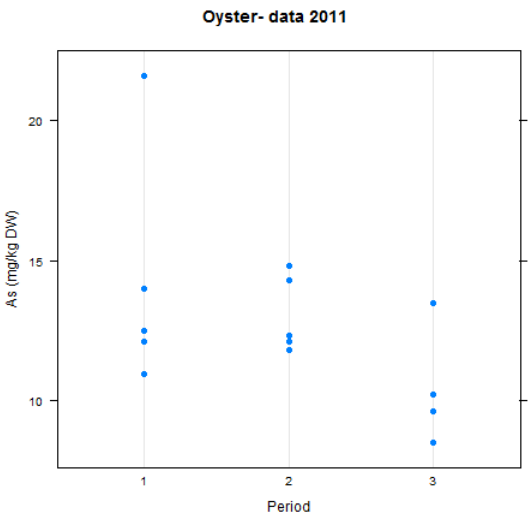
Concentration arsenic in mussel and oysters collected in 2010 and 2011.

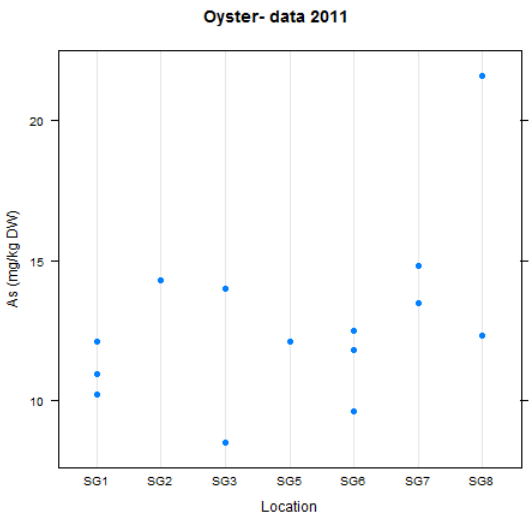




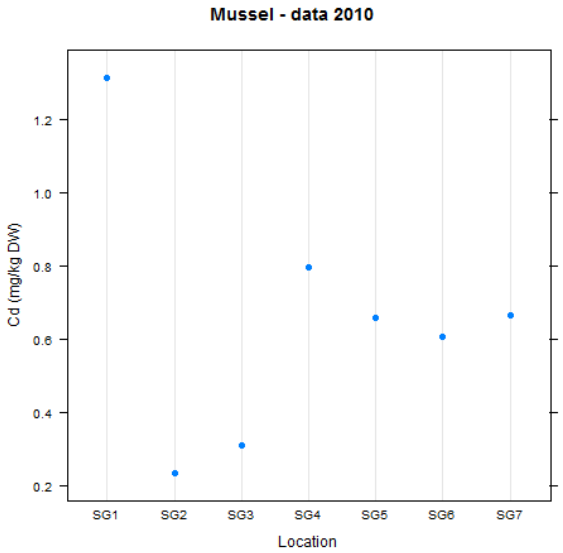


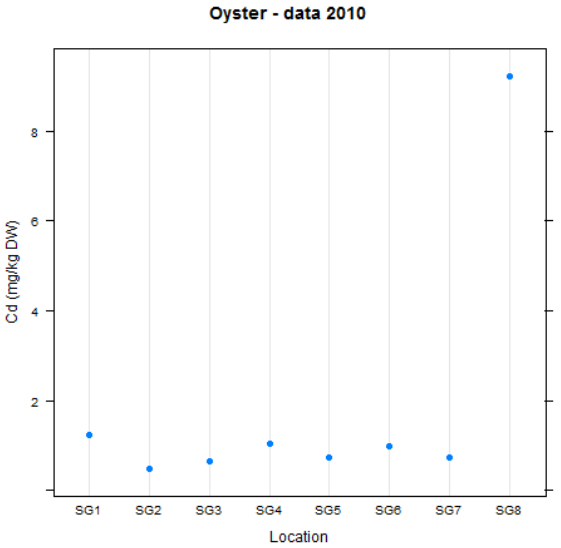


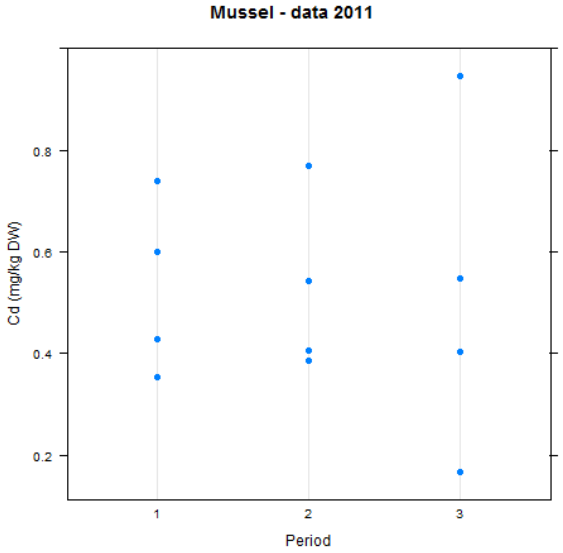


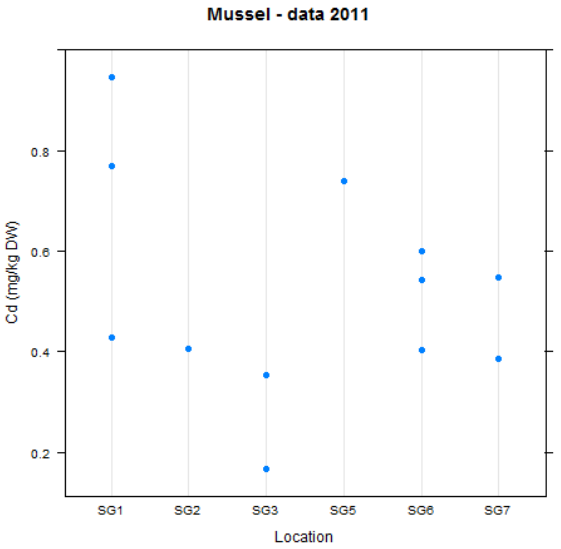


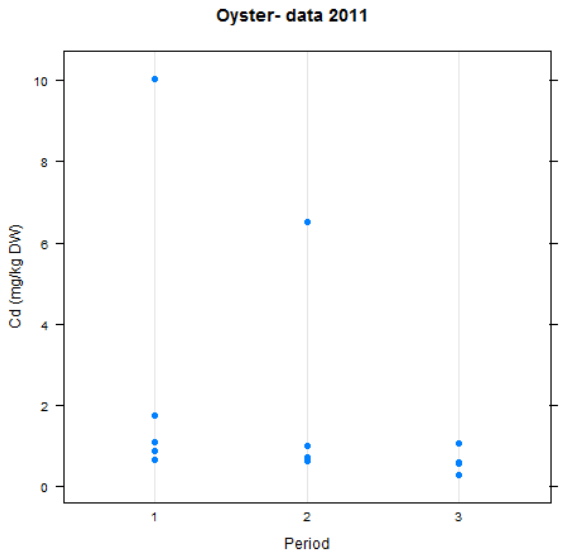
Concentration cadmium in mussel and oysters collected in 2010 and 2011.

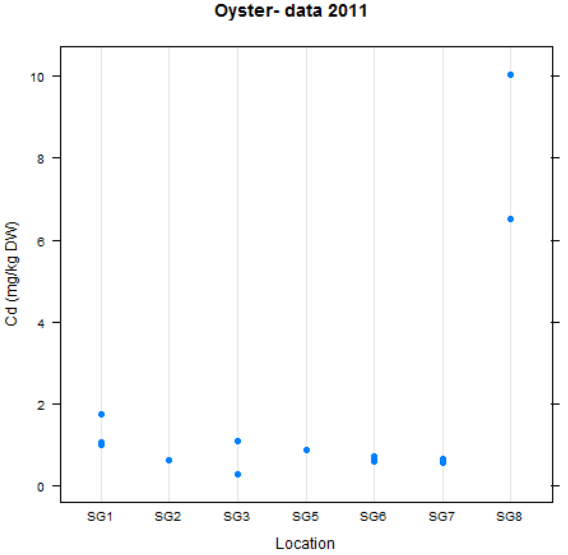




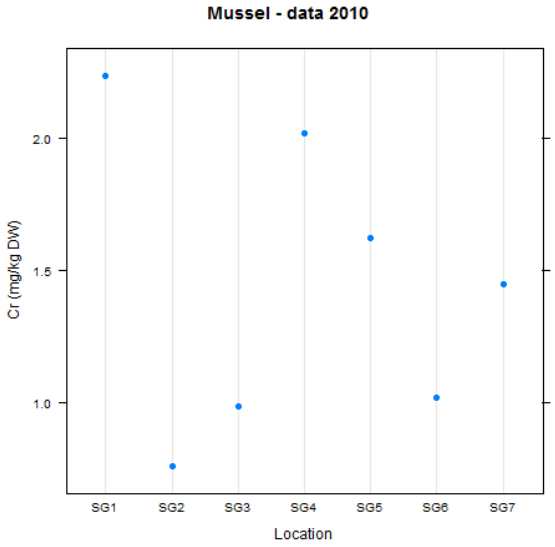


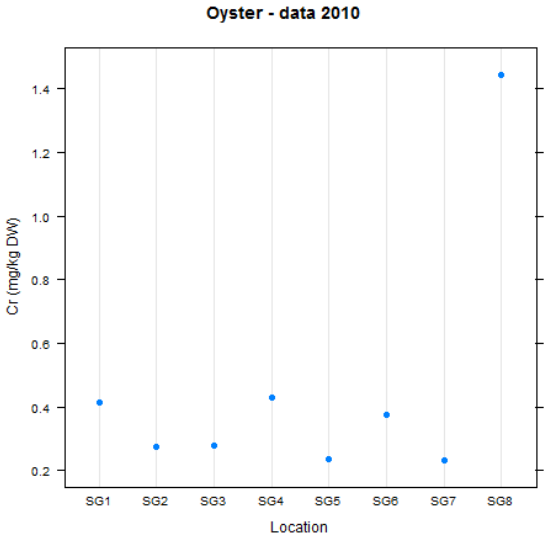


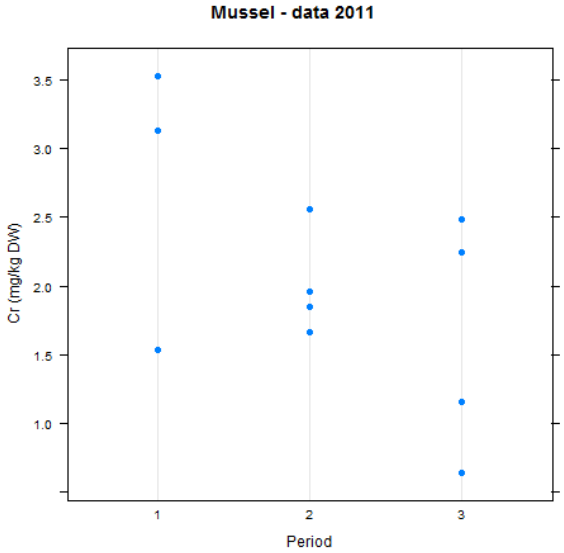


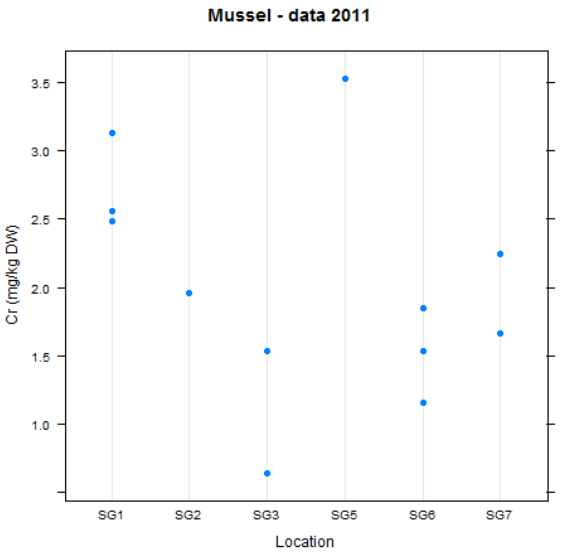


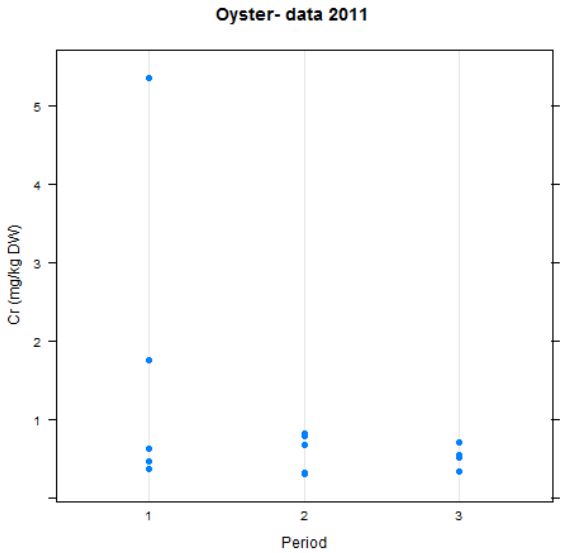
Concentration chromium in mussel and oysters collected in 2010 and 2011.

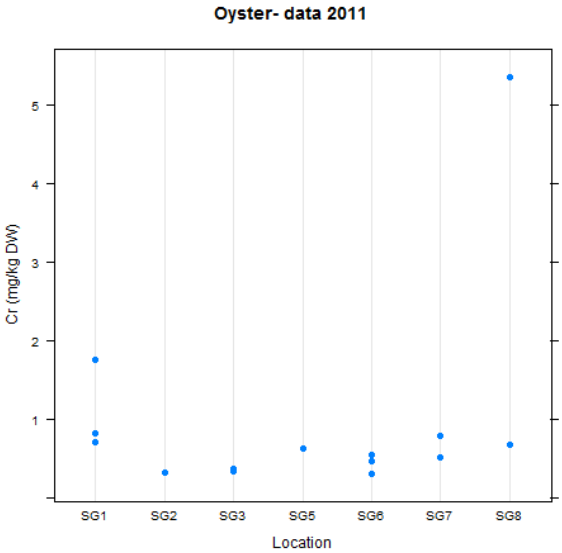




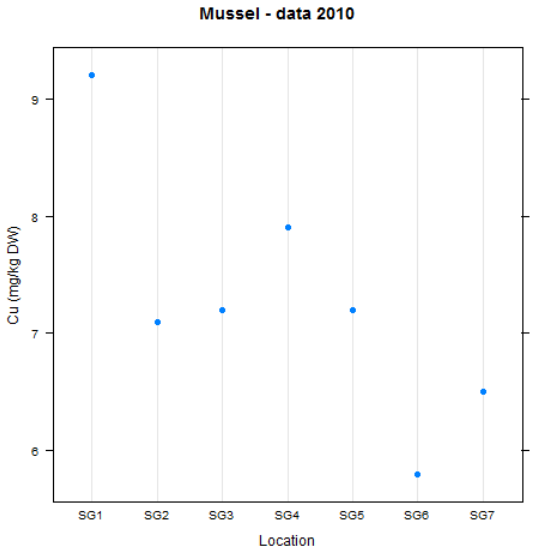


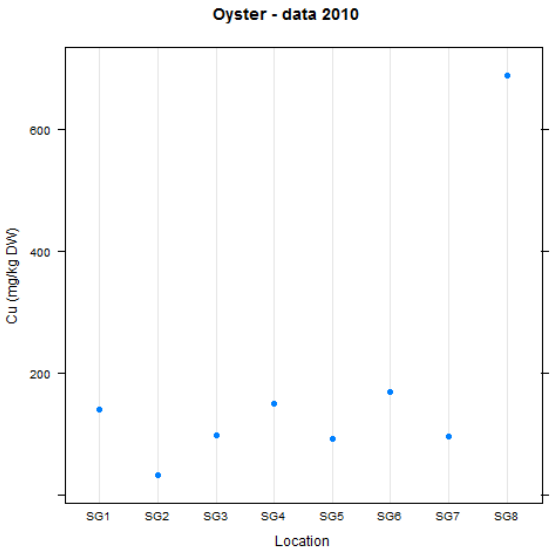


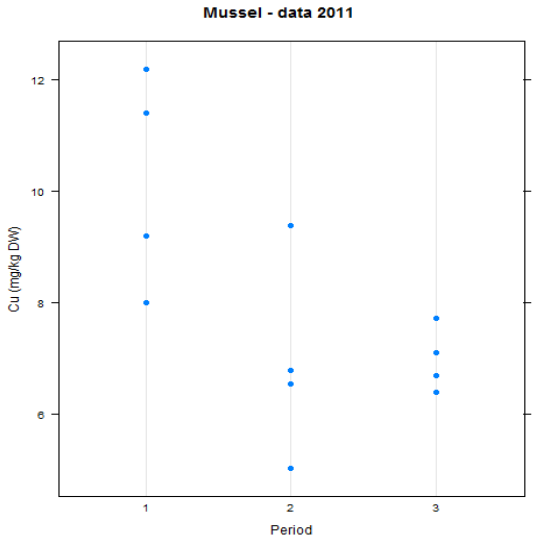


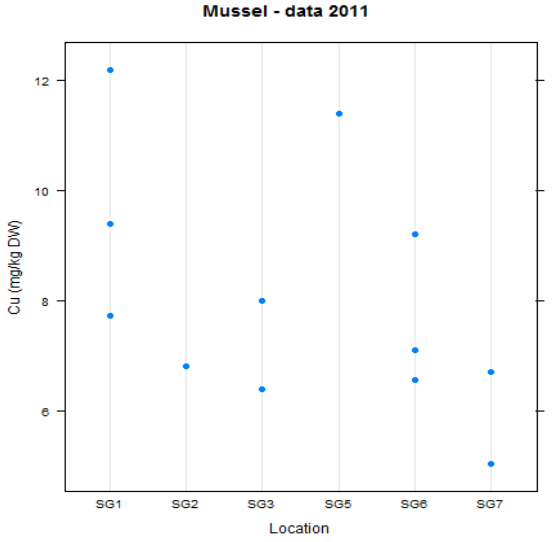


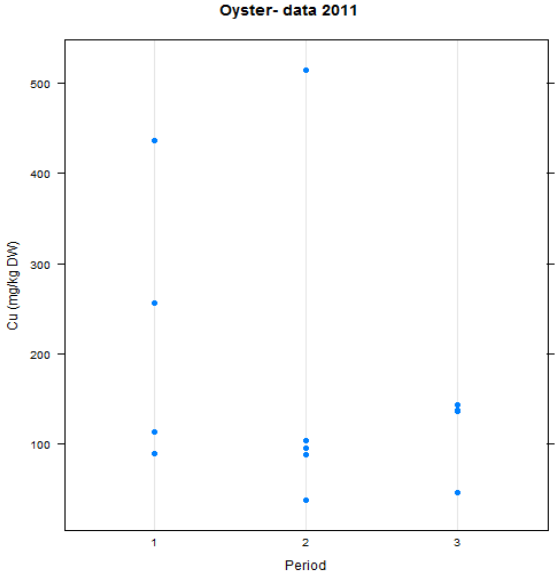
Concentration copper in mussel and oysters collected in 2010 and 2011.

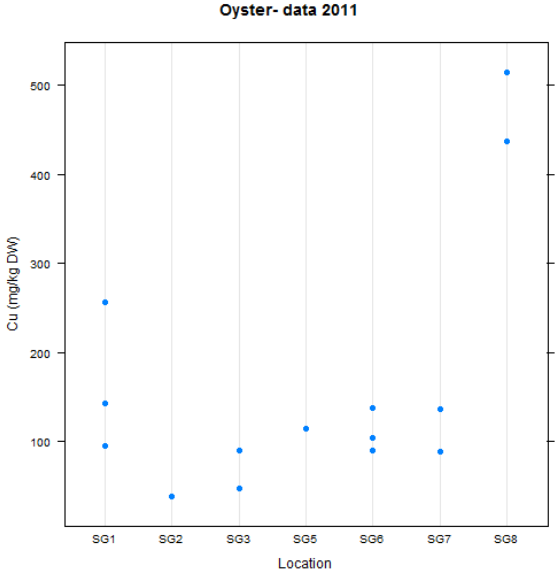




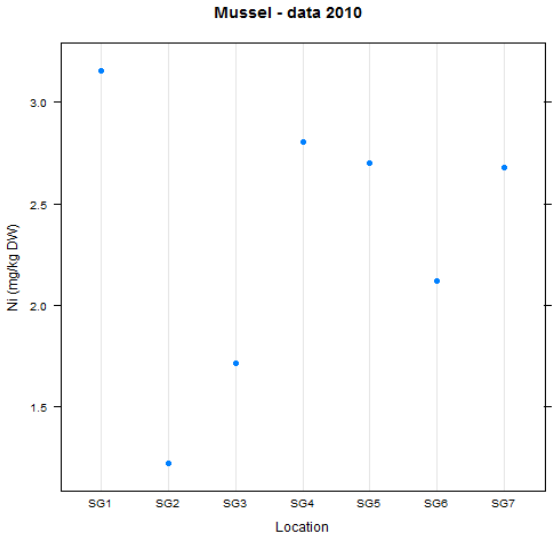


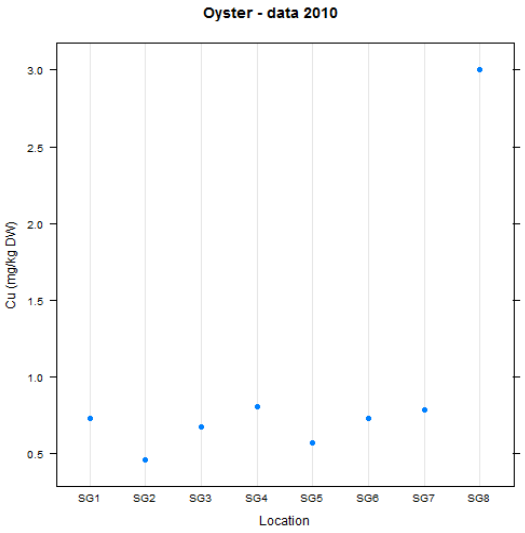


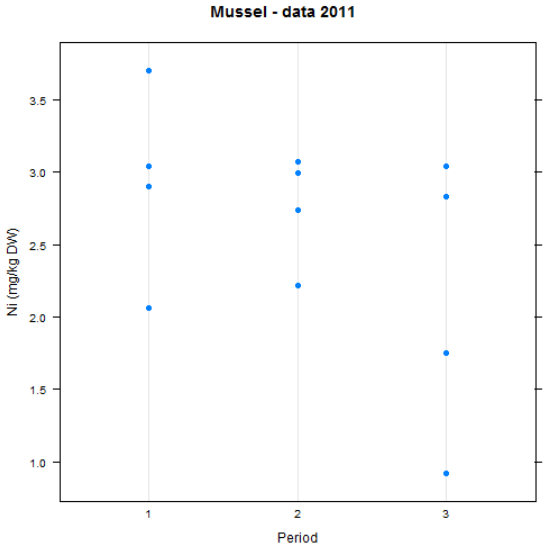


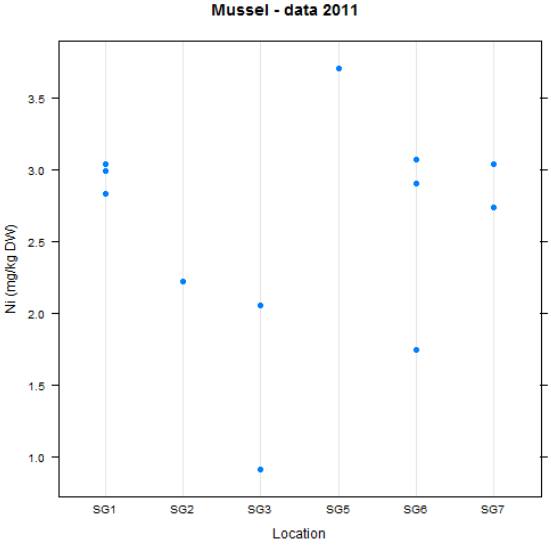


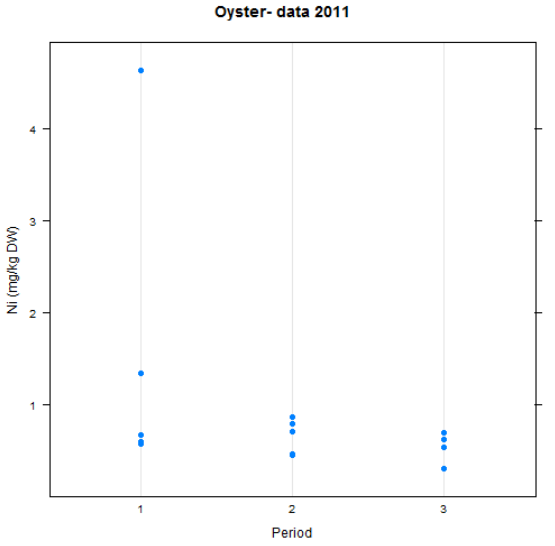
Concentration nickel in mussel and oysters collected in 2010 and 2011.

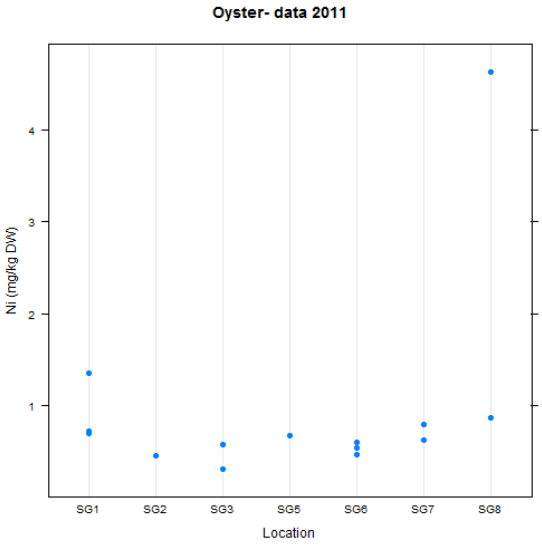




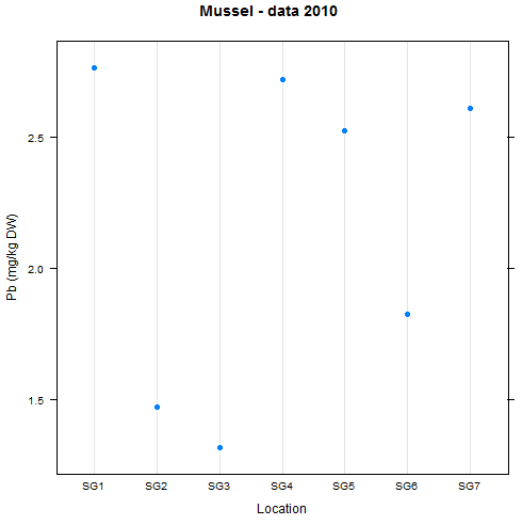


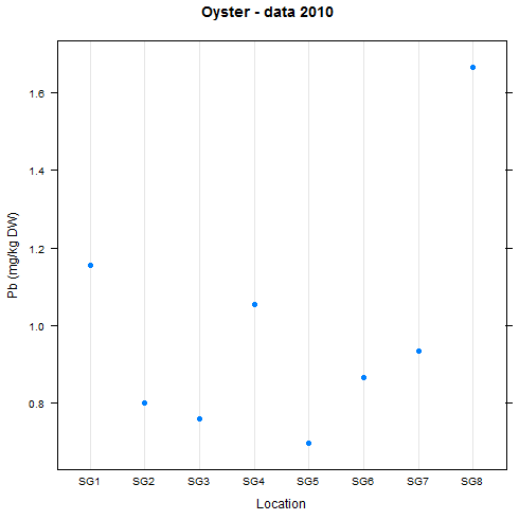


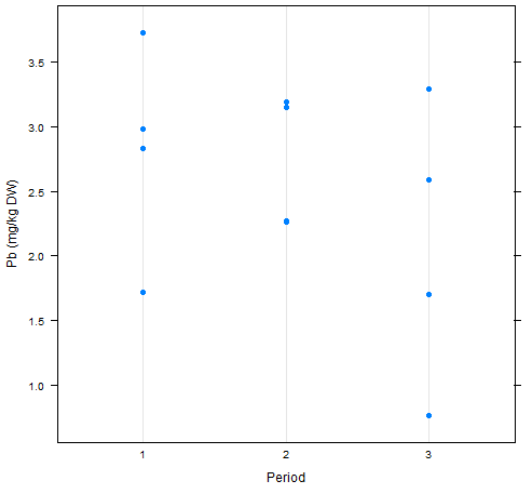


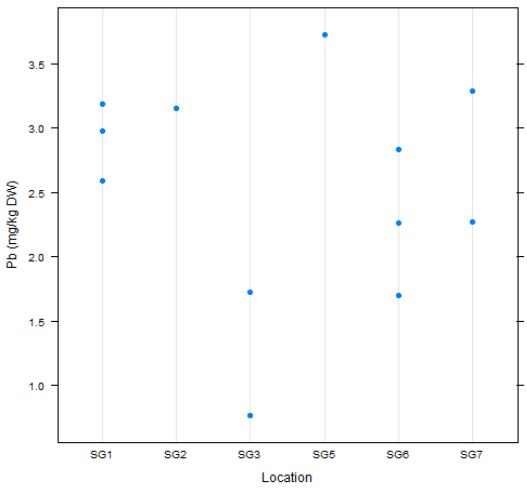


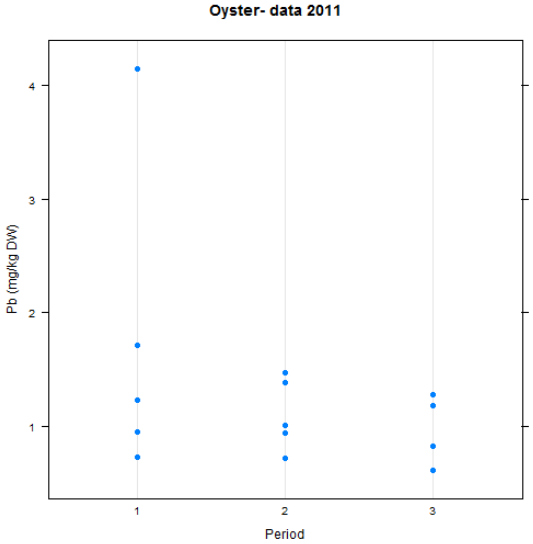
Concentration lead in mussel and oysters collected in 2010 and 2011.

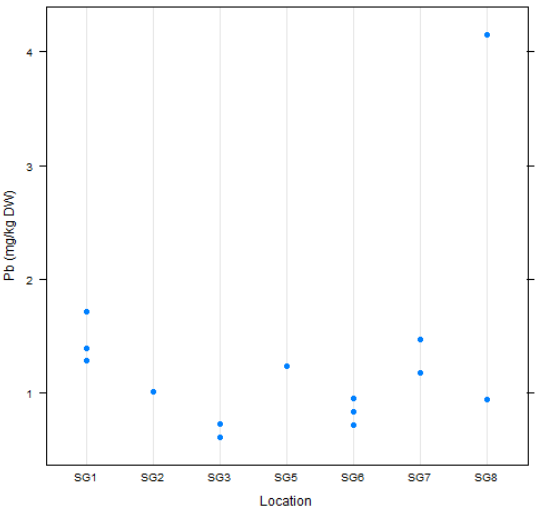




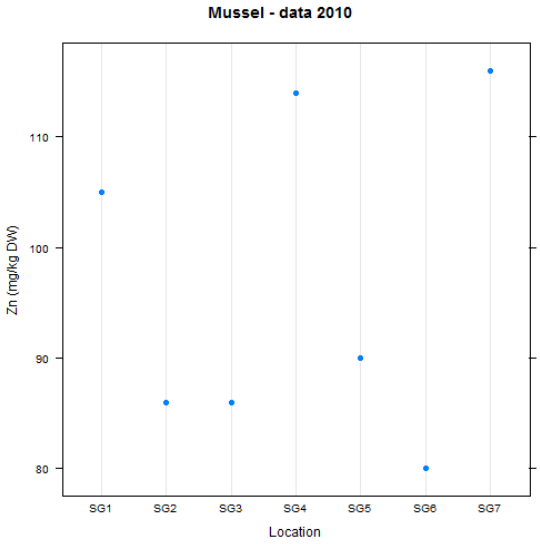


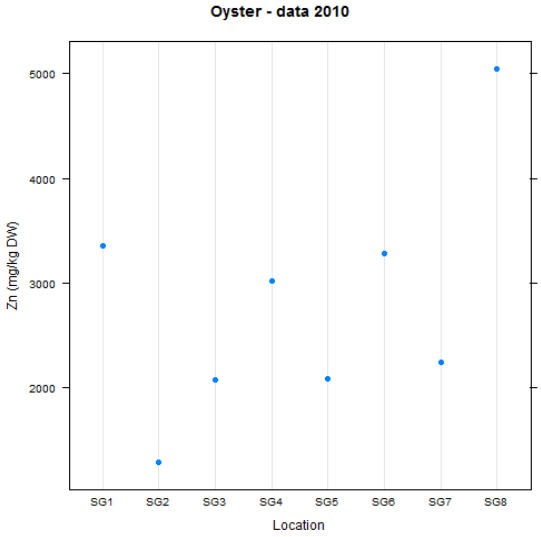


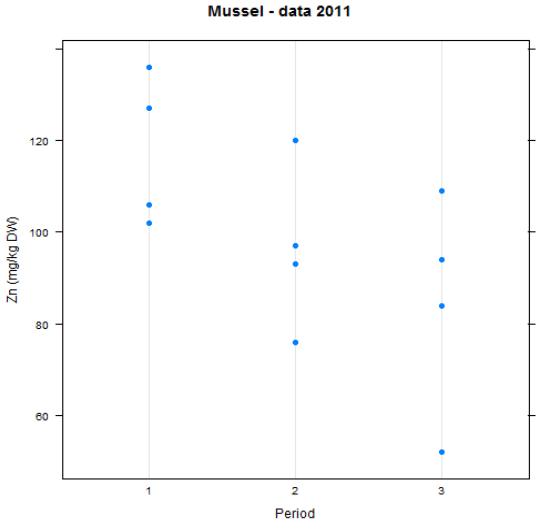


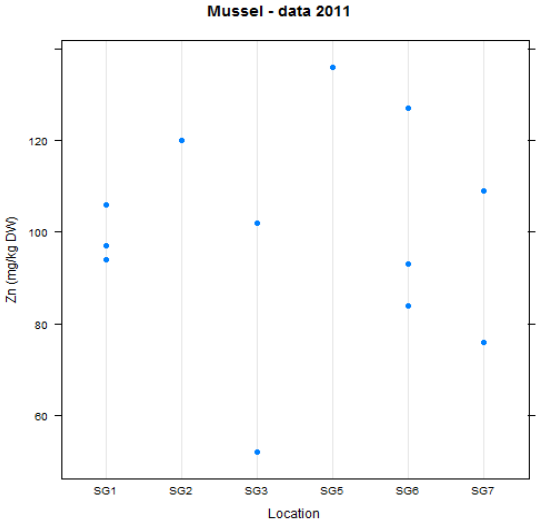


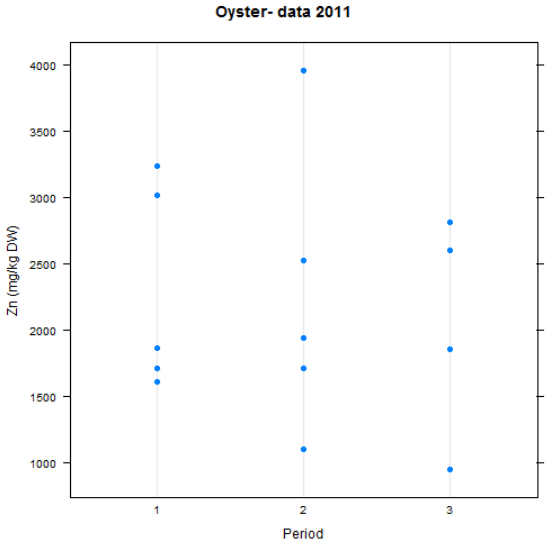
Concentration Zinc in mussel and oysters collected in 2010 and 2011.

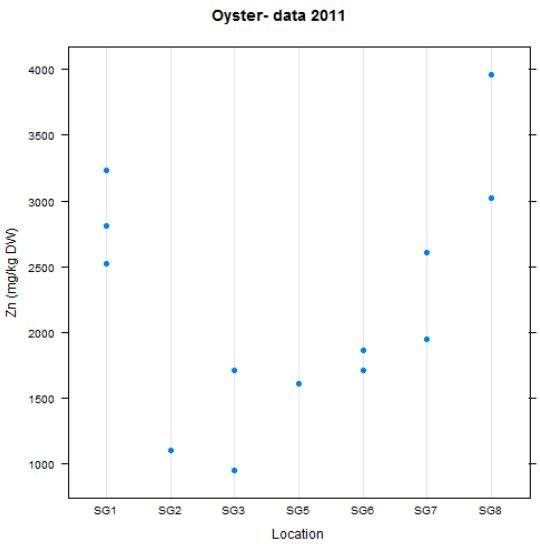




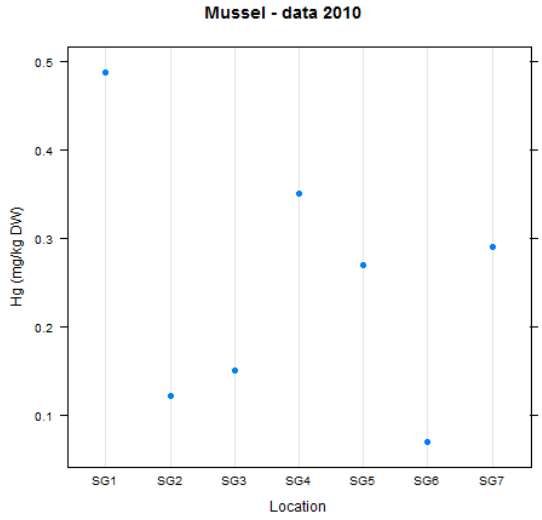


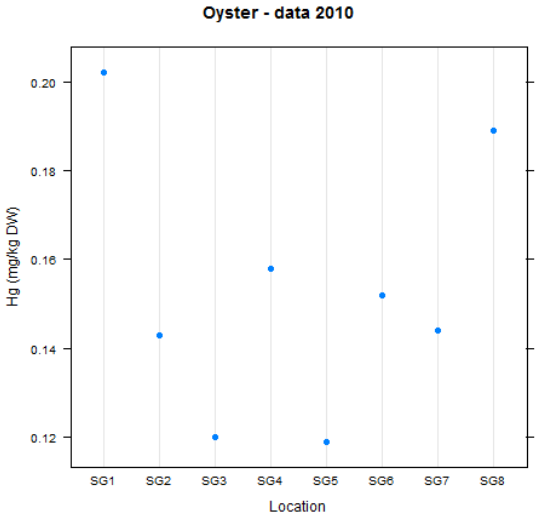


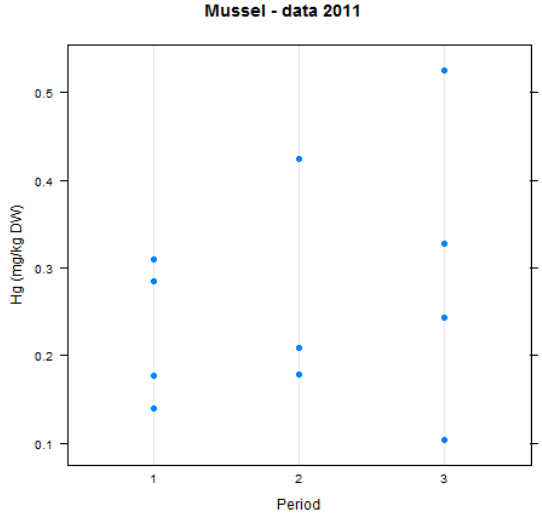


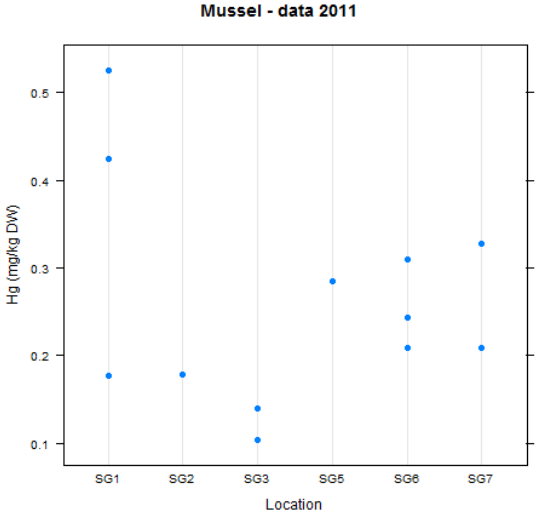


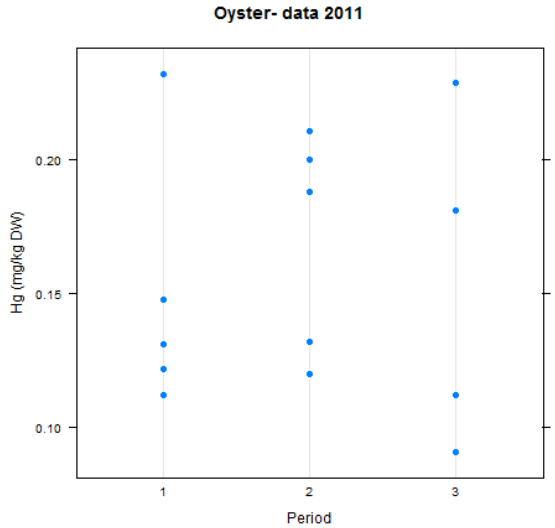
Concentration Mercury in mussel and oysters collected in 2010 and 2011.

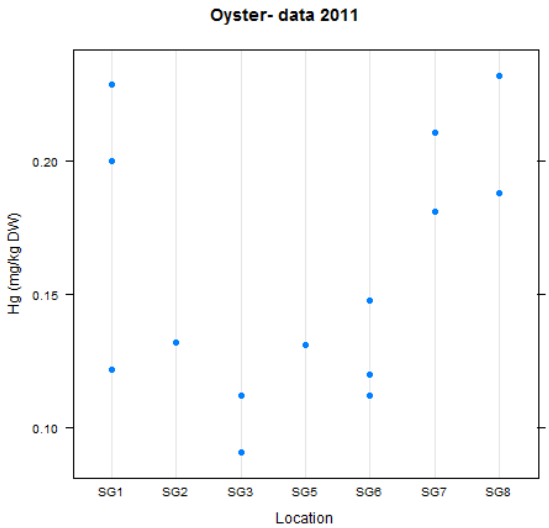






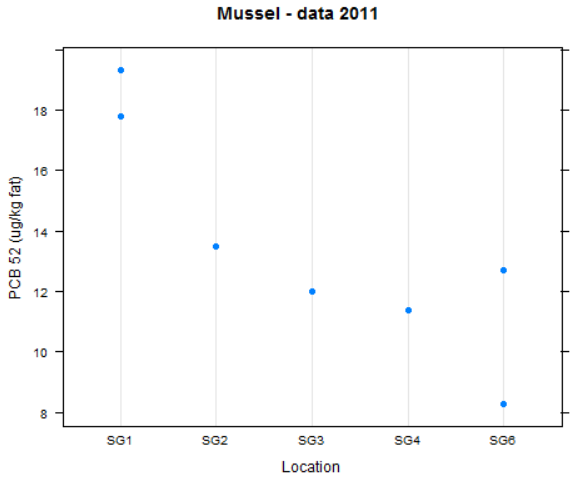


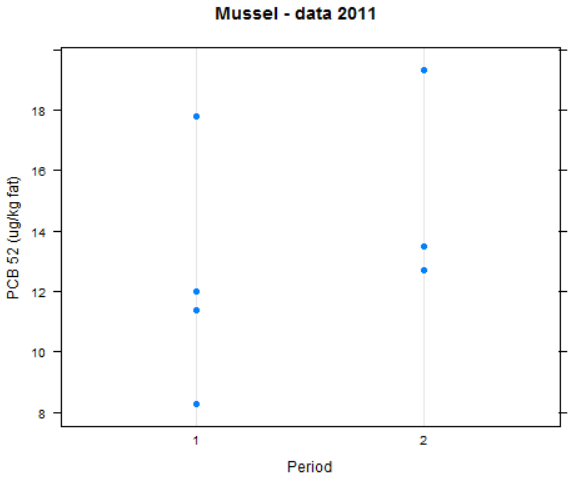


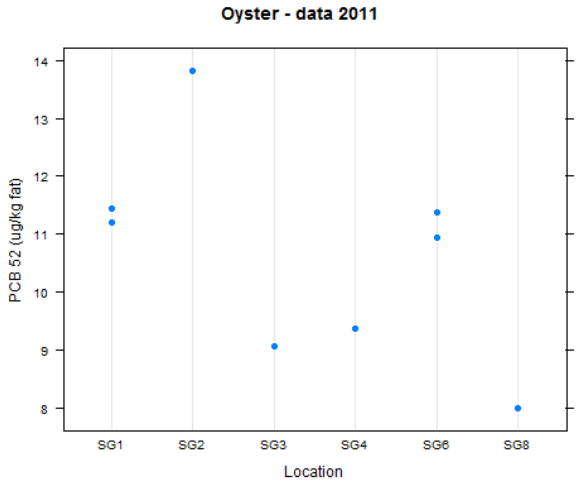


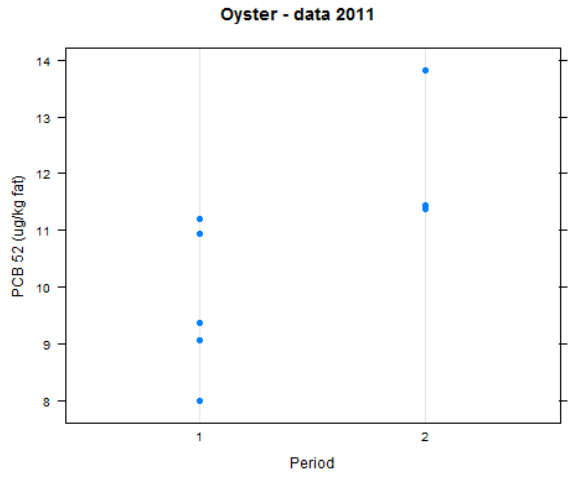
Appendix F. Plots concentrations of PCB's in oyster and mussel tissue

PCB 52 concentration in mussels and oysters.

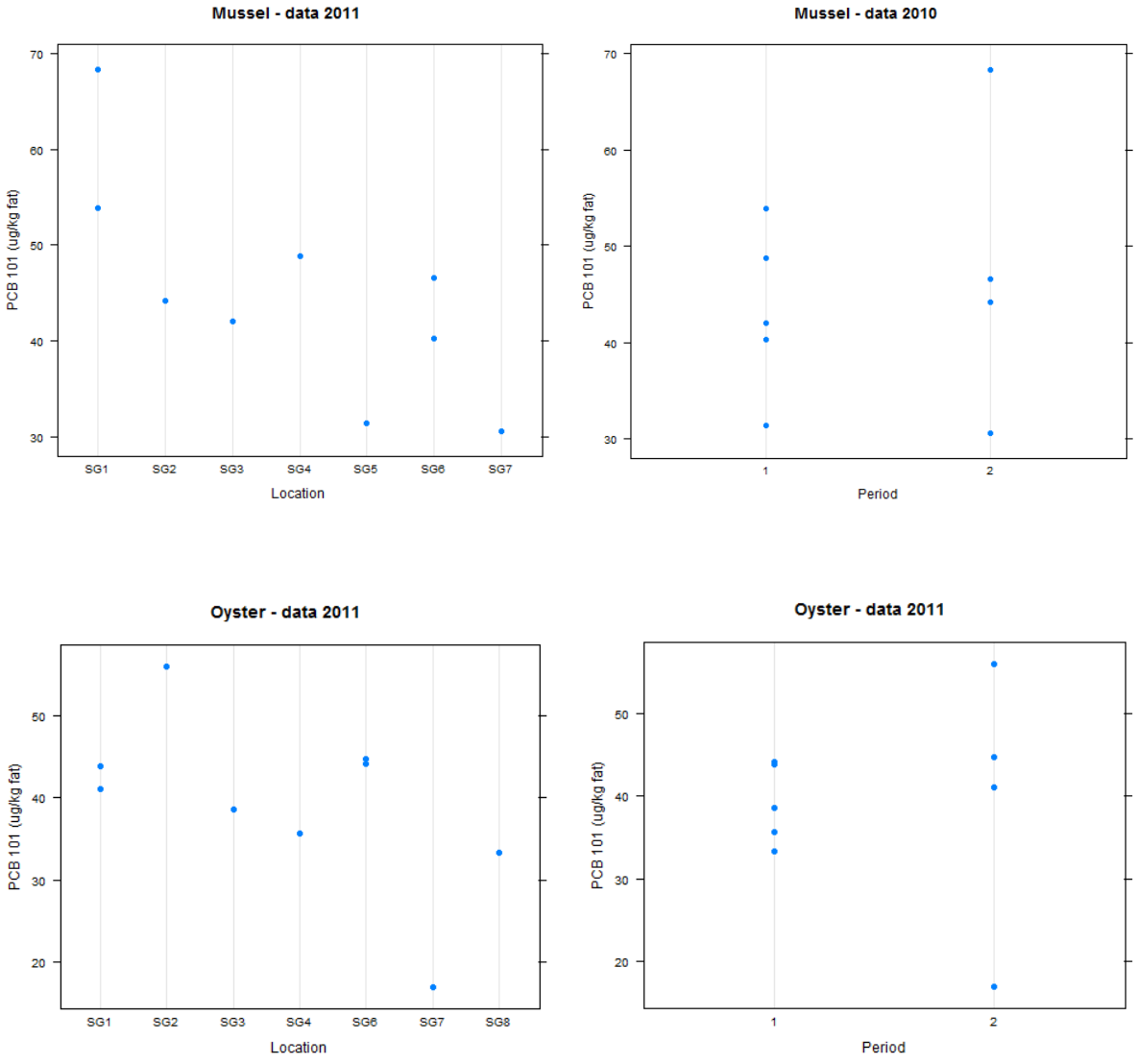




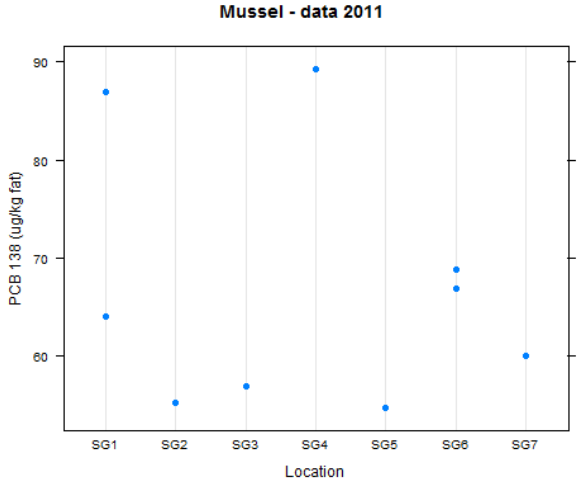


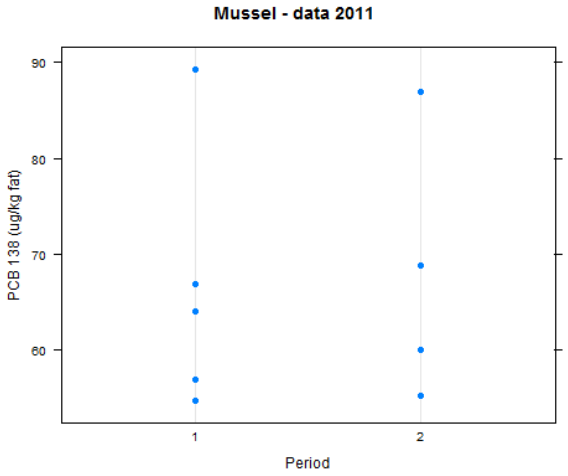


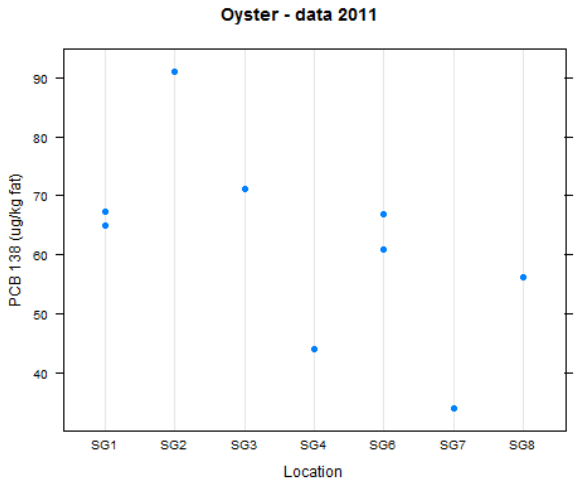
PCB 101 concentration in mussels and oysters.

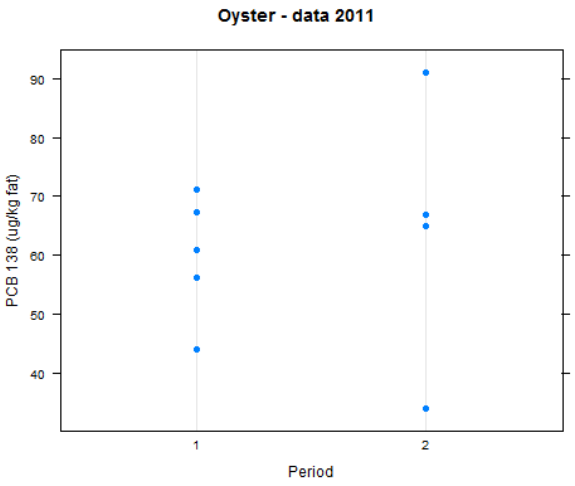


PCB 138 concentration in mussels and oysters.

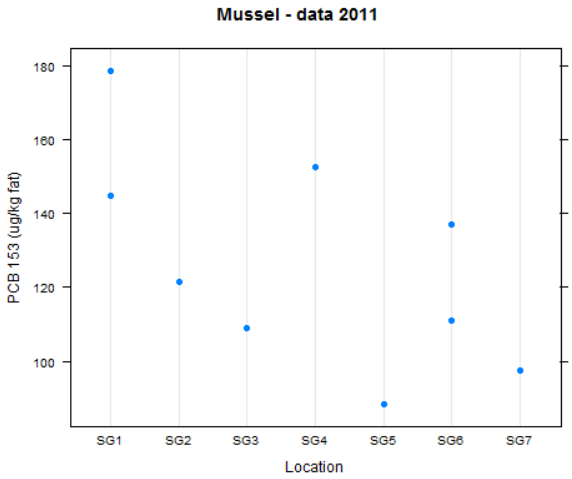


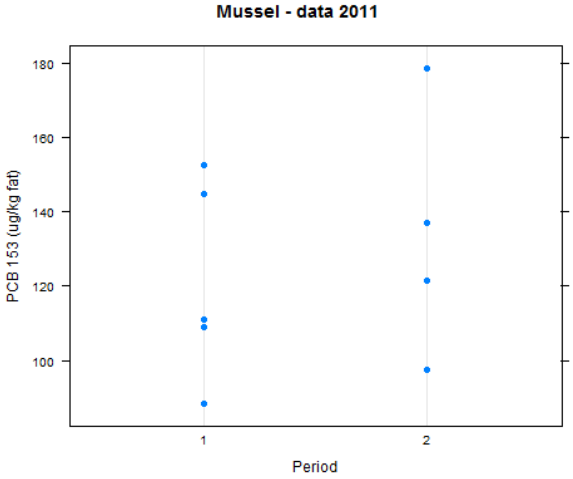


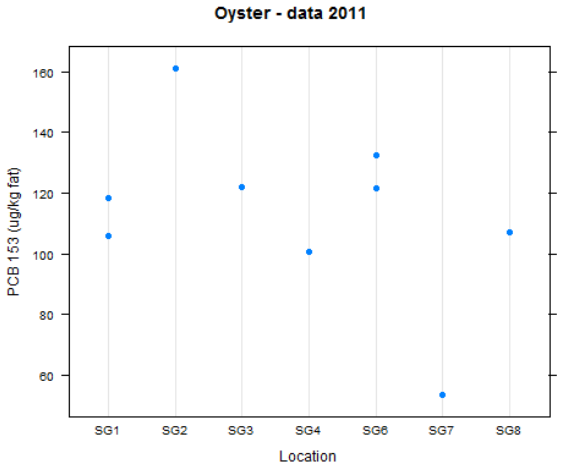


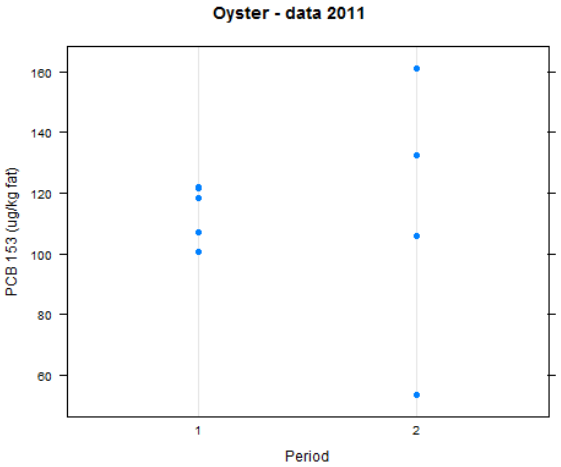


PCB 153 concentration in mussels and oysters

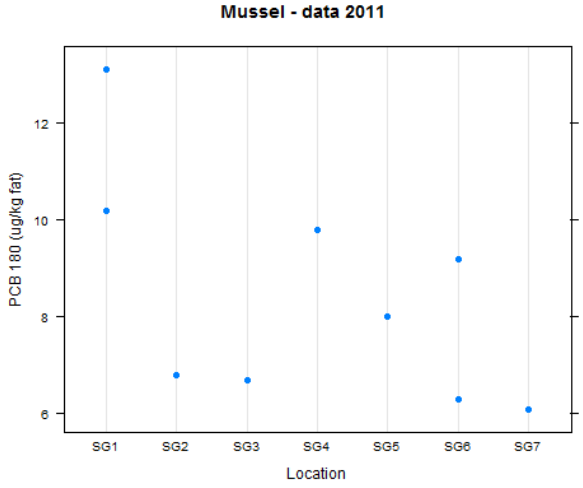


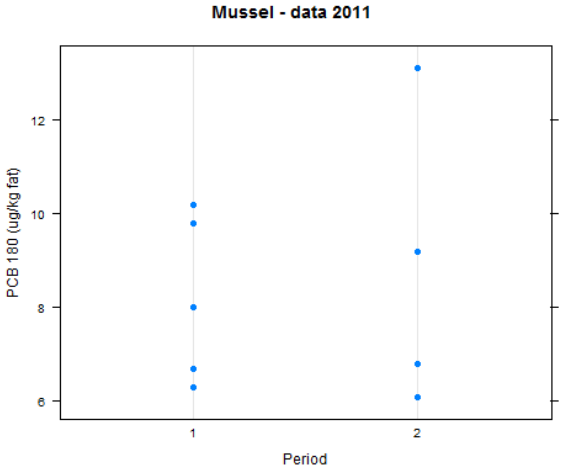


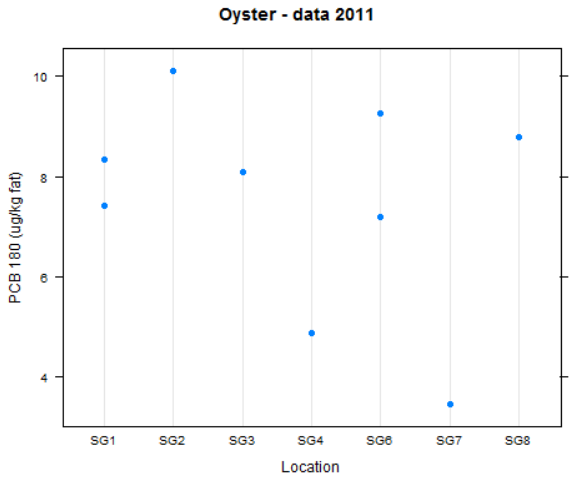


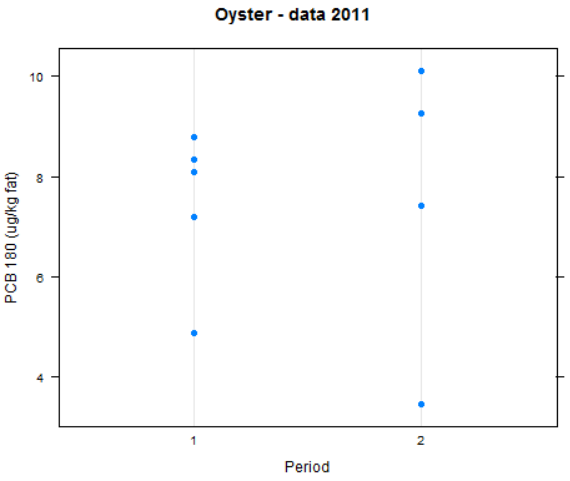


PCB 180 concentration in mussels and oysters.

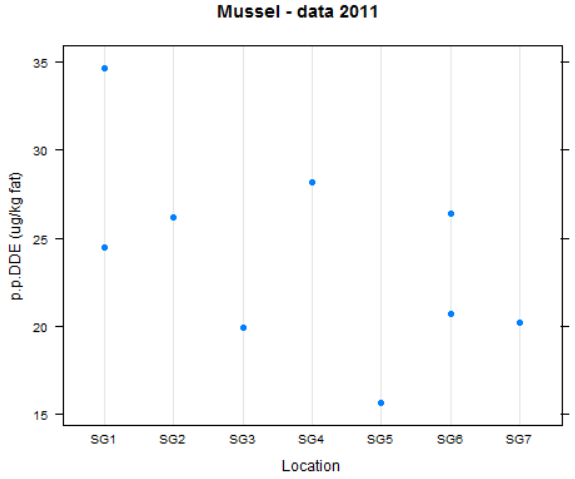


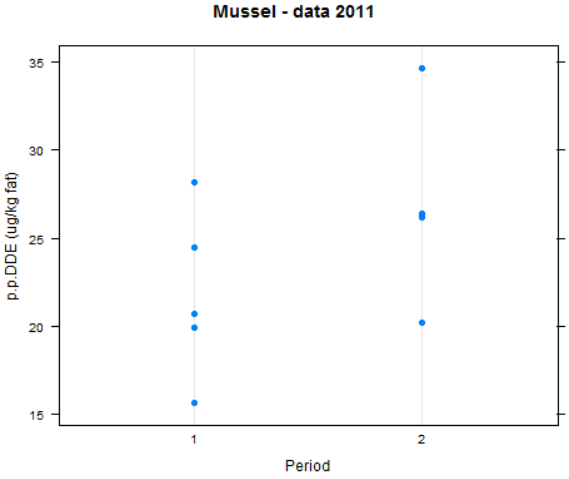


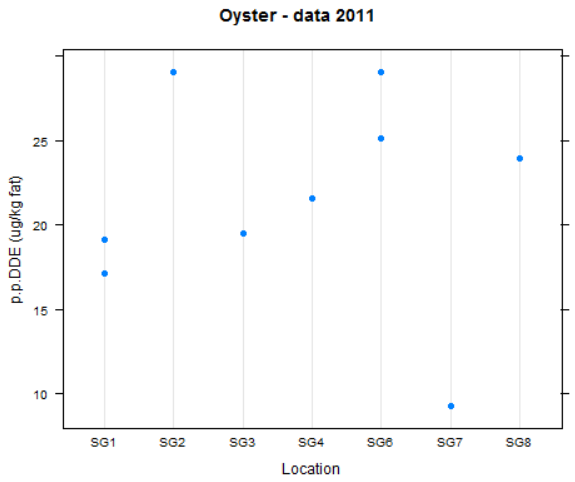


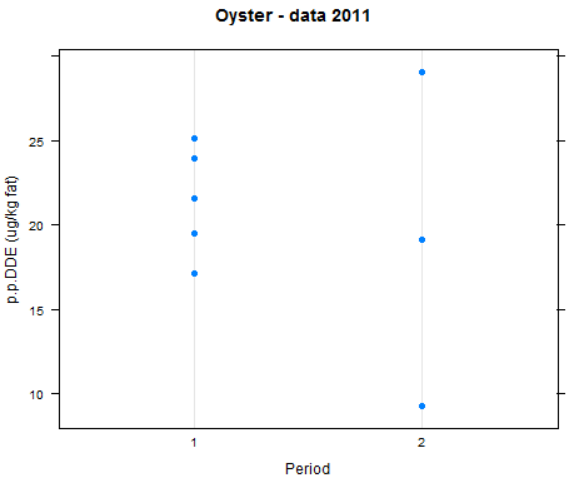


P.p.-DDE concentration in mussels and oysters.

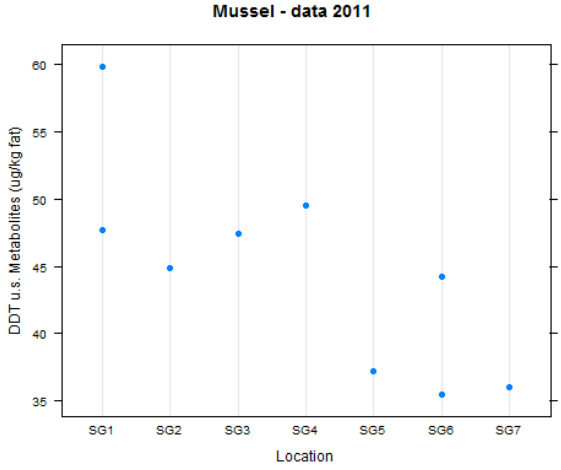


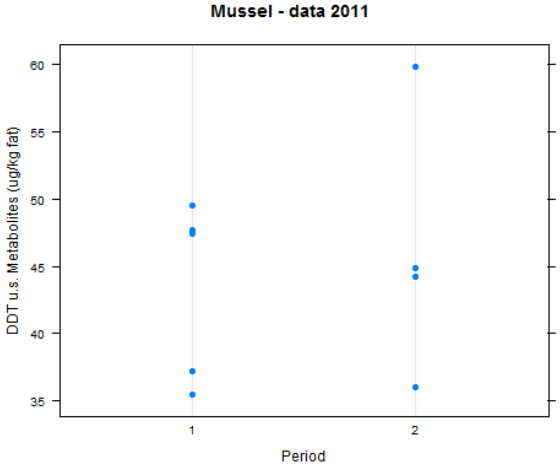


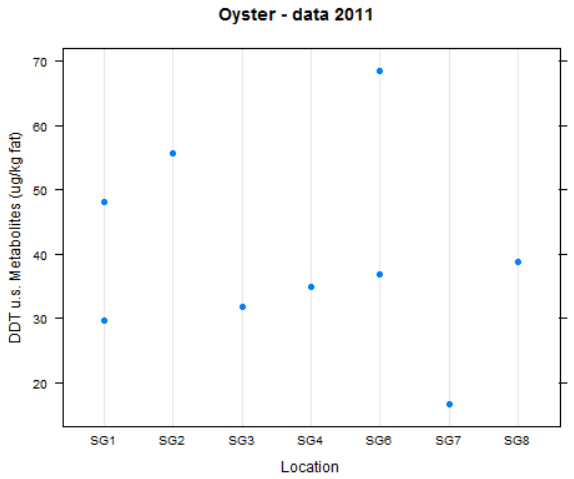


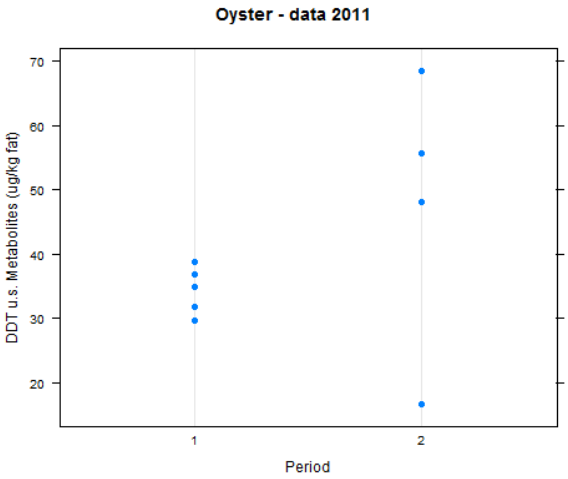


DDT u.s. metabolites concentration in mussels and oysters.



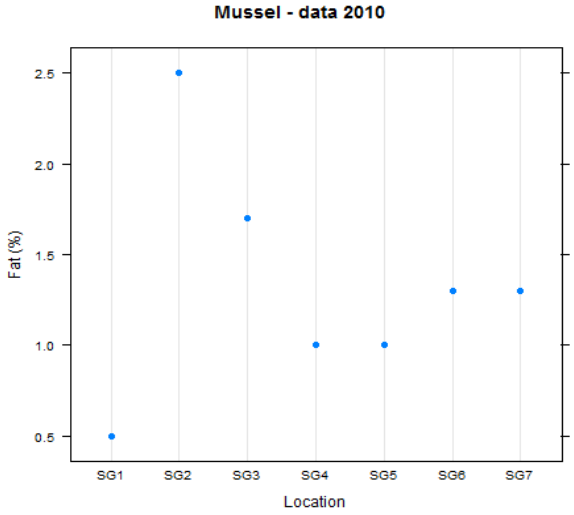


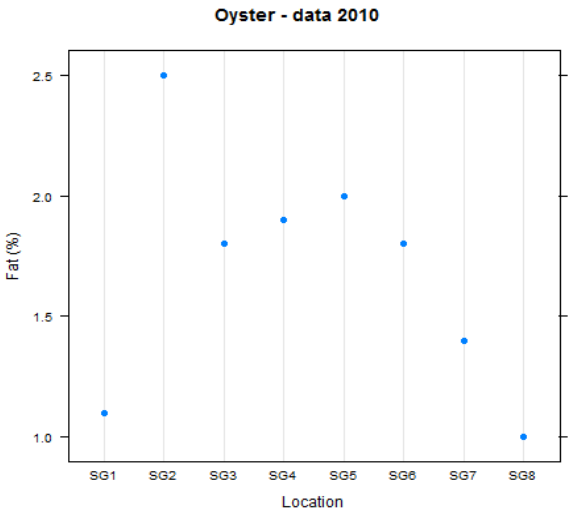




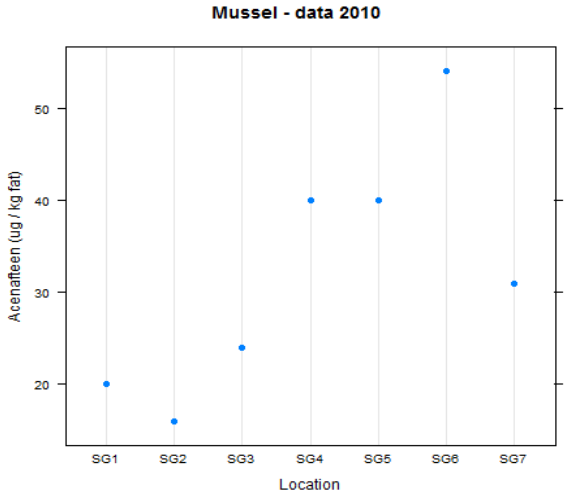
Appendix G. Plots of concentrations PAH's in oyster and mussel tissue.

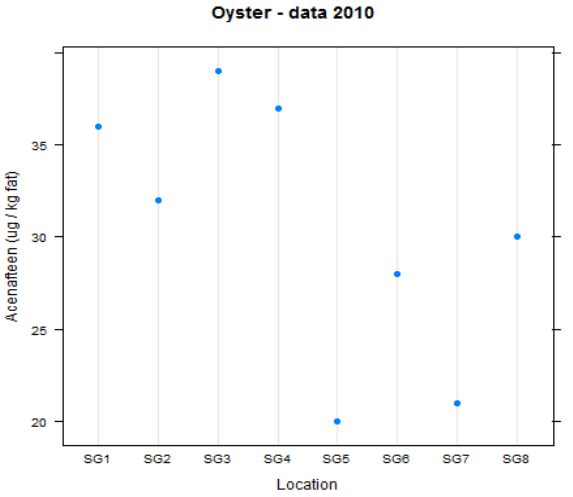
Concentration fat in mussels and oysters.



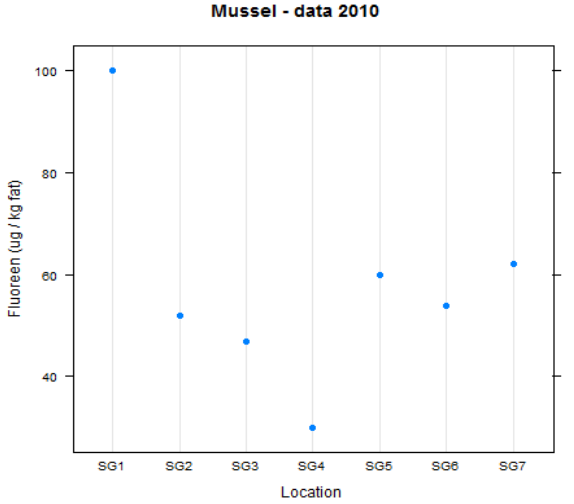


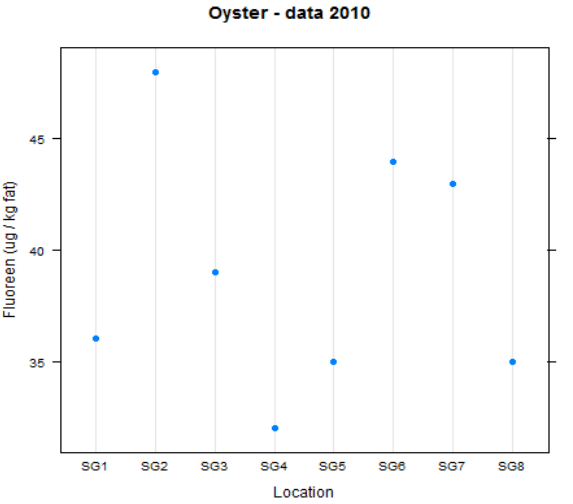
Concentration acenafteen in mussels and oysters.



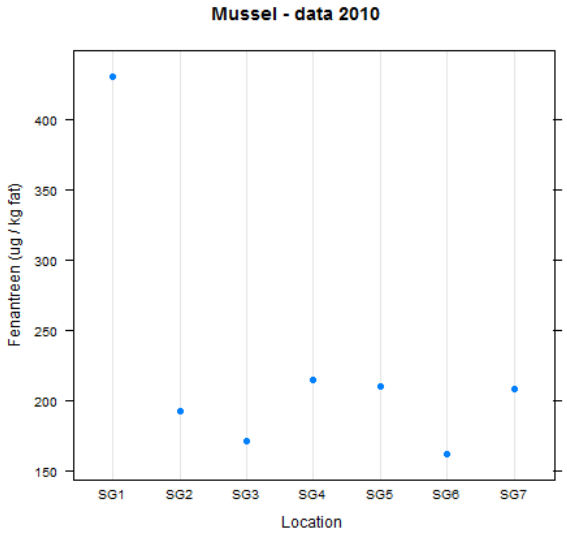


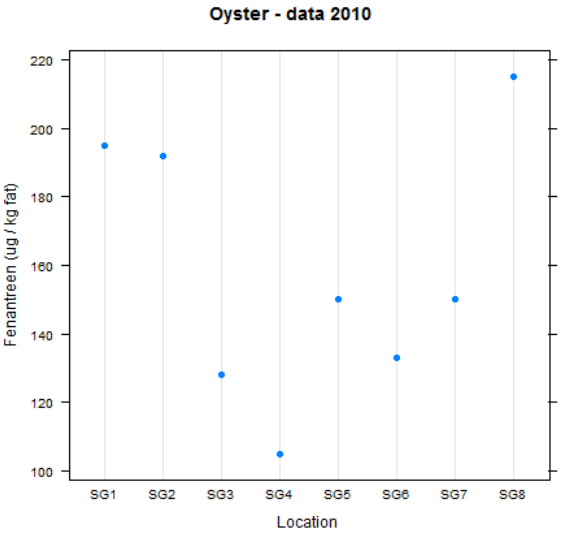
Concentration fluorene in mussels and oysters.



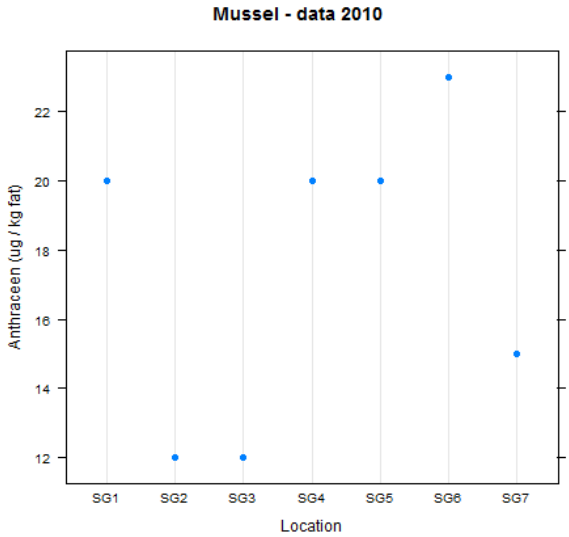


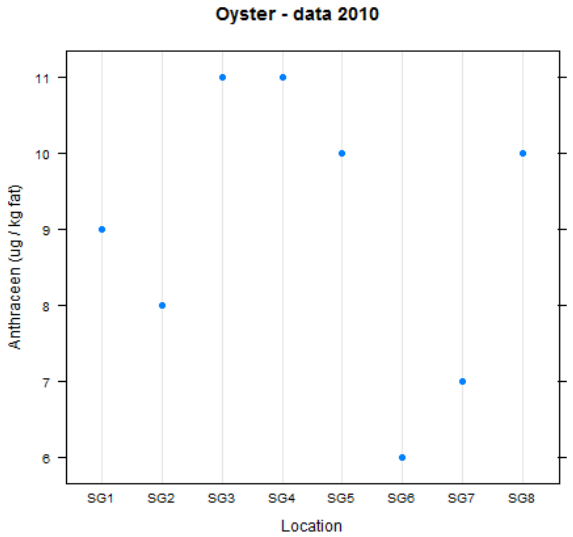
Concentration fenantreen in mussels and oysters.



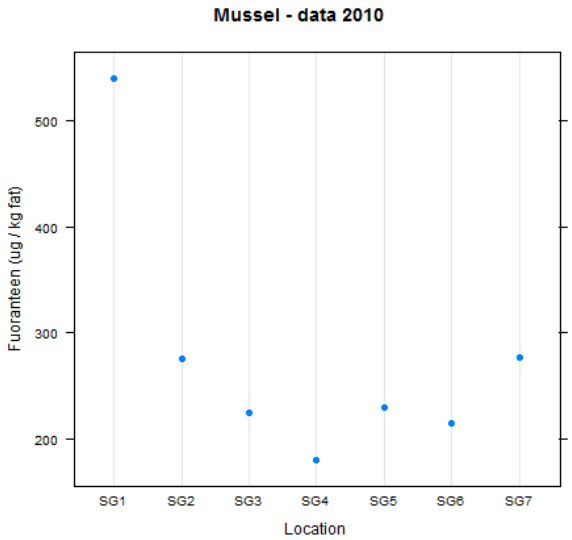


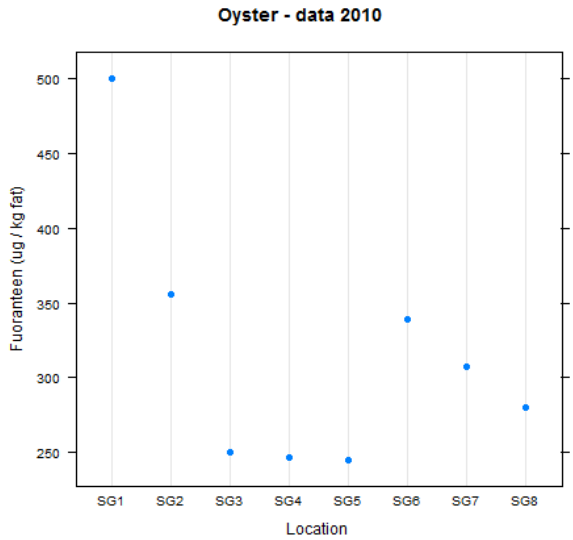
Concentration anthracene in mussels and oysters.



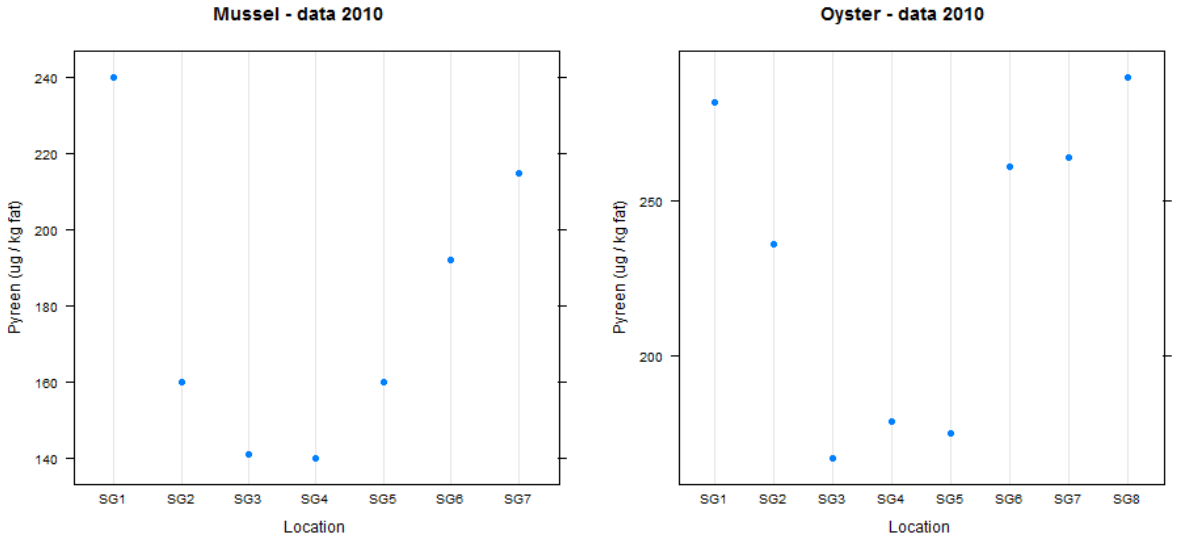


Concentration fuoranteen in mussels and oysters.

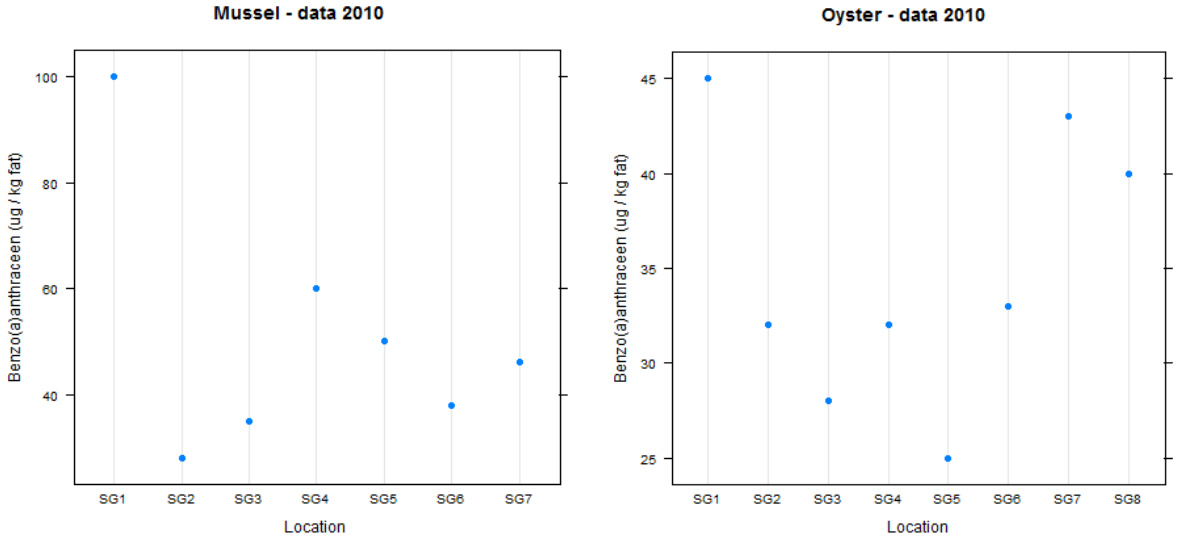




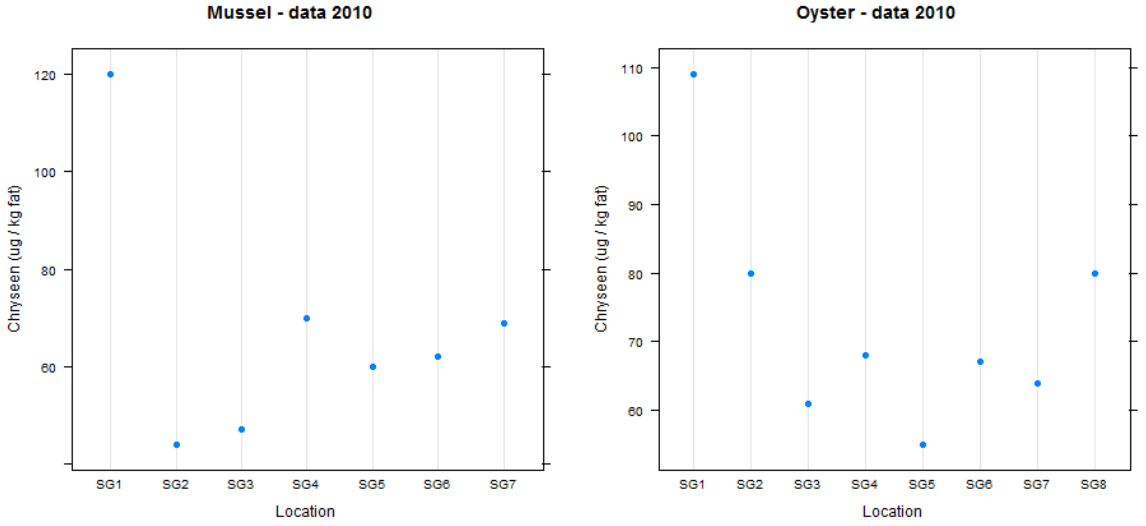
Concentration pyrene in mussels and oysters.



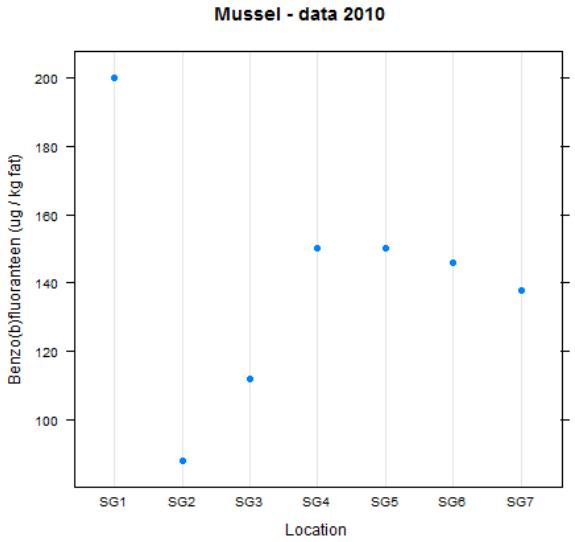
Concentration benzo(a)anthracene in mussels and oysters.

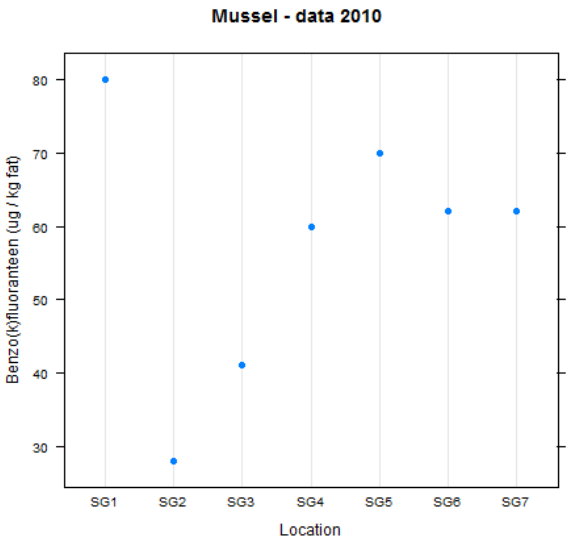


Concentration chryseen in mussels and oysters.

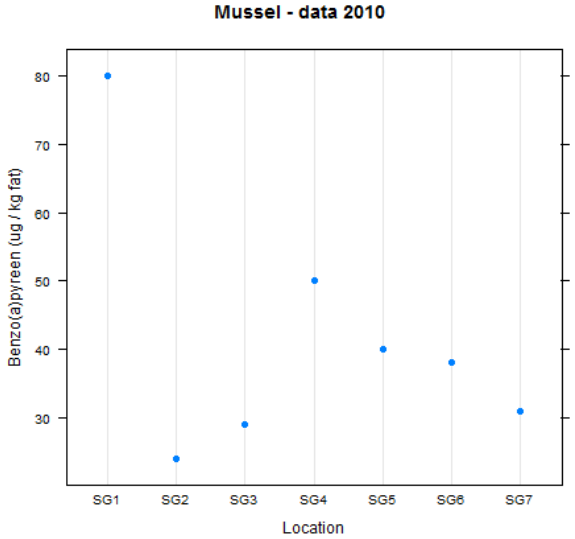


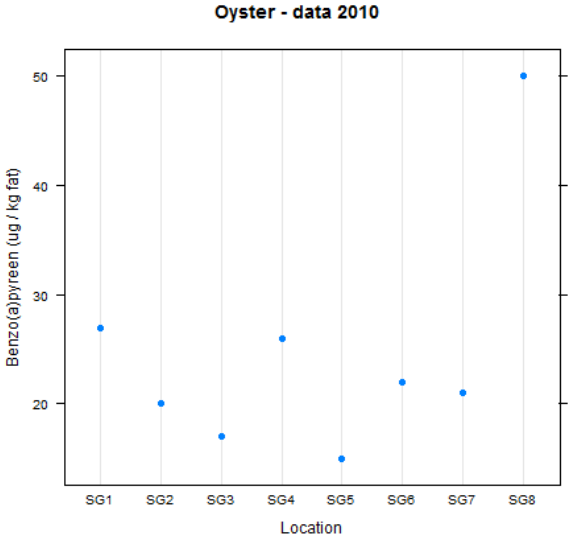
Concentration benzo(b)fluorantheen in mussels and oysters.



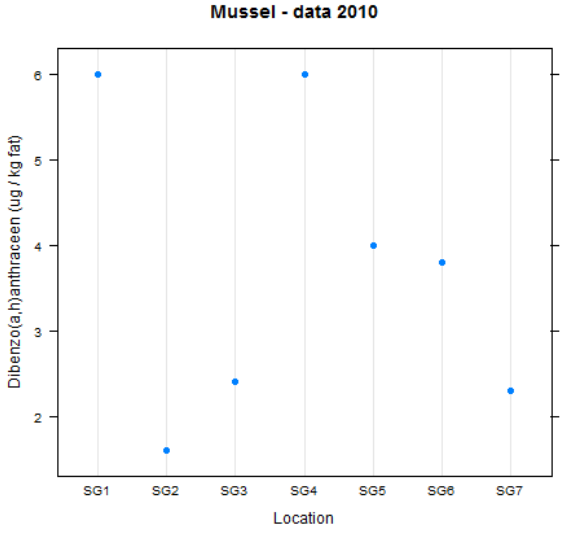


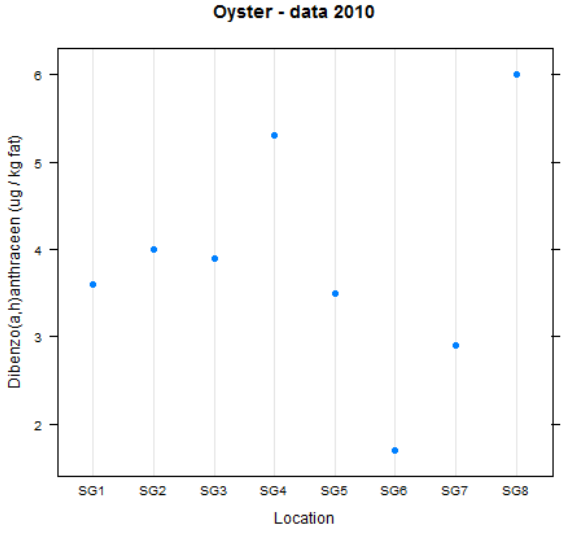
Concentration benzo(a)pyrene in mussels and oysters.



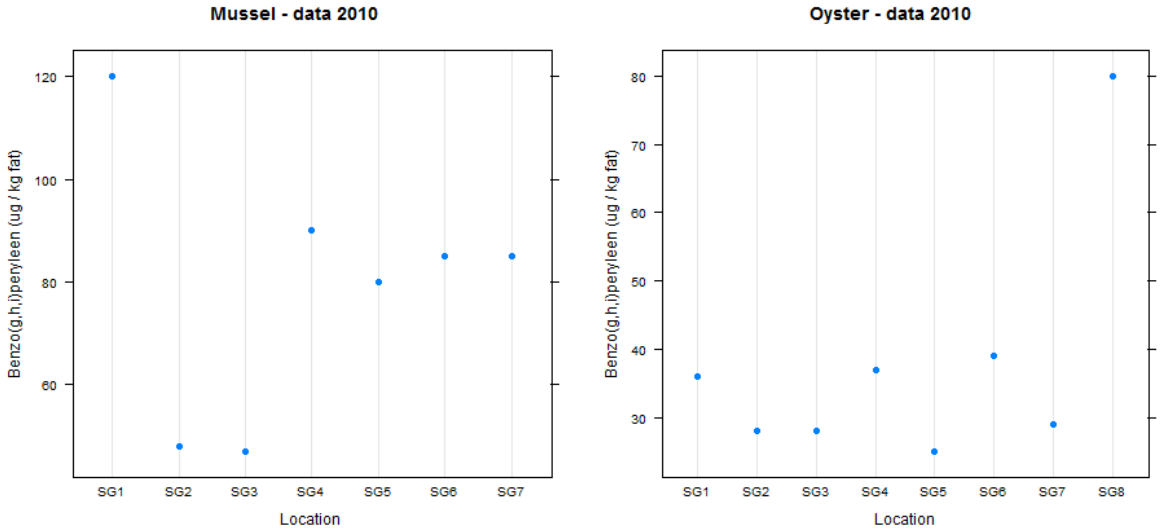


Concentration dibenzo(a,h)anthracene in mussels and oysters.

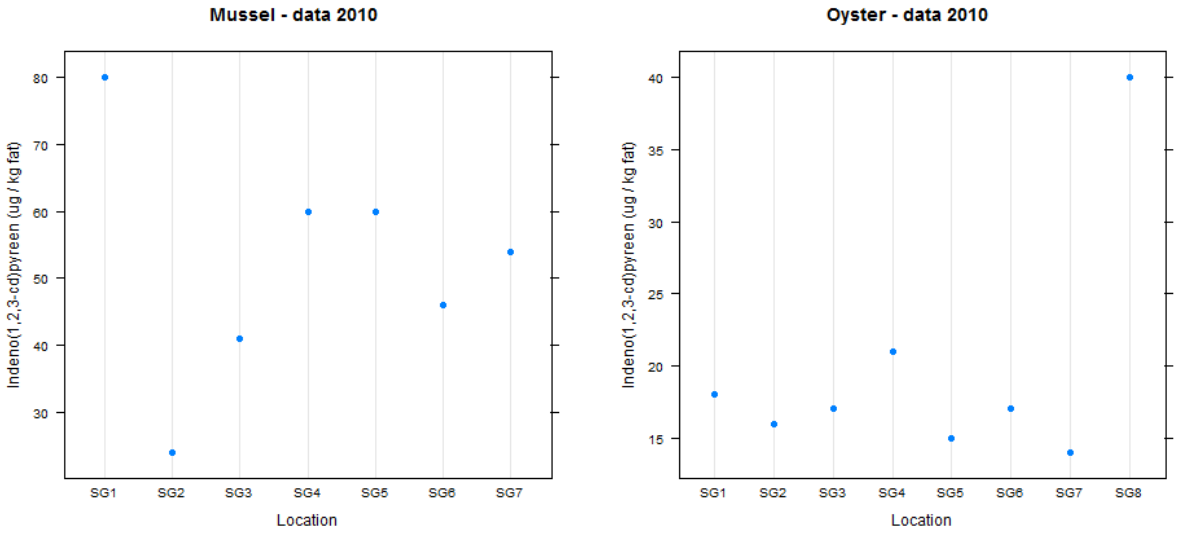




Concentration benzo(g,h,i)perylene in mussels and oysters.



Concentration indenol(1,2,3-cd)pyrene in mussels and oysters.



8. Appendix H. Monitoring data 2010 (Source: Productschap Vis)

			E.coli (kve/100 gram versgewicht)			
week	**gebied**	**soort**	**1**	**2**	**3**	**4**
2	WWN	mosselen	<200	<20	<200	<200
2	WWM	mosselen	<20	<20	<20	<200
2	WWZ	mosselen	<20	<20	<200	<20
6	WWN	mosselen	<20	<20	<20	<200
6	WWM	mosselen	<20	<200	<200	<20
6	WWZ	mosselen	<20	<20	<20	<20
11	WWN	mosselen	<200	<200	<20	<20
11	WWM	mosselen	<20	<20	<20	<20
11	WWZ	mosselen	<20	<20	<20	<20
16	WWN	mosselen	<20	<20	<20	<20
16	WWM	mosselen	<20	<20	<20	<20
16	WWZ	mosselen	<200	<20	<20	<20
21	WWN	mosselen	<20	<20	<20	<20
21	WWM	mosselen	<20	<20	<20	<20
21	WWZ	mosselen	<20	<20	<20	<20
26	WWN	mosselen	<20	<20	<20	<20
26	WWM	mosselen	<20	<20	<20	<20
26	WWZ	mosselen	<200	<200	<20	<20
27	WWN	mosselen	<200	<20	<20	<20
27	WWM	mosselen	<20	<20	<20	<20
27	WWZ	mosselen	<20	<20	<20	<20
29	WWN	mosselen	<20	<20	<200	<20
29	WWM	mosselen	<20	<20	<20	<20
29	WWZ	mosselen	<20	<20	<20	<20
31	WWN	mosselen	<200	<20	<20	<20
31	WWM	mosselen	<20	<20	<200	<20
31	WWZ	mosselen	<20	<20	<20	<20
33	WWN	mosselen	<20	<20	<20	<20
33	WWM	mosselen	<20	<20	<20	<20
33	WWZ	mosselen	<200	<20	<200	<20
35	WWN	mosselen	<200	<200	<20	<20
35	WWM	mosselen	<200	<20	<20	<200
35	WWZ	mosselen	<20	<20	<200	<200
37	WWN	mosselen	<20	<20	<20	<200
37	WWM	mosselen	<20	<200	<20	<20
37	WWZ	mosselen	<200	<200	<200	<20
41	WWN	mosselen	<20	<20	<20	<20
41	WWM	mosselen	<20	<20	<20	<200
41	WWZ	mosselen	<200	<20	<20	<20
43	WWN	mosselen	<200	<200	<200	<200
43	WWM	mosselen	<20	<200	<200	<200
43	WWZ	mosselen	<20	<20	<20	<20
44	WWM	oesters	<20	<200	<20	<20
44	WWZ	oesters	<20	840	3580	1620

			E.coli (kve/100 gram versgewicht)			
week	**gebied**	**soort**	**1**	**2**	**3**	**4**
44	FW	oesters	<200	<20	<20	<20
44	GW	oesters	<20	<20	<20	<20
45	WWZ	oesters	<20	<20	<20	<20
46	WWN	mosselen	<200	<20	<200	<20
46	WWM	mosselen	<20	<20	<20	<20
46	WWZ	mosselen	<20	<20	<200	<20
48	FW	oesters	<20	<20	<20	<20
48	GW	oesters	<20	<20	<20	<20
50	WWN	mosselen	<200	<200	<20	<20
50	WWM	mosselen	<200	<200	<200	<200
50	WWZ	mosselen	<20	<20	<20	<200

Appendix I. Monitoring data 2011 (source: Productschap Vis)

week	gebied	soort	1	2	3	4
2	WWN	mosselen	<200	<200	<200	<200
2	WWM	mosselen	<200	<20	<200	<200
2	WWZ	mosselen	<200	<20	<200	<200
6	WWN	mosselen	<20	<20	<200	<20
6	WWM	mosselen	<200	<200	<200	<20
6	WWZ	mosselen	<200	<200	<20	<200
11	WWN	mosselen	<20	<20	<20	<20
11	WWM	mosselen	<20	<20	<20	<200
11	WWZ	mosselen	<20	<200	<20	<20
15	WWN	mosselen	<200	<200	<200	<20
15	WWM	mosselen	<20	<20	<20	<20
15	WWZ	mosselen	<20	<20	<200	<20
20	WWN	mosselen	<20	<200	<20	<20
20	WWM	mosselen	<20	<20	<20	<20
20	WWZ	mosselen	<20	<20	<20	<20
23	WWN	mosselen	<200	<20	<20	<20
23	WWM	mosselen	<20	<20	<20	<20
23	WWZ	mosselen	<20	<20	<20	<20
25	WWN	mosselen	<20	<20	<20	<200
25	WWM	mosselen	<20	<20	<200	<20
25	WWZ	mosselen	<20	<20	<20	<200
27	WWN	mosselen	<20	<20	<20	<20
27	WWM	mosselen	<20	<20	<20	<20
27	WWZ	mosselen	<20	<20	<200	<20
29	WWN	mosselen	<20	<20	<200	<20
29	WWM	mosselen	<20	<20	<20	<20
29	WWZ	mosselen	<20	<20	<200	<20
31	WWN	mosselen	<200	<200	<20	<20
31	WWM	mosselen	<20	<20	<200	<20
31	WWZ	mosselen	<20	<20	<20	<20
33	WWN	mosselen	<20	<200	<20	<200
33	WWM	mosselen	<20	<20	<20	<200
33	WWZ	mosselen	<20	<20	<20	<20
35	WWN	mosselen	<20	<20	<200	<200
35	WWM	mosselen	<200	<20	<20	<20
35	WWZ	mosselen	<20	<20	<20	<20
37	WWN	mosselen	<20	<20	<20	<200
37	WWM	mosselen	<20	<20	<200	<200
37	WWZ	mosselen	<20	<20	<20	<20
39	WWN	mosselen	<20	<20	<20	<20
39	WWM	mosselen	<20	<20	<200	<200
39	WWZ	mosselen	<20	<20	<20	<20
41	WWN	mosselen	<200	<200	<200	<200
41	WWM	mosselen	<20	<20	<20	<200
41	WWZ	mosselen	<200	<20	<20	<20

week	gebied	soort	1	2	3	4
44	WWM	oesters	<20	<20	<20	<200
44	WWZ	oesters	<20	<20	<20	<20
44	FW	oesters	<20	<200	<20	<20
44	GW	oesters	<20	<20	<20	<20
46	WWN	mosselen	<200	<20	<200	<20
46	WWM	mosselen	<200	<20	<20	<20
46	WWZ	mosselen	<20	<20	<20	<20
48	WWM	oesters	<200	<200	<20	<200
48	WWZ	oesters	<20	<20	<20	<20
48	FW	oesters	<20	<20	<20	<20
48	GW	oesters	<20	<20	<20	<20
50	WWN	mosselen	<200	<200	<200	<20
50	WWM	mosselen	<20	<20	<200	<200
50	WWZ	mosselen	<20	<20	<20	<20

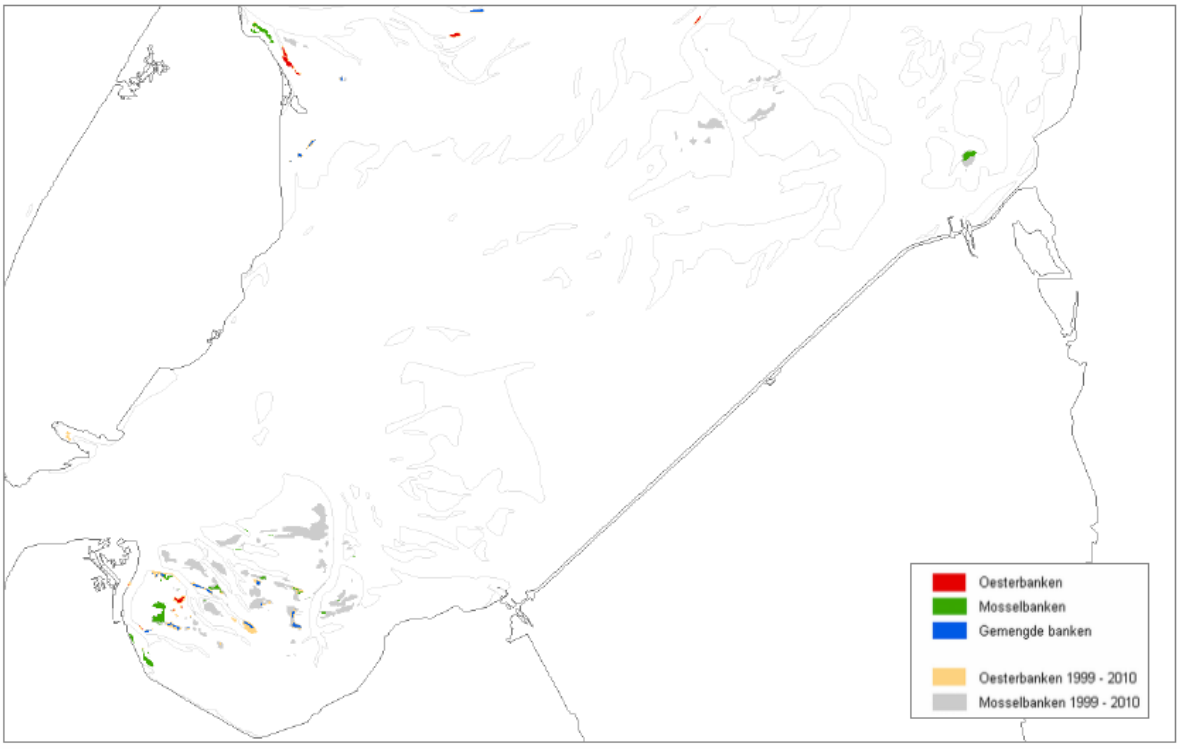


Figure 1. Spatial distribution of mussel and oyster beds.

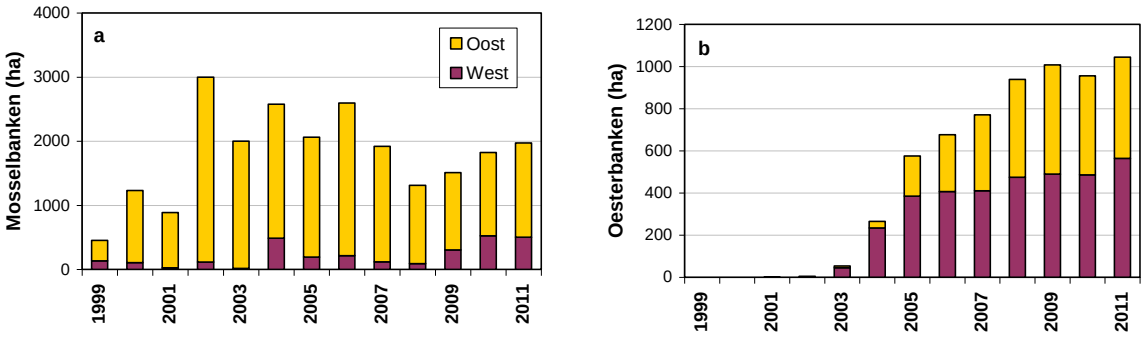


Figure 2. Development of mussel and oysters beds in the period 1999 – 2011.