ECASA

Study Site Report

Ria Formosa Coastal Lagoon

Portugal

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IMAR

ECASA- Summary for the Ria Formosa site

The Ria Formosa is a large (55km long, 6km wide) lagoon on the south coast of Algarve, centered on the city of Faro. The lagoon is a shallow (1.5m average, 3.5m in the channels) body of water separated from the Atlantic by a series of sandy barrier islands that restrict water exchange. Nevertheless, there are several seawater inlets and the tides are about the same size (1.5-3.0m) as the average depth, so most of the water in the lagoon gets flushed out and replaced during a tidal cycle. The summers in Portugal are hot and dry so there is little freshwater flowing into the lagoon and only one permanent river in the east (near Tavira). The Ria Formosa has an extensive area of salt marsh, mud flats and sandbanks that are crisscrossed by the channels and creeks. This shallow, soft bottom environment is ideal for the culture of clams that live in the mud. The clams feed by filtering the microscopic algae in the water, so that the clam farmers do not need to feed the clams by adding food. Most of the area of the lagoon outside the navigation channels is leased out to the clam farmers as a clam growing concessions, so the lagoon acts as one large clam farm. Many of these concessions were granted decades ago and are held by families and inherited. When a plot is first licensed, the farmer clears it to remove competing, low cost species, such as cockles, and also any seagrass (eelgrass). The plots are staked out, so that each farmer knows exactly the limits of the area. The clams are usually harvested once a year, so the farmer subdivides the plot and harvests only a part on a daily or weekly basis. Different tides expose different areas of sediment and so these are harvested in turn. The clams are harvested at low tide, manually, using a tool that looks like a modified hoe. The farmer turns over the sediment and picks the larger clams out, leaving small clams to rebury themselves in the mud. At certain times of the year the farmer will also "seed" the plots with juvenile clams usually purchased at a hatchery.

This type of clam aquaculture has a low environmental impact because the clams are not fed, nor are any antibiotics or pesticides introduced into the environment. However, the action of digging the clams has an effect on the water quality. As the farmer digs down he may uncover black, oxygen-poor sediment. This sediment is also loaded with nutrients (nitrogen and phosphorus) that fertilize the water, stimulating the growth of microscopic algae and also larger opportunistic green algae. Another effect is the increase in turbidity of the water as the tide resuspends the disturbed sediments.

The results of the ECASA study of the Ria Formosa have shown that the aquaculture of clams in the lagoon has a low environmental impact. The nutrient concentrations and turdidity of the water may increase as a result of clam harvesting. Clam culturing may have an impact on the species richness and the biodiversity may decrease, as the farmers remove competing species and eelgrass. However, the filter feeding clams can accumulate algal toxins and enteric (sewage) bacteria and so must be monitored regularly and depurated before commercialization. The visual impact is also low as the only visible signs of farming are some wooden stakes and some black patches of disturbed sediment where the clams have just been harvested.

The clams harvested in the Ria Formosa are an important addition to the local economy as they are a high value crop. They represent more than 90% of the national clam harvest. The Ria Formosa clams are famous throughout Portugal and there is even a clam festival, that shows the cultural importance of this activity. It is estimated that

about 5000 people depend on the clam industry, out of the total population around the lagoon of about 100000 people.

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1. Introduction to the aquaculture operation

1.1 Introductory background statement

More than 1.000 hectares of clam aquaculture, exist in the Ria Formosa coastal lagoon practically all are destined to clam and small areas with oysters. Numerous aquacultures work small areas of production of clams. This traditional activity is one of the most important in the Ria.

Field Campaign

ECASA contributor: IMAR-UALG. The ECASA field campaign was carried out during the spring and autumn of 2006 in the Ria Formosa coastal lagoon.

The following field deployments were made:

In the water column:

- Niskin bottle collection for Chlorophyll-*a;* Particulate Organic Carbon (POC), CHN, suspended particulate matter (SPM) and Nutrients.
- Temperature;
- Salinity.

Hydrodynamics:

Current profiles were taken in June and July 2000 at Ponte, Ramalhete and Barra Channels (western stations in Ria Formosa) during both the ebb and flood stage of the tide. This study was carried out by Durham, 2000.

In sediments:

No impact studies were carried out. The clams are cultured in the mud. Clam digging releases nutrients into the water column and also increases turbidity. The clam aquaculture affects the water column.

The following laboratory based analysis was carried out:

In the water column:

- Spectrophotometric method for Chlorophyll-*a* analysis;
- POC analysis will be processed at Plymouth;
- Samples for CHN analysis will be processed at Plymouth;
- Nutrients (nitrite, nitrate, phosphate, ammonium, silicate);
- SPM, Particulate Inorganic Matter (PIM) and Particulate Organic Matter(POM).

This report is intended to present the environmental conditions prevalent at the time of monitoring, from 10 April 2006 to 20 October 2006, every two weeks at low water in the early morning.

1.2 Summary statement of key site specific environmental issues

The Ria Formosa is a mesotidal coastal lagoon in the south of Portugal (Figure 1), between longitude 8º 02′ W and 7º 32′ W.

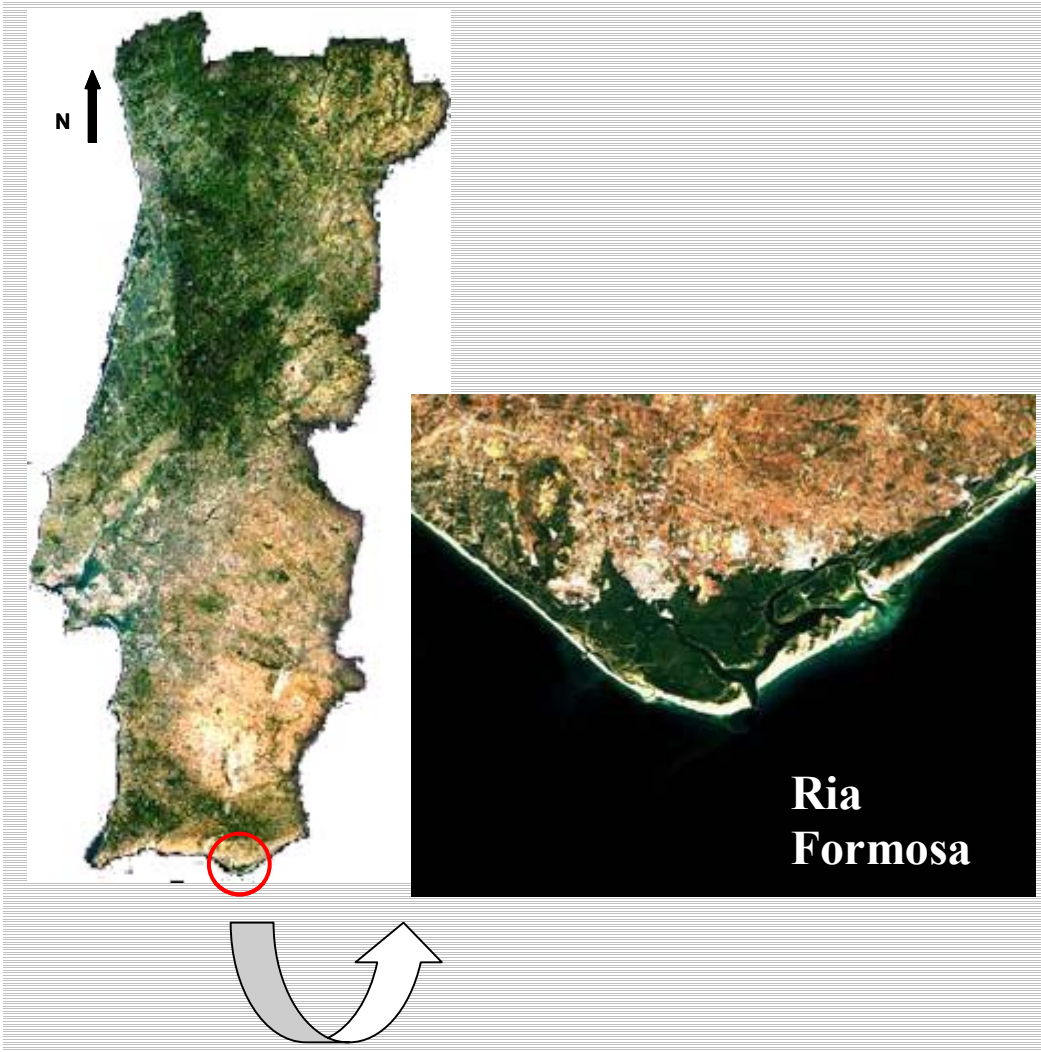


Figure 1 – Geographic location of Ria Formosa lagoon (Adapted from: geocid-snig.igeo.pt/Portugues/satelite.html).

2. Site specific regulatory and management background

2.1 The regulatory status of proposed location with respect to clam aquaculture developments.

The clam aquaculture in Ria Formosa is localized in a Natural Park since 1987 and internationally it forms part of the Natura 2000 European network for nature conservation. It is a Ramsar wetland and it is included in the Special Bird Protection Area European Directive 79/409/EEC.

2.2 Site description

The Ria Formosa coastal lagoon is classified as coastal water, because only one small permanent river flows into the East of the lagoon, the Rio Gilão. The other fourteen small, torrential streams flow into the lagoon only after heavy rainfall. The Ribeira de São Lourenço stream, that used to flow into the West of the lagoon, was completely damed in the 1800´s with a dyke (Fig.2). As consequence, this is a system without significant freshwater inputs and there is an insufficient salinity gradient in the lagoon to be classified as Transitional Water (Newton & Icely, 2002).

Figure 2 – Aerial photograph showing the dyke of São Lourenço interrupted the supply of freshwater to the west part of Ria Formosa.

This coastal lagoon is separated from the Atlantic Ocean by several barrier islands (Barreta or Deserta, Culatra, Armona, Tavira and Cabanas) and peninsulas (Ancão and Cacela). Water is exchanged by the tides with the oceanic waters through six inlets, five natural (Faro-Olhão, Armona, Fuzeta, Cacela and Tavira) and one artificial (Fig.3). At each tide, there is a 50-75% exchange of water. Tidal range varies from 2.8

m to 1.3 m at spring and neap tides, respectively. Salinity ranges from 13 to 36.5, and temperature from 12 to 27ºC (Loureiro, *et al*, 2006; Ferreira *et al*, 2003).

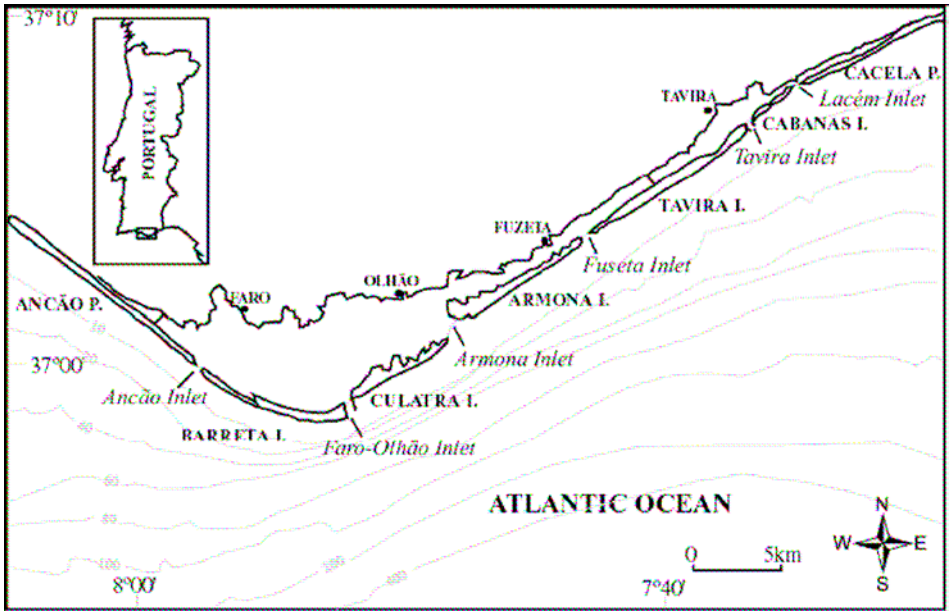


Figure 3 – Barrier islands (I), Peninsulas (P) and the inlets of Ria Formosa coastal lagoon (Adapted from: Carrasco, 2006).

The system is 55 km long, 6 km at its widest, and has an area of 160 km^2, of which one third is intertidal with an average channel depth of 3.5 m. The lagoon has 10.000ha that includes 5.000ha of saltmarsh and mud flats (Fig.4), 2.000ha of sand banks (Fig.5) and 1.000ha of saltpans and aquaculture ponds (Newton and Icely, *in press*; Newton *et al*, 2003). The typology therefore corresponds to very sheltered lagoon with a tidal range varying between 1.35 m and 3 m for neap and spring tides respectively (Edwards *et al.,* 2005).

Figure 4 - Saltmarsh and mud flats in the west part of Ria Formosa Lagoon (photo: Bruno Fragoso).

Figure 5 – Dunes in Peninsula of Anção in the west part of Ria Formosa Lagoon (photo: Bruno Fragoso).

2.3 Detailed description of the clam aquaculture

The clam aquaculture in the Ria Formosa is manly a traditional and extensive activity, (the food for the clams is exclusively natural), that is implemented along the channels (Fig.6). This productivity has given rise to the economically important industry. 1245 establishments are registered in the area and 1224 are clam aquaculture. These make up 93% of the national total and 97.5% of the regional total (ICN, 2005).
The clam aquaculture represents one of the activities with the highest economic return because clams are a species with a high commercial value that represents 90% of the total national production. The other importance of this activity is related with the number of persons employed both directly (4500 employees) and indirectly (ICN, 2005).

Figure 6 – Oyster and clam production in Ria Formosa (Photos courtesy of Ana Manjua).

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

The lagoon is an important resource for the Algarve because of the intensive fishing, aquaculture (Fig. 7 (a)), salt extraction (Fig. 7 (d)) and seasonal tourism activities (Fig. 7 (b)) (Loureiro *et al.,* 2006 and Tett *et al.*, 2003*)*.
Major regional developments in the form of urbanisation and intensified agriculture (Fig. 7(c)), together with rising numbers in both the resident population and annual tourist influx, pose an ever increasing stress upon the lagoon system. There are also several golf courses bordering the lagoon.

Figure 7 – The main activities in Ria Formosa (a) clam aquaculture (photo: Bruno Fragoso); (b) tourism (photo: Bruno Fragoso); (c) intense agriculture (photo: Bruno Fragoso); (d) traditional saltpands in the Tavira (photo: Sónia Cristina).

3.2 Hydrography and water quality

The hydrographic survey of the Ria Formosa describes a shallow, unstratified lagoon with a mean depth of 1.5m and a maximum depth of 14m (Netwon and Icely, 2004). In the winter months the lagoon is estuarine, whereas in the summer months it is anti-estuarine due to high temperatures, evaporation and salinity (Newton *et al.*, 2003).

The velocities of the currents are relatively small in the interior part of the lagoon, in opposite to the velocities in the entrances of the inlets. This area is mesotidal. The velocities of the flood and ebb currents are different at each inlet of the Ria and in different tide conditions. The water mass that circulates manly in the principal channels as in flood and ebb show the maximum velocities and decrease in direction to the interior of the lagoon (Calvário, 2005).

The fluctuation in rainfall produces a marked seasonal variation in the volume of freshwater discharged into Ria Formosa: the rivers beds are flooded by torrential rains in the winter and are often dry in the summer, this seasonal variation cause changes in the salinity regime. The inner lagoon is brakish in winter after heavy rainfall but hypersaline in summer (Fig.8) (Newton and Mudge, 2003). Table 1 summarize the winter and summer temperatures and salinity across all the lagoon sites.

Table 1. Summary of winter and summer temperature and salinity across all lagoon sites (from Newton & Mudge, 2003).

	Temperature (ºC)			Salinity		
	Minimum	**Maximum**	**Range**	**Minimum**	**Maximum**	**Range**
High Water (November)	16,4	19,2	6	32,1	35,6	3,5
High Water (August)	18,8	16,7	2	35,2	36	15,1
Low Water (November)	17	18,6	1,6	26,2	35,6	8,8
Low Water (August)	21	28,4	7,4	34,45	36,4	5,2

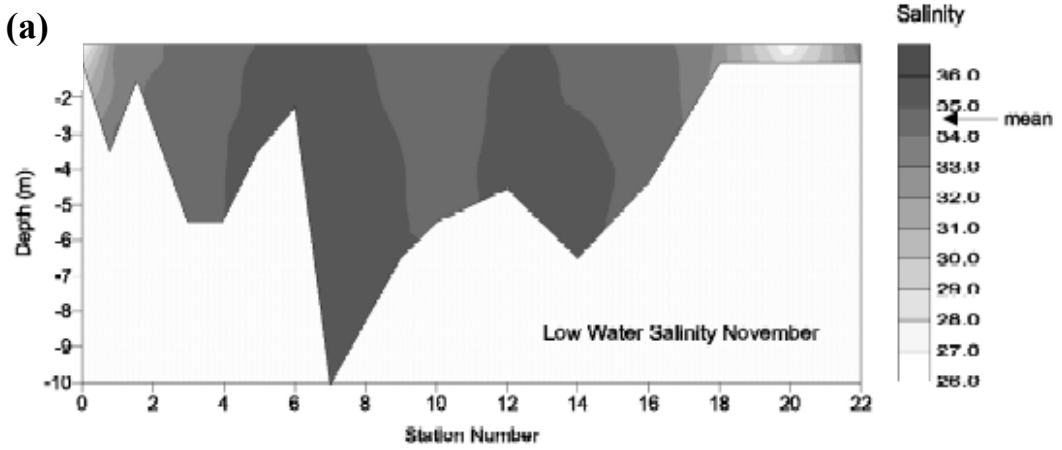


Figure 8 – Low water conditions (a) the salinity during November, (b) salinity during August (winter and summer condition) (from Newton & Mudge, 2003).

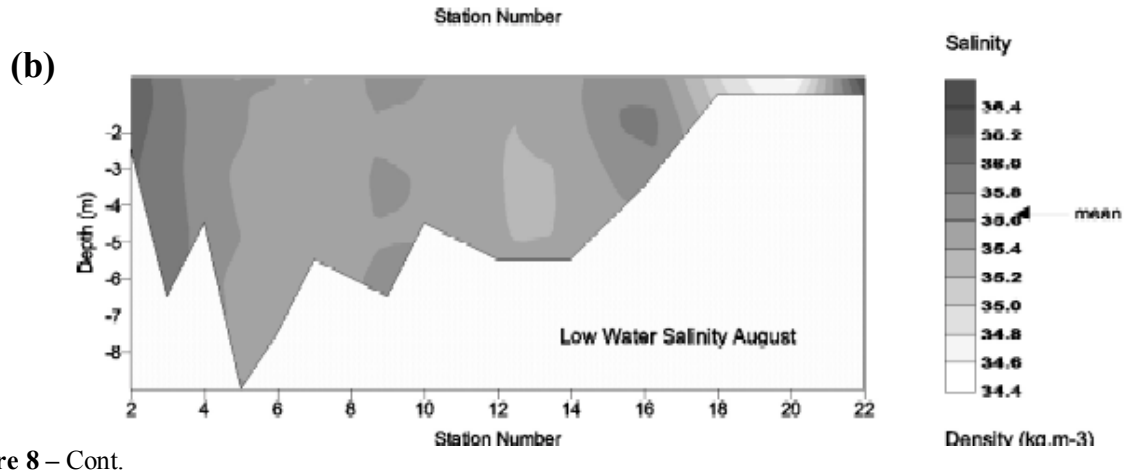


Figure 8 – Cont.

The mean chlorophyll *a* values for this system are shown in Figure 9, mean values are in the range of about 2–3 mg Chl-*a* m^{-3} (Newton *et al*., 2003).

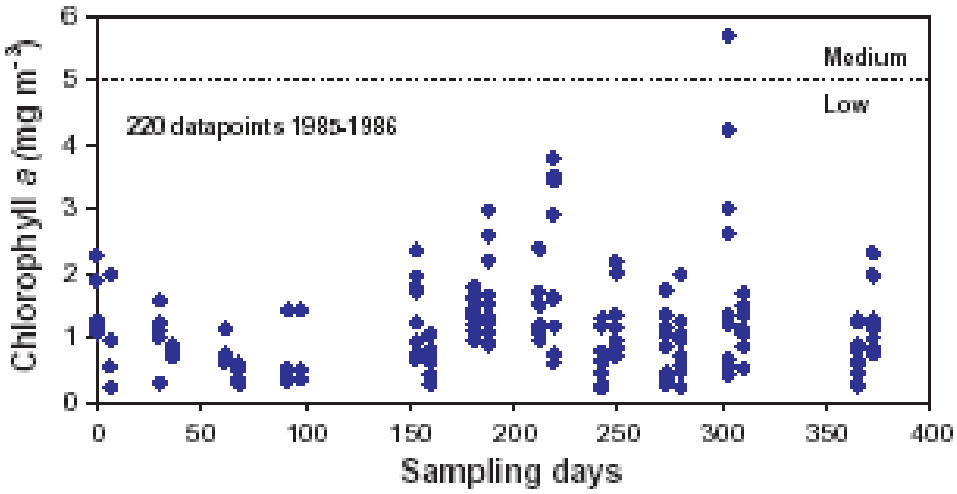


Figure 9 – Chlorophyll a in the lagoon over annual cycle starting in September 1985. The low-medium division of the NEEA category, for a primary symptom of eutrophication (Bricker et al., 1999), is show as dotted line (from Newton *et al*., 2003).

A preliminary analysis of the oxygen saturation data for the Ria Formosa over a 5 year period (TICOR data base) shows that most samples are saturated or super-saturated and that this is throughout the lagoon (Newton *et al*., 2003; Nobre *et al*., 2005).

The main sources of nutrients discharging into the Ria Formosa include the (Newton and Mudge, 2005, Ferreira *et al.*, 2003):

- Atlantic Ocean waters;
- effluents from domestic and industrial wastewater treatment plants (UWWTP);
- untreated domestic effluents;
- agricultural;
- non-point sources (rainfall runoff);
- benthic fluxes.

The Campina de Faro is the most intensively farmed area of the Algarve, and corresponds to the drainage basin of the Ria Formosa. Rapid urbanisation of this fertile area has been partially controlled by creating zones reserved for agriculture. The Atlantic Ocean waters flowing into the Ria Formosa provide a limited quantity of nutrients to the lagoon. However, nutrient supply within the lagoon is supplemented by the poorly treated domestic sewage inputs from a population of more than 100,000 inhabitants. This represents approximately 400 Metric tons of nitrogen per year and 200 Metric tons of phosphorus per year from domestic sewage and detergent. The population increases considerably in the summer months due to tourism. Domestic sewage is an important source of ammonium and phosphate particularly near the towns of Faro and Olhão (Newton and Mudge, 2005).
The hinterland of the lagoon is farmed intensively with the use of ammonium nitrate, urea and phosphate fertilisers. Rainfall, and resulting agricultural runoff, is seasonal with particularly high inputs associated with the autumn rains, further inputs during the rainy months and another pulse in spring when rainfall occurs after the springtime fertiliser application. In shallow areas of the lagoon, where a small volume of water is in contact with a large surface area of sediment, benthic fluxes are another important source of nutrients (Newton and Mudge, 2005).

Is presented in the Table 2 the mean, minimum and maximum values of the nutrients between 1987 and 2001 in Ponte and Ramalhete, this data belong to the TICOR data base.

Table 2. Nutrients mean minimum and maximum, at Ramalhete and Ponte station between 1987 and 2001 (data from the TICOR data base).

	Ammonia ($\mu mol\ l^{-1}$)		Nitrate ($\mu mol\ l^{-1}$)		Nitrite ($\mu mol\ l^{-1}$)		Phosphate ($\mu mol\ l^{-1}$)		Silicate ($\mu mol\ l^{-1}$)	
	Ramalhete	**Ponte**	**Ramalhete**	**Ponte**	**Ramalhete**	**Ponte**	**Ramalhete**	**Ponte**	**Ramalhete**	**Ponte**
Mean	1.32	2.17	3.05	5.39	0.16	0.30	0.71	0.74	5.43	13.52
Minimum	0.01	0.03	0.04	0.01	0.01	0.01	0.29	0.02	1.66	1.30
Maximum	4.67	17.3	80.00	163.1	1.16	3.0	2.04	2.8	12.13	81.3

3.2 Bathymetry, geology and habitats

The lagoon is delimited by a system of sand barrier islands and is interior consists of tidal flats and salt marshes with some subtidal channels (Tett *et al.,* 2003, Newton & Icely, JCR *in press*). The bottom substrate is sandy or muddy.
There is one main navigational channel of maximum depth 14m (Canal de Faro) and another shallower channel to the town of Olhão. Shallow channels and creeks meander between the salt marshes and mud flats (Nobre *et al.,* 2005).
Decree-Law December 1987 followed the former 1987 Natural Reserve ordinance. The Ria Formosa and some of its hinterland were included in a 78.000 ha National Park, in recognition of its environmental value. The Ria is considered of European importance for biodiversity and has been classified as a site of special interest for nature conservation (site 13 of the preliminary list for the NATURA 2000 network) under the protection of Habitats and Birds Directives (Community Directive 79/409/EEC) (Fig. 10). It is an important bird area (IBA) and has been designated Ramsar site for the protection of wetlands.

Figure 10 – Avifauna in Ria Formosa (Photos: Bruno Fragoso).

The concentration of nutrients and productivity make it an important system in terms of diversity and abundance of flora and fauna. The intertidal area is mainly covered by *S. maritima* and seagrasses (*Zostera noltii* and *Cymodocea nodosa*) (Fig.11).

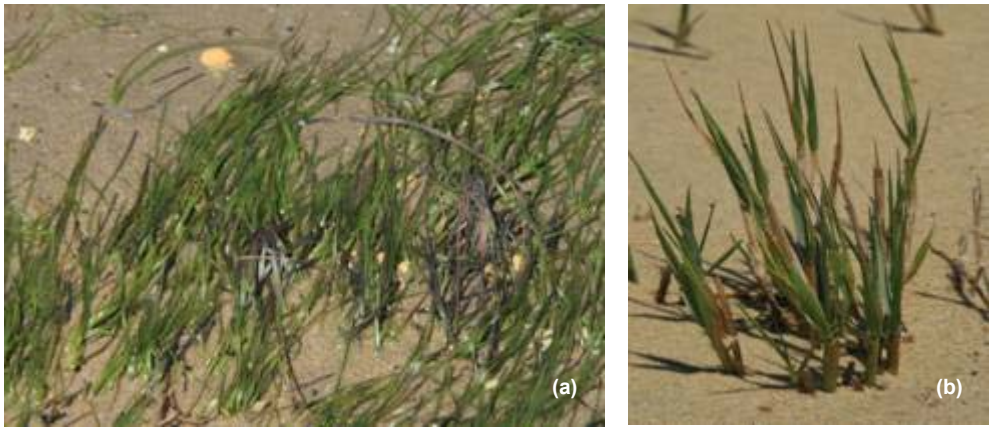


Figure 11 – Examples of saltmash and seagrass vegetation ((a) – *Zostera sp*.; (b)- *Spartina maritima*) (Photos: Bruno Fragoso).

3.3 Benthos and sediments

The Ria Formosa has high species richness and high diversity values for the benthic communities. In the Ria, several benthic habitats may be described: the tidal channels, the seagrass beds, the sandbanks and the mudflats.

Superficial layers of muddy sediments covered with *Z. noltii* were mostly composed of silt and clays (82%), while sandy sediments from clam rearing areas were only 3% silt and clay (Falção *et al.*, 2006).

The macrobenthic species reported to Ria Formosa are dominated by bivalves *Abra segmentum, Cerastoderma* spp and *Loripes lacteus*, the gastropods *Bittium reticulatum* and *Cerithium vulgatum*, the polychaetes *Hediste diversicolor, Heteromastus filiformis* and *Streblospio* spp, the crustaceans *Apseudes latreillii, Corophium* spp, and *Microdeutopus* spp. In the areas with low water renewal the bivalve *L. lacteus* is not present and the gastropod *Hydrobia spp,* the *Chironomus*

insect larvae and the polychaete *C. capitata* dominates (Calvário, 1995; Gamito, 2006; Sprung 1994).

3.4 Socio-economic impact

The Ria Formosa coastal lagoon is an important ecological system and provides a variety of uses, goods and resources. This is a system subjected to a variety of socio-economic drivers, producing increased pressures and impacts, which can result in environmental stress or even affect the public health.
The main pressures on the Ria Formosa are the local resident population; seasonal tourism (500 000); intensive farming, aviculture and several golf courses that border the lagoon (Fig. 12). As consequence, the anthropogenic nutrient inputs to the lagoon increase with this activities and produce an ecological impact over the biological communities, associated mostly with eutrophication processes in some inner areas on the lagoon.

Figure 12 – Golf courses around the western part of the Ria Formosa (Photo: Bruno Fragoso).

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

4.1 Background to field programme:

The samples were taken at two stations in the Ria Formosa between 10 April 2006 and 20 October 2006, every two weeks at early morning at low water. These stations are localized in the western end of the Ria Formosa coastal lagoon, Ponte (P) and Ramalhete (R) Fig. 13.
The Ramalhete station has a muddy substrate, with a complex circulation pattern where the water exchanges are slower than at Ponte. The Ramalhete channel receives the effluent from the Urban Waste Water Treatment Plant (UWWTP) for the urban conurbation of Faro. It is adjacent to the airport and affected by recreational activities between Faro City and the barrier islands of the lagoon and by bivalve culture (Newton and Mudge, 2003).

The Ponte station has a sandy muddy substrate. It is located on a channel that links the Barra São Luís oceanic inlet with the Ancão basin at the blind-end of the western lagoon. The side of the Ancão basin receives the effluent from the golf courses of the luxury tourist development at Quinta do Lago, and from intensive agriculture. This station is also affected by recreational and touristic activities, and by bivalve culture (Loureiro, *et al*, 2006).
Samples were collected for chlorophyll-*a,* POC, CHN, SPM and nutrients *in situ* temperature and the salinity observations were also made.

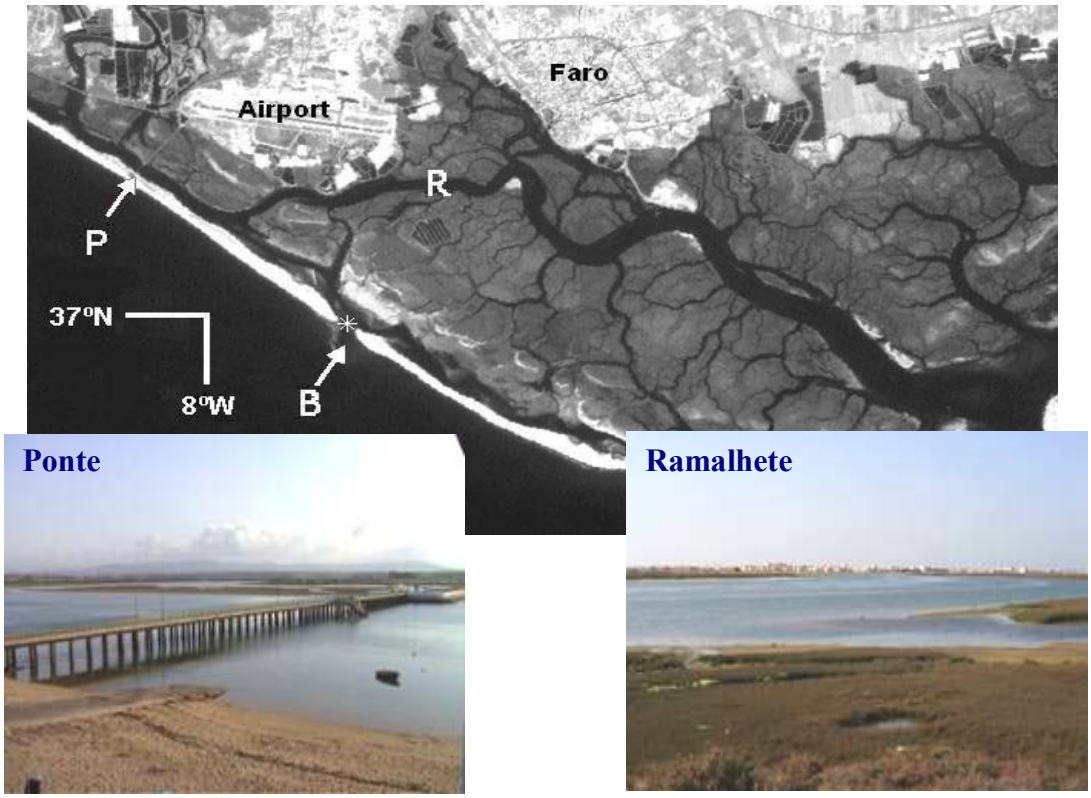


Figure 13 - Geographic location of the two stations in the Ria Formosa, Ponte (P) and Ramalhete (R) the location of the inlet (B) is show.

4.2 Sampling methods and materials, analytical methods.

All sampling and analysis was performed as per the ECASA book of protocols.

4.3 Models used and their parameterization

Two models were applied to the Ria Formosa study site, aiming at two different scales:
- Ecosystem scale: an ecosystem model was developed under the EcoWin2000 (E2K) modelling platform and
- Farm scale: the FARM^{TM} model was applied to one of the clam aquaculture areas in the Ria Formosa. Specifications of each model are detailed below.

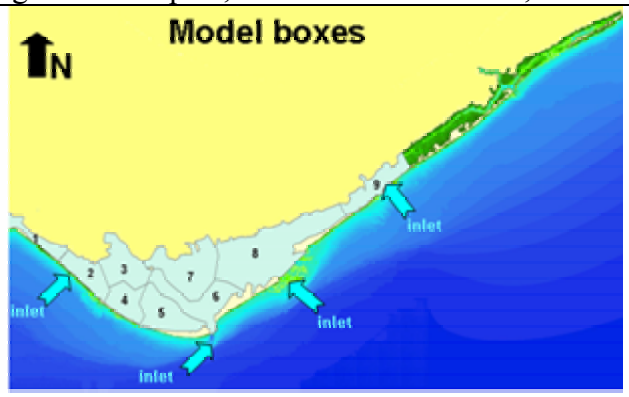
E2K makes use of an object-oriented programming (OOP) approach to implement ecological models for aquatic systems. The basic underlying structure is that of a spatial (1D, 2D and 3D) framework of boxes, within each of which the relevant biogeochemistry and population dynamics are resolved. E2K contains about one hundred objects, corresponding to hierarchies for simulating e.g. hydrodynamics, air temperature, oyster growth, seeding and harvesting processes, etc. Each object in E2K groups together multiple state variables (Ferreira, 1995).
This ecological model is applicable to the ecosystem scale, and the usage of object-oriented methods to simulate processes in ecological systems simplifies model development due to the flexibility associated with the modularity and inheritance properties of the objects themselves and provides a much greater conceptual approximation between natural ecosystems and interacting objects relative to structured programming (Ferreira, 1995).
The EcoWin 2000 ecological modelling platform was used to implement a research model simulating the major biogeochemical processes of pelagic and benthic variables as well as the seeding / harvesting features in the Ria Formosa. Water and pelagic state variables were redistributed within the Ria Formosa and exchanged with the ocean using the flows calculated with an hydrodynamic model – MOHID (Cancino and Neves, 1999 a and b), appropriate forcing was imposed at land and ocean boundaries for salinity, nutrients, phytoplankton (Nobre *et al.,* 2005) and shellfish data (e.g. seeding weight, seeding densities, areas cultivated, seeding/harvesting periods, harvesting weight, etc) were integrated as parameters/variables, where applicable.

The FARM model is designed in order to determine the appropriate shellfish density for optimal carrying capacity (the greatest sustainable yield of market sized animals within a given time period) in a given farm (Ferreira et al, 2007). The FARM model allows calculating the yield of the farm based on food supply, farm size and environmental parameters. It integrates the ASSETS model, what makes it able to assess farm related eutrophication effects (including mitigation).
The intended scope of the FARM model is for shellfish farms (without the use of artificial food) in coastal and estuarine waters. The model runs as a web-based client-server application with a very simple interface, hiding the complex internal processing which includes transport equations, shellfish individual growth for several species, population dynamics and dissolved oxygen balance.
Model parameterization includes values for environmental conditions (water temperature, current speed, Chl *a*, POM, TPM and dissolved oxygen), farm dimensions (width, length and depth) and cultivation practice (period and seeding densities).

4.4 Results.

EcoWin2000 model

Results from the ecosystem-scale model which include watershed drivers and pressures, biodiversity, etc are useful as decision-support for licensing thresholds, agriculture inputs, stakeholder consensus, WFD and marine Strategy compliance.



For the ecosystem model, 9 boxes were defined for the Ria Formosa study site. This model considers only 1 vertical layer and has 4 water inlets. Water fluxes were simulated making use of an hydrodynamic model (MOHID – a 3D water modelling system develop by MARETEC).

FARM™ model

Results from the farm scale model, which can be driven by results of ecosystem scale models and/or by measured data, are useful for determining optimal siting, culture densities, profit maximization, eutrophication status and nutrient emissions trading and valuation.
For the application of the farm scale model, only one aquaculture area was considered in the system. The aquaculture area modelled is highlighted in Figure 15.

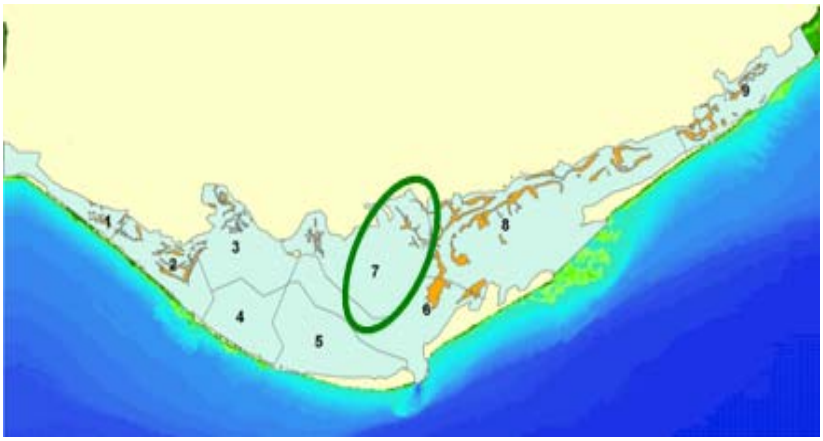
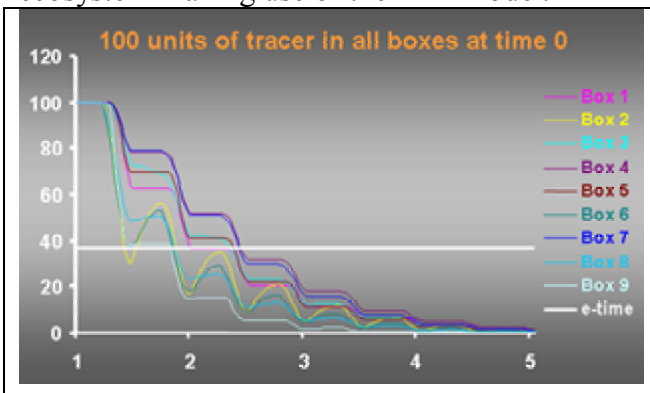


Figure 15 - Clam aquaculture areas in Ria Formosa. Highlighted area concerns the aquaculture area simulated with the FARM™ model (within box 7 of the ecosystem model).

Examples of both the ecosystem and farm models application to the Ria Formosa and its results are shown below.

Water

Water residence times in Ria Formosa were estimated as the e-folding time (time for the concentration in a grid cell to be reduced by a factor of 1/e, i.e., from an initial concentration of 100% to a concentration of about 36%) for each box defined in the ecosystem making use of the E2K model.



Residence times estimated for this system varied between 1 and 1.5 days. Figure 16 shows the results obtained for the water residence time estimation in Ria Formosa using the E2K model.

Figure 16- Residence time estimated for each E2K box defined for the Ria Formosa study site. Residence times were estimated using the e-folding time.

Samples were taken at the surface meters because this is very shallow lagoon. The Table 3 shows the mean, minimum and maximum of temperature, salinity, chlorophyll-a, oxygen and SPM. The Ramalhete and Ponte station show similar values of temperature, salinity and oxygen just the values of Chlorophyll a and SPM of Ramalhete are slightly higher comparing with the values of Ponte.

Table 3. Mean, minimum and maximum values for temperature, salinity, Chlorophyll-*a*, Oxygen and SPM for Ria Formosa.

	Temperature (C°)		Salinity		Chlorophll-a (µg/L)		Oxygen (mg/L)		SPM (mg/L)	
Station	**Ramalhete**	**Ponte**	**Ramalhete**	**Ponte**	**Ramalhete**	**Ponte**	**Ramalhete**	**Ponte**	**Ramalhete**	**Ponte**
Mean	20.5	21.3	36.5	36.4	1.77	1.3	6.95	6.73	41.02	36.93
Minimum	17.7	18.3	32.6	33.2	0.27	0.13	4.24	4.52	14.4	15.7
Maximum	25.9	26.8	39.6	37.9	9.61	5.87	9.32	8.74	86.4	76.4

Table 4 show the mean, minimum and maximum values of nutrients. Comparing these values with the mean minimum and maximum values of the TICOR data base (data between 1987 to 2001) is verified that the ammonia and nitrate are smaller during the period of study in 2006; the values of nitrite in Ramalhete are the same and in Ponte is slightly less; the phosphate values present similar values with the TICOR data base for the case of the silicates in Ramalhete station the values are higher than the values of the TICOR data base and in Ponte station the values are smaller comparing with tha data base.

Table 4. Nutrients mean minimum and maximum, at Ramalhete and Ponte station between 10 April 2006 to 20 October 2006.

	Ammonia (µmol l^{-1})		Nitrate (µmol l^{-1})		Nitrite (µmol l^{-1})		Phosphate (µmol l^{-1})		Silicate (µmol l^{-1})	
Station	**Ramalhete**	**Ponte**	**Ramalhete**	**Ponte**	**Ramalhete**	**Ponte**	**Ramalhete**	**Ponte**	**Ramalhete**	**Ponte**
Mean	0.88	1.46	1.07	1.03	0.12	0.20	0.81	0.69	7.94	8.55
Minimum	0.01	0.30	0.04	0.06	0.03	0.04	0.15	0.29	0.30	1.56
Maximum	4.68	5.08	8.84	4.10	1.16	0.75	2.04	1.25	64.00	19.17

Benthic communities

The benthic studies present in this part were made by Gamito, 2006. The benthic communities was been study near Olhão, in the central part of Ria Formosa, in 5 stations (A, B, C, D, F) that received the same incoming water through the Marim Channel, but they differed in water renewal regime.
A total of 96 families were identified in the five lagoons. 27 families had a mean density higher than 30 individuals m^{-2}, considering all the stations and sampling occasions, and represent 95.6% of all the data (Gamito, 2006).
Results obtained from benthic communities are shown in Table 5 and show the mean, maximal and minimal values of number of species, density, biomass, production, Shannon–Wiener diversity index and evenness, in each site in Ria Formosa.

Table 5. Mean, maximal and minimal values of number of species (S), density (N, number of individuals m^{-2}), biomass (B, ash free dry weight g m^{-2}), production (P, ash free dry weight g m^{-2} y^{-1}), Shannon–Wiener diversity index (H', bits) and evenness, in each site.

Site		S	N	B	P	H	J
A	Minimum	6	6322	2.9	28.50	0.6	0.22
	Mean	9	11400	9.5		1.8	0.58
	Maximum	12	21148	15.9		2.9	0.80
B	Minimum	31	4848	18.9	67.5	3.5	0.66
	Mean	39	8967	45.3		3.7	0.71
	Maximum	47	12364	70		4.1	0.78
C	Minimum	10	2365	6.1	27.2	2.1	0.56
	Mean	16	5624	22.7		2.8	0.71
	Maximum	27	8511	53.2		3.5	0.81
D	Minimum	17	2962	22.8	49	2.9	0.67
	Mean	21	6213	44.4		3.4	0.77
	Maximum	24	10279	79		3.6	0.82
E	Minimum	31	3133	1.8	22.3	3.2	0.58
	Mean	48	8798	7.4		4	0.72
	Maximum	63	12630	11.8		4.4	0.78

The most abundant families belonged to nine phyla (Annelida; Arthropoda; Coelenterata; Echinodermata; Mollusca; Nemertini; Phoronida, Sipuncula and Chordata). Within some of these phyla other large taxonomic groups were also considered: Olygochaeta and Polychaeta in the Annelida phylum; Amphipoda, Cirripedia, Cumacea, Decapoda, Isopoda, Insecta, Leptostraca and Tanaidacea in the Arthropoda phylum; Bivalvia, Gastropoda and Polyplacophora in the Mollusca phylum.

Currents

Maximum current profiles were taken along the two main channels, Ramalhete and Barra during both the ebb and flood stage of the tide. At the Ponte station, current readings were taken at times of the maximum ebb and maximum flood.
On June 26th, current profiles were collected every ½ hour over a tidal cycle in order to characterize the flow pattern at the main channel (MC). This survey showed that the times of high and low water levels occurred at slack water. High water occurred 45 minutes after the time of high water predicted at the tide gauge located at Anção inlet. The time of maximum ebb flow was determined to be 2.5 hours after high water while maximum flood occurred 2 hours before high water. The current velocity at maximum flood was found to be stronger than at maximum ebb flow (Table 6). A second detailed survey was completed on spring tide (04/07/00). Figure 17 illustrates only the near surface velocities for these two days. The day after neap tide (26/06/00), maximum flood was ¾ of the ebb flow but this ratio changed to 2/3 at spring tide. Water depth at high water springs, increased by 3.2 m from depth measured at neap tide (Durham, 2000).

Table 6- Maximum current velocities (Adapted from Durham, 2000).

Tidal Stage	Velocity (ms^{-1})
26-06-00 Max Ebb	- 0.9
26-06-00 Max Flood	0.6
03-07-00 Max Ebb	- 1.6
03-07-00 Max Flood	1.2

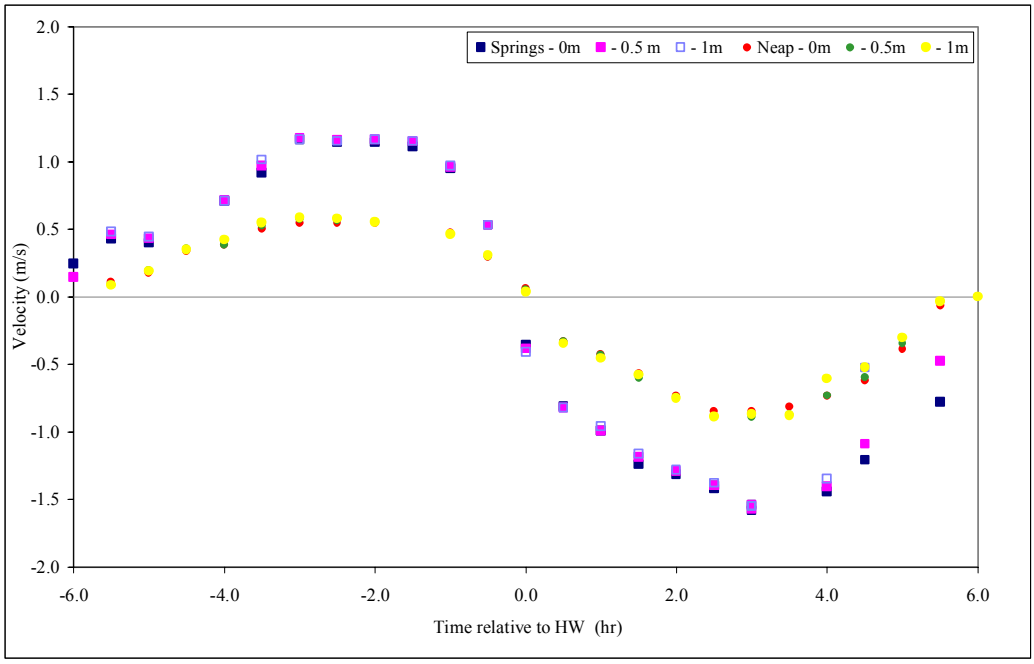


Figure 17- Surface velocities for neap and spring tide (Adapted from Durham, 2000).

On June 28th 2000, in the Ramalhete channel and the furthest from the inlet, was found to have the same depth average velocity (0.24 m s^{-1}) on both the ebb and flood

stage of the tides. Also, station Barra, west of the inlet had similar velocities on both stages of the tide (Durham, 2000).
During flood tide, water was flowing from both channels into the Ancão (basin in the western part of the lagoon) until close to high water. Before maximum flood, the flow in the Ramalhete channel, decreased considerably toward the Barra channel. A 0.14 m s^{-1} difference in depth averaged velocities was observed. At the mouth of the Ramalhete, less than an hour before high water, the direction of the flow reversed (Durham, 2000).
Ebbing currents at the mouth of the inlet were stronger and remained at a constant maximum velocity longer than flooding currents. From a neap to a spring tide, flood currents increased by 50% to 1.2 m s^{-1}, while ebbing currents increased by only 44% to 1.6 m s^{-1}. On the spring tide, it was calculated that 1.6 x 10^5 m^3 of water remained in the basin. However at neaps, 5 x 10^5 m^3 was removed from the basin (Durham, 2000).

Modelisation results

EcoWin2000 model

The ecological model outputs were validated against field data to check if conditions for shellfish growth were being properly simulated. Examples results from box 2 for the Ria Formosa model are shown in Figure 18.

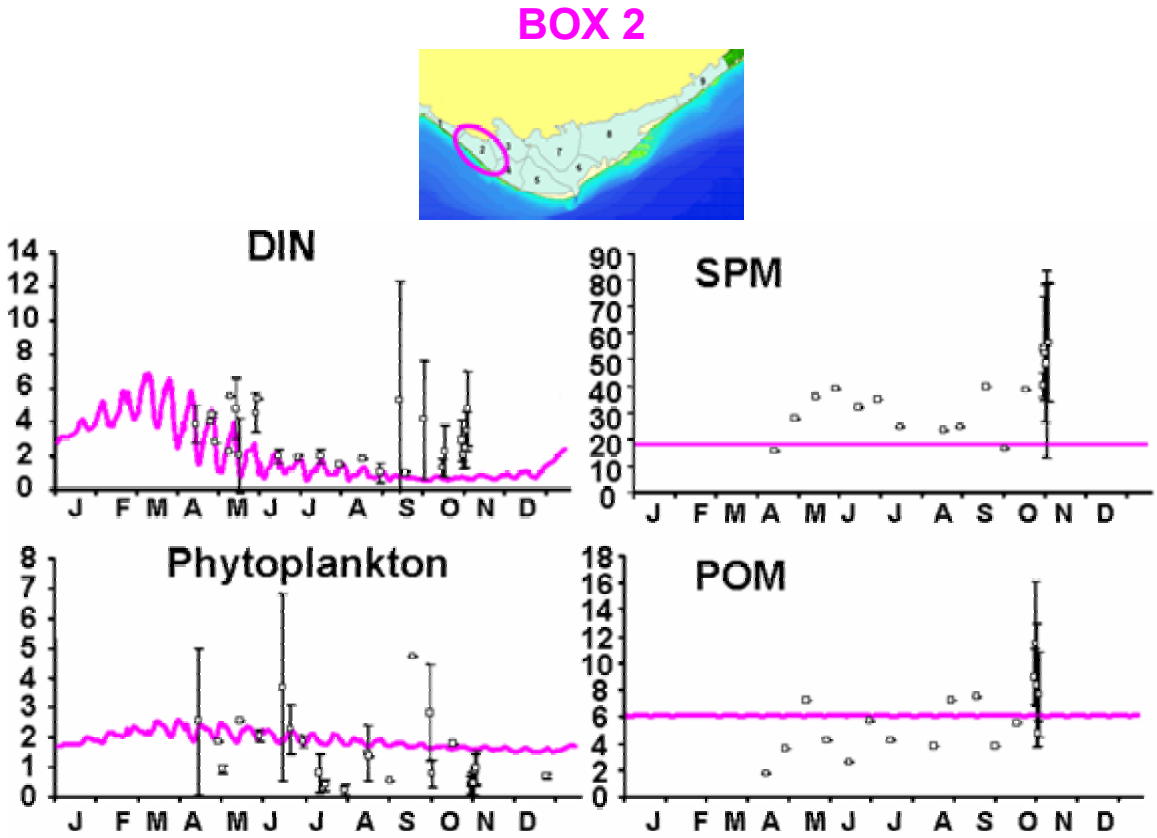


Figure 18- Validation of shellfish growth drivers simulated by EcoWin2000 for the Ria Model model. Model results are shown for one year (January – J to December – D). Lines represent model simulation and points represent field data with standard deviation bars.

The ShellSIM individual growth model was implemented and tested within the EcoWin2000 platform. Individual length and weight were simulated for one clam in each model box where cultivation occurs (Fig. 19), and with the addition of population dynamics to the individual model, shellfish stocks over multi-year periods could be estimated (Fig.20).

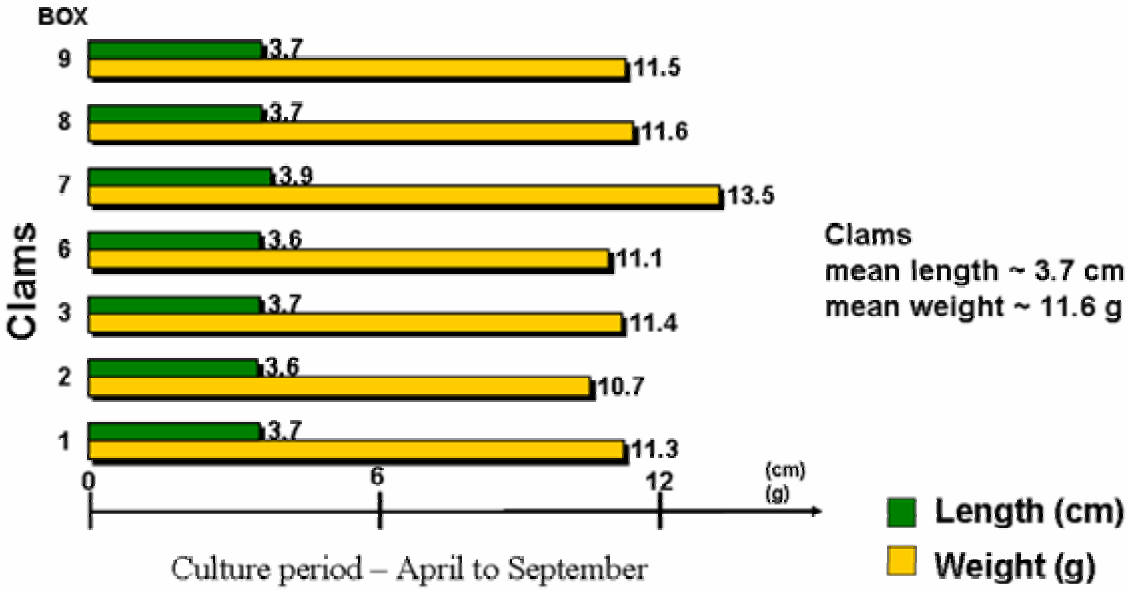


Figure 19- Individual length and weight simulated in E2K for clams cultured in Ria Formosa.

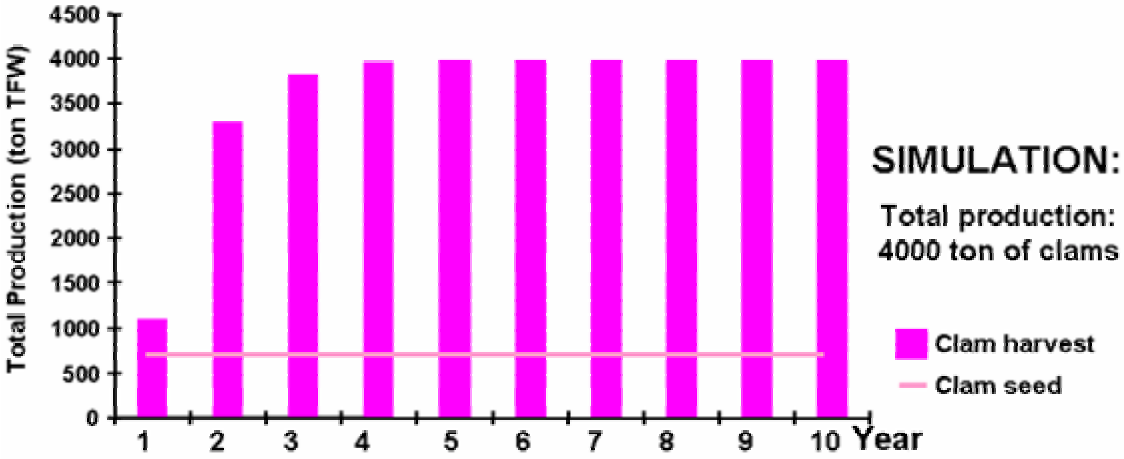


Figure 20- E2K production values simulation for Ria Formosa. Model was run for a 10 year period to check for consistently stable harvesting results. Model starts stabilizing after year 3.

The clam total production was estimated (with E2K) to be about 4000 ton per year (ton y^{-1}). This is in accordance with the reported values for total production which fluctuate between 3000 and 4000 ton y^{-1} (pers. com. Mr. Manjua, President of the Algarve Aquaculture Association).
The E2K model also enables to measure the ecological and economic efficiency in different parts of the ecosystem, by calculating the Average Physical Product (APP).

APP is defined as the ratio between harvested biomass (Total Physical Product – TPP) and seed biomass (Fig.21).

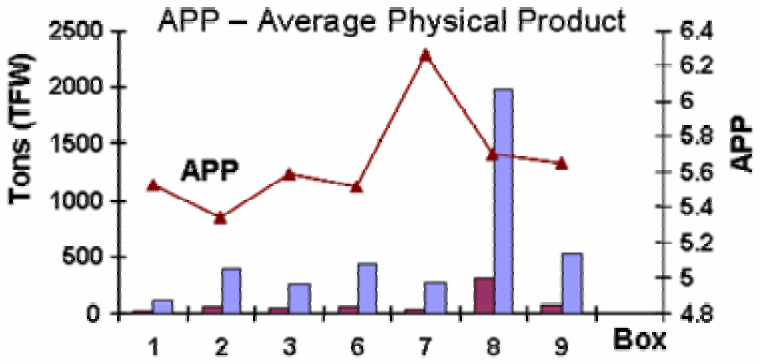


Figure 21- E2K model results for Ria Formosa per box with clam aquaculture. APP values are also shown, representing a measure of ecological and economy efficicency in the different areas.

Figure 21 shows model results per box for total seed biomass, TPP and APP, and Figure 22 shows the geographical distribution of the APP results per box and their comparison with a map for potential productivity in the Ria Formosa.

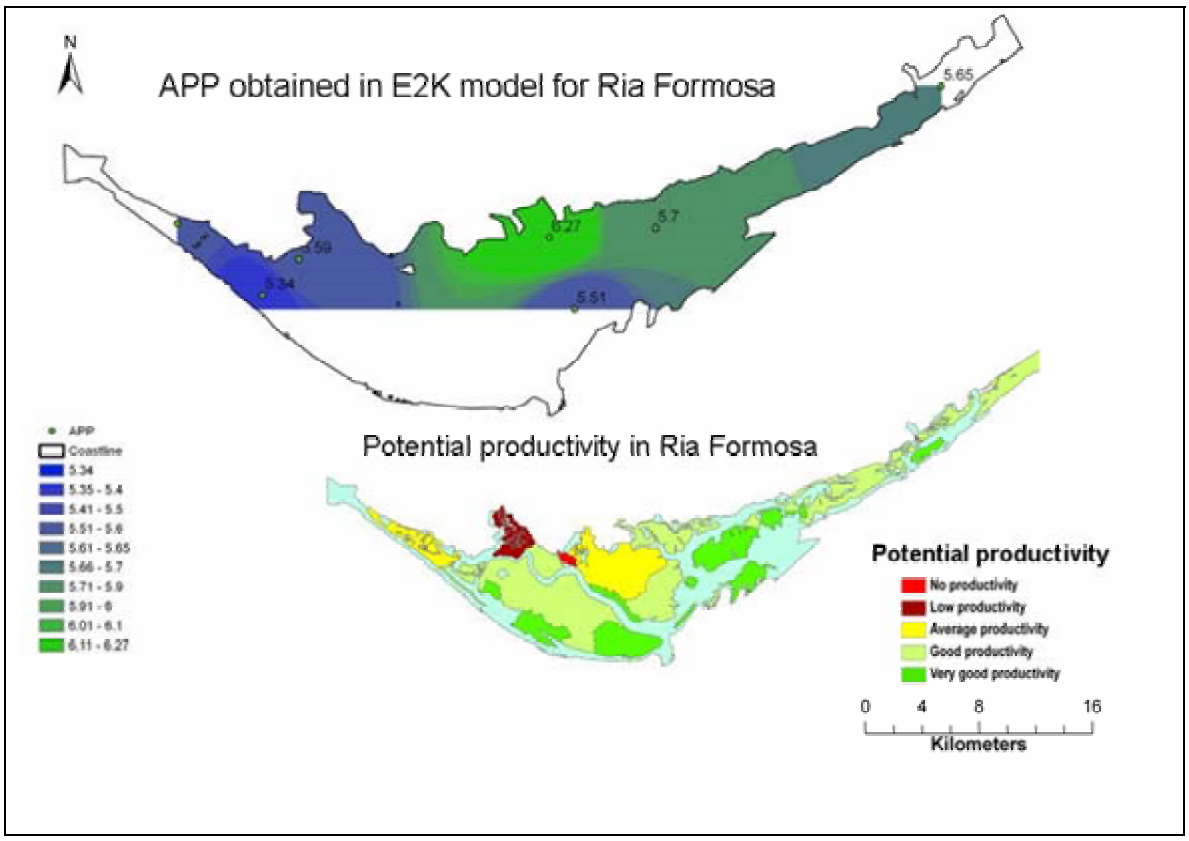
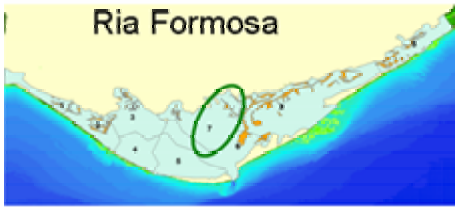


Figure 22 - Geographical Information System surface with APP results from E2K boxes with aquaculture areas and comparison with a potential productivity map for the Ria Formosa.

FARM™ model

The FARM™ model was applied to a clam farm in Ria Formosa. E2K outputs of daily averages for salinity, water temperature, oxygen, phytoplankton biomass, suspended particulate matter and organic particulate matter were used as inputs to the FARM model. The farm layout to which the FARM model was applied is described in Figure 23. The model was run for a cultivation period of 180 days using a clam seeding density of 90 ind m^{-2}. Integrating the ASSETS model, the FARM model is able to give outputs for eutrophication assessment regarding chlorophyll *a* and dissolved oxygen concentrations. Results for the eutrophication assessment are shown in Figure 24, where it can be seen that at these seeding densities, the clams would be responsible for a net removal of 13279 kg of nitrogen per year, equivalent to a sewage discharge of 4024 population equivalents per year (PEQ y^{-1}).



Box 7

(aquaculture = 11.4 ha)

- Farm layout:
  - 71 m x 1600 m
  - 3 m depth
- Culture practise:
  - Manila Clam
  - 1.35 ton ha-1 (90 ind m^{-2})

Figure 23- Description of the aquaculture area in Ria Formosa where the FARM model was

The ASSETS grades (which are in compliance with the Water Framework Directive) for chlorophyll and oxygen in the system are High and Medium, respectively, resulting in an overall score of Good.

An analysis of the interactions of the resulting TPP, APP and Marginal Physical Product (MPP – the first order derivative of the production function: TPP *vs* seed) is shown in Figure 25. The point of profit maximization in this system was determined for a MPP of 0.10 (MPP = $Price_{input}/Price_{output}$), corresponding to an APP of 1.02 and a TPP of 360 tons of clam total fresh weight.

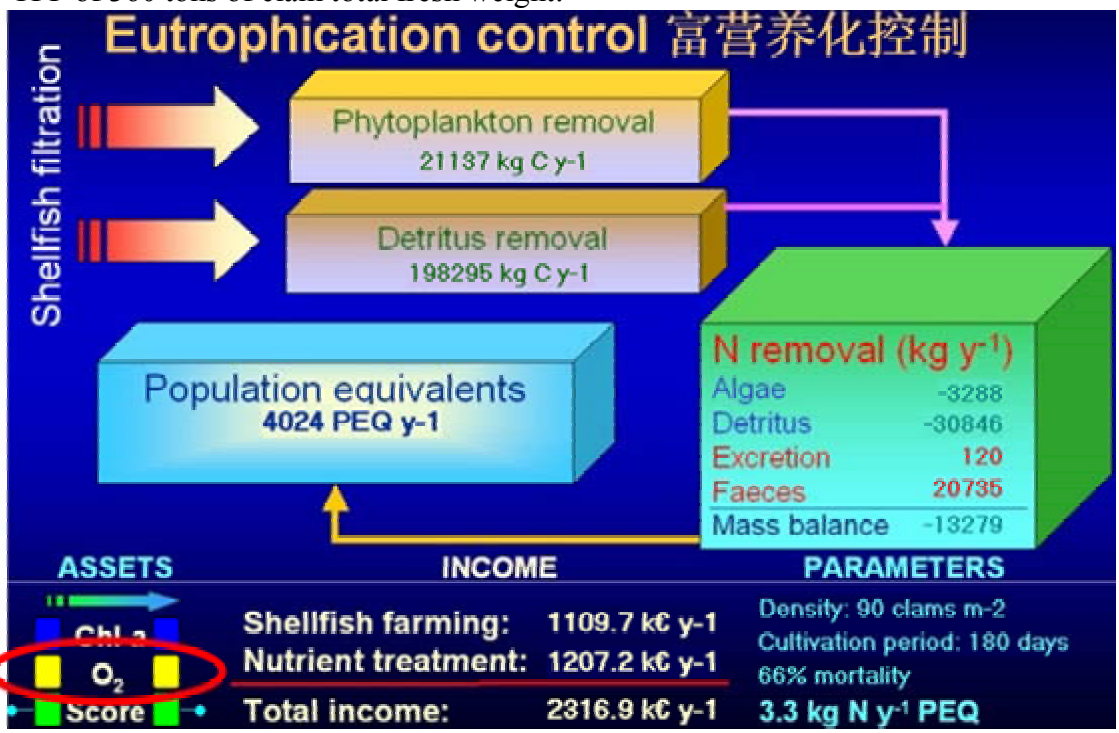


Figure 24- FARM results for Ria Formosa using the ASSETS model for eutrophication assessment.

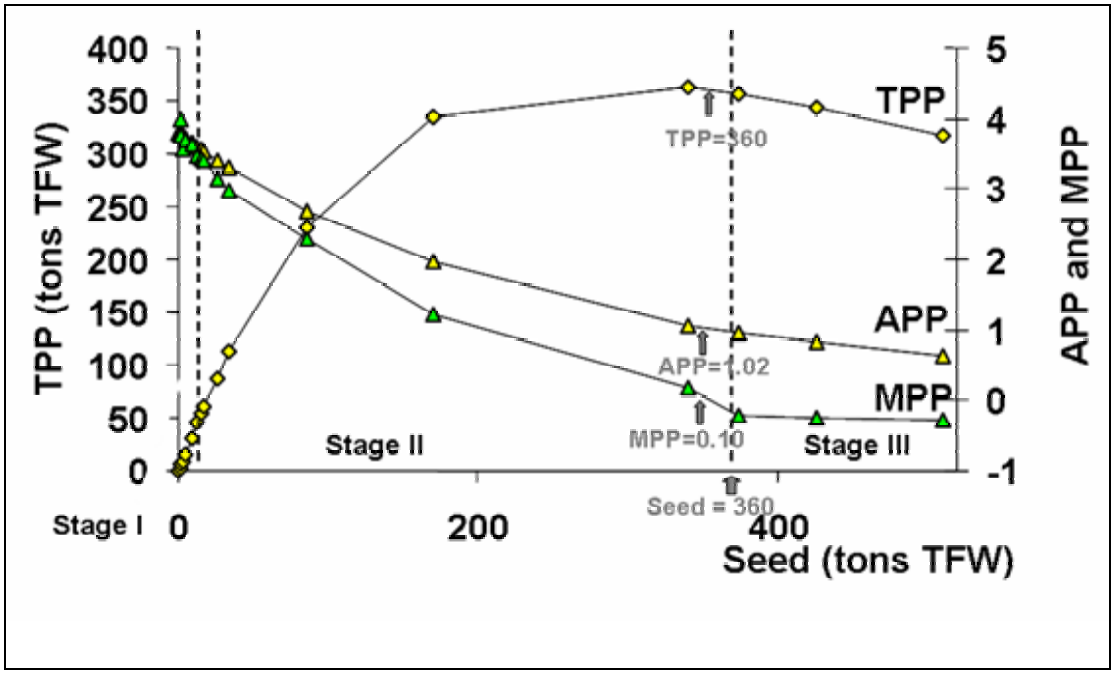
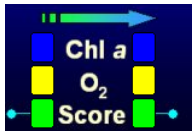


Figure 25 - Economical analysis for Ria Formosa using the FARM model. Runs were made for a cultivation period of 180 days.

Three scenarios were run with the FARM^{TM} model for Ria Formosa considering different loads of nutrients into the system (x 1.5, x 2 and x5 the standard loads). The results obtained for each scenario are synthesised in Table 7, where the ASSETS final grades are also shown. For the scenario with the x5 loads it can be seen that the final ASSETS score changes from Good to Moderate.

Table 7- FARM model results for the Ria Formosa scenarios. A total seed of 15.3 tons were used in all simulations (Price of input (Pi) = 1 € kg^{-1}; Price of output Po = 10 € kg^{-1} → TC = 15.3 k€)

Scenario	TPP (tons)	APP	TR (TVP k€)	Profit (k€)	Chl *a* (µg l^{-1})	DO (mg l^{-1})	ASSETS
Standard	54.7	3.57	547.3	532	2.5 → 2.3	3.1 → 2.5	
X 1.5	55.8	3.64	558.5	543	2.5 → 2.4	3.0 → 2.3	
X 2	56.9	3.71	569.4	554	2.5 → 2.3	3.0 → 2.2	
X 5	63.2	4.12	632.4	617	2.9 → 2.9	2.7 → 2.0	

4.5 Evaluation of Model Performance

EcoWin2000 model

Validation of the E2K results for shellfish growth drivers in Ria Formosa are shown in 16. The E2K results used in this validation are highly dependent on the boundary conditions for the river/ocean end-members and the water fluxes between boxes, which are set in this model following the results from the hydrodynamic model applied to the system. Simulated growth drivers, as phytoplankton biomass and dissolved inorganic nitrogen seem to be largely within the standard deviation bars of field data, though e.g. the phytoplankton results are not reflecting any bloom during the year. Differences between simulated results and field data might be due to an inadequacy in the hydrodynamic modelling as well as lack of information concerning the pattern of nutrient loads into the system, which vary with seasons (summer – high tourism and increase in population numbers *vs* winter – low population numbers).
Final production results obtained from E2K can only be validated against production records. As described above E2K results are within the production figures for the last years in the Ria Formosa.

FARM^{TM} model

FARM model results can only be validated if data on production for each different aquaculture site is known. There are no direct field measures that can be used to validate this model results.

4.6 Site specific conclusions

The indicators and modeling results show that the state of the environment at station "Ramalhete" is moderate to good and at the "Ponte station" it is good to high. Overall the state of the Ria Formosa lagoon is "good" although it is "moderate" in some of the inner parts of the lagoon.

Bivalve aquaculture in the Ria Formosa is an important socio-economic activity. The main environmental impacts are the grazing of the phytoplankton that results in low water column chlorophyll values and the disturbance of the sediment and seagrass habitat during harvesting of the clams using a modified hoe. Nevertheless, these practices are less environmentally damaging than other clam harvesting methods, such as dragging a sediment dredge or spraying the sediment surface with chemicals, (bleach, pesticides). Considering the Ecosystem Approach including socio-economic aspects and the consequences of the farm for other users and stakeholders, the clam aquaculture in the Ria Formosa lagoon is a low environmental impact activity with large socio-economic rewards. The clam aquaculture is important to the local culture. There is even a Clam festival in the town of Olhao.

The capacity of the environment in terms of waste assimilation is increased by the clam aquaculture as these are filter feeders. The grazing of the phytoplankton keeps the chlorophyll a concentrations low and offsets the formation of phytoplankton blooms, one of the symptoms of eutrophication.

Provision of environmental services to clam aquaculture include the depuration of the clams before commercialization, as well as monitoring for enteric bacteria and algal toxins. The clam aquaculture has a low aesthetic impact. The visual signs are stakes demarcation of areas and patches of disturbed sediments where the clams have been dug up. Oyster culture on the sediment on rafts is more obvious but is only practiced on a very small scale. Covering the sediment surface with netting to reduce bird predation, as in Canada, is not practiced.

Clam aquaculture is sustainable in the Ria Formosa although there have been recent reports of mortalities and decreases in production. The lagoon sytem maybe approaching carrying capacity as evidenced by the low Chlorophyll concentrations in the water column. Another development that is cause for concern is the appearance of large beds of opportunistic green algae that must be raked off the sediment surface by the clam growers (Fig.26).

Figure 26 – Shellfish producers scrapping the surface of the sediment full of opportunist macroalgae.

4.7 Culture type and environment type conclusions

ECASA tools for this culture type (clam aquaculture) and for this environment type (shallow lagoon system) are very useful. The ECASA study results demonstrated that clam aquaculture has a low environmental impact on the lagoon and may mitigate some of the effects of eutrophication.

The most appropriate tools and methods for Environmental Impact studies at such sites is early morning dissolved oxygen concentration. With respect to the sediment the redox potential should also be monitored. Current practice does not take these into account in a systematic way. For public health it is important to continue the monitoring of the enteric bacteria and algal toxins and the practice of depuration.

5. Acknowledgements

Special thanks to the IMAR- FCT (Algarve) team who helped in the field and laboratory work for the ECASA project.

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Appendix 1. Details of all methods used

The protocols for water column analysis followed the protocols of the ECASA project in the next paragraphs are summarized the principals analysis carryout for SPM, Oxygen, Chl-*a* and Nutrients.

Particulate matter in seawater *(Source: Plymouth Marine Laboratory and ICES (2004))*

Filter-preparation:
The filters were separate and soak in distilled water for > 1h; agitate and rinse 3-4 times in distilled water to remove fine loose particles of filter than each filter were partially dry on suction head to remove excess water.
Each filter were place individually into foil envelope/fan and oven dry overnight. When the filters were removed from the oven they were carefully number each filter on the exposed margin with a soft lead pencil and lay out on foil tray, fit a lid and were ash in muffle furnace at 450°C for >4h. The filters were cool in dessicator.

Particulate Organic Matter and Total Particulate Matter determination
Water sample were filtered (e.g. 1000 ml) than were rinse filter twice with 10 ml of 0.5M Ammonium formate solution to remove salt and then rinse with distilled water around margin of the filtration cup.
The filters were put in oven to dry (60°C for 2 days, 40°C for 1 week) and were weigh each filter for total particulate matter (TPM) than were ash at 450°C in muffle furnace for > 4h and were taken the weigh of each filter for inorganic particulates (PIM).

Chlorophyll-*a* determination (*Source: Plymouth Marine Laboratory)*

Sampling
Water sample were filtered (e.g. 1000 ml) through 47mm GF/F filter at relatively low vacuum pressure (<250 mm Hg) and fold filter in half (sample side inwards) place in labeled petri-dish and were freeze until required.

Chlorophyll extraction
For natural seawater and more delicate species (e.g *Phaeocystis; Isochrysis)* : were place the filter in bottom of centrifuge tube, add 10 ml 90% acetone then refrigerate (4°C) for at least 16, but not more than 24 hours. Gently the tubes were inverted several times before decanting off into spectrophotometer cuvette.
The samples were removed from fridge and centrifuge for 5 mins at 3,000 to 4,000 rpm.

Spectrophotometric determination
Were used wavelength 750nm to measure turbidity and 663nm for Chl-*a*, using bandwidth of 1 nm. Than were read absorbance at 750nm (E_{750}), 663nm (E_{663}), 750nm; add 2 drops HCl (leave 30 sec), read at 663nm (E_{663a}). The cuvettes were rinse with 90% acetone between samples.

Chlorophyll a (µg litre) =(26.7((E_{663} - E_{750}) - (E_{663a} - E_{750})) x vol.extract (ml)) / (vol filtered (litres) x path length (cm))

E_{663} = abs. prior to HCL
E_{663a} = abs. after addition of HCL

Dissolved nutrients in seawater *(Source: ICES 2004)*

The commonly designated nutrients are inorganic nitrogen compounds (NO_3^-, NO_2^- ,NH_4^+), phosphate (PO_4^{3-}) and silicate (SiO_4^{3-}). Nutrients in sea water are considered trace compounds and their analysis is liable to various sources of contamination. Sea water for nutrient analysis is usually collected manually with Niskin bottle (1m depth). The reference method for measuring nutrients in the following (including storage and pre-treatment) is Grasshoff (1976) "Methods of Seawater Analysis".

Sample handling and storage
Samples were collected to new plastic bottles, free from detergents (to avoid phosphorus contamination) and analyzed as soon as possible. When analyze was not possible in the sample day, samples were kept frozen and protected from light.

Sample pre-treatment
Sea water samples were filtrated to removed the suspended matter.

Calibration and the blank
Stock standards solutions were prepared for each nutrient using analytical grade reagents. Reagents containing crystal water wereshould be dried at a sufficiently low temperature in order not to remove the crystal water. Stock standard solutions with high concentrations (more thatn 1mM) were prepared and refrigerated in order to maintain the stability. Working solutions were prepared from the stocks daily. Deionized water was used for the blanks.

References
Grasshoff, K. 1976. Methods of seawater analysis. Verlag Chemie, Weinheim, New York.

Nitrate/Nitrite in seawater (Cadmium reduction method)

Principle
Nitrate is quantitatively reduced to nitrite by passage of the sample through a copperized cadmium column. The nitrite (reduced nitrate plus original nitrite) is then determined by diazotizing with sulfanilamide followed by coupling with N-(1-naphthyl) ethylenediamine dihydrochloride. The resulting solution has a magenta color, which is detectable at 540 nm.

Procedure
Nitrite/nitrate was determined by molecular absorbance spectrophotometry (Grasshoff et al. 1983), using 5 cm path length cells.

OrthoPhosphate in seawater

Principle
Ammonium molybdate and antimony potassium tartrate react in an acid medium with phosphate to form an antimony-phospho-molybdate complex. This complex is reduced to an intensely blue-colored complex by ascorbic acid. The color produced is proportional to the phosphate concentration in the sample. Though there is a density difference between seawater and reagent water the bias is less than 2%.

Though the method is written for seawater and brackish water it is also applicable to non-saline sample matrixes. The method is calibrated using standards prepared in deionized water. Once calibrated, samples of varying salinities (0 to 35 ppt) may be analyzed. The determination of background absorbance is necessary only for samples, which have color absorbing at 880 nm.

Procedure
Orthophosphate was determined by molecular absorbance spectrophotometry (Grasshoff et al. 1983), using 5 cm path length cells.

Ammonium (Phenolate method) in seawater

Principle
This method is based on the Berthelot reaction. Ammonia reacts with alkaline phenol, then with sodium hypochlorite to form indophenol blue. Sodium nitroprusside is added to enhance sensitivity. The samples were then analyzed by molecular absorbance spectrophotometry. The absorbance of the reaction product is measured at 630 nm and is directly proportional to the original ammonia concentration.

Silicates in seawater

Principle
Dissolved inorganic silicate in seawater reacts with an acidic molibdate reagent originating a silico molibdate complex, which is then reduced (by means of ascorbic acid), originating a blue silico complex. This is a pH-dependent reaction (pH3-4) and there might be some interferences due the presence of phosphate. Oxalic acid is added to eliminate this interference.

Procedure
Silicates in seawater were determined by molecular absorbance spectrophotometry, and the reaction product was measured at 810 nm, using 1cm path length cells. Note: all the volume measurement material, standard storage recipients and reaction tubes were plastic to avoid contamination.

Oxygen

For the determination of oxygen dissolved in seawater were used the Winkler method that is a iodometric titration.

Procedure

Field:

Were flushed Winkler bottles with the sample water (avoid the turbulence in the bottle), with the help of a transparent tube that is introduced into the winkler bottle almost until the bottom. The Winkler bottles were flush about twice the volume of the bottle to avoid the entrance of atmospheric oxygen and than the reagents (1mL each manganese (II) chloride, reagent 1, and alkaline iodide, reagent 2) were added and mixed.

Laboratory:

Before the titration the precipitated hydroxides were dissolved with 2 ml of H_2SO_4 and than were dissolved by shacking. A volume of 50 ml were transferred to a erlenmeyer and than were flowed by the titration with thiosulphate solution (0.02 n) and were added three drops of amide as a indicator and the titration were follow until the colour change between blue to white.

Determination of the blank

Pure water with a volume of 50ml is palced in a erlenmeyer and 2ml of H_2SO_4, 0.9 ml alkaline iodide solution and 0.9 ml manganese (II) chloride reagent were added separately. After each reagent addition the solution were thoroughly mixed to avoid any precipitation of manganese hydroxides. The titration follow the procedure described above.

Standardization of the thiosulphate solution

Pure water with a volume of 50ml is palced in a erlenmeyer and 2ml of H_2SO_4, 0.9 ml alkaline iodide solution and 0.9 ml manganese (II) chloride reagent were added separately. After each reagent addition the solution were thoroughly mixed to avoid any precipitation of manganese hydroxides. Than 10 ml of the iodate standard solution are added with a calibrated pipette and than was titrate the sample.

Calculation of the thiosulphate factor for a solution of 0.02 n:

$$f = \frac{5}{V}$$

(V = ml de thiosulphate required for the standardization of the titration)

Calculation of the concentration of the dissolved oxygen

For a solution of 0.02 n.

$$mgO_2l^{-1} = \frac{a \times f \times 0.16 \times 10^3}{V - 1.8}$$

a = ml de thiosulphate suse in the titration (subtrate previously the quantity o thiosulphate requires for the titration of the blank).

f = factor f of the thiosulphate solution

V = Volume of the Winkler bottle (ml)

Appendix 2. Environmental data

Water column

Table 2.1. Nutrients data for Ponte da Praia de Faro and Ramalhete station between 10 of April 2006 to 20 of October 2006.

Station	LATITUDE	LONGITUDE	Date	Hour	Tide Condition	$[NH_4^+]$		$[NO_2^-]$		$[NO_3^-]$		$[PO_4^{3-}]$		$[SiO_4^{4-}]$	
						µmol / dm^3	SD	µmol / dm^3	SD	µmol / dm^3	SD	µmol / dm^3	SD	µmol / dm^3	SD
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	10-04-2006	8:53	Neap Tide / Low Water	<0.3	–	0.75	0.17	2.04	0.79	0.76	0.09	14.80	0.96
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	24-04-2006	7:57	Neap Tide / Low Water	<0.4	–	0.40	0.07	<2	–	0.58	0.17	16.77	0.85
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	09-05-2006	8:03	Neap Tide / Low Water	5.08	0.34	0.11	0.01	0.89	–	0.86	0.57	13.04	2.98
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	23-05-2006	7:09	Neap Tide / Low Water	2.59	0.60	0.23	–	0.96	–	1.01	0.05	19.17	0.35
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	23-05-2006	–	Neap Tide / High Water	–	–	0.09	–	0.22	–	–	–	–	–
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	08-06-2006	7:45	Neap Tide / Low Water	1.11	0.37	0.17	–	1.00	–	0.91	0.32	8.29	2.72
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	22-06-2006	7:30	Neap Tide / Low Water	0.80	0.06	0.20	–	0.81	–	0.29	0.04	9.37	4.91
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	07-07-2006	7:07	Neap Tide / Low Water	<0.7	–	0.19	–	0.78	–	0.54	0.09	8.11	1.16
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	21-07-2006	7:30	Neap Tide / Low Water	<0.7	–	0.22	–	0.60	–	0.44	0.28	14.23	2.78
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	21-07-2006	–	Neap Tide / High Water	–	–	0.17	–	0.35	–	–	–	–	–
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	05-08-2006	–	Neap Tide / Low Water	–	–	0.15	–	0.06	–	–	–	–	–

Ponte da Praia de Faro	07 59.600 W	37 00.533 N	07-08-2006	8:21	Neap Tide / Low Water	1.44	0.11	0.21		<0.2	–	0.93	0.01	17.35	1.52
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	19-08-2006	7:21	Neap Tide / Low Water	0.30	0.04	0.20	–	0.09	–	0.70	0.01	10.53	0.16
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	19-08-2006	–	Neap Tide / High Water	–	–	0.17	–	< 0.6	–	–	–	–	–
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	06-09-2006	–	Neap Tide / Low Water	0.51	0.09	0.34	–	0.18	–	0.84	0.11	11.71	1.19
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	19-09-2006	8:35	Neap Tide / Low Water	2.29	0.28	0.21	–	4.10	–	0.58	0.04	14.39	0.37
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	04-10-2006	8:20	Neap Tide / Low Water	2.97	0.03	0.30	–	0.10	–	0.68	1.19	16.97	0.73
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	16-10-2006	8:40	Flood	<0.3	–	0.06	0.00	1.07	0.05	0.32	0.01	2.60	0.07
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	16-10-2006	11:40	High Water	1.14	0.09	0.10	0.01	0.76	0.17	0.53	0.02	4.36	0.00
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	16-10-2006	15:30	Ebb	1.24	0.68	0.18	0.01	0.85	0.05	0.90	0.02	10.16	0.18
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	16-10-2006	18:20	Low Water	2.65	0.73	0.15	0.01	1.13	0.06	0.82	0.01	9.13	0.11
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	17-10-2006	9:55	Flood	<0.9	–	0.09	0.01	0.89	0.05	0.58	0.02	3.79	0.03
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	17-10-2006	12:25	High Water	<0.3	–	0.04	0.01	0.74	0.22	0.35	0.01	2.52	0.04
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	17-10-2006	15:55	Ebb	<0.9	–	0.07	0.01	0.60	0.02	0.45	0.02	3.88	0.14
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	18-10-2006	7:50	Low Water	3.04	0.52	0.24	0.01	1.36	0.01	1.11	0.01	10.56	0.21
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	18-10-2006	10:30	Flood	<0.9	–	0.06	0.00	0.71	0.01	0.39	0.01	2.37	0.03

Ponte da Praia de Faro	07 59.600 W	37 00.533 N	18-10-2006	13:30	High Water	<0.3	–	0.06	0.01	1.17	0.37	0.37	0.01	1.56	0.03
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	18-10-2006	16:30	Ebb	<0.9	–	0.08	0.00	1.06	0.16	0.49	0.01	2.27	0.09
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	19-10-2006	8:10	Low Water	2.33	0.21	0.25	0.02	1.83	0.03	0.97	0.01	8.50	0.07
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	19-10-2006	11:10	Flood	2.32	1.65	0.13	0.00	1.17	0.01	0.60	0.01	4.46	0.09
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	19-10-2006	14:15	High Water	1.03	0.27	0.21	0.00	0.75	0.17	0.96	0.01	2.77	0.07
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	19-10-2006	17:15	Ebb	<0.9	–	0.17	0.00	1.00	0.11	0.64	0.02	4.72	0.16
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	20-10-2006	8:45	Low Water	4.53	0.46	0.45	0.01	2.75	0.17	1.25	0.03	12.79	0.16
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	20-10-2006	11:30	Flood	1.95	0.80	0.25	0.01	1.81	0.03	0.82	0.02	6.77	0.11
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	20-10-2006	14:25	High Water	<0.9	–	0.27	0.01	1.12	0.08	0.90	0.01	2.22	0.07
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	20-10-2006	17:35	Ebb	<0.9	–	0.18	0.01	1.40	0.06	0.53	0.05	3.52	0.10
Ramalhete	07 56.917 W	37 00.350 N	10-04-2006	7:59	Neap Tide / Low Water	<0.3	–	0.62	0.03	<0.8	–	0.44	0.08	6.10	0.10
Ramalhete	07 56.917 W	37 00.350 N	24-04-2006	7:03	Neap Tide / Low Water	0.12	0.04	0.35	0.19	0.16	–	0.33	0.10	11.01	0.53
Ramalhete	07 56.917 W	37 00.350 N	09-05-2006	7:15	Neap Tide / Low Water	4.68	0.99	0.08	0.01	0.63	–	0.50	0.12	10.44	2.71
Ramalhete	07 56.917 W	37 00.350 N	23-05-2006	6:25	Neap Tide / Low Water	0.76	0.08	0.06	–	0.62	–	0.71	0.11	12.27	0.06
Ramalhete	07 56.917 W	37 00.350 N	23-05-2006	–	Neap Tide / High Water	–	–	0.09	–	0.21	–	–	–	–	–

Ramalhete	07 56.917 W	37 00.350 N	08-06-2006	7:00	Neap Tide / Low Water	0.62	0.20	0.11	–	0.38	–	0.59	0.05	7.03	2.15
Ramalhete	07 56.917 W	37 00.350 N	22-06-2006	6:45	Neap Tide / Low Water	<0.3	–	0.11	–	0.30	–	0.62	0.17	6.37	2.54
Ramalhete	07 56.917 W	37 00.350 N	07-07-2006	6:30	Neap Tide / Low Water	<0.7	–	0.16	–	< 0.6	–	1.03	0.34	7.41	1.55
Ramalhete	07 56.917 W	37 00.350 N	21-07-2006	6:25	Neap Tide / Low Water	<0.7	–	0.10	–	0.39	–	1.33	0.78	7.83	0.23
Ramalhete	07 56.917 W	37 00.350 N	21-07-2006	–	Neap Tide / High Water	–	–	0.19	–	0.11	–	–	–	–	–
Ramalhete	07 56.917 W	37 00.350 N	05-08-2006	–	Neap Tide / Low Water	–	–	0.12	–	< 0.6	–	–	–	–	–
Ramalhete	07 56.917 W	37 00.350 N	07-08-2006	7:48	Neap Tide / Low Water	1.12	0.01	0.21	0.02	<0.2	–	1.23	0.03	7.04	0.38
Ramalhete	07 56.917 W	37 00.350 N	19-08-2006	–	Neap Tide / Low Water	0.21	0.07	0.14	–	< 0.6	–	1.21	0.22	3.18	0.25
Ramalhete	07 56.917 W	37 00.350 N	19-08-2006	–	Neap Tide / High Water			0.20	–	< 0.6	–				
Ramalhete	07 56.917 W	37 00.350 N	06-09-2006	7:50	Neap Tide / Low Water	0.25	0.10	0.22	–	< 0.6	–	1.01	0.05	5.72	0.58
Ramalhete	07 56.917 W	37 00.350 N	19-09-2006	8:00	Neap Tide / Low Water	2.15	0.68	0.22	–	< 0.6	–	0.72	0.03	6.37	0.62
Ramalhete	07 56.917 W	37 00.350 N	04-10-2006	7:30	Neap Tide / Low Water	2.01	0.18	0.26	–	< 0.6	–	1.40	0.78	9.00	0.80
Ramalhete	07 56.917 W	37 00.350 N	16-10-2006	9:05	Flood	1.26	0.10	0.18	0.03	<0.3	–	0.43	0.01	7.71	0.36
Ramalhete	07 56.917 W	37 00.350 N	16-10-2006	12:00	High Water	0.98	0.11	0.19	0.04	<0.3	–	0.37	0.01	8.38	0.11
Ramalhete	07 56.917 W	37 00.350 N	16-10-2006	15:30	Ebb	0.99	0.11	0.11	0.01	<0.1	–	0.19	0.02	9.66	0.15
Ramalhete	07 56.917 W	37 00.350 N	16-10-2006	18:55	Low Water	1.18	0.19	0.06	0.00	<0.3	–	0.25	0.01	8.00	0.36

Ramalhete	07 56.917 W	37 00.350 N	17-10-2006	7:30	Low Water	1.10	0.13	0.05	0.00	<0.1	–	0.52	0.03	5.87	0.32
Ramalhete	07 56.917 W	37 00.350 N	17-10-2006	10:00	Flood	0.79	0.13	0.07	0.01	<0.3	–	0.15	0.10	8.10	0.29
Ramalhete	07 56.917 W	37 00.350 N	17-10-2006	12:45	High Water	0.94	0.15	0.08	0.01	<0.1	–	0.39	0.01	6.11	0.14
Ramalhete	07 56.917 W	37 00.350 N	17-10-2006	16:15	Ebb	1.19	0.23	0.19	0.03	0.32	0.04	0.50	0.02	9.20	0.76
Ramalhete	07 56.917 W	37 00.350 N	18-10-2006	7:55	Low Water	1.62	0.52	0.18	0.01	0.82	0.03	0.26	0.01	20.23	0.17
Ramalhete	07 56.917 W	37 00.350 N	18-10-2006	10:45	Flood	1.72	0.68	0.17	0.07	0.10	0.03	0.66	0.11	7.88	0.25
Ramalhete	07 56.917 W	37 00.350 N	18-10-2006	13:45	High Water	0.91	0.06	0.17	0.05	<0.1	–	0.49	0.06	7.40	0.14
Ramalhete	07 56.917 W	37 00.350 N	18-10-2006	16:54	Ebb	0.67	0.08	0.17	0.04	<0.1	–	0.49	0.11	7.09	0.79
Ramalhete	07 56.917 W	37 00.350 N	19-10-2006	8:25	Low Water	1.49	0.22	0.24	0.05	< 0.6	0.03	0.98	0.31	11.36	0.29
Ramalhete	07 56.917 W	37 00.350 N	19-10-2006	11:15	Flood	1.36	0.19	0.18	0.05	<0.3	–	0.65	0.02	6.95	1.08
Ramalhete	07 56.917 W	37 00.350 N	19-10-2006	14:25	High Water	0.95	0.17	0.14	0.03	<0.3	–	0.44	0.05	5.39	0.07
Ramalhete	07 56.917 W	37 00.350 N	19-10-2006	17:15	Ebb	0.83	0.05	0.13	0.03	<0.1	–	0.37	0.06	8.15	0.95
Ramalhete	07 56.917 W	37 00.350 N	20-10-2006	8:55	Low Water	1.59	0.10	0.39	0.04	0.59	0.08	1.29	0.34	15.50	0.42
Ramalhete	07 56.917 W	37 00.350 N	20-10-2006	11:50	Flood	1.09	0.17	0.29	0.06	0.37	0.08	0.74	0.15	10.95	0.18
Ramalhete	07 56.917 W	37 00.350 N	20-10-2006	14:45	High Water	0.82	0.11	0.24	0.05	<0.3	–	0.52	0.07	10.13	0.59
Ramalhete	07 56.917 W	37 00.350 N	20-10-2006	17:55	Ebb	0.82	0.13	0.18	0.05	<0.1	–	0.34	0.04	7.79	0.46

Table 2.2. Temperature data for Ponte da Praia de Faro and Ramalhete station between 10 of April 2006 to 20 of October 2006.

Station	LATITUDE	LONGITUDE	Date	Hour	Tide Condition	Temperature (ºC)
Ramalhete	07 56.917 W	37 00.350 N	10-04-2006	7:59	Neap Tide / Low Water	17,1
Ramalhete	07 56.917 W	37 00.350 N	24-04-2006	7:03	Neap Tide / Low Water	15,9
Ramalhete	07 56.917 W	37 00.350 N	09-05-2006	7:15	Neap Tide / Low Water	18.1
Ramalhete	07 56.917 W	37 00.350 N	23-05-2006	6:25	Neap Tide / Low Water	17.7
Ramalhete	07 56.917 W	37 00.350 N	08-06-2006	7:00	Neap Tide / Low Water	21.3
Ramalhete	07 56.917 W	37 00.350 N	22-06-2006	6:45	Neap Tide / Low Water	25.3
Ramalhete	07 56.917 W	37 00.350 N	07-07-2006	6:30	Neap Tide / Low Water	21.4
Ramalhete	07 56.917 W	37 00.350 N	21-07-2006	6:25	Neap Tide / Low Water	24.4
Ramalhete	07 56.917 W	37 00.350 N	07-08-2006	7:48	Neap Tide / Low Water	25.9
Ramalhete	07 56.917 W	37 00.350 N	19-08-2006	-	Neap Tide / Low Water	20.7
Ramalhete	07 56.917 W	37 00.350 N	06-09-2006	7:50	Neap Tide / Low Water	25.4
Ramalhete	07 56.917 W	37 00.350 N	19-09-2006	8:00	Neap Tide / Low Water	20.6
Ramalhete	07 56.917 W	37 00.350 N	04-10-2006	7:30	Neap Tide / Low Water	19.6
Ramalhete	07 56.917 W	37 00.350 N	16-10-2006	9:05	Flood	20.0
Ramalhete	07 56.917 W	37 00.350 N	16-10-2006	12:00	High Water	20.0
Ramalhete	07 56.917 W	37 00.350 N	16-10-2006	15:30	Ebb	21.0
Ramalhete	07 56.917 W	37 00.350 N	16-10-2006	18:55	Low Water	20.0
Ramalhete	07 56.917 W	37 00.350 N	17-10-2006	7:30	Low Water	19.5
Ramalhete	07 56.917 W	37 00.350 N	17-10-2006	10:00	Flood	19.5
Ramalhete	07 56.917 W	37 00.350 N	17-10-2006	12:45	High Water	20.0
Ramalhete	07 56.917 W	37 00.350 N	17-10-2006	16:15	Ebb	21.0
Ramalhete	07 56.917 W	37 00.350 N	18-10-2006	7:55	Low Water	19.0
Ramalhete	07 56.917 W	37 00.350 N	18-10-2006	10:45	Flood	20.0
Ramalhete	07 56.917 W	37 00.350 N	18-10-2006	13:45	High Water	20.0
Ramalhete	07 56.917 W	37 00.350 N	18-10-2006	16:54	Ebb	21.0
Ramalhete	07 56.917 W	37 00.350 N	19-10-2006	8:25	Low Water	19.0
Ramalhete	07 56.917 W	37 00.350 N	19-10-2006	11:15	Flood	19.8
Ramalhete	07 56.917 W	37 00.350 N	19-10-2006	14:25	High Water	20.0

Ramalhete	07 56.917 W	37 00.350 N	19-10-2006	17:15	Ebb	20.0
Ramalhete	07 56.917 W	37 00.350 N	20-10-2006	8:55	Low Water	19.0
Ramalhete	07 56.917 W	37 00.350 N	20-10-2006	11:50	Flood	20.0
Ramalhete	07 56.917 W	37 00.350 N	20-10-2006	14:45	High Water	20.0
Ramalhete	07 56.917 W	37 00.350 N	20-10-2006	17:55	Ebb	20.5
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	10-04-2006	8:53	Neap Tide / Low Water	18,2
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	24-04-2006	7:57	Neap Tide / Low Water	16,4
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	09-05-2006	8:03	Neap Tide / Low Water	19.5
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	23-05-2006	7:09	Neap Tide / Low Water	18.3
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	08-06-2006	7:45	Neap Tide / Low Water	22.9
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	22-06-2006	7:30	Neap Tide / Low Water	25.4
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	07-07-2006	7:07	Neap Tide / Low Water	23.2
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	21-07-2006	7:30	Neap Tide / Low Water	25.8
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	07-08-2006	8:21	Neap Tide / Low Water	26.8
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	19-08-2006	7:21	Neap Tide / Low Water	22.1
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	06-09-2006	-	Neap Tide / Low Water	25.9
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	19-09-2006	8:35	Neap Tide / Low Water	21.5
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	04-10-2006	8:20	Neap Tide / Low Water	21.4
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	16-10-2006	8:40	Flood	21.0
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	16-10-2006	11:40	High Water	20.0
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	16-10-2006	15:30	Ebb	20.8
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	16-10-2006	18:20	Low Water	20.6
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	17-10-2006	9:55	Flood	20.1
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	17-10-2006	12:25	High Water	20.0
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	17-10-2006	15:55	Ebb	20.1
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	18-10-2006	7:50	Low Water	20.0
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	18-10-2006	10:30	Flood	20.8
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	18-10-2006	13:30	High Water	20.6
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	18-10-2006	16:30	Ebb	20.5
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	19-10-2006	8:10	Low Water	19.9
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	19-10-2006	11:10	Flood	20.0

Ponte da Praia de Faro	07 59.600 W	37 00.533 N	19-10-2006	14:15	High Water	21.0
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	19-10-2006	17:15	Ebb	20.1
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	20-10-2006	8:45	Low Water	20.0
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	20-10-2006	11:30	Flood	20.1
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	20-10-2006	14:25	High Water	20.8
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	20-10-2006	17:35	Ebb	20.5

Table 2.3. Salinity data for Ponte da Praia de Faro and Ramalhete station between 10 of April 2006 to 20 of October 2006.

Station	LATITUDE	LONGITUDE	Date	Hour	Tide condition	Salinity
Ramalhete	07 56.917 W	37 00.350 N	10-04-2006	7:59	Neap Tide / Low Water	36,4
Ramalhete	07 56.917 W	37 00.350 N	24-04-2006	7:03	Neap Tide / Low Water	34,8
Ramalhete	07 56.917 W	37 00.350 N	09-05-2006	7:15	Neap Tide / Low Water	37.4
Ramalhete	07 56.917 W	37 00.350 N	23-05-2006	6:25	Neap Tide / Low Water	37.6
Ramalhete	07 56.917 W	37 00.350 N	08-06-2006	7:00	Neap Tide / Low Water	38.3
Ramalhete	07 56.917 W	37 00.350 N	22-06-2006	6:45	Neap Tide / Low Water	37.5
Ramalhete	07 56.917 W	37 00.350 N	07-07-2006	6:30	Neap Tide / Low Water	39.6
Ramalhete	07 56.917 W	37 00.350 N	21-07-2006	6:25	Neap Tide / Low Water	37.8
Ramalhete	07 56.917 W	37 00.350 N	07-08-2006	7:48	Neap Tide / Low Water	38
Ramalhete	07 56.917 W	37 00.350 N	19-08-2006	-	Neap Tide / Low Water	38
Ramalhete	07 56.917 W	37 00.350 N	06-09-2006	7:50	Neap Tide / Low Water	37.9
Ramalhete	07 56.917 W	37 00.350 N	19-09-2006	8:00	Neap Tide / Low Water	37.3
Ramalhete	07 56.917 W	37 00.350 N	04-10-2006	7:30	Neap Tide / Low Water	37.1
Ramalhete	07 56.917 W	37 00.350 N	16-10-2006	9:05	Flood	36.5
Ramalhete	07 56.917 W	37 00.350 N	16-10-2006	12:00	High Water	36.5
Ramalhete	07 56.917 W	37 00.350 N	16-10-2006	15:30	Ebb	36.7
Ramalhete	07 56.917 W	37 00.350 N	16-10-2006	18:55	Low Water	36.7
Ramalhete	07 56.917 W	37 00.350 N	17-10-2006	7:30	Low Water	36.5
Ramalhete	07 56.917 W	37 00.350 N	17-10-2006	10:00	Flood	36.6
Ramalhete	07 56.917 W	37 00.350 N	17-10-2006	12:45	High Water	36.7
Ramalhete	07 56.917 W	37 00.350 N	17-10-2006	16:15	Ebb	35.7

Ramalhete	07 56.917 W	37 00.350 N	18-10-2006	7:55	Low Water	32.6
Ramalhete	07 56.917 W	37 00.350 N	18-10-2006	10:45	Flood	35.6
Ramalhete	07 56.917 W	37 00.350 N	18-10-2006	13:45	High Water	35.6
Ramalhete	07 56.917 W	37 00.350 N	18-10-2006	16:54	Ebb	35.7
Ramalhete	07 56.917 W	37 00.350 N	19-10-2006	8:25	Low Water	35.4
Ramalhete	07 56.917 W	37 00.350 N	19-10-2006	11:15	Flood	35.1
Ramalhete	07 56.917 W	37 00.350 N	19-10-2006	14:25	High Water	35.7
Ramalhete	07 56.917 W	37 00.350 N	19-10-2006	17:15	Ebb	35.7
Ramalhete	07 56.917 W	37 00.350 N	20-10-2006	8:55	Low Water	35.6
Ramalhete	07 56.917 W	37 00.350 N	20-10-2006	11:50	Flood	35.5
Ramalhete	07 56.917 W	37 00.350 N	20-10-2006	14:45	High Water	35.6
Ramalhete	07 56.917 W	37 00.350 N	20-10-2006	17:55	Ebb	36.2
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	10-04-2006	8:53	Neap Tide / Low Water	36
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	24-04-2006	7:57	Neap Tide / Low Water	35,3
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	09-05-2006	8:03	Neap Tide / Low Water	36.9
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	23-05-2006	7:09	Neap Tide / Low Water	37.4
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	08-06-2006	7:45	Neap Tide / Low Water	37.6
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	22-06-2006	7:30	Neap Tide / Low Water	36.8
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	07-07-2006	7:07	Neap Tide / Low Water	37.7
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	21-07-2006	7:30	Neap Tide / Low Water	37.4
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	07-08-2006	8:21	Neap Tide / Low Water	37.9
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	19-08-2006	7:21	Neap Tide / Low Water	36.8
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	06-09-2006	-	Neap Tide / Low Water	37.7
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	19-09-2006	8:35	Neap Tide / Low Water	37.7
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	04-10-2006	8:20	Neap Tide / Low Water	37
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	16-10-2006	8:40	Flood	36.6
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	16-10-2006	11:40	High Water	36.5
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	16-10-2006	15:30	Ebb	36.5
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	16-10-2006	18:20	Low Water	36.4
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	17-10-2006	8:05	Low Water	36.7
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	17-10-2006	9:55	Flood	36.5

Ponte da Praia de Faro	07 59.600 W	37 00.533 N	17-10-2006	12:25	High Water	36.5
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	17-10-2006	15:55	Ebb	35.9
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	18-10-2006	7:50	Low Water	33.2
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	18-10-2006	10:30	Flood	36.1
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	18-10-2006	13:30	High Water	36.3
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	18-10-2006	16:30	Ebb	36.2
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	19-10-2006	8:10	Low Water	34.2
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	19-10-2006	11:10	Flood	35.5
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	19-10-2006	14:15	High Water	35.9
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	19-10-2006	17:15	Ebb	35.6
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	20-10-2006	8:45	Low Water	34.5
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	20-10-2006	11:30	Flood	35.5
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	20-10-2006	14:25	High Water	36.1
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	20-10-2006	17:35	Ebb	35.9

Table 2.4. Chlorophyll-*a* (Chl-*a*) data for Ponte da Praia de Faro and Ramalhete station between 10 of April 2006 to 20 of October 2006.

Station	LATITUDE	LONGITUDE	Date	Hour	Tide condition	Chl-*a* (µg/L)
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	10-04-2006	8:53	Neap Tide / Low Water	0.80
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	24-04-2006	7:57	Neap Tide / Low Water	1.87
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	09-05-2006	8:03	Neap Tide / Low Water	2.54
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	23-05-2006	7:09	Neap Tide / Low Water	1.87
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	08-06-2006	7:45	Neap Tide / Low Water	5.87
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	22-06-2006	7:30	Neap Tide / Low Water	2.00
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	07-07-2006	7:07	Neap Tide / Low Water	0.53
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	21-07-2006	7:30	Neap Tide / Low Water	0.13
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	07-08-2006	8:21	Neap Tide / Low Water	1.34
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	06-09-2006	-	Neap Tide / Low Water	4.72
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	04-10-2006	8:20	Neap Tide / Low Water	1.78
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	16-10-2006	08.45	Flood	0.27
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	16-10-2006	11.40	High water	0.27

Ponte da Praia de Faro	07 59.600 W	37 00.533 N	16-10-2006	18.20	Low Water	0.80
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	17-10-2006	08.20	Low Water	0.53
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	17-10-2006	09.55	Flood	0.27
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	17-10-2006	12.25	High water	0.27
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	17-10-2006	15.55	Ebb	0.53
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	18-10-2006	08.50	Low Water	0.53
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	18-10-2006	13.30	High water	0.53
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	18-10-2006	16.30	Ebb	0.53
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	19-10-2006	08.10	Low Water	1.60
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	19-10-2006	11.10	Flood	0.53
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	19-10-2006	14.45	High water	0.53
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	19-10-2006	17.15	Ebb	1.60
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	20-10-2006	08.40	Low Water	1.60
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	20-10-2006	11.30	Flood	1.07
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	20-10-2006	14.25	High water	1.07
Ramalhete	07 56.917 W	37 00.350 N	10-04-2006	7:59	Neap Tide / Low Water	9.61
Ramalhete	07 56.917 W	37 00.350 N	24-04-2006	7:03	Neap Tide / Low Water	0.53
Ramalhete	07 56.917 W	37 00.350 N	09-05-2006	7:15	Neap Tide / Low Water	4.81
Ramalhete	07 56.917 W	37 00.350 N	23-05-2006	6:25	Neap Tide / Low Water	0.80
Ramalhete	07 56.917 W	37 00.350 N	08-06-2006	7:00	Neap Tide / Low Water	2.54
Ramalhete	07 56.917 W	37 00.350 N	22-06-2006	6:45	Neap Tide / Low Water	2.00
Ramalhete	07 56.917 W	37 00.350 N	07-07-2006	6:30	Neap Tide / Low Water	0.27
Ramalhete	07 56.917 W	37 00.350 N	21-07-2006	6:25	Neap Tide / Low Water	0.40
Ramalhete	07 56.917 W	37 00.350 N	07-08-2006	7:48	Neap Tide / Low Water	1.87
Ramalhete	07 56.917 W	37 00.350 N	06-09-2006	7:50	Neap Tide / Low Water	7.57
Ramalhete	07 56.917 W	37 00.350 N	04-10-2006	7:30	Neap Tide / Low Water	2.94
Ramalhete	07 56.917 W	37 00.350 N	16-10-2006	09.05	Flood	0.53
Ramalhete	07 56.917 W	37 00.350 N	16-10-2006	12.00	High water	0.53
Ramalhete	07 56.917 W	37 00.350 N	16-10-2006	15.30	Ebb	1.34
Ramalhete	07 56.917 W	37 00.350 N	16-10-2006	18.55	Low Water	0.80
Ramalhete	07 56.917 W	37 00.350 N	17-10-2006	10.00	Flood	0.27

Ramalhete	07 56.917 W	37 00.350 N	17-10-2006	12.45	High water	1.60
Ramalhete	07 56.917 W	37 00.350 N	17-10-2006	16.15	Ebb	0.53
Ramalhete	07 56.917 W	37 00.350 N	18-10-2006	07.55	Low Water	1.07
Ramalhete	07 56.917 W	37 00.350 N	18-10-2006	10.45	Flood	0.53
Ramalhete	07 56.917 W	37 00.350 N	18-10-2006	13.45	High water	1.07
Ramalhete	07 56.917 W	37 00.350 N	18-10-2006	16.54	Ebb	1.07
Ramalhete	07 56.917 W	37 00.350 N	19-10-2006	11.15	Flood	1.60
Ramalhete	07 56.917 W	37 00.350 N	19-10-2006	14.25	High water	1.07
Ramalhete	07 56.917 W	37 00.350 N	19-10-2006	17.15	Ebb	1.07
Ramalhete	07 56.917 W	37 00.350 N	20-10-2006	08.55	Low Water	2.14
Ramalhete	07 56.917 W	37 00.350 N	20-10-2006	11.50	Flood	0.53
Ramalhete	07 56.917 W	37 00.350 N	20-10-2006	14.45	High water	1.07
Ramalhete	07 56.917 W	37 00.350 N	20-10-2006	17.55	Ebb	1.07

Table 2.5. Oxygen data for Ponte da Praia de Faro and Ramalhete station between 10 of April 2006 to 20 of October 2006.

Station	LATITUDE	LONGITUDE	Date	Hour	Tide condition	[O2] (mg/L)
Ramalhete	07 56.917 W	37 00.350 N	10-04-2006	7:59	Neap Tide / Low Water	8.44
Ramalhete	07 56.917 W	37 00.350 N	24-04-2006	7:03	Neap Tide / Low Water	9.32
Ramalhete	07 56.917 W	37 00.350 N	09-05-2006	7:15	Neap Tide / Low Water	9.25
Ramalhete	07 56.917 W	37 00.350 N	23-05-2006	6:25	Neap Tide / Low Water	7.14
Ramalhete	07 56.917 W	37 00.350 N	08-06-2006	7:00	Neap Tide / Low Water	6.44
Ramalhete	07 56.917 W	37 00.350 N	22-06-2006	6:45	Neap Tide / Low Water	5.83
Ramalhete	07 56.917 W	37 00.350 N	07-07-2006	6:30	Neap Tide / Low Water	4.63
Ramalhete	07 56.917 W	37 00.350 N	21-07-2006	6:25	Neap Tide / Low Water	5.53
Ramalhete	07 56.917 W	37 00.350 N	07-08-2006	7:48	Neap Tide / Low Water	5.33
Ramalhete	07 56.917 W	37 00.350 N	19-08-2006		Neap Tide / Low Water	6.68
Ramalhete	07 56.917 W	37 00.350 N	06-09-2006	7:50	Neap Tide / Low Water	4.24
Ramalhete	07 56.917 W	37 00.350 N	19-09-2006	8:00	Neap Tide / Low Water	4.68
Ramalhete	07 56.917 W	37 00.350 N	04-10-2006	7:30	Neap Tide / Low Water	6.66
Ramalhete	07 56.917 W	37 00.350 N	16-10-2006	9:05	Flood	6.17
Ramalhete	07 56.917 W	37 00.350 N	16-10-2006	12:00	High Water	6.28

Ramalhete	07 56.917 W	37 00.350 N	16-10-2006	15:30	Ebb	7.98
Ramalhete	07 56.917 W	37 00.350 N	16-10-2006	18:55	Low Water	7.34
Ramalhete	07 56.917 W	37 00.350 N	17-10-2006	7:30	Low Water	6.06
Ramalhete	07 56.917 W	37 00.350 N	17-10-2006	10:00	Flood	6.38
Ramalhete	07 56.917 W	37 00.350 N	17-10-2006	12:45	High Water	7.13
Ramalhete	07 56.917 W	37 00.350 N	17-10-2006	16:15	Ebb	7.98
Ramalhete	07 56.917 W	37 00.350 N	18-10-2006	7:55	Low Water	5.75
Ramalhete	07 56.917 W	37 00.350 N	18-10-2006	10:45	Flood	7.02
Ramalhete	07 56.917 W	37 00.350 N	18-10-2006	13:45	High Water	7.45
Ramalhete	07 56.917 W	37 00.350 N	18-10-2006	16:54	Ebb	8.83
Ramalhete	07 56.917 W	37 00.350 N	19-10-2006	8:25	Low Water	6.54
Ramalhete	07 56.917 W	37 00.350 N	19-10-2006	11:15	Flood	6.70
Ramalhete	07 56.917 W	37 00.350 N	19-10-2006	14:25	High Water	7.77
Ramalhete	07 56.917 W	37 00.350 N	19-10-2006	17:15	Ebb	8.51
Ramalhete	07 56.917 W	37 00.350 N	20-10-2006	8:55	Low Water	6.75
Ramalhete	07 56.917 W	37 00.350 N	20-10-2006	11:50	Flood	7.86
Ramalhete	07 56.917 W	37 00.350 N	20-10-2006	14:45	High Water	8.46
Ramalhete	07 56.917 W	37 00.350 N	20-10-2006	17:55	Ebb	8.30
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	10-04-2006	8:53	Neap Tide / Low Water	7.28
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	24-04-2006	7:57	Neap Tide / Low Water	8.74
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	09-05-2006	8:03	Neap Tide / Low Water	8.15
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	23-05-2006	7:09	Neap Tide / Low Water	5.83
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	08-06-2006	7:45	Neap Tide / Low Water	5.63
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	22-06-2006	7:30	Neap Tide / Low Water	6.14
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	07-07-2006	7:07	Neap Tide / Low Water	7.24
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	21-07-2006	7:30	Neap Tide / Low Water	5.22
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	07-08-2006	8:21	Neap Tide / Low Water	5.63
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	19-08-2006	7:21	Neap Tide / Low Water	6.16
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	06-09-2006		Neap Tide / Low Water	4.52
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	19-09-2006	8:35	Neap Tide / Low Water	7.55
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	04-10-2006	8:20	Neap Tide / Low Water	5.64

Ponte da Praia de Faro	07 59.600 W	37 00.533 N	16-10-2006	8:40	Flood	6.92
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	16-10-2006	11:40	High Water	6.28
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	16-10-2006	15:30	Ebb	7.18
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	16-10-2006	18:20	Low Water	7.34
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	17-10-2006	8:05	Low Water	6.22
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	17-10-2006	9:55	Flood	6.49
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	17-10-2006	12:25	High Water	6.81
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	17-10-2006	15:55	Ebb	7.23
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	18-10-2006	7:50	Low Water	6.38
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	18-10-2006	10:30	Flood	6.38
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	18-10-2006	13:30	High Water	7.34
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	18-10-2006	16:30	Ebb	7.77
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	19-10-2006	8:10	Low Water	6.38
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	19-10-2006	11:10	Flood	6.60
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	19-10-2006	14:15	High Water	7.02
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	19-10-2006	17:15	Ebb	7.77
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	20-10-2006	8:45	Low Water	6.64
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	20-10-2006	11:30	Flood	6.31
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	20-10-2006	14:25	High Water	7.97
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	20-10-2006	17:35	Ebb	7.41

Table 2.6. Suspended Particulate Matter (SPM), particulate organic matter (POM) and particulate inorganic matter (PIM) data for Ponte da Praia de Faro and Ramalhete station between 10 of April 2006 to 20 of October 2006.

Station	LATITUDE	LONGITUDE	Date	Hour	Tide condition	SPM (mg/l)	POM (mg/l)	PIM (mg/l)
Ramalhete	07 56.917 W	37 00.350 N	10-04-2006	7:59	Neap Tide / Low Water	33.2	3.6	29.6
Ramalhete	07 56.917 W	37 00.350 N	24-04-2006	7:03	Neap Tide / Low Water	28.2	3.3	24.9
Ramalhete	07 56.917 W	37 00.350 N	09-05-2006	7:15	Neap Tide / Low Water	34.8	4.6	30.2
Ramalhete	07 56.917 W	37 00.350 N	23-05-2006	6:25	Neap Tide / Low Water	35.1	3.4	31.7
Ramalhete	07 56.917 W	37 00.350 N	08-06-2006	7:00	Neap Tide / Low Water	29.4	3.4	26
Ramalhete	07 56.917 W	37 00.350 N	22-06-2006	6:45	Neap Tide / Low Water	29.5	4.1	25.4

Ramalhete	07 56.917 W	37 00.350 N	07-07-2006	6:30	Neap Tide / Low Water	24.7	4.6	20.1
Ramalhete	07 56.917 W	37 00.350 N	07-08-2006	7:48	Neap Tide / Low Water	34.6	5.8	28.8
Ramalhete	07 56.917 W	37 00.350 N	19-08-2006		Neap Tide / Low Water	21.2	7.7	13.5
Ramalhete	07 56.917 W	37 00.350 N	06-09-2006	7:50	Neap Tide / Low Water	37.6	8	29.6
Ramalhete	07 56.917 W	37 00.350 N	19-09-2006	8:00	Neap Tide / Low Water	36.9	15.9	21
Ramalhete	07 56.917 W	37 00.350 N	04-10-2006	7:30	Neap Tide / Low Water	38.1	9.4	28.7
Ramalhete	07 56.917 W	37 00.350 N	16-10-2006	08.50	Flood	42.7	8.8	33.9
Ramalhete	07 56.917 W	37 00.350 N	16-10-2006	11.56	High water	44.6	10.1	34.5
Ramalhete	07 56.917 W	37 00.350 N	16-10-2006	14.55	Ebb	16.5	3	13.5
Ramalhete	07 56.917 W	37 00.350 N	16-10-2006	18.31	Low Water	45.2	8.8	36.4
Ramalhete	07 56.917 W	37 00.350 N	17-10-2006	7:30	Low Water	41.8	10.9	30.9
Ramalhete	07 56.917 W	37 00.350 N	17-10-2006	10:00	Flood	35.2	6.6	28.6
Ramalhete	07 56.917 W	37 00.350 N	17-10-2006	12:45	High water	77.6	14.8	62.8
Ramalhete	07 56.917 W	37 00.350 N	17-10-2006	16:15	Ebb	75.2	15.4	59.8
Ramalhete	07 56.917 W	37 00.350 N	18-10-2006	7:55	Low Water	40.2	5	35.2
Ramalhete	07 56.917 W	37 00.350 N	18-10-2006	10:45	Flood	73.4	14.2	59.2
Ramalhete	07 56.917 W	37 00.350 N	18-10-2006	13:45	High Water	32.8	4.4	28.4
Ramalhete	07 56.917 W	37 00.350 N	18-10-2006	16:45	Ebb	39.2	5.8	33.4
Ramalhete	07 56.917 W	37 00.350 N	19-10-2006	8:25	Low Water	23.4	3.8	19.6
Ramalhete	07 56.917 W	37 00.350 N	19-10-2006	11:15	Flood	86.4	11.2	75.2
Ramalhete	07 56.917 W	37 00.350 N	19-10-2006	14:25	High water	77.2	9.8	67.4
Ramalhete	07 56.917 W	37 00.350 N	19-10-2006	17:15	Ebb	72.6	11.2	61.4
Ramalhete	07 56.917 W	37 00.350 N	20-10-2006	8:55	Low Water	45.4	4.4	41
Ramalhete	07 56.917 W	37 00.350 N	20-10-2006	11:50	Flood	18.8	1.2	17.6
Ramalhete	07 56.917 W	37 00.350 N	20-10-2006	14:45	High water	14.4	1.8	12.6
Ramalhete	07 56.917 W	37 00.350 N	20-10-2006	17:55	Ebb	26.8	3.2	23.6
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	10-04-2006	8:53	Neap Tide / Low Water	15.7	1.7	14
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	24-04-2006	7:57	Neap Tide / Low Water	27.7	3.6	24.1
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	09-05-2006	8:03	Neap Tide / Low Water	36	7.2	28.8
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	23-05-2006	7:09	Neap Tide / Low Water	38.8	4.2	34.6
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	08-06-2006	7:45	Neap Tide / Low Water	32.2	2.6	29.6

Ponte da Praia de Faro	07 59.600 W	37 00.533 N	22-06-2006	7:30	Neap Tide / Low Water	35.1	5.7	29.4
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	07-07-2006	7:07	Neap Tide / Low Water	24.8	4.2	20.6
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	07-08-2006	8:21	Neap Tide / Low Water	23.4	3.8	19.6
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	19-08-2006	7:21	Neap Tide / Low Water	24.5	7.2	17.3
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	06-09-2006		Neap Tide / Low Water	39.7	7.5	32.2
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	19-09-2006	8:35	Neap Tide / Low Water	16.3	3.8	12.5
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	04-10-2006	8:20	Neap Tide / Low Water	38.3	5.5	32.8
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	16-10-2006	08.45	Flood	42	9.3	32.7
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	16-10-2006	11.40	High water	35.4	5.2	30.2
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	16-10-2006	15.05	Ebb	37.9	8.7	29.2
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	16-10-2006	18.20	Low Water	37	8.8	28.2
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	17-10-2006	8:05	Low Water	45.5	9.6	35.9
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	17-10-2006	9:55	Flood	37.6	8.4	29.2
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	17-10-2006	12:25	High water	38.2	8.4	29.8
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	17-10-2006	15:55	Ebb	74.4	17.4	57
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	18-10-2006	8:50	Low Water	67.4	10.8	56.6
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	18-10-2006	10:30	Flood	68.4	13.2	55.2
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	18-10-2006	13:30	High Water	22.4	3	19.4
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	18-10-2006	16:30	Ebb	15.8	2.6	13.2
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	19-10-2006	8:10	Low Water	18.2	3.8	14.4
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	19-10-2006	11:10	Flood	27.6	4.4	23.2
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	19-10-2006	14:15	High water	43	5.8	37.2
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	19-10-2006	17:15	Ebb	20.8	3.6	17.2
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	20-10-2006	8:45	Low Water	42.2	4.6	37.6
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	20-10-2006	11:30	Flood	37.2	5.6	31.6
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	20-10-2006	14:25	High water	41.8	4.8	37
Ponte da Praia de Faro	07 59.600 W	37 00.533 N	20-10-2006	17:35	Ebb	76.4	11	65.4

Appendix 3. Models and their output

The EcoWin2000 is made available as a dll file (together with an excel file where main parameters are defined) from which the model can be run.

FARM™ model is implemented as web-based client-server application it is available at www.farmscale.org.