Fifth Framework Programme of the European Commission 1998-2002
Energy, Environment and Sustainable Development (EESD) Programme

FerryBox

From On-line Oceanographic Observations to Environmental Information

Report on the Functionality of the Ferrybox Systems Onboard of the Ferries

Description of the FerryBox Systems

Contract number : EVK2-2002-00144

Deliverable number : D-2-1

Revision : 2.0

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Document Reference Sheet

This report is an update of the previously delivered system and route description (deliverable no. D-2-1 – revisions 1.0, 1.1, 1.2, 1.3 and 1.4) of the FerryBoxes involved in the project for final publication on the FerryBox website and the FerryBox Report CD-ROM.

It includes the status of the systems as per end of the first project year which partly differs from the state at the end of the first six-month period. This report is public.

Editor: This report was finally edited and compiled by the leader of work package 2, W. Petersen (GKSS).

Contributors: All operators of FerryBox systems involved in the project respectively in work package 2 contributed to this report with system information.

Keywords

FerryBox, European FerryBox Project, underway measurements, Ferrybox system description, Ferrybox functionality, metrology of Ferrybox systems, measurement principles, calibration methods, maintenance, quality assurance, sensors

Document Reference Sheet

This document has been elaborated and issued by the European FerryBox Consortium.

P 1	**GKSS**	**GKSS Research Centre Institute for Coastal Research**	**Coordinator**
P 2	**NERC.NOC**	**NERC.NOC – National Oceanography Centre Southampton University and National Environment Res. Council** formerly NERC.SOC – Southampton Oceanography Centre	
P 3	**NIOZ**	**Royal Netherlands Institute of Sea Research**	
P 4	**FIMR**	**Finnish Institute of Marine Research**	
P 5	**HCMR** (formerly NCMR)	**Hellenic Centre for Marine Research** (formerly National Centre for Marine Research)	
P 6	**NERC.POL**	**Proudman Oceanographic Laboratory**	
P 7	**NIVA**	**Norwegian Institute for Water Research**	
P 8	**HYDROMOD**	**HYDROMOD Scientific Consulting**	
P 9	**CTG** **(formerly CIL)**	**Chelsea Technology Group (formerly Chelsea Instruments Ltd.)**	
P 10	**IEO**	**Spanish Institute of Oceanography**	
P 11	**EMI**	**Estonian Marine Institute** (in cooperation with the Estonian Maritime Academy)	

The European FerryBox Project was co-funded by the European Commission under the Fifth Framework Programme of the European Commission 1998-2002 – Energy, Environment and Sustainable Development (EESD) Programme under contract no. EVK2-2002-00144.

Document Control Table

Project acronym:	FerryBox		Contract no.:	EVK2-2002-00144	
Deliverable No.:	D-2-1		Revision:	2.0	
WP number and title:	WP-2	Operation and metrology of the FerryBox Systems			
Work Package Manager:	Wilhelm Petersen, GKSS				
Work Package Team:	FerryBox Work Package 2 Team				
Title of deliverable:	Report on the Functionality of the Ferrybox Systems Onboard of the Ferries Description of the FerryBox Systems				
Document owner:	European FerryBox Project Consortium				
Category of deliverable:	Final Report				
Document classification:	PU – Public				
Contents of deliverable:	Description of ferry routes, Ferrybox systems and sensors applied in the project and of the parameters measured along the ferry tracks.				
Pages (total):	39	Figures:	9	Tables:	20
Remarks:	Revision 2.0 replaces the previously delivered revision 1.2 of this report entirely. Revision 2.0 was assembled for publication on the FerryBox website and the FerryBox Report CD-ROM.				
Editor:	Wilhelm Petersen	Leader work package 2	GKSS		
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Project web site :	http://www.ferrybox.org				

Revision Control

Revision	Date (MM-YYYY)	Released by	Distribution	Purpose of release and remarks
1.0	06-2003	Co-ordinator	European Commission and project consortium	First six-monthly reporting
1.1	01-2004	Co-ordinator	European Commission and project consortium	Updated version for first year reporting
1.2	02-2004	Co-ordinator	Extended and public.	Minor corrections (especially for entries of routes 1-A and 1-B) and some adaptations for general public distribution.
1.3	02-2006	Co-ordinator	EU	Final update of route information
2.0	04-2006	Leader FerryBox WP-6	FerryBox website and FerryBox Report CD-ROM	Final editing for the FerryBox Report CD-ROM

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1 Overview on the FerryBox Routes

The installation of the measurement systems on all ferry routes were nearly completed within the first year of the project. The proposed two year operation cycle of all Ferryboxes therefore starts with the beginning of the second year (November 2003) of the project. An overview over the ferry routes is shown in the table and figure below.

Table 1-1: Ferry routes with FerryBox systems involved in the project.

Route No.	Area	Ferry Route
R-1-A	Baltic Sea	Helsinki (FI) – Travemünde (D)
R-1-B		Helsinki (FI) – Tallinn (EE)
R-2	Skagerrak	Oslo (N) – Hirtshals (DK)
R-3	North Sea	Cuxhaven (D) – Harwich (UK)
R-4	Wadden Sea	Den Helder – Texel (NL)
R-5	Irish Sea	Liverpool (UK) – Belfast (IR)
R-6	Solent	Southampton – Cowes (Isle of Wight) (UK)
R-7	Bay of Biscay	Portsmouth (UK) – Bilbao (ES)
R-8	Aegean Sea	Athens – Heraklion (GR)

Only at the route in the Irish Sea the system is not running up to now because NERC.POL had to change the route and has now selected a new line from Liverpool to Belfast. The FerryBox on this route will come into operation at end of December 2003.

The line from Southampton to Cowes which started work in 1999 was out of operation due to technical problems in 2003. A new system was built and in April 2004 fitted. The system was withdrawn from service in November 2004.

2 Description of the Actual System Status

This chapter presents a brief description of the status of the Ferrybox systems involved in the project as per the end of the first project year.

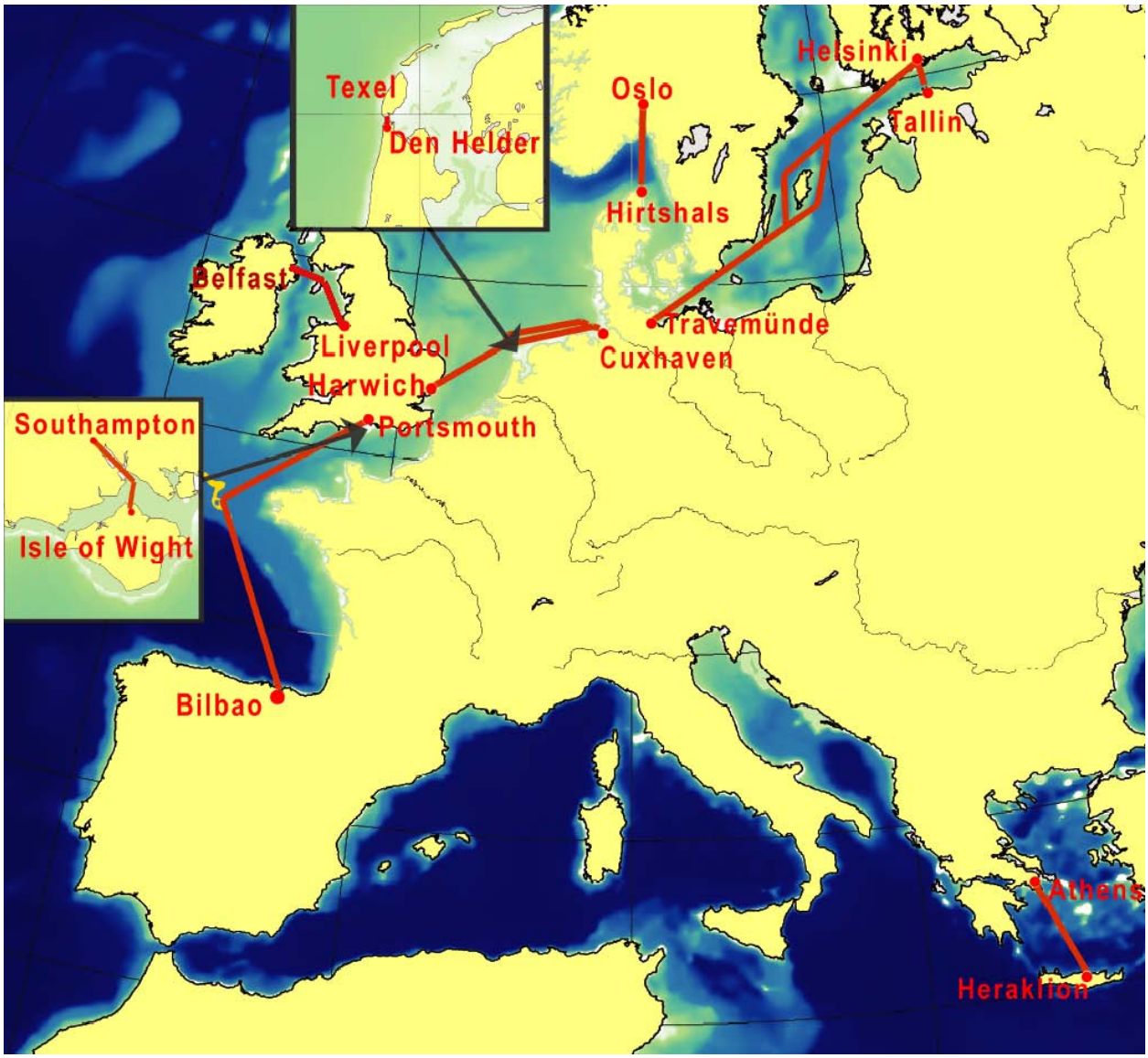

Figure 2-1: Map of ferry routes used in the EU funded FerryBox project.

An overview on measured parameters, applied sensors, measuring ranges and related information is provided by the tables in Chapter 4.

2.1 Routes 1-A and 1-B: Helsinki – Travemünde and Helsinki – Tallinn

Operators: **FIMR** **for Route 1-A**

FIMR and EMI **for Route 1-B**

Figure 2-2: Ferries ”M/S Finnpartner“ sailing on route R-1-A (upper photo) and “M/S Romantika” sailing on route R-1-B equipped with Ferrybox systems.

In the Baltic Sea the Ferrybox systems on both routes are in operational mode.

Calibration and validation processes were carried out periodically. Due to the long experience of FIMR and EMI with Ferrybox systems no substantially problems occurred.

Table 2-1: Main features of the FerryBox system on route R-1-A.

Route no.:	**R-1-A**	**Operator:**	**FIMR**
Description			**Remarks**
Route:	Helsinki (Finland) – Travemünde (Germany)		
Ship:	MS Finnpartner		
Ferry company:	Finnlines, Finland		
System type:	Flow through system		
Frequency:	Flow though data three times per week. Automated sampling for phytoplankton, chlorophyll-*a* and nutrients once per week from April to September.		
Travel time:	36 hours		
Control:	Once per week		
Features:	Brackish water salinity about 5 – 7		
Measured parameters:	Conductivity, water temperature, fluorescence; automated samples for nutrients, chlorophyll-*a*, phytoplankton		
Spatial resolution:	Flow through system: salinity, temperature and fluorescence every 200 m Water sampling for laboratory analysis at fixed latitudes		
Remote control:	No		
Data transfer:	Diskette		
Data storage:	Every 20 s outside harbour area		
Depth of water intake:	5 m		
Web site:	http://www.fimr.fi/en/itamerikanta.html		

Table 2-2: Main features of the Ferrybox system on route R-1-B.

Route no.:	**R-1-B**	**Operators:**	**FIMR and EMI**
Description			**Remarks**
Route:	Helsinki (Finland) – Tallinn (Estonia)		
Ship:	M/S Romantika		
Ferry company:	Tallink, Estonia		
System type:	Flow through system		
Frequency:	Flow through data twice per day. Automated sampling for phytoplankton, chlorophyll-*a* and nutrients once per week.		
Travel time:	3.5 hours		
Control:	Once per week		
Features:	Brackish water salinity about 5		
Measured parameters:	Conductivity, water temperature, fluorescence; automated samples for nutrients, chlorophyll-*a* and phytoplankton		
Spatial resolution:	Flow through system: salinity, temperature and fluorescence approximately every 200 metres Water sampling for subsequent laboratory analysis at fixed latitudes		
Remote control:	No		
Data transfer:	Diskette		
Data storage:	Every 20 s outside harbour area		
Depth of water intake:	4 m		
Web site:	http://www.fimr.fi/en/itamerikanta.html		

2.2 Route 2: Oslo – Hirtshals

Operator: NIVA

Figure 2-3: Ferry ”Color Festival“ equipped with a Ferrybox system sailing on route R-2.

The system has been in operation since August 2001 and in the first FerryBox year (2002) the sensor chamber and the air trapping unit has been rebuilt to increase the water flow and reduce the effect of the walls of the chamber on the Seapoint turbidity sensor. The water flow (2 l/min) caused still problems with air bubbles on the sensor optics.

The Seapoint turbidity sensor was replaced with a self cleaning Polymetron sensor in November 2003. After testing period this has been in operation since January 2004. Different water inlet was tested in 2003 and some of them caused air bubbles which the air trap could not handle. In spring 2005 a redesign of the systems was performed including a new place onboard with separate water intake for the Ferry-box system. Air pressure cleaning of the outlet and fresh water cleaning of the system whenever the ferry is in harbour has been used for periods, but presently only weekly mechanical cleaning are used.

The optional LiCor PAR sensor had interference and was in July 2005 replaced with RAMSES irradiance sensor. Also radiance sensors are from July 2005 in operation on the ferry. The routine maintenance has been implemented and is operated manually on weekly bases. Monthly calibration of the optical sensors is now implemented using Formazine turbidity standards for the Polymetron sensor and solid state fluorescence device for the Chl-a fluorescence sensor. Turbidity and Chl-a are also controlled with water samples.

The STD is controlled with a thermometer and salinity samples minimum twice per year.

Table 2-3: Main features of the Ferrybox system on route R-2.

Route no.:	**R-2**	**Operators:**	**NIVA**
Description			**Remarks**
Route:	Oslo (Norway) – Hirtshals (Denmark)		Operation from August 2001. New harbour in Denmark in April 2006.
Ship:	Color Festival		
Ferry company:	Color Line		
System type:	Flow through system. Design of NIVA.		
Frequency:	1 round trip per day		
Travel time:	Night time 12 hours, day time 6 hours		
Control:	The system is controlled with a LabView software,		
Features:	Automatic or remotely controlled water sampling and above water radiance measurements for satellite validation.		Water samples triggered during satellite overpass.
Measured parameters:	Conductivity, water temperature, turbidity, Chl-a fluorescence, light sensors. Samples collected for Chl-a with HPLC and TSM measurements		
Spatial resolution:	Every 400 to 800 m depending on night or day measurements 1 observation per minute.		
Remote control:	Via satellite link		
Data transfer:	Continuous over satellite link to NIVA database		
Data storage:	Onboard and database at NIVA		
Depth of water intake:	3-4 meters		
Web site:	http://www.ferrybox.no		Public presentation of the data

2.3 Route 3: Cuxhaven – Harwich

Operator: GKSS

Figure 2-4: Ferry "Duchess of Scandinavia" equipped with a Ferrybox system sailing on route R-3.

The ferry company stopped the line with the old ship (Admiral of Scandinavia) in November 2002 and came in operation with a new ship (Duchess of Scandinavia) in April 2003. Due to the non-availability of a ferryboat during the first months and problems to find a suitable place onboard of the new boat the FerryBox system came first into operational mode in September 2003.

For installation of the successfully used system the cupboard of the whole system had to be cut in smaller parts and the flow-through system had to be totally dismantled. After reinstallation an intensive calibration and testing of the system was carried out including all additional sensors.

For nitrate a new UV-nitrate sensor developed by GKSS and the company TRIOS (Germany) has been installed and undergoes intense tests by comparing the results with a chemical nitrate analyser and comparing with samples analysed in the laboratory.

The reliability of the results of the algal group analyser (bbe Moldaenke) is tested by comparison with the result of cell counting and HPLC analysis. Furthermore, this instrument is tested for measuring the Genty parameter in order to get estimates about the physiological status of the algae.

Table 2-4: Main features of the Ferrybox system on route R-3.

Route no.:	**R-3**	**Operator:**	**GKSS**
Description			**Remarks**
Route:	Cuxhaven (Germany) – Harwich (United Kingdom)		Reconstructed system in operation on new ferry boat since September 2003.
Ship:	Duchess of Scandinavia		
Ferry company:	DFDS Seaways		
System type:	Flow through system		
Frequency:	1 round trip every 2 days		
Travel time:			
Control:	Supervised by an industrial programmable logic control		
Features:	Automatic cleaning procedure by acidified tap water after each trip in the harbour		
Measured parameters:	Conductivity, water temperature, turbidity, dissolved oxygen, fluorescence, ammonium, nitrate/nitrite, phosphate, silicate, different algae groups		
Resolution:	Approximately 100 m – every 10 s; nutrients approximately 6 km – every 10 minutes		
Remote control:	System can be remotely controlled by GSM		
Data transfer:	Controlled by an industrial standard PC		
Data storage:	Controlled by an industrial standard PC		
Depth of water intake:	5 m		
Web site:	http://coast.gkss.de/projects/ferrybox		

2.4 Route 4: Den Helder – Texel

Operator: NIOZ

Figure 2-5: Ferry ”Schulpengat“ equipped with a Ferrybox system sailing on route R-4.

A new Acoustic Doppler Current Profiler (ADCP) has been prepared and installed below the Ferry.

For the flow-through system new pipes have been installed and new temperature, fluorescence and turbidity sensors were purchased and the software was adapted therefore.

After preparation of the flow-through system during the first months of the project this upgraded FerryBox system obtained now operational mode.

Table 2-5: Main features of the Ferrybox system on route R-4.

Route no.:	**R-4**	**Operator:**	**NIOZ**
Description			**Remarks**
Route:	Den Helder – Texel (the Netherlands)		Upgraded system in operation since 2003. Display in passenger lounge.
Ship:	Schulpengat		
Ferry company:	TESO (Texels Eigen Stoomboot Onderneming)		
System type:	Flow through system and hull mounted acoustic current profiling system (ADCP)		
Frequency:	Every 30 minutes, daily between 06.00 and 22.00 local time		
Travel time:			
Control:	External logging and display on ferry		
Features:			
Measured parameters:	Salinity, water temperature, fluorescence, turbidity horizontal current speed and direction		Optical measurements (fluores-cence, turbidity) are suspect due to air bubbles in the system
Resolution:	5 – 10 m		
Remote control:	By telemetry		
Data transfer:	Transferred to the nearby research centre by telemetry		
Data storage:	At the nearby research centre		
Depth of water intake:	0.50 m		
Web site:	http://www.nioz.nl/nioz_nl/9d47a8435be9d28bba07efb502044ac5.php		

2.5 Route 5: Liverpool – Belfast

Operator: NERC.POL

Figure 2-6: Ferry ”Liverpool Viking“ equipped with a Ferrybox system sailing on route R-5.

This FerryBox system was first installed on a ferry between Liverpool and Douglas (IOM). After several logger failures, the first results (recording temperature, salinity and turbidity) were successfully obtained during January 2003. Following subsequent trials, severe difficulties with both the functioning of the instrumentation and the ferry operation denoted that the use of the IOM ferry as an instrument platform was suspended.

One further dataset of a few days was obtained in May 2003. Intense inter-calibrations for all sensors were carried out with surface measurements onboard moored stations at the mouth of the Mersey (53°32’N, 3°21.8’W).

Discussions with the ferry operator Norse Merchant have taken place with the view of instrumenting two additional ferries in the Irish Sea between Liverpool and Dublin and Liverpool and Belfast. Progress has been made with instrumenting the Liverpool – Belfast ferry. This has involved substantial mechanical engineering of pipework, instrument chamber, and electrical work plus purchase of new instrumentation (Seapoint turbidity sensor, Sea-Bird SBE16 plus CTD). The work is nearly completed and entering into operation is expected before the end of December 2003.

Table 2-6: Main features of the Ferrybox system on route R-5.

Route no.:	R-5	Operator:	NERC.POL
Description			**Remarks**
Route:	Liverpool (UK) – Belfast (Northern Ireland)		
Ship:	Liverpool Viking		
Ferry company:	Norse Merchant		
System type:	Flow through system		
Frequency:			
Travel time:			
Control:	External logging		
Features:			
Measured parameters:	Conductivity, water temperature, turbidity, fluorescence		
Resolution:	Approximately 300 m (sampling frequency 30 s)		
Remote control:	None		
Data transfer:	External logging, plus data telemetry of spot values via ORBCOMM satellite every 15 minutes – started 18 October 2004.		
Data storage:	Files, final data banked at BODC		
Depth of water intake:	3.5 m		
Web site:	http://coastobs.pol.ac.uk		

2.6 Route 6: Southampton – Cowes

Operator: NERC.NOC

Figure 2-7: Ferry " Red Falcon "equipped with a Ferrybox system sailing on route R-6.

2.6.1 General System Description

This route was one of two operated by NERC.NOC as part of the FerryBox project. This system was only operated in spring to autumn to follow the progress of plankton blooms in Southampton Water and the Solent (which is a so called OSPAR "Potential Problem Area with respect to eutrophication"). Operations started in 1999 and the same equipment was used up until 2003 when severe technical difficulties were encountered with the equipment when the FerryBox was re-installed on the Red Funnel ferry in April 2003. Data was collected in April but this proved to too labour intensive to sustain due the unreliability of the system. Collection of new data from this route in 2003 was then planned to be deferred until autumn when a new system would be tested. However no new data was collected until April 2004

A new system for the Red Funnel ferry similar to that used on the Pride of Bilbao Route 7 was built and tested on shore in late 2003. In January 2004 the Red Funnel ferry used for the NERC.NOC FerryBox went out of service for 3 months for extensive modifications. It returned to service in April 2004 and our equipment was reinstalled with the sensors and logger in the engine room and the backup logger GPS and data transmission system on the bridge. This system was operated successfully through until November 2004. When it was withdrawn from service due to lack of manpower being available to keep both two FerryBox systems running and expand the equipment on Route 7. During the changes to the ship our cable from the engine room to the bridge had been damaged so we were unable to transmit data from the sensors to NERC.NOC during 2004. We were able to maintain a programme of weekly calibration and sampling crossing on the ferry in 2004.

2.6.2 Technical Arrangements and Comparability of Measurements

Weekly calibration crossing were undertaken in 2004 during which 2 scientists travelled on the round trip between Southampton and Cowes. The sensors and the housings were cleaned and then water samples were collected from the FerryBox installation at regular intervals during the rest of the crossing (about 15 samples). Samples were collected for nutrients chlorophyll-a, salinity and suspended solids.

In addition the Formazine standard supplied by NIVA was used to calibrate the MINI^{Tracka} turbidity sensor *in situ* on the Ferry. The turbidity sensor was also controlled using a set of neutral density filters. The solid state standard supplied by CTG was used to control the output from the MINIpack fluorimeter. All this date was entered into the FerryBox project calibration forms developed by John Elliott of CTG with the help of Mark Hartman from NERC.NOC.

Table 2-7: Main features of the Ferrybox system on route R-6.

Route no.:	**R-6**	**Operator:**	**NERC.NOC**
Description			**Remarks**
Route:	Southampton- Cowes Isle of Wight (UK)		Started operation in 1999. No data in 2003. Operated April to November in 2004. Work stopped Feb 2005 with completion of calibration and reporting of 2004 data
Ship:	Red Falcon		
Ferry company:	Red Funnel Lines		
System type:	Flow through system		
Frequency:	Up to 8 round trips per day		April to October
Travel time:	1 hour in each direction		3 hour round trip
Control:	Continuous system		
Features:	Real time data transmission 1999 -2003		
Measured parameters:	Conductivity, water temperature, turbidity, fluorescence		Weekly calibrations in 2004. Data entered into CTG FerryBox spread sheets
Resolution:	1Hz,		
Remote control:	Non		Cell phone link provided knowledge of failures
Data transfer:	1 minute averages every 15 minutes by cell phone link. In 2004 only GPS position reports sent by ORBCOMM		
Data storage:	NERC.NOC data base		
Depth of water intake:	3 meters		
Web site:	http://www.noc.soton.ac.uk/ops/ferrybox_index.php		

2.7 Route 7: Portsmouth–Bilbao

Operator: NERC.NOC and IEO

Figure 2-8: Ferry "Pride of Bilbao" equipped with a Ferrybox system sailing on route R-7.

2.7.1 General System Description

This system started operation in April 2002. The same equipment was used until September 2004 when the engine room logging system failed. A new logger was fitted in October 2004 based on the design developed earlier in the year for the FerryBox on route 6. The system used in 2002 to 2004 consists of a Chelsea Technologies Group (CTG) MINIpack measuring pressure, conductivity, temperature and chlorophyll-a fluorescence, a CTG MINI^{Tracka} configured for fluorescence, and a Sea-Bird SBE-48 hull mounted temperature sensor. In December 2004 the system was extended by fitting an Aanderaa Oxygen Optode and a CTG MINI^{Tracka} configured for turbidity. In June a system measuring the partial pressure of carbon dioxide in seawater was brought into operation. In addition tests of the CTG Mark 1 Fast Repetition Rate Flourimeter were carried out.

In 2002 and 2003 a number of problems were encountered with damaged cables between bridge deck level computer and the GPS and ORBCOMM antennas. At end of October 2003 approximately a total of 14 days of data had been lost due to number of logging system crashes. In September 2004 the logging system in the engine room failed and had to be replaced leading to loss of six weeks of data. This system had worked for 30 months in space with temperatures reach 40°C in summer and humidity is near 100% year round. In 2002 and 2003 although the system had continued to function during the period of highest engine room temperatures around September connecting to the UNIX system was unreliable and this lead to a loss of data in 2003 when the logging system could not be restarted after a data down load.

Data which are sampled at 10 minute intervals are sent back via the ORBCOMM satellite link to NERC.NOC in Southampton. The reliability of the ORBCOMM link has improved progressively through the project due to increased experience with the system. In 2005 we were able to increase the sampling rate to 5 minute intervals.

These quasi-real-time data are displayed on the public web page of NERC.NOC http://www.noc.soton.ac.uk/ops/ferrybox_index.php as MATLAB® plots which map the data in time and space. These maps are updated every half hour. The data is also stored in a SQL data base connected to the web page. From which there is public access to the numerical data.

On the ferry data are logged with a frequency of 1 Hz. These data are retrieved manually once per week after the sensor heads have been cleaned. These fine-resolution data are transferred to on-line storage at NERC.NOC, and post-processed to match calibration samples. This data is used to generate the data set that will be transferred to BODC. The data transferred to BODC will be data binned in five minute intervals.

2.7.2 Technical Arrangements and Comparability of Measurements

Approximately monthly calibration crossing were undertaken in 2003, 204 and 2005 during which 3 scientists travelled on the round trip between Portsmouth and Bilbao. Water samples were collected from the FerryBox installation at regular intervals throughout the voyage. Sampling frequencies were for nutrients half hourly, chlorophyll-a hourly, salinity every two hours. On the return leg samples for taxonomy and HPLC analysis of pigments were collected every two hours.

A system for optimum calibration of the MINIpack conductivity sensor is being developed on basis of comparison of the individual monthly calibrations. The variation between the monthly salinity calibrations of the MINIpack is less than 0.5%. Different methods of preservation of the chlorophyll-a samples applied for calibration of the fluorimeters have been tested. The optimum method is immediate filtration on the ship followed by storage of the filter in acetone at –30 ºC.

In addition to the work in the FerryBox project the Pride of Bilbao has been used by SAHFOS Plymouth for continuous plankton recorder (CPR) tows since June 2004. A second NERC.NOC project lead by Ian Robinson is measuring sea surface temperature. The Infrared Sea surface temperature Autonomous Radiometer (ISAR) has been developed to provide accurate and reliable measurements of the radiative sea surface temperature (SST_{skin}) to an accuracy of ±0.1 K without the need of operator intervention. A PhD student is studying the variations in temperatures from all the sensors on the ferry and AVHRR satellite data (further information is given at http://www.noc.soton.ac.uk/lso/isar/).

Comparison of data from different temperature sensors suggests water sampled by FerryBox sensors is being mixed in the ships sea chest from which it is sampled. This has a smoothing effect on the data with a time constant of about 10 minutes.

Comparison of the data with the surveys carried out by IEO as part of the FerryBox project and ICCM Vigo who ran a Ship of opportunity system from Vigo to St Nazaire (in 2002 – 2 004) orthogonal to route 7 has helped identify problems with the stability of the salinity measurements in the CTG MINIpack system.

Table 2-8: Main features of the Ferrybox system on route R-7.

Route no.:	R-7	Operator:	NERC.POL and IEO
Description			**Remarks**
Route:	Portsmouth (UK) – Bilbao (Spain)		FerryBox system fully operational since April 2002. New logger fitted October 2004, System expanded in 2005
Ship:	Pride of Bilbao		
Ferry company:	P & O Ferries Ltd.		
System type:	Flow through system in parallel to ship's refrigerator cooling water. Continuous flow with manual shut off.		
Frequency:	In 2002-2004 1 round trip per week – February to mid March, 2 round trips per week – mid March to early January In 2005 shuttle service from late January to new year 2006		
Travel time:	About 33 hours per crossing, 72 hours per round trip		
Control:	Data management: PC with UNIX from 2004 DOS		
Features:	Modular system, extendable for other chemical sensors/analysers; antifouling prevention by weekly manual inspection and cleaning.		
Measured parameters:	Conductivity, water temperature, turbidity, fluorescence. From 2005 oxygen, pCO2		
Resolution:	At full speed (20 knots) data rate is 1 Hz giving a spatial resolution of approximately 10 metres. Data are mapped with 5 minute (time) resolution.		Comparison with ISAR hull temperature suggest s that mixing in the ship chest smoothes data.
Remote control:			
Data transfer:	ORBCOMM satellite link and e-mail. At 5 minute interval data sample sent to web page. Weekly manual collection of 1Hz data		Public access to un-calibrated 5 minute averages via web page.
Data storage:	Combined file of all data channels including GPS collected in engine room and backed up to the ISAR system computer on bridge SQL data base at NERC.NOC for web access, 1 Hz data stored at NOC. 5 minute averaged data sent to BODC as individual parameter files		
Depth of water intake:	5 m		
Web site:	http://www.noc.soton.ac.uk/ops/ferrybox_index.php		

2.8 Route 8: Athens – Heraklion

Operator: HCMR

Figure 2-9: Ferry “Kriti II” equipped with a Ferrybox system sailing on route R-8.

HCMR had to find a new ferry company since it turned out, that on the originally planned line chemicals were added into the water system onboard of the ferry. HCMR has purchased a new FerryBox system from the German manufacturer 4H-Jena for this route.

After clarifying technical details together with the partner GKSS the system was delivered in October 2003. The installation onboard of the ferry was completed at end of October and finally tested by 4H-Jena in November 2003. Since then the FerryBox is in operational use measuring the standard parameters temperature, salinity, turbidity and fluorescence.

Table 2-9: Main features of the Ferrybox system on route R-8.

Route no.:	R-8	Operator:	HCMR
Description			**Remarks**
Route:	Athens – Heraklion (Greece)		FerryBox system operational with data gaps during November/2003-to-October/2004 FerryBox system not in operation after October/2004 because 1) of technical problems and 2) the ship was moved to another route in the Ionian Sea. Operation is expected to recommence in early 2005 independently of ferry route and after repairmen/improvement by the manufacturer.
Ship:	Kriti II		
Ferry company:	Anek Lines		
System type:	Flow through system		
Frequency:	1 trip every night in alternating directions		
Travel time:	9 hours		
Control:	Supervised by an industrial programmable logic control		
Features:	Automatic cleaning procedure (by acidified water) in the harbour after each trip.		
Measured parameters:	Conductivity, water temperature, turbidity, fluorescence		
Resolution:	Raw measurements every 1 s – approx. every 10 m; stored averages every 60 sec – approx. every 600 m		
Remote control:	Limited remote access on the various settings via GSM when sailing in GSM covered areas.		
Data transfer:	Cell phone data telemetry via industrial standard PC		
Data storage:	On board and on the land station controlled by industrial standard PC		
Depth of water intake:	Approximately 5 m		
Web site:	http://www.poseidon.hcmr.gr/ferrybox		

3 Overview on Calibration Methods

The table below summarises suggested calibration procedures applicable respectively recommended for application for FerryBox systems.

Further details were provided in a separate report (ref. deliverable no. D-2-2).

Table 3-1: Overview on proposed calibration procedures of Ferrybox systems for standard sensors.

Overview on Calibration Procedures of the Ferrybox Systems Involved in the European FerryBox Project				
Standard Sensors				
Parameter	**Procedure**	**Frequency**	**Known problems**	**Remarks**
water temperature	calibration with a reference measurement	two times per year	Measuring inside of the ship may result in temperature shifts.	-
salinity	check with certified seawater	monthly	Different behaviour depending on the measuring principles (conductivity, inductively).	
turbidity	check by Formazine solution	monthly	Results should be presented in Formazine units following the ISO standard. Calculation of SPM concentrations is difficult as the calibration coefficient depends on quality of SPM (organic, inorganic material, size of the particles etc.). Therefore absolute values of SPM concentrations are only valid for defined SPM quality.	Behaviour depends on measuring principle (nephelometry or transmission), normally nephelometer are used.
chlorophyll-a	sampling with subsequent HPLC analysis	fortnightly	Big differences between different species of algae, light regime and nutrients Therefore, only in-vivo-fluorescence/chlorophyll-a ratio can be determined.	Samples should be filtered (GF/F filters) immediately after sampling and the filters have to be frozen (liquid nitrogen) soon after filtering. Use of certified chlorophyll-a standards possible?

4 Measurement Principles and Sensors

The tables below provide tabular summaries of measurement principles and sensors implemented in the different FerryBox systems applied in the project.

Brief information is also given on maintenance intervals and calibration procedures.

Table 4-1: Overview on measurement principles and sensors for the Ferrybox on route R-1-A.

Route no.:	R-1-A	Helsinki (Finland) – Travemünde (Germany)								Operator:	FIMR
Parameter	**Measurement principle**	**Sensor**	**Manufac-turer**	**Unit**	**Detec-tion range**	**Accu-racy**	**Reso-lution**	**Typical obs. range (min. - max.)**	**Maintenance procedure**	**Maintenance interval**	**Quality assessment and other remarks**
water temperature	Pt 2000	T sensor 3444	Aanderaa (Norway)	°C	7.5 – 41	0.1	0.1	0 – 25	cleaning, calibration check	monthly	Comparison with calibrated digital Fluke thermometer; two temperature sensors, one at the entrance of the inlet tube and the second at the outlet from the device.
conductivity	inductively	S/T sensor 3210	Aanderaa (Norway)	ms/ cm	0 – 40	0.2	0.04	0 – 30	cleaning, calibration check	monthly	Salinity sensors calibrated against salinometry with Autosal model 8400A Guild-line using IAPSO Standard Seawater provided by Ocean Scientific International.
turbidity	light scattering (blue)	Scufa II	Turner design (USA)	NTU	0 – 50		0.05	0 – 20	cleaning, calibration check	weekly	Calibration done with Formazine; no constant laboratory analysis, and thus meas-urements as preliminary with a turbidity sensor.
chlorophyll-a (2 sensors)	fluorescence	Scufa II 10-AU-005-CE	Turner design (USA)	µg/l	0 – 200		0.01	0.5 – 55	cleaning, calibration check	weekly	Validation against laboratory measurements of water samples stored by the Fer-ryBox system; extraction done within 24h, if stored longer storage below –18 °C; comparison with laboratory analyses.
automatic water sampler	phytoplankton nutrients chl-a-analysis		ISCO (USA)						cleaning	weekly	Temperature volume control.

Table 4-2: Overview on measurement principles and sensors for the Ferrybox on route R-1-B.

Route no.:	R-1-B		Helsinki (Finland) – Tallinn (Estonia)						Operator:	FIMR and EMI
Parameter	**Measurement principle**	**Sensor**	**Manufac-turer**	**Unit**	**Detec-tion range**	**Accu-racy**	**Reso-lution**	**Typical obs. range (min. - max.)**	**Maintenance procedure**	**Maintenance interval**	**Quality assessment and other remarks**
water temperature	Pt 2000	T sensor 3444	Aanderaa (Norway)	°C	7.5 – 41	0.1	0.1	0 – 25	cleaning, calibration check	yearly	Comparison with calibrated digital Fluke thermometer. Two temperature sensors, one at the entrance of the inlet tube and the second at the outlet from the device.
conductivity	inductively	S/T Sensor 3210	Aanderaa (Norway)	ms/ cm	0 – 40	0.2	0.04	0 – 30	cleaning, calibration check	yearly	Salinity sensors calibrated against salinometry with Autosal model 8400A Guild-line using IAPSO Standard Seawater provided by Ocean Scientific International.
chlorophyll-a	fluorescence	10-AU-005-CE	Turner design (USA)	µg/l	0 – 200		0.01	0.5 – 55	cleaning, calibration check	weekly	Validation against laboratory measurements of water samples stored by the Fer-ryBox system.
automatic water sampler	phytoplankton nutrients chl-a-analysis		ISCO (USA)						cleaning	weekly	Temperature volume control.

Table 4-3: Overview on measurement principles and sensors for the Ferrybox on route R-2.

Route no.:	R-2			Oslo (Norway) – Hirtshals (Denmark)						Operator:	NIVA
Parameter	**Measurement principle**	**Sensor**	**Manufac-turer**	**Unit**	**Detec-tion range**	**Accu-racy**	**Reso-lution**	**Typical obs. range (min. - max.)**	**Maintenance procedure**	**Maintenance interval**	**Quality assessment and other remarks**
water temperature		SBE 45 Micro TSG	Sea-Bird	˚C	-5.0 – 35.0	0.002	0.0001	-1 – 25	cleaning, calibration check	twice per year	
conductivity	inductivity	SBE 45 Micro TSG	Sea-Bird	ms/ cm	0 – 70	0.0003	0.00001	10 – 35	cleaning, calibration check	twice per year	
chlorophyll-a	fluorescence	Chloro-phyll-a fluoro-meter	SeaPoint Sensor Inc	µg/l	0 – 25	< 2%	0.02	0 – 25	cleaning	weekly	
turbidity	light scattering 880 nm	Turbidity sensor	SeaPoint Sensor Inc	FTU	0 – 25	<2 %	0.05	0 – 25	cleaning	weekly	In operation until December 2003
			Polymetron sensor	FTU	0 – 50	< 2 %	0.05	0 – 25	self cleaning with a wiper	Weekly	In operation from January 2004
light	irradiance detector	PAR, cosines sensor	LiCor	µE/m^2 /sec	1		0.1	0 – 1800	cleaning	monthly	Tested in periods from 2001 – 2004
	hyper-spectral radiance detec-tor	Radiance and ir-radiance sensor	TriOS Ramses sensor	W*m-2*nm-1*sr-1	0 – 1	0.25 *10^{-6}			cleaning	monthly	Installed in July 2005
automatic water sampler	pumping from water supply	triggered by way-points or manually	ISCO (USA), 24 bottles						cleaning of water bottles	weekly	Water sampler can be re-motely triggered.

Table 4-4: Overview on measurement principles and sensors for the Ferrybox on route R-3.

Route no.:	R-3				Cuxhaven (Germany) – Harwich (UK)					Operator:	GKSS
Parameter	**Measurement principle**	**Sensor**	**Manufac-turer**	**Unit**	**Detec-tion range**	**Accu-racy**	**Reso-lution**	**Typical obs. range (min. - max.)**	**Maintenance procedure**	**Maintenance interval**	**Quality assessment and other remarks**
water temperature	PT100	PT100		˚C		0.1	0.01	2 – 25	cleaning, calibration check	yearly	
conductivity	inductively	EXCELL TSG	FSI (USA)	ms/ cm	0 – 50	0.02	0.001	10 – 36	cleaning, calibration check	6-monthly	Inter-calibration with labora-tory measurements.
turbidity (2 sensors)	light scattering (red)	CUS31-W2A	Endress & Hauser (Germany)	FTU	0 – 999	10%	0.001		cleaning, calibration check	monthly	Comparison with filtrated samples; uncertainties due to small air bubbles with different quality of SPM.
	light scattering (blue)	Scufa II	Turner design (USA)	NTU	0 – 50	tba	0.05	-	cleaning, calibration check	monthly	
dissolved oxygen	Clark electrode	COS4-2	Endress & Hauser (Germany)	mg/l	0 – 20	0.2% F.S.	0.2 % F.S.	8 – 15	cleaning, calibration check	monthly	Calibration outside of the flow through system.
pH	pH-electrode (gel)	CPS11				0.05	0.01	7.5 – 9.0	cleaning, calibration check	monthly	Calibration outside of the flow through system.
chlorophyll-a	fluorescence	Scufa II		µg/l	0 – 200	tba	0.5	0.5 – 35	cleaning, calibration check	monthly	Inter-calibration with HPLC measurements; different quality of SPM.

Table 4-4 continued.

Route no.:	R-3 (continued)				Cuxhaven (Germany) – Harwich (UK)					Operator:	GKSS
Parameter	**Measurement principle**	**Sensor**	**Manufac-turer**	**Unit**	**Detec-tion range**	**Accu-racy**	**Reso-lution**	**Typical obs. range (min. - max.)**	**Maintenance procedure**	**Maintenance interval**	**Quality assessment and other remarks**
algae groups (chlorophyll-a)	fluorescence (excitation at different wavelengths)	Chlorophyll-sensor	bbe-moldaenke (Germany)		1 – 200	0.1	0.5	depends on algae group			Inter-calibration with HPLC measurements and cell counting (2-monthly); test phase.
nitrate	UV detection	UV-NO3 Analyser	Trios (Germany)	µmol/l	0.5	50	0.1		cleaning, calibration check	monthly	Comparison with filtrated samples; first tests.
nitrate	photometric	automatic pump photometer (APP)	ME (Germany)	µmol/l	0.5 – 300	15%	0.01	0 – 250	cleaning, change of chemicals, calibration check	fortnightly	Inter-calibration with monthly taken samples.
ammonia	fluorometric	automatic pump photometer (APP modified)	ME (Germany)	µmol/l	0.1 – 20	15%	0.01	0 – 7	cleaning, change of chemicals, calibration check	fortnightly	Instrument modified for fluo-rescence measurements (OPA reagent).
o-phosphate	photometric	automatic pump photometer (APP)	ME (Germany)	µmol/l	0.05 – 10	15%	0.05	0 – 3	cleaning, change of chemicals, calibration check	fortnightly	
silicate	photometric	automatic pump photometer (APP)	ME (Germany)	µmol/l	0.2 – 100	15%	0.01	0 – 70	cleaning, change of chemicals, calibration check	fortnightly	

Table 4-5: Overview on measurement principles and sensors for the Ferrybox on route R-4.

Route no.:	R-4				Den Helder – Texel (the Netherlands					Operator:	NIOZ
Parameter	**Measurement principle**	**Sensor**	**Manufacturer**	**Unit**	**Detection range**	**Accuracy**	**Resolution**	**Typical obs. range (min. - max.)**	**Maintenance procedure**	**Maintenance interval**	**Quality assessment and other remarks**
water temperature (hull mounted)	PT100	SBE-38	Sea-Bird	˚C	0 – 40	0.005	0.0001	2 – 25	calibration check	yearly	Sensor mounted on the bottom of the ferry.
water temperature (flow-through)	PT100	SBE-21	Sea-Bird	˚C	0 – 40	0.005	0.0001	2 – 25	cleaning, calibration check	yearly	Flow-through system.
conductivity (flow-through)	inductivity	SBE-21	Sea-Bird	mS/cm	0 – 40	0.01	0.001	10 – 35	cleaning, calibration check	yearly	Inter-calibration with laboratory measurements; flow-through system.
currents (hull-mounted)	Doppler-shift	ADP – 1MHz	Nortek	m/s	0 – 5	0.1	0.001	0 – 2	calibration check	yearly	Inter-calibration with measurements from research vessels; sensors/transducer mounted on the bottom of the ferry.
backscatter (hull-mounted)	echo-intensity	ADP – 1 MHz	Nortek	dB	0 – 100	1	1	0 – 80	calibration check	yearly	Inter-calibration with OBS and filtered samples; sensors/transducer mounted on the bottom of the ferry.
optical backscatter (flow-through)	light scattering		Seapoint	FTU	00 – 999	10%	0.001	0 – 100	cleaning, calibration check	monthly	Inter-calibration with laboratory measurements; flow-through system.
fluorescence (flow-through)	fluorescence		Seapoint	10^{-6} g/l	00 – 150	10%	0.02	0 – 50	cleaning, calibration check	monthly	Inter-calibration with laboratory measurements; flow-through system.

Table 4-6: Overview on measurement principles and sensors for the Ferrybox on route R-5.

Route no.:	R-5				Liverpool (UK) – Belfast (Northern Ireland)					Operator:	NERC.POL
Parameter	**Measurement principle**	**Sensor**	**Manufacturer**	**Unit**	**Detection range**	**Accuracy**	**Resolution**	**Typical obs. range (min. - max.)**	**Maintenance procedure**	**Maintenance interval**	**Quality assessment and other remarks**
water temperature	aged thermistor	SBE 16 plus SeaCat	Sea-Bird	˚C	-3 – 35	± 0.005	0.0001	2 – 20	Two systems, swapped fortnightly for cleaning, servicing and checking the operation of the sensors.	fortnightly	Quality assessment for all sensors will be done by inter-comparison with permanent near surface measurements from a mooring at the mouth of the Mersey (53º32´N – 3º21.8´W).
conductivity	cell resistance	SBE 16 plus SeaCat	Sea-Bird	S/m	0 – 9	±0.0005	0.00005	2 – 4		fortnightly	
turbidity	scattered light red LED (880 nm)		Seapoint	Volts / FTU	0 –25 FTU 0 – 125 FTU 0 – 750 FTU	<2 % deviation from linear		not yet established		fortnightly	
chlorophyll-a	fluorescence blue LED (470 ± 30 nm)	CTG MINI^{Tracka} II	Chelsea Instruments	V / µg/l	0.03 – 100 µg/l		0.01 µg/l	not yet established		fortnightly	

Table 4-7: Overview on measurement principles and sensors for the Ferrybox on route R-6.

Route no.:	R-6				Southampton- Cowes Isle of Wight (UK)					Operator:	NERC.NOC
Parameter	**Measurement principle**	**Sensor**	**Manufacturer**	**Unit**	**Detection range**	**Accuracy**	**Resolution**	**Typical obs. range (min. - max.)**	**Maintenance procedure**	**Maintenance interval**	**Quality assessment and other remarks**
water temperature	Pt-resistance	CTG MINIpack	CTG	˚C	-2 – 35	0.003	0.0005	8 – 25	weekly cleaning	yearly	Manufacturers calibration; only annual re-calibration
conductivity	induction cell	CTG MINIpack	CTG	mmho /cm	0 – 70	0.005	0.001	25 – 45	weekly cleaning, weekly calibration 2004	yearly	Salinity / conductivity calibrated against weekly water samples;
chlorophyll-a	fluorescence excitation	CTG MINIpack	CTG	µg/l	0.03 – 100		0.01	0 – 20	weekly cleaning, weekly calibration 2004 weekly drift check	yearly	Inter-calibration with acetone extracted chlorophyll-a First test of solid state test block
turbidity	light scattering 470nm	CTG MINI^{Tracka}	CTG	FTU	0.04 – 100		0.01	10 – 30	weekly cleaning weekly calibration checks with Formazine	yearly	Comparison with filtrated samples & NIVA Formazine.

Table 4-7: Overview on measurement principles and sensors for the Ferrybox on route R-7.

Route no.:	R-7				Portsmouth (UK) – Bilbao (Spain)					Operator:	NERC.NOC and IEO
Parameter	**Measurement principle**	**Sensor**	**Manufacturer**	**Unit**	**Detection range**	**Accuracy**	**Resolution**	**Typical obs. range (min. - max.)**	**Maintenance procedure**	**Maintenance interval**	**Quality assessment and other remarks**
water temperature (hull mounted)	aged thermistor and VISHAY reference resistor	SBE 48 hull mounted	Sea-Bird	˚C	-5 – 35	0.002	0.0001	8 – 25	calibration check	two-yearly	Considered accuracy relative to true sea water temperature is 0.1 ˚C.
water temperature	Pt-resistance	CTG MINIpack	CTG	˚C	-2 – 35	0.003	0.0005	8 – 25	calibration check	yearly	Has been compared with SBE 48. Shows delay in water system.
conductivity	induction cell	CTG MINIpack	CTG	mmho/cm	0 – 70	0.005	0.001	25 – 45	weekly cleaning, monthly calibration check	yearly	Conductivity/salinity calibrated against monthly samples. Stable performance in 2003 & 2004. Accuracy better than 0.1. Much poorer and less stable in 2005
chlorophyll-a	fluorescence excitation	CTG MINIpack	CTG	µg/l	0.03 – 100		0.01	0 – 20 100 possible	weekly cleaning, monthly calibration check	yearly	Inter-calibration with acetone extracted chlorophyll-a Reliable ways of preserving calibration samples were tested.
turbidity	light scattering 470nm	CTG MINIpack	CTG	FTU	0.04 – 100		0.01	0-5	weekly cleaning	yearly	
oxygen	dynamic luminescence quenching	Oxygen Optode 3830	Aanderaa	micro-Moles/l	0 – 500	< 8uM or 5%	< 1% or 0.4%	200 – 400	weekly cleaning monthly calibration check	yearly	New 2005; better than specifications; little drift

Table 4-8: Overview on measurement principles and sensors for the Ferrybox on route R-8.

Route no.:	R-8			Athens – Heraklion (Greece)						Operator:	HCMR
Parameter	**Measurement principle**	**Sensor**	**Manufacturer**	**Unit**	**Detection range**	**Accuracy**	**Resolution**	**Typical obs. range (min. - max.)**	**Maintenance procedure**	**Maintenance interval**	**Quality assessment and other remarks**
water temperature	PT100	PT100	FSI (USA)	˚C	-3 – 45	0.01	0.0001	13 – 29	On board washing / factory calibration	Yearly factory maintenance; daily on board washing with acidified water.	Based on yearly factory maintenance
conductivity	inductively	EXCELL TSG	FSI (USA)	mS/cm	2 – 42	0.02	0.0001	37 – 39	On board washing / factory calibration	Yearly factory maintenance; daily on board washing with acidified water.	Comparison with laboratory salinity readings obtained from on- route water samples (every 2-3 months)
turbidity	light scattering (blue)	Scufa II	Turner design (USA)	NTU	0 – 50		0.05	0.4 – 1.5	On board washing and cleaning / factory calibration	Yearly factory maintenance; daily on board washing; internal on board cleaning every 2-3 months	Comparison with filtrated samples every 2-3 months before and after internal on board cleaning
chlorophyll-a	fluorescence	Scufa II		µg/l	0 – 200		0.01	0.5 – 35	On board washing and cleaning / factory calibration	Yearly factory maintenance; daily on board washing; internal on board cleaning every 2-3 months	Comparison with filtrated samples every 2-3 months before and after internal on board cleaning and/or comparison with spectro-photometric chlorophyll-a laboratory values from on route acetone extracts.