ECASA Study Site Report

Visma mussel farm,
Northern Adriatic Sea

Italy

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Version 2

ECASA – In Confidence

This document provides a comprehensive account of ECASA project activities as related to each study site. During the project, the evolving document will be made available to all ECASA partners in order for cross-checking of appropriate activities and input from WP leaders. Once complete (June 2007, draft target), these documents will collectively provide the European ECASA assessment and from them the final outcomes of the project will be derived.

At the end of the project these documents will be made available publicly on the ECASA website. Until that time they are to be treated *In Confidence*, authorized users include the ECASA partners and the Study Site farmer.

Please do not add section headings to the document until you have discussed this with the coordinator.

Non Technical Summary A 1-page summary in layman's language.

0. Contents

1. Introduction to the aquaculture operation
1.1 Introductory background statement

The Company.
Vi.S.Ma società cooperativa have been established since XXXX. Vi.S.Ma produces Mediterranean mussel (*Mytilus galloprovincialis*) and employs 9 people. The company holds 1 marine site for longline mussel farming and produces approximately 600 x 10^3 kg *per annum*. This site was established in 1993.

Field Campaign
ECASA contributors: DCF-UNIVE, ICRAM, HAIFA. The ECASA field campaign was carried out during the summer of 2006. The field stations were identified during two pre-surveys carried out in the area. The field campaign was held in July XX 2006. Sediment samples were taken at three stations. Water quality parameters were collected at two stations and mussels were sampled at one site: the sampling will be repeated with monthly frequency, in order to obtain a time series of data to be used for the verification of the individual-based model of *Mytilus Galloprovincialis*. Bioassays were carried out in collaboration with D. Angel, HAIFA. The following field deployments were made:

macrobenthos collection
meiobenthos collection
box-corer
bottle water collection
CTD profiles
Incubation bags for bioassays
altro? ICRAM

The following laboratory based analysis was carried out:

ICRAM

The procedures used in both field and laboratory work can be found in Appendix 1.

1.2 Summary statement of key site specific environmental issues (this is basically a synopsis of section 3.0)

XXXXX

1.3 Information of farmer's environmental strategy:
chiedere se aderiscono a qualche codice di condotta responsabile??

Current regulatory status

The area was designated by the local authority Genio Civile of Rovigo, after collecting the opinion of 12 different agencies, namely:
fare l'elenco

2. Site specific regulatory and management background
2.1 The regulatory status of proposed location with respect to fish farming developments.

The current regulatory status in Italy demands to each county, *Regione*, the responsibility to concede the licenses for marine mussel culture sites. In the case of the Emilia-Romagna and Marche counties, to which belongs the coastal area located southward the Po river outlet, started to implement a ICZM plan, in order to conciliate different coastal uses. On the contrary, Veneto county, that is responsible for the coastal area were Visma farm is located, no Integrated Coastal Zone Management, ICZM, plan was implemented. Therefore, the case of each site is treated individually, and the decision is based on a technical consultation of 12 different agencies, namely: mettere i nomi

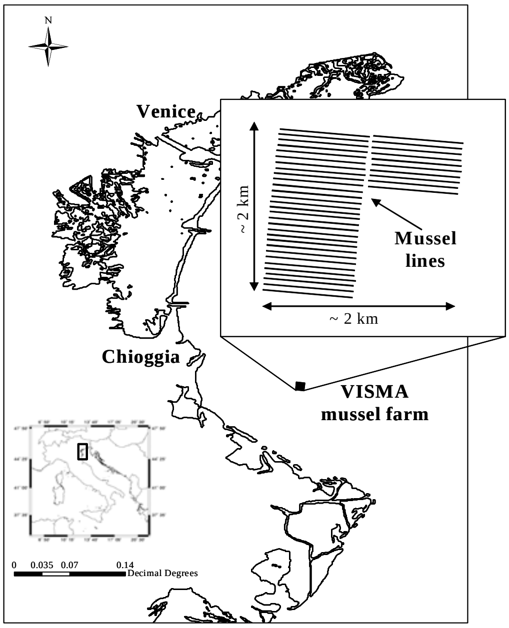
The major use conflicts for this area are:

1. the presence of important commercial ship routes;
2. the presence of gas platforms;
3. the marine protected area named "Tegnue di Chioggia";
4. the professional fishery, including beam-trawl fishery and *Chamelea galena* fishery;
5. the recreational fishery;

With respect to food safety (citare una legge??), Visma farm is located in waters classified as 'zone A', which means that the reared mussels does not need a depuration period, and can be sold directly after their harvest.

2.2 Site description

The study site is located in the Northern Adriatic Sea, southward Adige river outlet and northward Po river outlet. The farm is located approximately 3 miles offshore the coastline, see Fig. XX



The Northern Adriatic Sea is the Northernmost region of the Mediterranean Sea, extending as far north as 45°47'N and bounded by the Italian peninsula to the West and the Balkans to the East. It is a shallow sub basin of the Adriatic whose southern open boundary is arbitrary taken as the 100-m isobath, approximately located north of 43°20'N. The Physical Oceanography of the Northern Adriatic was recently reviewed by Poulain et al. (2001). The Northern Adriatic is influenced by intense surface (wind stress, heat and water fluxes) and lateral (river runoff and open southern boundary transport) fluxes. Dominant winds are Bora, from the North-East and Sirocco, from the South-East. Freshwater is discharged into the Northern Adriatic from major rivers located along the Italian coast: Isonzo, Stella, Tagliamento, Livenza, Piave, Sile, Brenta, Adige, Po, Reno, Lamone,

Savio and Foglia. The Po river represents the major freshwater input, with an annual mean discharge rate of 1500-1700 m^3s^{-1}. This affects the entire Adriatic freshwater balance and gives it the characteristics of a dilution basin. Along the Italian coast, a generally vigorous and thin current, the Western Adriatic Current-WAC, transports relatively cold and freshwater out of the Northern Adriatic. Dense cold water also flows southeast underneath the WAC, before exiting the Northern Adriatic. This two layer structure disappears in winter, when the WAC transports low-temperature and low-salinity waters that are well mixed in the vertical.
Biogeochemical characteristics of the Adriatic waters were reviewed by Zavattarelli et al. (1998). The dataset analyzed in this work consists in 5086 individual casts, containing measurements relative to the concentration of biogeochemical properties, temperature and salinity. For the Shallow Northern Adriatic sub-region, where the Visma study site is located, the nutrient profiles are generally characterized by high surface concentrations, vertically decreasing down to 10m depth. From 10m depth the profiles are constant or increasing with depth. The annual peak for nitrate is in wintertime (January to March), while for phosphate is in autumn (October to December). Phosphate in the upper 10m column shows a reduced variability with respect to nitrate. Silicate increases with depth, indicating a major source of this nutrient coming from diagenetic processes in the sediment. The dissolved oxygen profile shows a progressive decrease in the concentration with depth in all seasons. Chlorophyll-a shows highest concentrations in winter, with a progressive decrease trough spring and summer and a recover in late summer-autumn. Bernardy-Aubry et al. (2004) studied the succession of algal species in the North-Western Adriatic coast during a 10 year sampling period (1990-1999). According to these authors, the dominant specie in late-winter (February) is *Skeletonema costatum*. During spring the community is dominated by diatoms, while the algal biomass in summer is mostly supported by flagellates. The late summer peak is characterized by the presence of large diatoms, with an high carbon content.

2.3 Detailed description of the farm

The ECASA study site in the Northern Adriatic Sea is a longline mussel farm. Mediterranean mussel, *Mytilus galloprovincialis*, has been produced since 1991 with an average annual production of 600 MT ($6x10^5$Kg).
The farm supplies work to 9 people.

2.4 Proposed management strategy: biomass, medicines, chemicals, cycle, feed inputs, growth measurements.

Mussels are cultured in a 10-12 months grow out cycle. Seedling is concentrated during June, July and August. Mussels are collected after having reached the commercial size of 50mm. Harvest period starts in spring, but a relevant part of the production is concentrated in summer, approximately in July and August.

2.5 Physical farm logistics, including type of gear used (Cages, long lines, rafts…), moorings, access, lighting and anti-predator measures (use maps, and diagrams).

The cultivated area occupies 3 km^2, and could be extended up to 4 km^2, on the basis of the governmental lease. The structure consists in 38 km of cables, with an average spacing of 40m between subsequent lines. The average distance between suspended mussel ropes is of 0.7m and the average length of a rope is 2m. Ropes are suspended at a depth which is comprised between 2m and 7m.

2.6 Production and Processing

Mussel are collected and processed on board. The company ship is equipped in order to select the harvestable mussels, based on their shell length. Cleaning and packaging are also performed on board. VISMA farm is located in an area classified as 'zone A', which means that the reared mussels does not need a depuration period, and can be sold directly after their harvest.

3. Description of the site and quantification of effects on the environment – existing information only, not collected by ECASA.
3.1 Land use, landscape and visual quality (use maps and photographs)

Visma farm is located off-shore the city of Chioggia, which population exceeds the 50.000 inhabitants. The major activities practiced in Chioggia are related to fishery, aquaculture and tourism. The Visma farm local area is interested mainly by trawl fishery and mussel farming. Mussel farm distribution, with the ECASA site highlighted in red, is represented in Fig. XX. This maritime area is also an important route for commercial ships.
With respect to natural amenities, the seabed in the area is interested by the Tegnue rocky aggregations, which is characterized by an high biodiversity. This area, which is of was recently studied in the framework of the INTERREG III project (http://www.arpa.veneto.it/home/htm/interreg.asp). Different recreational areas are located along the coast, between Chioggia and the Po Delta, including the towns of Sottomarina, Rosolina and Albarella.

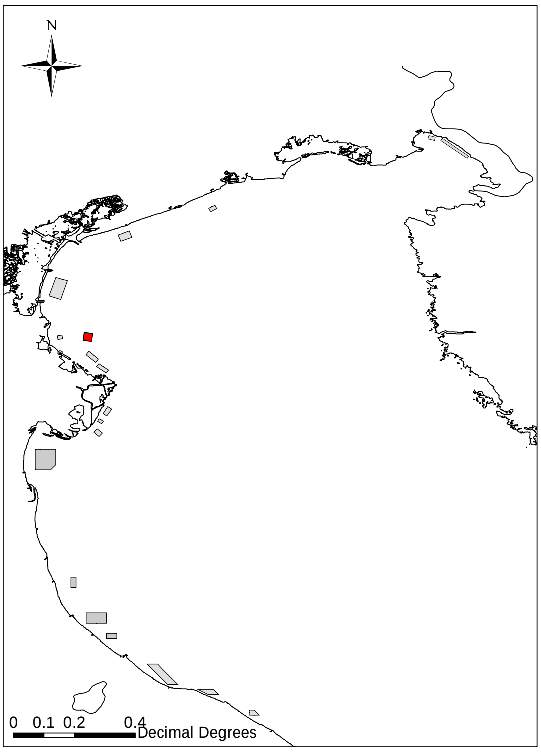


Fig XX.

Fig XX.

3.2 Hydrography and water quality

The area is subject, depending on the season and winds, to the discharges of Brenta and Adige rivers from the north and/or to the discharge of the northern Po distributaries from south, during the stratified period (spring-autumn). The large scale cyclonic circulation in the Adriatic sea induce a northerly flow along the western coast and a southerly return flow along the western coast (Orlic et al., 1992).

The drainage basin of the Adige river is 11954 km^2, the mean daily discharge is 155 m^3 s^{-1} (period 2004-2005) which is markedly reduced with respect to the previous data relative to the period 1931-1982: 225,5 m^3 s^{-1} (Annali idrologici Ufficio idrografico e mareografico di Venezia). The river Brenta (and its tributary Bacchiglione) which had a daily discharge of 90m^3 s^{-1} (period 1956/65; Cavazzoni Galaverni, 1972) has now a discharge of 76 m^3 s^{-1}.

The Po river has a drainage basin of 71000 km^2 and a mean daily discharge of 1157 m^3 s^{-1} for the period (2002-2006) whereas the mean daily discharge for the period 1917-2001 was 1516 m^3 s^{-1}. The Po has a seasonal biannual flooding in May-June and October November. The central and northern distributaries of the Po delta, Po di Maistra and Po della Pila; account for >70% of the total discharge and with southerly winds, during the stratified periods can influence the study area (Orlic et al. 1994). In winter the Po river remains confined mostly in a narrow strip along the western coasts wheras during summer the plume extends offshore in the cross-basin direction (Barale et al., 1986).

Mussel farm area

The seasonal warming begins in April and reaches the maximum in August (25-26 °C and 20-21 °C in surface waters and bottom waters, respectively) wheras the winter cooling reaches its maximum between January and february or March. (5-6°C and 7-8 °C in surface waters and bottom waters , respectively). Large interranual variations of temperature and salinità are typical of the Northern Adriatic Sea. In winter 2000-01 water the minimum temperatures , aroun 10°C, were reached in March .

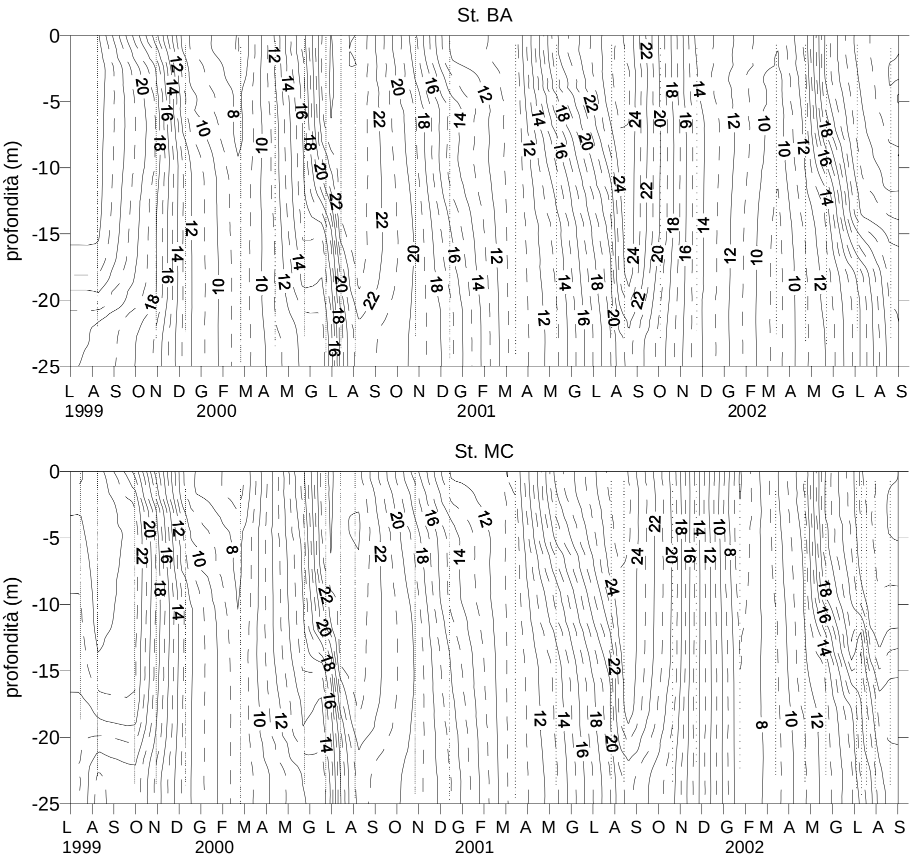


Figure 3.3.1 Monthly variations of temperature profiles in two station in the mussel farm area. (from Giovanardi et al, 2003).

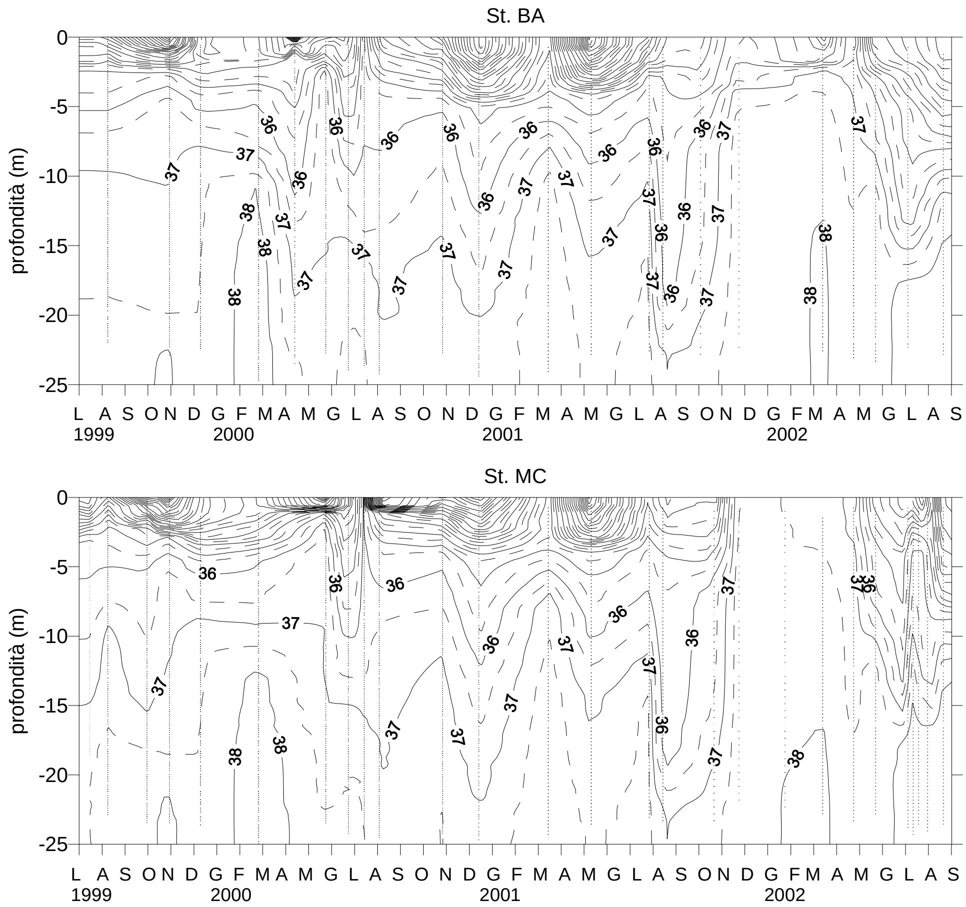


Figure 3.3.2 Monthly variations of salinity profiles in two station in the mussel farm area. (from Giovanardi et al, 2003).

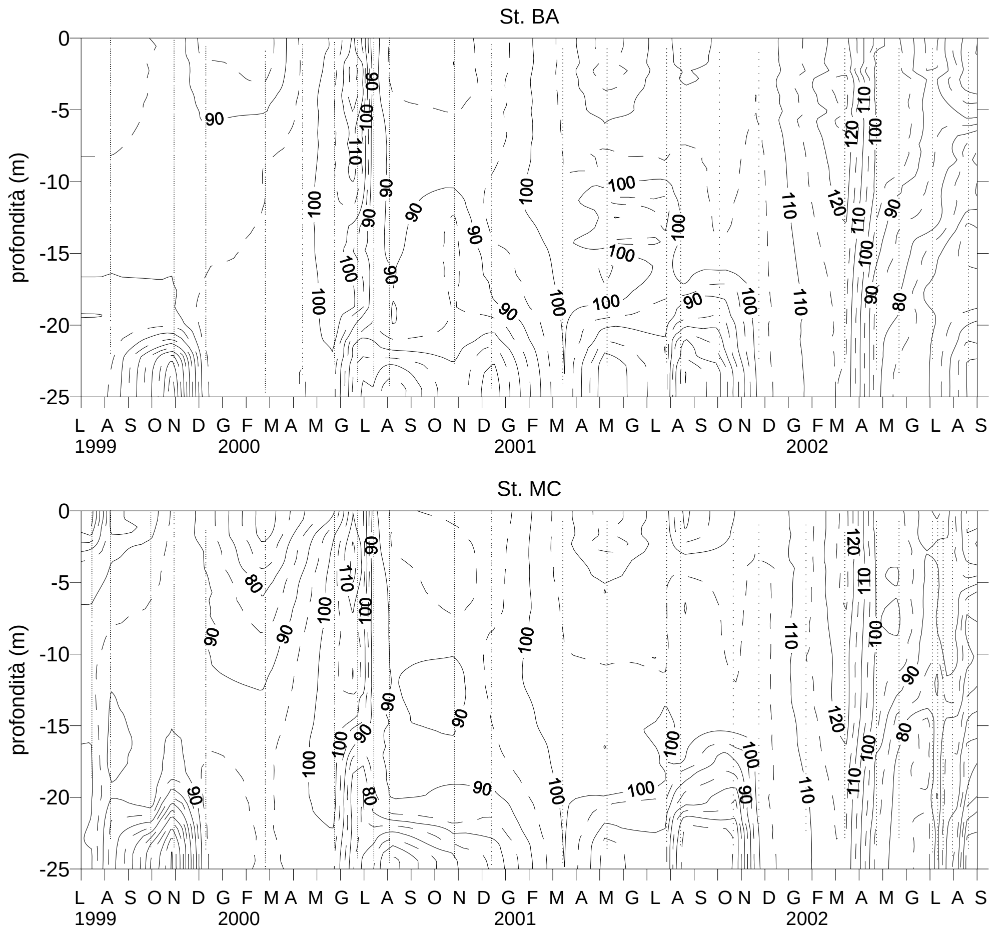


Figure 3.3.3 Monthly variations of dissolved oxygen (% of saturation) profiles in two stations in the mussel farm area. (from Giovanardi et al, 2003).

3.2 Bathymetry, geology and habitats.

The site lies in a belt of clayey silt which extends parallel to the coastline in the NW-SE direction (Brambati et al., 1984). Fine sediments such as silt and clay are mainly supplied from the northern Adriatic Sea rivers (Brambati, 1973) and they are distributed the along the italian coast by the Western Adriatic Coastal current. During the transport the sediments are mechanically sorted out by their grain size in such that the sediment grain size decrases ass the distance increases southward from the river sources (Brambati, 1973, Wang and Pinardi, 2002).

3.3 Benthos and sediments

Benthic community data were collected by Icram-Chioggia, during a three years research program (Jul 99- May 01), underneath the VISMA cultivation site. The averaged taxa composition is reported in tab. 2. Dominant species are: the bivalve mollusc *Corbula gibba*, the amphipod crustacean *Amphelisca diadema* and the errant polichaetes *Lumbrineris gracilis* (Cornello et al., 2005).

taxa	**RELEVANCE %**
BIVALVES	24.1

GASTEROPODS	1.3
ERRANT POLICHAETES	28.4
SEDENTARY POLICHAETES	23.7
AMPHIPODS	10.3
DECAPODS	3.7
ECHINODERMS	6.6
OTHER	1.9

Tab. 2. Taxa composition beneath the cultivation site.

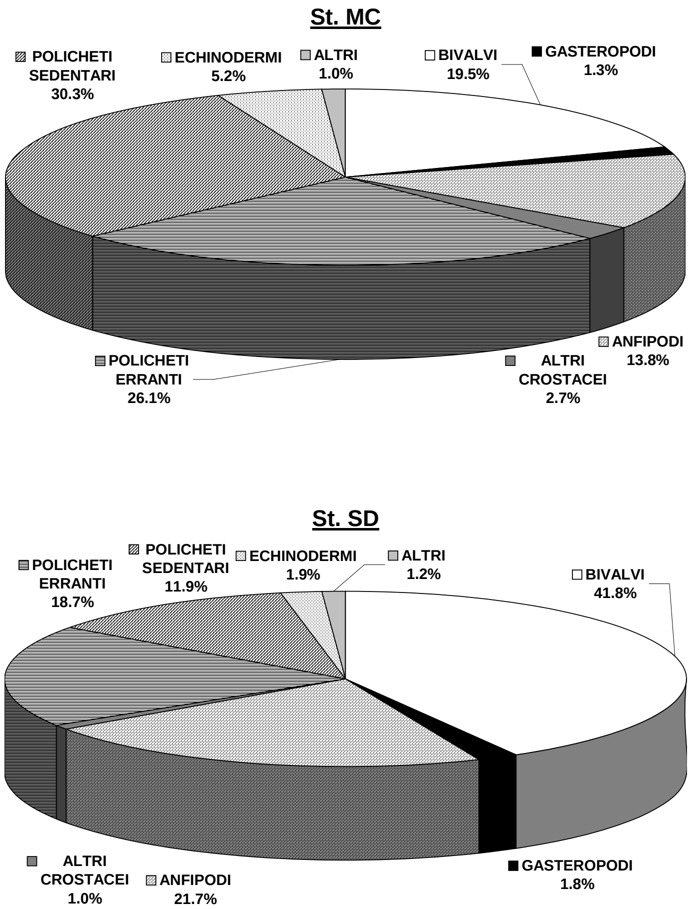


Figure 3.3.1. Composition of the soft bottom macrozoobenthos in the area of the mussel farm (Giovanardi et al., 2003).

3.4 Marine mammals; seals, cetaceans, otters

Dolphins
Sea Turtles

3.5 Birds

3.6 Fisheries and wild fish populations.

Clams (*Chamelea gallina*) fishery is an important activity within the first three miles from the coast. This fishery, which is practiced by means of an 'hydraulic dredge', in facts conflicts with the use of the sea for mussel farming purposes. For this reason, the assignation of a new area for mussel culture use is priory discussed, in the framework of a county commission named 'commissione regionale per la pesca', which involves stakeholders from both mussel culture and clam fishery sectors.
According to 2003-2004 data (http://www.adrifish.org), the major captures in the Chioggia area are Anchovies, Sardines, Cuttlefish, Sole, Mantis Squillid. One of the gear used is 'rapido', a kind of beam-trawl for soles and scallops employed in the Northern Adriatic sea. A relatively high level of disturbance of this gear on benthic communities was assessed by Pranovi et al. (1998) for a study site located in this area. In this sense, the presence of a mussel farm can have a positive impact on the sediment underneath preventing from the boat transit.

3.7 Noise

The Visma farm is located approximately at three miles from the shoreline.

3.8 Transport

The site is accessed by boat on a daily basis, operating out of the Visma society based in Chioggia harbor.

3.9 Socio-economic impact

See 2.3 above

4 Results of ECASA field studies: Indicators and Models applied and evaluated.

4.1 Background to field programme: dates, staff, boats, stations sampled, etc.

The Visma long line mussel farming was located in the northern Adriatic basin in an offshore area southern Chioggia harbour (Figure 4.1.1.1; 4.1.1.2). Sampling were developed using the owner's mussel farming boat, the VISMA II ICRAM staff (Michele Giani, Daniela Berto, Fabio Savelli). The University of Venice staff (Federico Rampazzo) carried out the sampling and the analyses. All the surveys for sediments samplings and oceanographic measures were carried out with the VISMA II vessel.

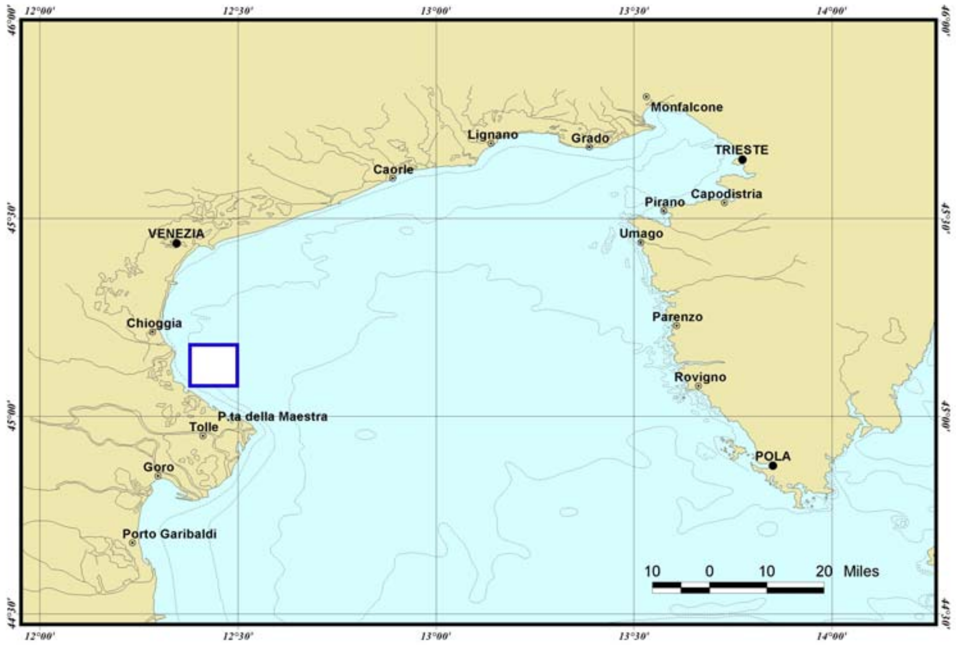


Figure 4.1.1.1 –Studying area.

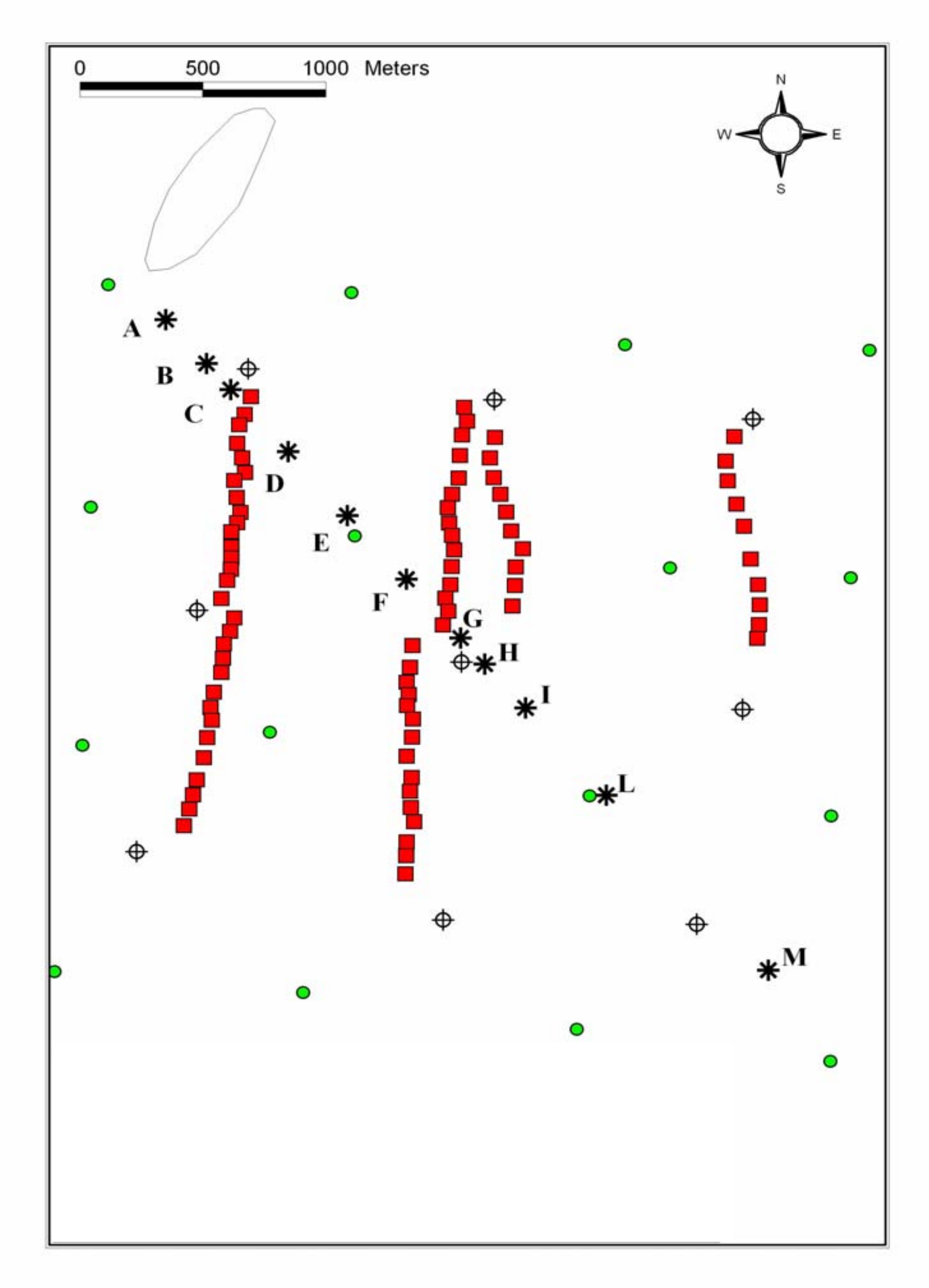


Figure 4.1.1.2 –Sampling area.

4.1.2 Water sampling

Water sampling were performed monthly from 18 July 2006 in 3 station (A, E, G) of the Visma farming area along a NW-SE transect (Tab. 4.1.2.1.) order to evaluated chemical waters properties as: dissolved organic carbon, particulate organic carbon, particular total nitrogen, suspended matter and POM, particulate phosphorus, chlorophyll-a, ammonium, nitrate, nitrite, silicates, Phosphate, (SRP), TDP, TDN.

The dates of sampling were: 18 July 2006, 17 August 2006, 21 September 2006, 14 November 2006, 14 December 2006.

CTD profiles were developed during all the sampling dates to evaluate: temperature, salinity dissolved oxygen, fluorescence and turbidity.

Table 4.1.2.1-Water sampling stations coordinates and depth.

Station	Latitude N	Longitude E	Depth (m)
A	45°07.941'	12°26.592'	sup, -10m, -20m
E	45°07.498'	12°27.162'	sup, -10m, -20m
G	45°07.249'	12°27.533'	sup, -10m, -20m

4.1.3 Sediments sampling

4.1.3.1 Surface sediments

On 21 December 2005 first presurvey sampling of surface sediments (0-1 cm) were carried out in a series of 20 stations (Tab. 4.1.3.1.1) in order to characterize the area in which the cultivation site take place.

Tab 4.1.3.1.1 -First presurvey stations, coordinates and depth

Station	Date	Latitude N	Longitude E	Bottom Depth (m)
1	December 21, 2005	45°08.037'	12°26.386'	20.7
2	December 21, 2005	45°08.035'	12°27.141'	23.6
3	December 21, 2005	45°07.933'	12°27.994'	24.3
4	December 21, 2005	45°07.937'	12°28.753'	25.1
5	December 21, 2005	45°07.410'	12°28.718'	24.9
6	December 21, 2005	45°07.420'	12°28.157'	24.8
7	December 21, 2005	45°07.472'	12°27.176'	24.1
8	December 21, 2005	45°07.521'	12°26.354'	22.2
9	December 21, 2005	45°06.969'	12°26.354'	23.5
10	December 21, 2005	45°07.012'	12°26.933'	23.8
11	December 21, 2005	45°06.887'	12°27.931'	24.2
12	December 21, 2005	45°06.857'	12°28.681'	24.6
13	December 21, 2005	45°06.290'	12°28.703'	25.6
14	December 21, 2005	45°06.346'	12°27.915'	24.0
15	December 21, 2005	45°06.412'	12°27.063'	24.3
16	December 21, 2005	45°06.444'	12°26.290'	23.5
17	December 21, 2005	45°05.905'	12°26.271'	23.0
18	December 21, 2005	45°05.857'	12°27.016'	24.1
19	December 21, 2005	45°05.800'	12°27.855'	24.2
20	December 21, 2005	45°05.762'	12°28.596'	25.1

On 13 July 2006 a second and more detailed presurvey of surface sediments were performed in order to characterize a smaller area in the cultivation site, thought to be more exposed to impact from the mussel culture activities. Superficial sediments (0-0.5 cm) were carried out in 10 station of the long-line mussel farming (Tab 4.1.3.1.2)

Tab 4.1.3.1.2 -Second detailed presurvey stations coordinates and bottom depth.

Station	Date	Latitude N	Longitude E	Bottom depth (m)
A	July 13, 2006	45°07.955'	12°26.545'	21.5
B	July 13, 2006	45°07.852'	12°26.701'	22.5
C	July 13, 2006	45°07.808'	12°26.775'	22.7
D	July 13, 2006	45°07.654'	12°26.952'	23.5
E	July 13, 2006	45°07.515'	12°27.146'	23.4
F	July 13, 2006	45°07.389'	12°27.343'	23.4
G	July 13, 2006	45°07.240'	12°27.512'	23.6
H	July 13, 2006	45°07.185'	12°27.592'	23.80
I	July 13, 2006	45°07.077'	12°27.717'	23.9
L	July 13, 2006	45°06.882'	12°27.979'	24.0
M	July 13, 2006	45°06.498'	12°28.503'	25.1

4.1.3.2 Surface sediments

On 18 July 2006 cores sampling were performed in station B, D, G of the Visma study site (Tab 4.1.3.2.1). Cores were collected from level 0 cm to level 11.5 cm.

Table 4.1.3.2.1 -Cores sampling station coordinates and bottom depth.

Station	Date	Latitude N	Longitude E	Bottom depth (m)
B	July 18, 2006	45°07.848'	12°26.682'	22.6
D	July 18, 2006	45°07.651'	12°26.941'	23.4
G	July 18, 2006	45°07.249'	12°27.535'	n.c

Sediments samples were used to determine the following parameters: grain size, water content, loss of ignition (250 and 450 °C), total carbon, total nitrogen, organic carbon, inorganic carbon, total phosphorus, inorganic phosphorus.
Dissolved oxygen, Eh, pH, T, at interface water/sediments were measured during cores sampling.

4.1.4 Bioassay experiment

On 20 July 2005 an experiment of Bioassay have been started in the forth stations (Table 4.1.4.1) in the study area. The sites were chosen on in an area near the mouth Adige river (S2, 2.3 km SE of the mouth), near adjacent to the mussel farm (G) and at increasing distances in the SE direction (H, L). The geographical setting of the stations is showed in the figure 4.1.1.2.
Four dialysis bag were placed in each station at two level of depth (1.5 and 6 m) filled with 950 ml of filtered seawater (20 μm) collected in the A station (45°07.955' N; 12°26.545'E). Analysis of POC, phosphorus and chlorophyll a were performed in the filtered seawater and unfiltered of A station in triplicate.

The bags were collected after 5 days, on the 25 July 2005.

Table 4.1.4..1 –Bioassay station coordinates and bottom depth.

Station	Start date (dd/mm/yy)	Time of deployment (hh:mm)	End date (dd/mm/yy)	Time of collection (hh:mm)	Latitudide N	Longitudide E	Bottom depth (m)
S2	July 20, 2006	8.05	July 25, 2006	15.20	45°08.895'	12°23.129'	19.6
G	July 20, 2007	9.00	July 25, 2007	14.40	45°07.238'	12°27.507'	23.5
H	July 20, 2008	9.51	July 25, 2008	14.35	45°07.178'	12°27.570'	23.6
L	July 20, 2009	10.42	July 25, 2009	14.21	45°06.888'	12°27.958'	23.6

CTD profiles was performed at the begin and the of experiment in all stations. POC, phosphorus and chlorophyll a concentrations were evaluated in the seawater collected from each bag, at the end of experiment. Analysis of chlorophyll *a* were determined by ICRAM-ROME.

4.2 Sampling methods and materials, analytical methods. (Refer to the book of protocols for detailed methods)

Surface sediment samples were collected by box corer (15x17x26,5) and samples were kept in transparent plastic tubes, Falcon.

Water samples were collected by Nyskin bottles at fixed depths (surface, -10m, - 20m).

Water samples for DOC analysis were filtered on Whatman GF/F (25 mm Ø) filters precombusted at 450°C for 4 h in glass vials, previously washed with sulphocromic mixture, rinsed with MilliQ water and combusted at 450°C for 4 h. 100 µl $HgCl_2$ were added to the filtered samples, which were stored at -20°C.

Water samples for analyses of POC,TPN (particulate total nitrogen) were filtered through precombusted Whatman GF/F (25 mm Ø) filters at 450°C for 4 h. Filters were then stored at -20°C.

Water samples for analyses of dissolved nutrients, particulate phosphorous and Chlorophyll were filtered through precombusted Whatman GF/F (47 mm Ø) filters at 450°C for 4 h and stored at -20°C

Analyses of suspended matter were performed filtering water samples through precombusted Whatman GF/F (47 mm Ø) filters at 450°C for 4 h and stored at room temperature. Filters were rinsed with MilliQ water.

DOC concentration were measured using a Shimmadzu TOC 5000 Analyzer with a 1.2% Pt on silica as catalyst at 680°C. Samples were acidified (pH 2) with 2 µmol L^{-1} HCL and purged with pure air for 10 minutes immediately prior to analysis. DOC concentrations were calculated by subtracting the system blanks and dividing by the slope of the calibration curve. Potassium hydrogen phthalate was used as standard. 100 µL of sample was injected for each analysis and the concentration was calculated as the average of three to five replicates. The average instrumental blank was 8.7± 0.9 µmol L-1 and the reproducibility was hight (<3%).

POC and TPN concentrations were determined with a CHN Fisons Mod. EA1108 Elemental Analyzer, after acidification with HCl (8N) to remove inorganic carbonate fraction, with higth reproducibility (<2%). Acetanilide was used as standard.

Particulate phosphorous content in filters were determined with an Atomic Emission of Inductively Coupled Plasma (ICP-AES) after ignition in a muffle at 550°C for 4h and HCl 1N extraction and centrifugation for 16h.

Suspended matter were weighted after drying at 60°C for one night and then at 450°C for 4 h.

Chlorophyll-a was analysed fluorimetrically, after extraction and centrifugation of material collected on GF/F filters with 90% acetone. Reproducibility was <8%.
Temperature, salinity and dissolved oxygen were measured with CTD.
Dissolved nutrients samples were analysed after addition of potassium persulfate and oxidation by autoclaving at 120°C for 40 min according to Koroleff (1983). Orthophosphate and nitrate (reduced to nitrite by a copper-cadmium reduction column) concentrations were determined following the colorimetric methods of Hansen et. al. (1983) using a multichannel continuous flux analyser (Braan Luebbe Autoanalyzer III).
Particulate sulphur were determined by a CHNS–O analyser Fison (Italy) model EA1108.
Eh, pH, T the measurement was performed in situ, by means of a portable pH/ion meterwith a combination electrode. Grain size analyses were performed using a laser *Malvern Mastersizer 2000*. Water content and loss of ignition were determined weighting samples after drying at 60°C for one night and then at 250 and 450°C for 4 h.
Total carbon, total organic carbon, total nitrogen, particulated organic carbon (POC) and total particulated nitrogen (TPN) were determined by a CHNS–O analyser Fison (Italy) model EA1108.
Organic carbon was determined after removal of carbonates with HCl (8N) treatment. BCSS were used as certified reference materials for quality control and acetanilide was used as standard. Inorganic carbon were calculated by difference between total and organic carbon. Total and inorganic phosphorus contents were determined by Atomic Emission of Inductively Coupled Plasma (ICP-AES), after digestion with a mixture of concentrated HNO_3, H_2O_2 and HF (2:0.5:0.1 v/v). BCSS were used as certified reference materials for quality control. All samples were centrifuged to remove interstitial water, were stored at –20°C until analysis and a freeze-dryer system was used to dry the wet sediment (the process can take up to a few days) . Finally samples were sieved at 200 µm.

4.3 Models used and their parameterization.

MG-IBM *Mytilus Galloprovincialis* Individual Based model

The model is based on the computation of the *Scope for Growth* as the difference between net anabolism and fasting catabolism. Values for the maximum respiration rate and the maximum filtration (clearance) rate where quantified on the basis of the results of specie-specific studies on mussel physiology. Data used for model application at the Visma study site and their source are listed in Tab. XX. Model forcing are time series of water temperature, chlorophyll-a and POC concentrations. These parameters, along with mussel growth data were collected with monthly frequency at the Visma study site during a whole rearing cycle, in order to obtain a time series of data to be used for model verification. Initial condition for the model is the value of mussel dry weight at seeding. The value of this parameter was set on the basis of the husbandry data provided by the farmer.

Data type	**Frequency**	**Length of the time series**	**Source**	**Data use in relation to the model**
Water temperature	monthly	10 months	Field data collected at the study site	Forcing
Particulate organic carbon	monthly	10 months	Field data collected at the study site	Forcing
Chlorophyll-a	monthly	10 months	Field data collected at the study site	Forcing
Mussel dry weight	monthly	10 months	Field data collected at the study site	Model output corroboration
Mussel wet weight	monthly	10 months	Field data collected at	Model output

			the study site	corroboration
Mussel length	monthly	10 months	Field data collected at the study site	Model output corroboration
Mussel dry weight at seedling	-	-	Interview with the farmer	Model initial condition

Tab XX. Field data collected at the Visma study site, and their use in relation to the MG-IBM model application.

MGCC *Mytilus Galloprovincialis* Carrying Capacity model

MGCC is an integrated model system for the assessment of Mediterranean mussel carrying capacity in the northern Adriatic sea. Model state variables are the concentrations of DOC, POC, nitrate, ammonia, reactive phosphorous and silicates. Densities of phytoplankton, zooplankton and mussels in farming sites. The model, which was designed to work both at local and regional scales, was applied at Visma farm in order to:

1) study the local impact of mussel farming on chlorophyll-a and dissolved ammonia concentrations;
2) forecast the different growth of mussels reared in different areas of the farm.

The validation of the model at a local scale is a preliminary step trough model application at the regional scale.
Model input data, and their sources, are listed in Tab. XX.

Data type	**Frequency**	**Length of the time series**	**Source**	**Data use in relation to the model**
Current velocities	20 minutes	10 months	Hydrodynamic model of the Adriatic Sea	Forcing
Bathymetry	-	-	Field data collected at the study site	-
Water temperature	Monthly	10 months	Field data collected at the study site	Forcing
Chlorophyll-a	Monthly	10 months	Field data collected at the study site	Forcing & model output corroboration
NO_x	Monthly	10 months	Field data collected at the study site	Forcing & model output corroboration
NH_4	Monthly	10 months	Field data collected at the study site	Forcing & model output corroboration
SiO_4	Monthly	10 months	Field data collected at the study site	Forcing & model output corroboration
PO_4	Monthly	10 months	Field data collected at the study site	Forcing & model output corroboration
POC	Monthly	10 months	Field data collected at the study site	Forcing & model output corroboration
DOC	Monthly	10 months	Field data collected at the study site	Forcing & model output corroboration
Irradiance	Hourly	10 months	ISMAR dataset	Forcing
Farm position and detailed geometry	-	-	Interview with the farmer	-
Mussel dry weight at seedling	-	-	Interview with the farmer	Model initial condition

Tab XX. Field data collected at the Visma study site, and their use in relation to the MGCC model

application.

MERAMOD+EDM Modelling interactions between mussel farm biodeposition, sediment biogeochemistry and nutrient recycling

The coupling between two mathematical models, i.e. a particle tracking model and an early diagenesis model, was carried out in close collaboration with partner 1, SAMS. The first model was already available (MERAMOD, http://meramed.akvaplan.com), while the second one was set up using the simulation environment BRNS (Aguilera et al., 2005). The integrated model, which structure is represented in Appendix 2 Fig.XX, was applied at the Visma mussel farm in order to study the long-term influence of mussel faeces remineralization on the redox dynamics in the top sediments. Input and output information related to each model are listed in Tab. XX CHIEDERE A ROBERTO SE IL NUOVO CAMPIONAMENTO VA INSERITO QUI, O COME SI FA.

Data type	**Source**	**Data use in relation to the model**
Time series of current velocity module and direction (20 min frequency)	Hydrodynamic model of the Adriatic Sea	Meramod input
Rate of faeces production per mussel line	MG-IBM model output	Meramod input
Position and geometry of the farm, husbandry information	Interview with the farmer	Meramod input
Flux of mussel faeces to the bottom	MERAMOD output	EDM input
Flux of organic detritus to the bottom, not originated from the mussel farm	Giani et al. (2001)	EDM input
Superficial sediment temperature	Field data collected at the study site	EDM input
Flux of $Fe(OH)_3$, MnO_2 to the bottom.	Model calibration	EDM input
Fe2+ pore waters	Field data collected at the study site	EDM input
Mn2+ pore waters	Field data collected at the study site	EDM input
SO4 pore waters	Field data collected at the study site	EDM input
PO4 pore waters	Field data collected at the study site	EDM input
NH4 pore waters	Field data collected at the study site	EDM input
O2 pore waters	Field data collected at the study site	EDM input
porosity	Field data collected at the study site	EDM input
OC solid phase	Field data collected at the study site	EDM input

Tab XX. Field data collected at the Visma study site, and their use in relation to the MERAMOD+EDM model application.

4.4 Results. (Give tables of bulk data/model outputs electronically and/or in appendices. Here only give highlights and summary information).

4.4.1 Oceanographic features

The mussel farm lies in an area under the influence of the discharges of Brenta and Adige rivers form the North and of Po prodelta (Po di levante tributary,) from the south. The winds and the seasonal stratification conditions together with the general cyclonic circulation determine the relative influence of the freshwaters in the area of the mussel farm.

A marked halocline is usually present in the upper 5-8 meters. During winter with low riverine discharge the water column can be quite homogeneous (as in april 2007, figure 4.4.1.1).

As the northern Adriatic basin reach the highest latitudes in the Mediterranean sea and due to its shallowness it is subject to wide variations in temperature of seawater from 28°C in summer to 12°C or in winter (figure 4.4.1.2). During the winter 2006/2007 there has not been the usual winter cooling and the temperature of the waters in the basin has been 3-4°C warmer than in previous years.

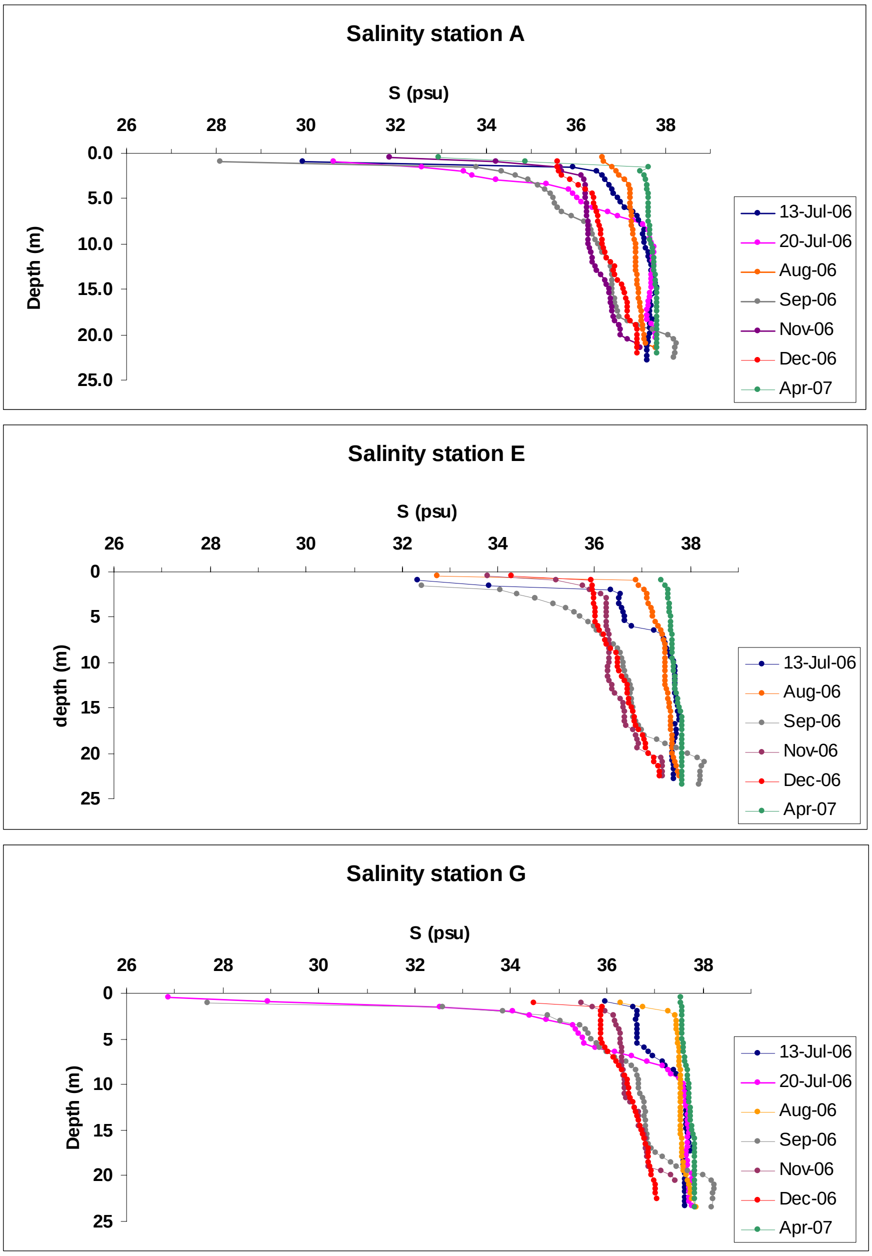
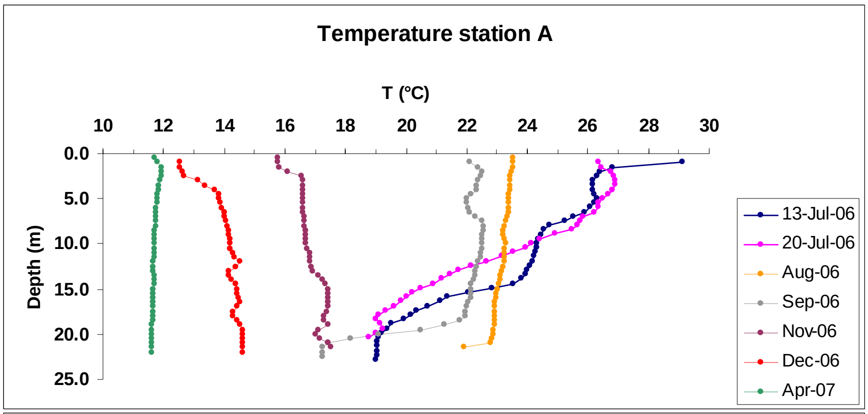
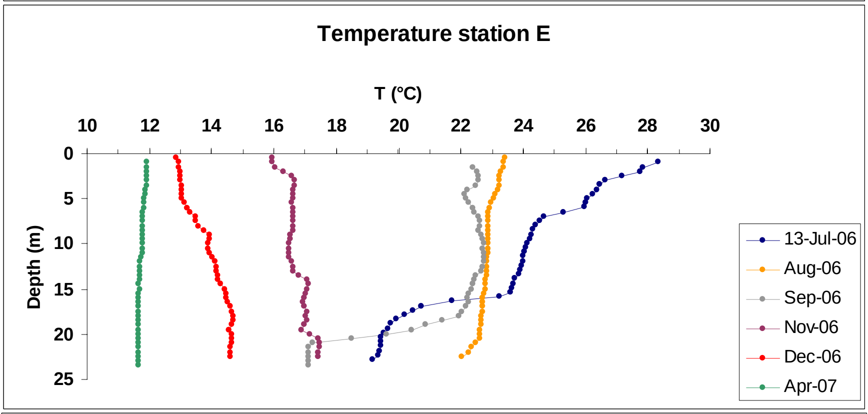


Figure 4.4.1.1 Salinity profiles.


Temperature station A
T (°C)
10 12 14 16 18 20 22 24 26 28 30
Depth (m)
0.0 5.0 10.0 15.0 20.0 25.0
13-Jul-06
20-Jul-06
Aug-06
Sep-06
Nov-06
Dec-06
Apr-07


Temperature station E
T (°C)
10 12 14 16 18 20 22 24 26 28 30
Depth (m)
0 5 10 15 20 25
13-Jul-06
Aug-06
Sep-06
Nov-06
Dec-06
Apr-07

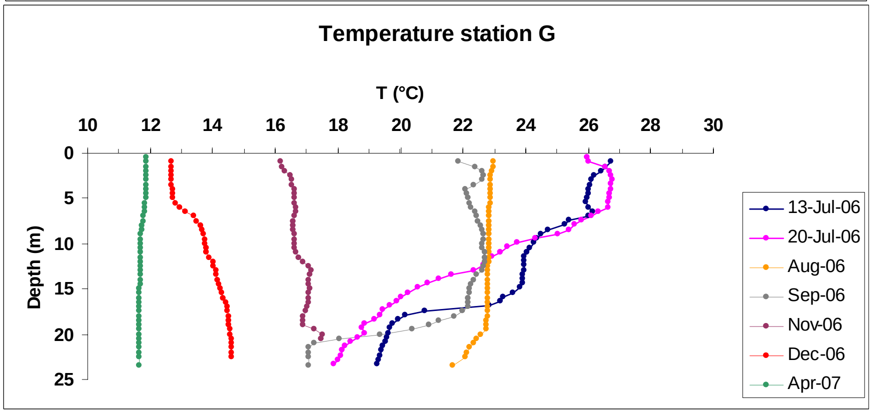

Temperature station G
T (°C)
10 12 14 16 18 20 22 24 26 28 30
Depth (m)
0 5 10 15 20 25
13-Jul-06
20-Jul-06
Aug-06
Sep-06
Nov-06
Dec-06
Apr-07

Figure 4.4.1.2 Temperature profiles.

4.4.2 Nutrients and organic matter

E station showed the highest nutrients concentrations, on average, respect the other two one's (s A and G). (Table 4.4.2.1).

Table 4.4.2.1 -Nutrients concentrations and statistical parameters for A, E, G stations.

Station A	**P-PO4 (µM)**	**N-NH3 (µM)**	**N-NO2 (µM)**	**N-NO3 (µM))**	**P-totsol (µM)**	**N-totsol (µM)**	**Si-SiO2 ((µM)**
Average	0.07	0.78	0.13	2.69	0.25	15.6	4.51
St. Dev.	0.04	0.74	0.16	4.75	0.04	5.7	5.54
Mediana	0.06	0.49	0.07	1.22	0.27	13.4	2.01
25 Percentile	0.05	0.42	0.04	0.81	0.21	12.7	0.96
75 Percentile	0.07	0.90	0.14	1.61	0.28	16.7	3.99
n	9.00	9.00	8.00	8.00	9.00	9	9.00

Station E	**P-PO4 (µM)**	**N-NH3 (µM)**	**N-NO2 (µM)**	**N-NO3 (µM)**	**P-totsol (µM)**	**N-totsol (µM)**	**Si-SiO2 (µM)**
Average	0.13	0.62	0.29	6.67	0.30	17.9	6.36
St. Dev.	0.16	0.68	0.46	14.81	0.20	15.8	10.42
Mediana	0.07	0.28	0.10	1.18	0.25	13.1	2.53
25 Percentile	0.05	0.18	0.08	0.73	0.21	12.1	0.94
75 Percentile	0.12	0.74	0.18	1.79	0.30	14.5	4.45
n	9.00	9.00	6.00	8.00	9.00	9	9.00

Station G	**P-PO4 (µM)**	**N-NH3 (µM)**	**N-NO2 (µM)**	**N-NO3 (µM)**	**P-totsol (µM))**	**N-totsol (µM)**	**Si-SiO2 (µM)**
Average	0.10	0.84	0.17	4.26	0.28	19.1	6.09
St. Dev.	0.05	0.67	0.27	9.92	0.09	12.5	10.00
Mediane	0.08	0.63	0.07	1.16	0.26	13.6	2.02
25 Percentile	0.08	0.43	0.05	0.56	0.24	12.8	0.87
75 Percentile	0.13	1.09	0.12	1.65	0.33	17.9	5.43
n	9.00	9.00	9.00	9.00	9.00	8	9.00

Chlorophyll-a concentrations , on average, tends to be similar in all the three stations, with low values (Table 4.4.2.2).

Table 4.4.2.2 -Chlorophyll values and statistical parameters for the A, E, G stations.

Station A	Chl-a (μg/(L)
Average	2.2
St. Dev.	4.1
Mediane	0.7
25 Percentile	0.5
75 Percentile	1.6
n	12

Station E	Chl-a (μg/L)
Average	1.6
St. Dev.	1.5
Mediane	0.8
25 Percentile	0.6
75 Percentile	1.7
n	11

Station G	Chl-a (μg/L)
Average	2.1
St. Dev.	4.5
Mediane	0.7
25 Percentile	0.5
75 Percentile	1.0
n	12

DOC values showed a decrease of concentrations from station A to station G . Highest POC values have been found for E station and lower for station A and G. . Total particulate nitrogen content are similar in all the three stations. Similar values of C/N ratio (mol/mol) were found for all stations A, E, and G (Table 4.4.2.3).

Table 4.4.2.3 –Dissolved organic carbon (DOC), particulate organic carbon (POC), total particulate nitrogen (TPN) and atomic ratios of organic carbon and nitrogen (C/N) values and statistical parameters A, E, G stations.

Station A	DOC (μM)	POC (μM)	TPN (μM))	C/N (mol/mol)
Average	205.1	19.9	2.7	8.5
St. Dev.	59.4	22.2	3.4	3.9
Mediane	199.2	11.6	1.5	7.3
25 Percentile	161.5	10.7	1.1	6.6
75 Percentile	233.0	13.6	1.9	8.4
n	14	15	15	15

Station E	DOC ((μM)	POC (μM)	TPN (μM)	C/N (mol/mol)
Average	188.3	23.8	2.8	8.7
St. Dev.	70.1	32.5	3.2	3.4
Mediane	156.5	13.4	1.5	7.3
25 Percentile	127.4	11.3	1.3	6.2
75 Percentile	258.2	16.2	2.4	9.3
n	15	15	15	15

Station G	DOC (μM)	POC ((μM)	TPN ((μM))	C/N (mol/mol)
Average	173.1	13.5	1.8	8.3
St. Dev.	57.3	10.7	1.8	3.3
Mediane	162.7	9.9	1.3	7.6
25 Percentile	126.9	8.3	0.9	6.0
75 Percentile	198.0	13.7	1.7	9.4
n	15	15	15	15

4.4.3 Sediments characteristics

4.4.3.1 Surface sediments

The results of the parameters analysed on first (21 December 2005) and second presurvey (13 July 2006) were reported on the *Appendix 3. Environmental data (* Table 4.4.3.1.1; Table 4.4.3.1.2, respectively) .The significant increase of pelite and water content from NE to SW is probably determined by the general sedimentology of the area. Probably an increase of pelite in the NW part of the mussel farm could be due to the enhanced sedimentation in the area with a major impact of the riverine suspended matter transport (Figure 4.4.3.1.1; A and B). The organic carbon showed a similar distribution of pelite and water content, with en enrichment from NE toSW in study area (Figure 4.4.3.1.1; C). Higher total phosphorus concentrations found in the surface sediments in correspondence of mussel farm point out that the this element could be a tracer for the impact of the mussel culture (Figure 4.4.3.1.1; D).

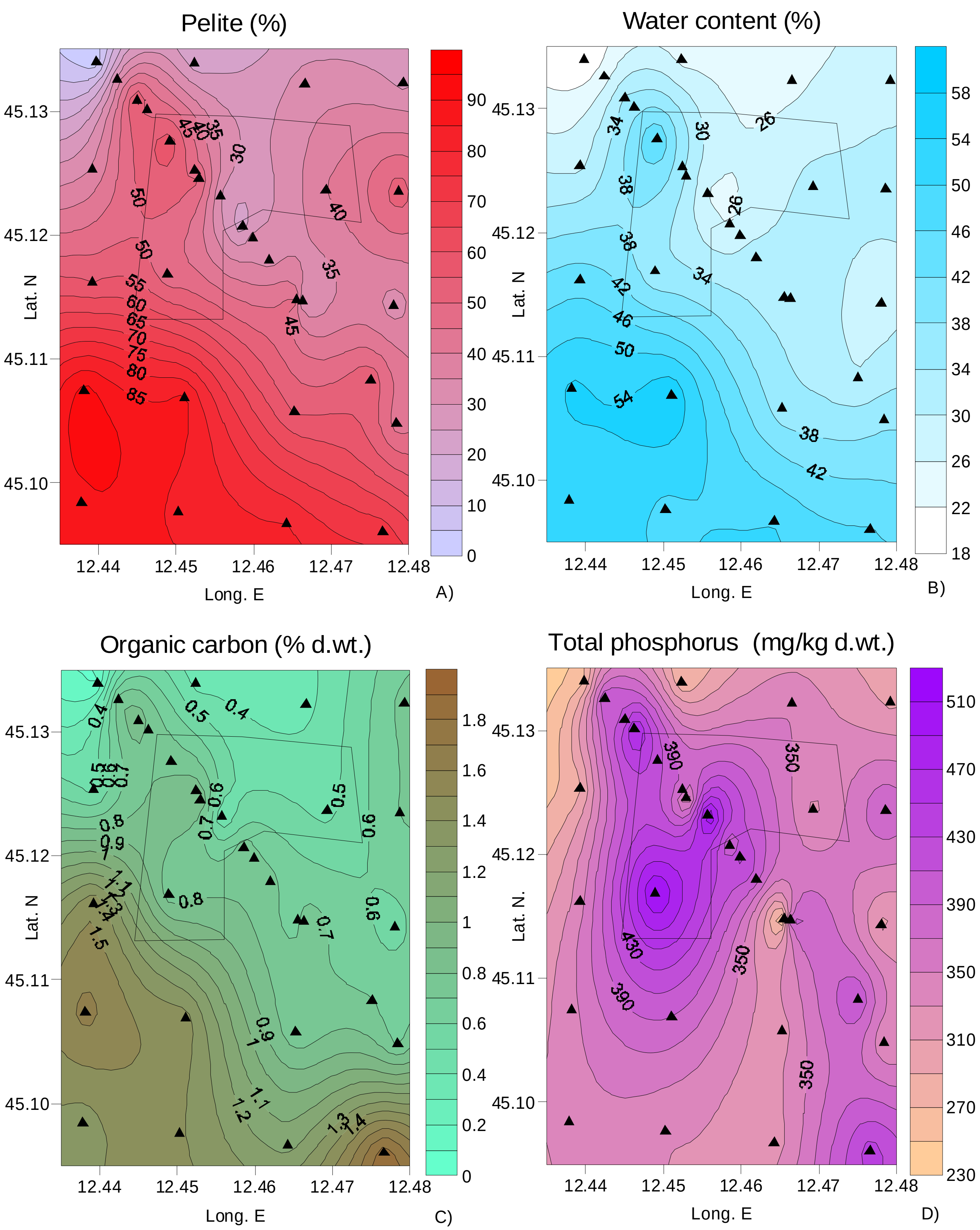


Figure 4.4.3.1.1. Distribution of pelite (A), water content (B), organic carbon (C) and total phosphorus (D) in surficial sediments.The poligon represents the area of the mussel farm.

4.4.3.2. Sediment cores

The electrochemical potential (Eh) values showed in each core B, D, G a positive or less negative values of in surface (0-0.5 cm). Negatives Eh were observed with increasing depth of cores. The major values of pH was at D core than B and G cores (Table 4.4.3.2.1).

Table 4.4.3.2.1 - Electrochemical potential (Eh) and pH in vertical profiles at B, D and G cores. Average and standard deviation were reported. The analysis was replicates (n=3)

Parameter	***level (cm)***	***B Station***		***D Station***		***G Station***	
		Average	St. Dev.	Average	St. Dev.	Average	St. Dev.
Eh (mv)							
	0-0.5	160.6	34.6	-13.6	73.1	5.5	119.2
	0.5-1.5	-114.1	35.8	-117.9	9.9	-105.1	30.5
	1.5-2.5	-150.4	5.7	-129.5	8.6	-122.9	13.3
	2.5-3.5	-143.8	22.0	-145.9	6.8	-150.2	31.4
	3.5-4.5	-158.2	5.5	-145.0	3.1	-169.1	23.7
	4.5-5.5	-142.2	44.3	-159.3	11.1	-179.5	43.1
	5.5-6.5	-152.8	10.6	-151.5	11.6	-182.6	60.6
	6.5-7.5	-164.3	10.2	-155.3	9.8	-158.4	7.1
	7.5-8.5	-163.8	6.9	-142.9	3.9	-139.2	
	8.5-9.5	-157.8	7.6	-152.3	6.4		
	9.5-10.5	-156.3	8.8	-165.0	7.6		
	10.5-11.5			-157.8	4.2		
average		***-122.1***		***-136.3***		***-133.5***	
dvst		***94.8***		***40.8***		***58.1***	
pH	0-0.5	7.5	0.0	7.8	0.0	7.7	0.1
	0.5-1.5	7.5	0.1	7.7	0.1	7.5	0.1
	1.5-2.5	7.5	0.0	7.6	0.1	7.6	0.1
	2.5-3.5	7.6	0.0	7.7	0.0	7.6	0.0
	3.5-4.5	7.6	0.0	7.8	0.1	7.6	0.1
	4.5-5.5	7.6	0.1	7.8	0.1	7.6	0.1
	5.5-6.5	7.7	0.1	7.8	0.2	7.6	0.0
	6.5-7.5	7.6	0.1	7.7	0.3	7.6	0.1
	7.5-8.5	7.6	0.0	7.8	0.2	7.7	
	8.5-9.5	7.7	0.1	7.8	0.2		
	9.5-10.5	7.6	0.0	7.8	0.1		
	10.5-11.5			7.8	0.0		
average		***7.6***		***7.7***		***7.6***	
dvst		***0.1***		***0.1***		***0.0***	

The percentage of water content was higher in at the D core (35.4± 4.5 %), than the B and G cores (25.4 ±3.2% and 25.9 ±4.4%, respectively). Highest difference between the determination of loss of organic matter at 250° C (1.9±1.1%) and at 450°C (3.3±1.1%) was observed at the D core, whereas the B and G cores showed similar values. This suggested a possible more refractory organic material at the D site respect the other one's (Table 4.4.3.2.2).

Table 4.4..3.2.2 - LOI at 250°C and at 450°C in vertical profiles at B, D and G cores. Average and standard deviation were reported. The analysis was replicates (n=3)

Parameter	***level (cm)***	***B Station***		***D Station***		***G Station***	
		Average	St. Dev.	Average	St. Dev.	Average	St. Dev.
LOI (250°C)	0-0.5	1.6	0.4	1.7	0.8	1.8	1.0
	0.5-1.5	2.8	1.6	1.6	0.4	2.6	1.0
	1.5-2.5	2.4	0.9	1.5	0.7	2.0	1.0
	2.5-3.5	2.6	0.8	1.4	0.7	2.0	0.4
	3.5-4.5	2.8	1.3	1.8	0.6	2.0	0.8
	4.5-5.5	1.8	1.0	1.5	0.7	2.4	0.5
	5.5-6.5	2.2	1.4	2.1	0.8	2.4	1.0
	6.5-7.5	1.7	0.7	2.1	1.0	2.1	1.5
	7.5-8.5	3.0	2.1	1.9	1.4	1.6	
	8.5-9.5	1.3		3.4	2.9		
	9.5-10.5	1.6		1.1			
	10.5-11.5			1.5			
average		***2.2***		***1.8***		***2.1***	
dvst		***0.6***		***0.6***		***0.3***	
LOI (450°C)	0-0.5	2.7	0.8	2.9	0.1	2.0	0.3
	0.5-1.5	2.0	0.4	3.3	2.0	2.1	0.5
	1.5-2.5	2.0	0.2	2.7	1.0	2.3	0.1
	2.5-3.5	2.6	1.2	3.6	0.4	2.4	0.4
	3.5-4.5	2.3	1.0	3.4	1.1	2.3	0.5
	4.5-5.5	1.4	0.1	3.3	1.1	2.2	0.6
	5.5-6.5	2.2	1.4	3.4	0.4	2.4	0.8
	6.5-7.5	1.0	0.2	3.9	1.1	2.5	1.3
	7.5-8.5	2.2	1.9	4.1	1.3	1.5	
	8.5-9.5	1.5		3.6	1.6		
	9.5-10.5	1.8		5.7			
	10.5-11.5			3.8			
average		***2.0***		***3.6***		***0.6***	
dvst		***0.5***		***0.8***		***0.3***	

Low content (27±6 %) of sand was evaluated at D site whereas B and G cores showed high values, 52± 4 % and 58± 6% respectively. High content of pelitic fraction (clay +silt) was found at D core (71.5±5.9 %) respect to the other sites (Figure 4.4.3.2.1.).

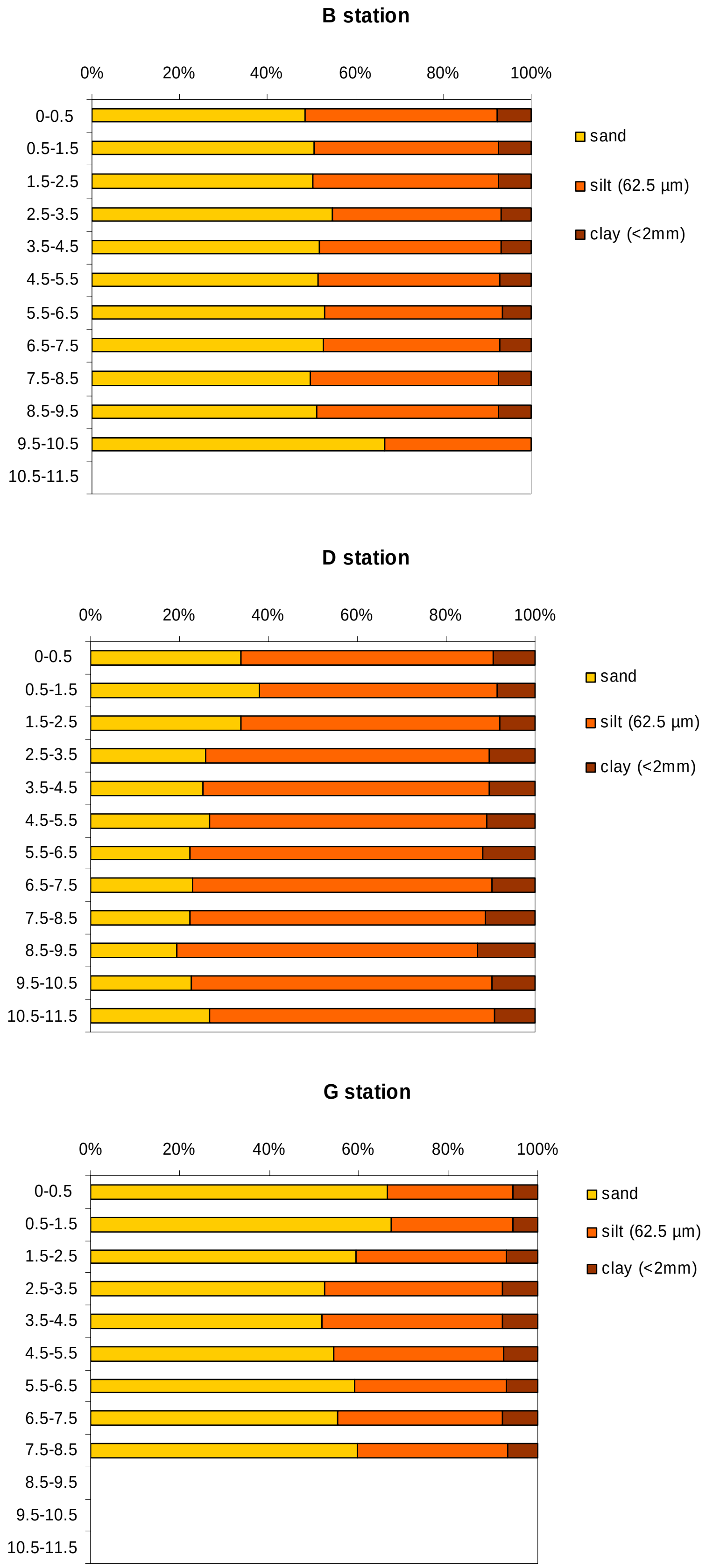


Figure 4.4.3.2.1 – Percentage distribution of sand, silt and clay in vertical profiles at B, D and G cores.

Organic carbon (C_{org}) showed a high concentrations in the D and G cores, whereas the minimum values was determined at G core (Table 4.4.3.2.3).

Table 4.4.3.2.3 - Total (C_{tot}) organic (C_{org}), inorganic (C_{inorg}) carbon concentrations in vertical profiles at B, D and G cores. Average and standard deviation were reported. The analysis was replicates (n=3)

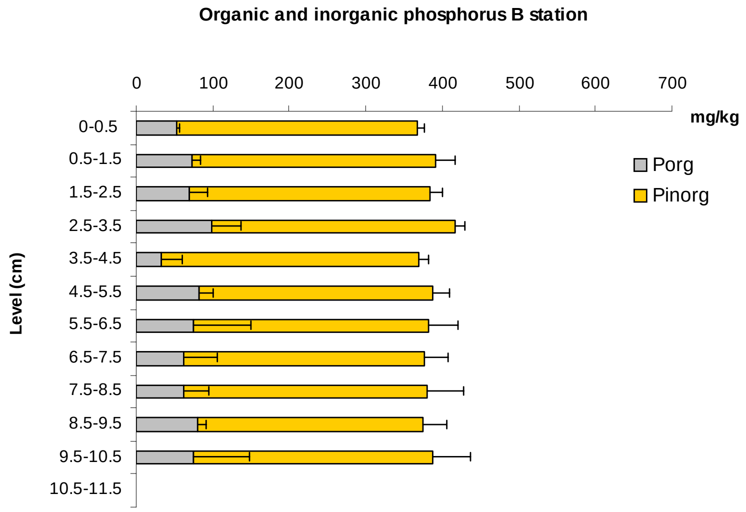
Parameter	***level (cm)***	***B Station***		***D Station***		***G Station***	
		Average	St. Dev.	Average	St. Dev.	Average	St. Dev.
C_{tot} (%)							
	0-0.5	6.2	0.1	6.2	0.4	5.8	0.9
	0.5-1.5	6.5	0.2	6.5	0.0	5.8	0.1
	1.5-2.5	6.6	0.2	5.9	0.5	5.3	1.2
	2.5-3.5	6.7	0.0	6.4	0.4	5.7	0.5
	3.5-4.5	6.5	0.2	6.4	0.3	5.5	0.8
	4.5-5.5	6.5	0.3	6.3	0.3	5.4	0.4
	5.5-6.5	6.5	0.3	6.5	0.1	5.9	0.2
	6.5-7.5	6.1	0.6	6.1	0.7	6.0	0.2
	7.5-8.5	6.5	0.1	6.3	0.0	6.3	
	8.5-9.5	6.5	0.2	6.5	0.3		
	9.5-10.5	6.4	0.2	5.4	1.3		
	10.5-11.5			6.4	0.1		
average		***6.5***		***6.2***		***5.7***	
dvst		***0.2***		***0.3***		***0.3***	
C_{org} (%)	0-0.5	0.7	0.2	0.9	0.2	0.5	0.1
	0.5-1.5	0.9	0.1	0.9	0.2	0.6	0.1
	1.5-2.5	0.7	0.2	0.9	0.3	0.6	0.0
	2.5-3.5	0.9	0.1	1.1	0.2	0.6	0.1
	3.5-4.5	0.9	0.1	1.0	0.2	0.8	0.2
	4.5-5.5	0.9	0.1	1.0	0.2	0.7	0.0
	5.5-6.5	1.0	0.2	1.0	0.1	0.7	0.1
	6.5-7.5	0.8	0.0	1.1	0.1	0.7	0.1
	7.5-8.5	0.9	0.0	1.1	0.1	0.7	
	8.5-9.5	0.9	0.2	1.0	0.2		
	9.5-10.5	0.8	0.1	0.9	0.0		
	10.5-11.5			1.0	0.1		
average		***0.8***		***1.0***		***0.7***	
dvst		***0.1***		***0.1***		***0.1***	
C_{inorg} (%)	0-0.5	5.5	0.1	5.3	0.2	5.2	0.8
	0.5-1.5	5.6	0.2	5.6	0.2	5.2	0.2
	1.5-2.5	5.9	0.1	4.9	0.2	4.7	1.1
	2.5-3.5	5.8	0.1	5.3	0.3	5.2	0.6
	3.5-4.5	5.7	0.2	5.4	0.2	4.7	0.9
	4.5-5.5	5.6	0.2	5.4	0.2	4.8	0.4
	5.5-6.5	5.5	0.2	5.4	0.1	5.1	0.3
	6.5-7.5	5.3	0.6	5.0	0.6	5.3	0.3
	7.5-8.5	5.7	0.1	5.3	0.1	5.6	
	8.5-9.5	5.6	0.1	5.5	0.5		
	9.5-10.5	5.6	0.2	4.5	1.3		
	10.5-11.5			5.4	0.2		
average		***5.6***		***5.3***		***5.1***	
dvst		***0.1***		***0.3***		***0.3***	

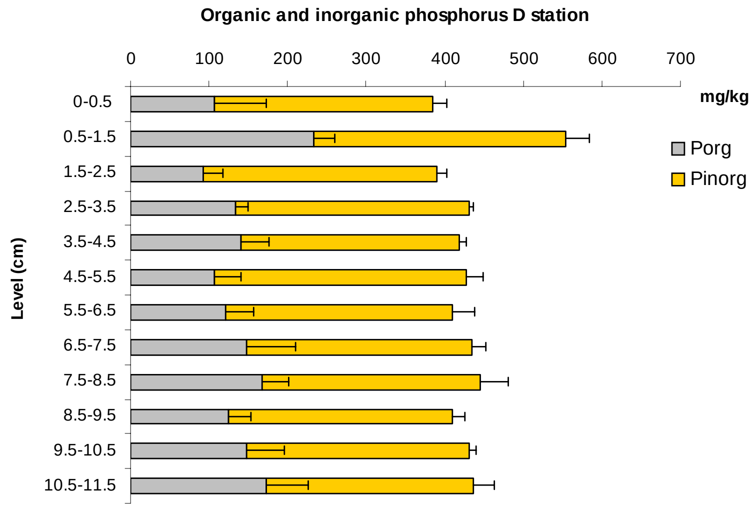
The higher content of total nitrogen (N_{tot}) at the D sites respect the other one's and the high atomic ratios of C_{org}/N_{tot} values could be attributed to the change in supply rate, and type of, organic matter, and partly due to microbial consumption in the sediment. Anaerobical microbial consumption of organic matter in the sediment should resulted in a small increase in C_{org}/N_{tot} with depth (Table 4.4.3.2.4).

Table 4.4..3.2.4 - Total nitrogen (N_{tot}) and atomic ratio (C_{org}/N_{tot}) in vertical profiles at B, D and G cores. Average and standard deviation were reported. The analysis was replicates (n=3)

Parameter	***level (cm)***	***B Station***		***D Station***		***G Station***	
		Average	St. Dev.	Average	St. Dev.	Average	St. Dev.
N_{tot}	0.5-1.5	0.09	0.01	0.09	0.01	0.07	0.01
	1.5-2.5	0.09	0.02	0.08	0.03	0.07	0.02
	2.5-3.5	0.10	0.01	0.09	0.04	0.06	0.01
	3.5-4.5	0.08	0.01	0.10	0.04	0.07	0.01
	4.5-5.5	0.09	0.02	0.09	0.04	0.07	0.01
	5.5-6.5	0.08	0.01	0.09	0.01	0.06	0.01
	6.5-7.5	0.09	0.01	0.09	0.02	0.08	0.00
	7.5-8.5	0.08	0.01	0.10	0.02	0.07	
	8.5-9.5	0.08	0.00	0.09	0.02		
	9.5-10.5	0.08	0.01	0.25	0.25		
	10.5-11.5			0.05	0.07		
average		***0.09***		***0.10***		***0.07***	
dvst		***0.01***		***0.05***		***0.01***	
C_{org}/N_{tot}	0.5-1.5	12.3	0.3	12.1	1.1	11.5	4.5
	1.5-2.5	9.9	4.1	14.8	1.7	11.0	3.1
	2.5-3.5	11.1	1.3	14.1	3.8	11.3	4.2
	3.5-4.5	12.0	1.7	12.7	3.0	14.0	4.0
	4.5-5.5	11.7	1.9	13.6	3.5	11.8	2.1
	5.5-6.5	14.1	2.3	13.7	1.4	13.3	0.9
	6.5-7.5	11.3	1.6	15.0	3.7	11.4	2.7
	7.5-8.5	12.4	1.1	13.1	1.8	11.3	
	8.5-9.5	12.4	2.7	13.2	2.0		
	9.5-10.5	11.3	0.5	8.4	8.5		
	10.5-11.5			13.6			
average		***11.8***		***13.1***		***12.0***	
dvst		***1.1***		***1.8***		***1.1***	

Highest values of organic phosphorus, on average 141± 38 mg kg^{-1}, was determined at D core whereas similar average values were observed for B and G sites, 69± 17 mg kg^{-1} and 77 ± 24 mg kg^{-1} (Figure 4.4.3.2.2).





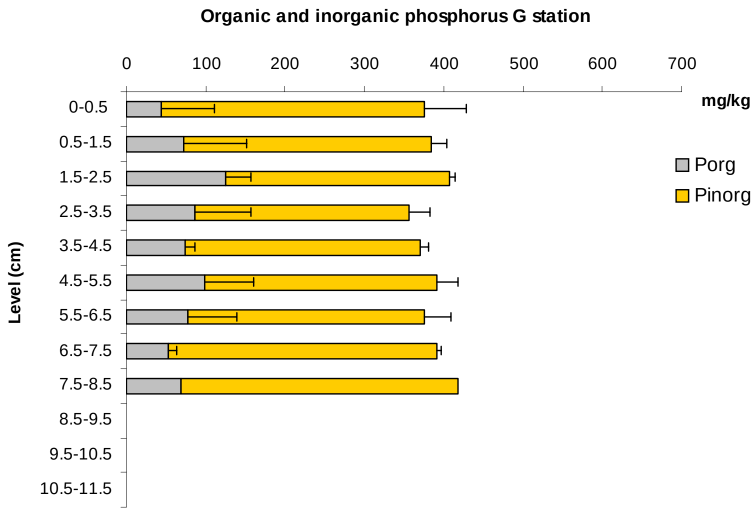
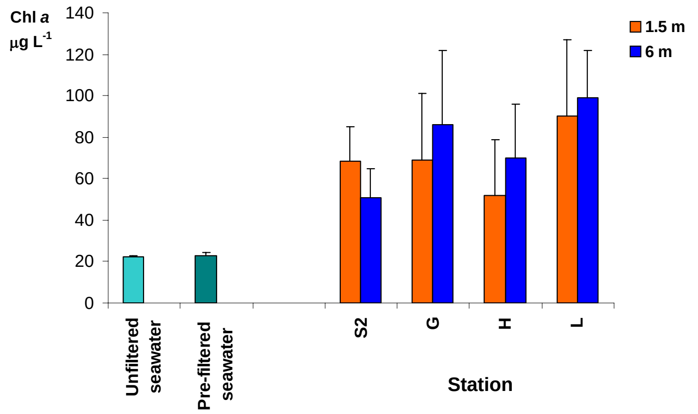


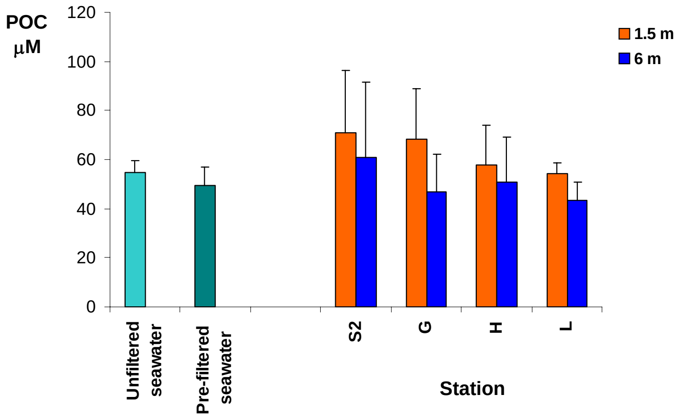
Figure 4.4.3.2.2 – Distribution of organic (Porg) and inorganic (Porg) phosphorus (mg kg^{-1})in vertical profiles at B, D and G cores.

4.4.4 Bioassay experiment

Chla *a* concentrations showed a marked increase at all stations (2.2-4.4 times) with respect to the initial concentrations. The increase was more relevant at 6 m depth particularly at L and G sites (3.8-4.4 times).

Differently from chlorophyll a, the POC and PON showed a more limited increase (1.1-1.7 times) with respect to the initial concentrations. At 6m depth at all station but the S2 there has been no increase with respect to the initial concentrations (Figure 4.4.4.1).





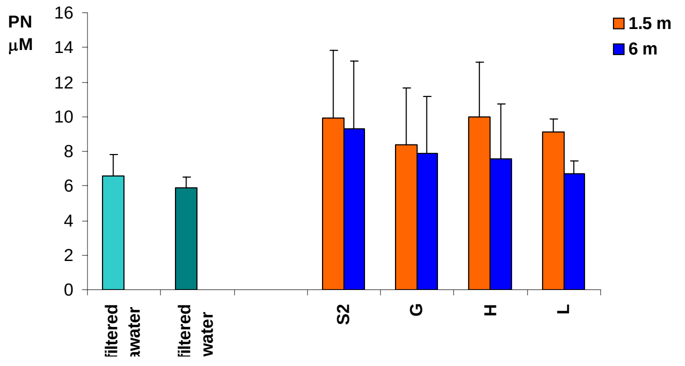


Figure 4.4.4.1 – Chlorophyll a, particulate organic carbon (POC) and particulate nitrogen (PN) concentrations in bioassay experiment.

MG-IBM Mytilus Galloprovincialis *Individual Based model*

MGCC Mytilus Galloprovincialis *Carrying Capacity model*

DEPOMOD+EDM Modelling interactions between mussel farm biodeposition, sediment biogeochemistry and nutrient recycling

da fare

4.5 Evaluation of Indicator Performance

Discuss and evaluate (statistically as appropriate) the validity etc of the Indicators under test.

4.6 Evaluation of Model Performance

Discuss and evaluate (statistically as appropriate) the validity etc of the models under test.

4.7 Site specific conclusions

Use the Indicators and Modelling results to determine the state of the environment at the Zone A and B scales, and comment on effects at the Zone C scale.

Consider the Ecosystem Approach including socio-economic aspects and the consequences of the farm for other users and stakeholders.

Comment on the capacity of the environment in terms of waste assimilation, provision of environmental services to aquaculture as well as aesthetic and cultural aspects. Comment on sustainability and future prospects for aquaculture within Zones A, B and C.

4.8 Culture type and environment type conclusions

Discuss what has been learned about the use of ECASA tools for this culture type and for this environment type.

Evaluate and prioritize the most appropriate tools and methods for Environmental Impact studies at such sites and also comment on appropriate monitoring strategies – compare ECASA recommendations with current practice.

5. Acknowledgements

Gianluca Franceschini, at ICRAM Chioggia. VISMA Farmers

6. References

Appendices

Appendix 1

Appendix 2. Details of all methods used (indicators, models, etc)

Appendix 3. Environmental data.

Table 4.4.3.1.1 Surface sediments sampled on 21 December 2005

Station	Sand (%)	Clay (%)	Silt (%)	Eh (mV)	pH	Water content (%)	OM (%)	C tot (%)	N tot (%)	C org (%)	C inorg (%)	Sulphur%	F (m
1	98.4	0.0	1.6	219.2	8.37	18.5	0.92	2.57	<d.l.	0.09	2.47	0.03	2
2	78.2	3.2	18.5	161.2	8.05	24.9	1.59	5.69	0.04	0.36	5.33	0.11	2
3	67.7	5.7	26.6	32.5	7.75	24.9	2.42	5.73	0.05	0.37	4.72	0.09	3
4	71.5	5.0	23.5	7.9	7.87	29.1	2.78	5.88	0.07	0.74	5.14	0.13	3
5	46.7	8.2	45.1	37.0	7.90	31.1	3.18	5.68	0.07	0.71	4.97	0.14	3
6	59.9	6.7	33.4	33.8	8.02	31.6	3.49	5.55	0.05	0.47	5.08	0.11	3
7	47.9	8.3	43.8	-20.6	7.86	34.1	3.29	5.73	0.09	0.91	4.81	0.16	3
8	64.8	6.4	28.9	40.3	7.80	29.1	2.26	5.25	0.39	0.46	5.25	0.11	2
9	45.0	8.8	46.2	-40.8	7.72	44.4	4.26	6.92	0.14	1.49	4.79	0.32	3
10	53.5	8.5	37.9	20.3	7.80	34.7	2.60	6.05	0.08	0.74	5.31	0.09	5
11	53.4	8.0	38.6	26.8	7.89	31.6	1.98	4.80	0.06	0.64	4.16	0.13	2
12	67.6	5.6	26.8	14.9	7.83	28.1	1.29	4.86	0.06	0.57	4.29	0.06	3
13	57.8	5.4	36.9	-157.1	7.81	37.3	2.69	4.44	0.04	0.68	3.76	0.11	3
14	45.7	7.4	46.8	19.4	7.72	35.8	2.68	5.74	0.08	0.72	5.02	0.10	3
15	13.8	11.7	74.4	211.8		57.5	6.13	6.73	0.13	1.45	5.28	0.21	3
16	7.7	10.2	82.1	29.4	7.71	54.7	4.87	7.34	0.15	1.63	5.70	0.23	3
17	10.9	8.8	80.3	14.0	7.70	50.6	1.68	7.28	0.14	1.35	5.84	0.21	3
18	17.2	10.8	72.1	-14.1	5.51	48.8	2.47	6.75	0.11	1.41	5.34	0.20	3
19	19.8	10.8	69.4	-5.8	7.89	49.9	2.39	6.53	0.11	1.16	5.37	0.17	3
20	26.9	9.9	63.2	-24.6	7.79	46.3	0.55	6.94	0.17	1.88	5.06	0.22	4

Table 4.4.3.1.2 Surface sediments sampled on 18 July 2006

Station	Sand (%)	Clay (%)	Silt (%)	Eh (mV)	Water content (%)	OM (%)	C tot (%)	N tot (%)	C org (%)	C inorg (%)	Ptot (mg/kg)
A	68.2	4.1	27.7	241	24.2	2.6	6.28	0.09	0.77	5.51	413
B	42.9	5.6	51.4	191.9	34.4	4.4	6.28	0.10	0.87	5.41	410
C	52.2	6.2	41.6	198.7	36.1	3.9	5.81	0.07	0.77	5.04	483
D	42.0	7.6	50.4	72.1	46.3	5.7	6.28	0.08	0.77	5.52	419
E	53.9	7.3	38.8	-77.7	34.7	2.2	6.07	0.09	0.86	5.21	386
F	70.2	4.3	25.5	94.8	25.7	2.7	6.02	0.06	0.39	5.62	517
G	78.2	3.3	18.5	-93.6	25.7	2.5	6.46	0.07	0.77	5.68	385
H	67.4	4.9	27.7	-134.7	28.8	3.1	6.16	0.07	0.72	5.44	437
I	67.1	4.5	28.4	86	31.6	3.3	5.94	0.06	0.73	5.21	402
L	71.1	3.8	25.0	40	33.5	3.2	5.73	0.07	0.78	4.95	397
M	45.4	6.3	48.4	159	30.2	2.5	5.80	0.06	0.71	5.09	414

Appendix 4. Models and their output

Give details of model output for all the models evaluated. Indicate model source and availability.