OCCASION

This publication has been made available to the public on the occasion of the 50th anniversary of the United Nations Industrial Development Organisation.

DISCLAIMER

This document has been produced without formal United Nations editing. The designations employed and the presentation of the material in this document do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations Industrial Development Organization (UNIDO) concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries, or its economic system or degree of development. Designations such as "developed", "industrialized" and "developing" are intended for statistical convenience and do not necessarily express a judgment about the stage reached by a particular country or area in the development process. Mention of firm names or commercial products does not constitute an endorsement by UNIDO.

FAIR USE POLICY

Any part of this publication may be quoted and referenced for educational and research purposes without additional permission from UNIDO. However, those who make use of quoting and referencing this publication are requested to follow the Fair Use Policy of giving due credit to UNIDO.

CONTACT

Please contact publications@unido.org for further information concerning UNIDO publications.

For more information about UNIDO, please visit us at www.unido.org

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

23354

CONTRACT No. 16001085

Between

THE UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION (UNIDO)

And

NIGERIAN INSTITUTE FOR OCEANOGRAPHY AND MARINE RESEARCH (NIOMR)

UNIDO PROJECT NUMBER: GP/ RAF/04/004

TECHNICAL REPORT
OCTOBER, 2006

TECHNICAL REPORT ON SEABOARD TRAINING ON MARINE POLLUTION MONITORING TECHNIQUES IN THE GCLME REGION

1.0 Introduction:

In accordance with the terms and conditions stated in the Contract document No. 16001085 between the United Nations Industrial Development Organization (UNIDO) and the Nigerian Institute for Organization and Marine Research (NIOMR), the Contractor (NIOMR) conducted a Seaboard Training on Marine Pollution Monitoring Techniques for the Guinea Current Large Marine Ecosystem (GCLME) countries from 4–9 September 2006. A safety briefing was held in the evening of 3rd September 2006 to acquaint participants with safety hints and requirements on board the survey vessel and in the laboratories for the duration of the training period. A preliminary report on the conduct of the opening and field exercise has been forwarded to UNIDO.

The main goal of the training was to build the capacity of scientists in the GCLME Region to undertake routine marine pollution monitoring for purposes of marine pollution prevention and control. In this context and as part of its long-term strategy on environmental management aimed at total compliance with best practices and environmental regulations in her assigned mandate, the Physical and Chemical Oceanography Division for and on behalf of the Nigerian Institute for Oceanography and Marine Research, Lagos, carried out onboard training and laboratory-based hands-on analysis of analytes of interest (hydrocarbon, heavy metals, nutrients) and the physico-chemical characteristics of seawater off the coast of Lagos in the Gulf of Guinea. This was further proof of the Institute's commitment to environmental protection, and operational observance of environmental safeguard procedures, regulations and her desire to share same with participating States within the Region.

2.0 Objectives of the training exercise:

The aim of the environmental monitoring exercise was as follows:

a) to acquaint participants with practical knowledge on environmental monitoring in the marine environment;

b) to provide ship-board training on physical and chemical oceanographic measurements and sampling procedures at sea:

c) to demonstrate and provide hands-on training on sampling protocol (sample handling, chain of custody, etc.,) and chemical analysis of contaminants and nutrients in seawater;

d) to acquaint participants with knowledge on biological and microbiological sampling for benthos and pathogens respectively;

3.0 MATERIALS AND METHODS:

A comprehensive manual stating the materials and methods for the field and laboratory – based exercises is contained in the booklet titled 'Ship-board Training Manual - a training manual for ship-board coastal and marine oceanographic survey and associated laboratory work' specifically written for the exercise. This guided the facilitators and trainees in the conduct of the field and laboratory-based work. The schedule of sea trips for trainees is as shown in Annex I. The general notes on sampling at sea (chapter two), procedures in water sampling (chapter four), and protocols on specific methodologies (chapter six) were thoroughly explained to acquaint the trainees with the theoretical background and practical applications.

The laboratory sessions thereafter examined field samples for analysis on the following: physico-chemistry of water and sediments; nutrients; heavy metals in bottom sediments and fish samples; organochlorine compounds metabolites and polyaromatic hydrocarbons; fish, sediment and water microbiology; sediment characteristics; and benthos. Additional notes are provided on methods and materials, where appropriate to indicate specific protocols employed.

4.0 RESULTS:

4.1 PHYSICO-CHEMISTRY:

Table 1 shows the surface water physico-chemical parameters at sampling locations off Lagos coast as measured by the trainees for samples 1-7 under the supervision of their facilitators/instructors. Samples 8-19 are for measurements from the Niger delta area in the eastern flank of the Nigerian coast for comparison.

Table 1: Surface Water Physico-Chemical Parameters at Sampling Locations in the Gulf of Guinea

S/N	Date	Stn No.	Sample No.	Location	Max Depth at Collection point (m)	T^0C	Sal. ‰	pH	Cond mS/cm^{-1}	Secchi Disc Turbidity (m)	DO $mg\ L^{-1}$
1	04/09/06	1		06^0 20 450 N 003^0 25 507 E	20	26.5	32.3	8.3	48.0	9.0	5.0
2	05/09/06	2		06^0 20 140 N 003^0 27 022 E	20	26.4	33.1	8.4	48.8	6.0	5.1
3	06/09/06 (1)	3		06^0 21. 484 N 003^0 24.593 E	16	26.6	33.0	8.3	48.6	5.0	6.7
4	06/09/06 (2)	4		06^0 18.775 N 003^0 28.275 E	-	26.4	31.8	8.1	48.8	5.2	6.4
5	07/09/06 (1)	5		06^0 20.00 N 003^0 24.01 E	18.0	26.3	28.0	8.2	49.5	4.0	4.9
6	07/09/06 (2)	6		06^0 26.00 N 003^0 30.00 E	32.0	27.0	28.0	8.0	47.8	4.0	6.2
7	08/09/06	7		06^0 20 619 N 003^0 25 920 E	19.0	26.4	34.1	8.39	51.7	5.5	7.1
8	23/08/06	8		05^0 34.15 N 004^0 56.88 E	20.7	27.4	32.8	7.6	49.53	7.0	6.8
9	23/08/06	9		05^0 34.33 N 004^0 55.47 E	25.4	27.0	33.40	7.5	50.90	2.3	6.9
10	23/08/06	10		05^0 35.92 N 004^0 56.86 E	18.7	27.3	31.88	7.8	48.77	7.0	6.9
11	23/08/06	11		05^0 35.12 N 004^0 55.48 E	24.8	27.3	32.90	7.7	50.20	7.0	7.2

Table 1: (Continued): Surface Water Physico-Chemical Parameters at Sampling Locations in the Gulf of Guinea

S/N	Date	Stn No.	Sample No.	Location	Max Depth at Collection point (m)	T^0C	Sal. ‰	pH	Cond mS/cm^{-1}	Secchi Disc Turbidity (m)	DO $mg\ L^{-1}$
12	23/08/06	12		05^0 35. 47 N 004^0 56.18 E	20.5	27.5	29.64	7.7	44.76	6.7	6.4
13	23/08/06	13		05^0 34.27 N 004^0 55.86 E	23.0	27.2	30.11	7.9	46.08	8.5	6.8
14	24/08/06	14		05^0 34.57 N 004^0 57.70 E	19.5	27.4	29.88	7.6	45.71	8.2	7.0
15	24/08/06	15		05^0 33.89 N 004^0 56.55 E	22.9	27.3	30.00	7.5	45.90	8.0	6.8
16	24/08/06	16		05^0 33.39 N 004^0 56.50 E	17.4	27.4	30.76	7.6	46.75	7.0	6.8
17	24/08/06	17		05^0 34.20 N 004^0 56. 90 E	22.0	27.4	30.18	7.5	46.18	6.0	6.4
18	25/08/06	18		05^0 16.42 N 005^0 08.92 E	19.0	27.0	32.96	7.8	49.77	8.5	6.4
19	25/08/06	19		05^0 15.50 N 005^0 07.00 E	26.6	27.1	33.36	7.2	50.37	9.0	6.5

4.2 Nutrient levels in the Gulf of Guinea

Nitrate, Nitrite, Phosphate, Silicate, etc are important nutrients required for optimal productivity in the marine ecosystem. As they serve as nutrients to the aquatic life, they could also serve as pollution indicators. Apart from their natural levels in marine water, they also gain ingress into the marine environment through seepage or runoff. Their levels need to be monitored in the marine system.

Nutrients are generally determined spectrophotometrically. HACH DR 2010, HACH DR 3000, and Shimadzu Spectrophotometer were used during this workshop. Participants were conducted through the stages of sample pretreatment, reagent preparations, colour development for respective nutrients (Phosphate, Nitrate, Nitrite, and Silicate), instrument determination (result readout), and data analyses/interpretation.

Available Phosphate Determination in Samples

Ammonium molybdate and antimony Potassium Tartrate, in an acidic medium were added to filtered samples. The phosphate present formed Antimony-phospho–molybdate complex. This complex was reduced to an intensely blue-coloured complex by adding Ascorbic acid. The colour intensity is proportional to the phosphate concentration. Only orthophosphate forms blue colour in the determination. Polyphosphates and Organophosphates may be converted to the orthophosphate form by sulphuric acid hydrolysis and persulphate digestion respectively. Blank and standards were incorporated, and required time was allowed for proper colour development.

Nitrate –Nitrite Determination in Samples:

Nitrate was reduced to nitrite by cadmium reduction. The nitrite (originally present plus reduced nitrate) was determined by diazotizing with sulphanilamide and coupling with N-(1-naphthyl)–ethylenediamine dihydrochloride to form a highly coloured azo dye which was measured spectrophotometrically. Separate, rather than combined nitrate-nitrite value were obtained by carrying out the procedure first with, and then without, the initial cadmium reduction step. Blank and standards were incorporated, and required time was allowed for proper colour development.

Silicate Determination in Samples:

Silicate and Phosphate in the sample react with molybdate ion under acidic conditions to form yellow Silicomolybdic acid and Phosphomolybdic acid complexes. Citric acid was added to destroy the Phosphate complexes. Silicate was then determined by measuring the remaining yellow colour. Blank and standards were incorporated, and required time was allowed for proper colour development.

Extraction of Sediment Samples for Nutrient Analyses:

Extraction of sediment samples was carried out by weighing 1g of air-dried sample into an extraction flask. This was followed by the addition of respective extraction solution, e.g. for available phosphate, 10ml of Bray P-1 extraction solution (0.25N HCl & 0.2N NH_4F) was added and shaking immediately for 1 minute and filtered. Extracts/filtrates from the extraction process were then determined for nutrients using the respective spectrophotometric determination as for water samples.

Nutrients Level in Seawater Samples of the Gulf of Guinea.

The nutrient results for water samples collected at 15 different locations are as presented in table 2 below.

Table 2: Results of Nutrients level in Gulf of Guinea Waters

Location	Nutrients (ppm)			
	Phosphate	Nitrate	Nitrite	Silicate
1	0.466	0.279	0.061	2.60
2	0.127	2.246	0.069	1.10
3	0.084	5.024	0.023	1.74
4	0.857	2.430	0.048	2.22
5	0.260	1.720	0.152	1.40
6	0.093	3.628	0.122	3.19
7	0.105	1.362	0.053	2.46
8	0.071	2.204	0.018	1.87
9	0.136	0.360	0.078	2.14
10	0.366	1.460	0.026	1.90
11	1.027	3.636	0.108	1.67
12	0.510	0.852	0.008	4.24
13	0.048	1.128	0.034	3.22
14	0.324	3.096	0.142	1.44
15	0.058	1.574	0.026	1.65

The range in ppm of Phosphate, Nitrate, Nitrite, and Silicate in the Gulf of Guinea water were found to be (0.027 – 1.027), (0.279 – 5.024), (0.008 – 0.152), and (1.10 – 4.24) respectively. The mean values in ppm for Phosphate, Nitrate, Nitrite, and Silicate in the Gulf of Guinea waters were found to be 0.302, 2.067, 0.065, and 2.189 respectively. The ranges of Phosphate, Nitrate, and Nitrite are within the range of results for past work on nutrients analyses in the Gulf of Guinea (Phosphate(0.75 – 2.55), Nitrate(0.45 – 0.52), Nitrite(0.021 – 0.03) – Lekki EPZ EIA (2004)).

Nutrients Level in Sea Sediment Samples of the Gulf of Guinea.

The nutrient results for sediment samples collected at 15 different locations are as presented in table 3 below.

Table 3: Results of Nutrients level in Gulf of Guinea Sediment

Location	Nutrients (ppm)			
	Phosphate	Nitrate	Nitrite	Silicate
1	1.139	0.504	0.026	16.45
2	2.545	0.320	0.037	14.36
3	1.840	0.716	0.012	8.14
4	3.381	0.144	0.028	15.72
5	2.015	0.310	0.018	20.69
6	1.610	0.426	0.048	9.21
7	1.474	0.280	0.006	11.08
8	2.017	1.241	0.073	18.77
9	1.583	0.730	0.015	10.28
10	1.644	0.326	0.008	13.37
11	3.580	0.412	0.021	8.49
12	1.243	1.269	0.034	12.65
13	0.976	1.492	0.013	16.96
14	1.948	0.875	0.062	20.42
15	2.562	0.761	0.009	12.41

The range in ppm of Phosphate, Nitrate, Nitrite, and Silicate in the Gulf of Guinea sediment were found to be (0.976 – 3.580), (0.144 – 1.492), (0.006 – 0.073), and (8.14 – 20.69) respectively. The mean values in ppm for Phosphate, Nitrate, Nitrite, and Silicate in the Gulf of Guinea sediment were found to be 1.970, 0.654, 0.027, and 13.933 respectively. The mean values for Phosphate and Nitrite are within the range of results for past work on the Gulf of Guinea (Phosphate (2.58), Nitrite (0.51) – OML 67 & 70 (2002)).

4.3 HEAVY METAL CONCENTRATIONS:

Table 4: Concentration of Heavy Metals in bottom sediments collected at different locations in the Gulf of Guinea LME

S/N	Date	Stn No.	Sample No.	Location	Concentration of Heavy Metals (mg kg^{-1})									
					Fe	Cu	Zn	Cr	Pb	Cd	V	Ni	Co	Mn
1	04/09/06	1	6	06° 20 450 N 003° 25 507E	12250	0.52	60.2	32.1	48.33	ND	< 0.1	43.2	-	520.4
2	05/09/06	2	7	06° 20 140 N 003° 27 022E	12500	0.63	61.4	40.8	49.46	0.01	< 0.1	48.1	-	561.8
3	06/09/06 (1)	3	8	06° 21 484 N 003° 24 593E	11500	0.78	59.7	28.3	49.05	< 0.1	< 0.1	33.7	-	432.5
4	06/09/06 (2)	4	9	06° 18 775 N 003° 28 275E	14000	1.13	60.6	51.1	53.92	2.3	0.72	50.5	-	682.3
5	07/09/06 (1)	5	10	06° 20 000 N 003° 24 01E	13000	2.66	63.2	49.6	58.67	3.01	0.36	44.9	-	612.2
6	07/09/06 (2)	6	11	06° 26 000 N 003° 30 000E	15000	4.38	79.83	48.2	59.4	3.67	0.85	49.4	-	700.1
7	08/09/06	7	12	06° 20 619 N 003° 25 920E	-	-	-	-	-	-	-	-	-	-
8	23/08/06	8	13	05° 34.15 N 004° 56.88 E	7500	9.06	58.90	18.0	29.20	1.65	26.90	14.8	16.99	249
9	23/08/06	9	14	05° 34.33 N 004° 55.47 E	7850	10.34	35.46	14.8	29.09	0.82	20.12	10.8	13.0	239
10	23/08/06	10	15	05° 35.92 N 004° 56.86 E	7950	8.56	51.64	13.6	27.05	0.92	23.54	12.7	17.67	245
11	23/08/06	11	16	05° 35.12 N 004° 55.48 E	7950	10.35	36.0	12.3	24.49	0.96	16.2	7.8	13.4	236

Table 4 shows the concentrations of heavy metals in bottom sediments collected from the locations sampled and those examined for comparison from the eastern flank of the Nigerian coast. Table 5 shows the concentrations of heavy metals in fish samples obtained from trawling grounds just off the Lagos coast. Data on the morphometric characteristics of the fish samples (croaker) is shown in Table 5a.

Table 4 (Continued): Concentration of Heavy Metals in bottom sediments collected at different locations in the Gulf of Guinea LME?

S/N	Date	Stn No.	Sample No.	Location	Concentration of Heavy Metals (mg kg $^{-1}$)									
					Fe	Cu	Zn	Cr	Pb	Cd	V	Ni	Co	Mn
12	23/08/06	12	17	05^0 35.47 N 004^0 56.18 E	7550	8.47	40.53	13.0	21.68	0.35	21.4	11.3	10.60	185
13	23/08/06	13	18	05^0 34.27 N 004^0 55.86 E	7800	9.96	44.37	13.2	21.53	0.71	13.05	7.20	13.87	224
14	24/08/06	14	19	05^0 34.57 N 004^0 57.70 E	7650	8.54	48.69	15.0	17.40	o.57	21.66	10.9	13.56	231
15	24/08/06	15	20	05^0 33.89 N 004^0 56.55 E	7650	7.90	41.45	19.8	21.72	0.40	11.25	10.5	12.58	197
16	24/08/06	16	21	05^0 33.39 N 004^0 56.50 E	7950	7.92	45.19	15.3	25.39	0.63	20.50	9.40	15.05	320
17	24/08/06	17	22	05^0 34.20 N 004^0 56. 90 E	7900	8.24	54.04	14.70	26.04	1.21	38.29	22.4	15.37	242
18	25/08/06	18	23	05^0 16.42 N 005^0 08.92 E	6150	2.73	13.63	13.5	15.38	0.09	23.60	12.9	5.82	196
19	25/08/06	19	24	05^0 15.50 N 005^0 07.00 E	7400	8.13	42.43	16.8	18.59	0.77	24.42	11.1	13.6	196

Table 5: Concentration of Heavy Metals in Fish Samples from Nigerian Trawling Grounds

S/N	Sample No.**	Concentration of Heavy Metals (mg kg^{-1} Wet Weight)									
		Fe	Zn	Cr	Pb	Cu	Cd	Ni	V	Ba	Mn
1	1	3.0	1.12	ND	0.05	0.04	ND	ND	ND	0.2	ND
2	2	4.54	1.38	ND	0.11	0.10	0.08	ND	ND	2.5	ND
3	3	4.05	1.64	ND	0.13	0.06	0.02	ND	ND	2.18	ND
4	4	2.9	1.24	ND	0.06	0.08	ND	ND	ND	0.4	ND
5	5	3.8	1.34	ND	0.08	0.06	ND	ND	ND	O.8	ND
6	6	3.6	1.38	ND	0.08	0.05	0.06	ND	ND	1.4	ND
7	7	4.2	1.44	ND	0.12	0.04	0.02	ND	ND	ND	ND
8	8	4.4	1.46	ND	0.14	0.09	0.04	ND	ND	2.1	0.01
9	9	3.8	1.60	ND	0.11	0.10	ND	ND	ND	2.2	ND
10	10	3.8	1.64	ND	0.05	0.03	0.04	ND	ND	1.4	0.01
11	11	4.5	1.82	ND	0.06	0.03	0.02	ND	ND	2.6	ND
12	12	3.82	1.32	ND	0.08	0.04	0.03	ND	ND	ND	ND
13	13	3.0	1.46	ND	0.08	0.05	0.04	ND	ND	0.8	ND
14	14	3.8	1.14	ND	0.12	ND	ND	ND	ND	0.4	ND
15	15	4.2	1.26	ND	0.11	0.06	0.01	ND	ND	1.3	ND

** See Table 5a

** **Table 5a: Morphometric data on results in Table 5**

Sample No.	Sample Type	Weight of Wholefish (g)	Total Length (cm)	Forklength (cm)
1	Pseudotolithus senegalensis (Muscle) RHS*	420	34.5	28.8
2	Pseudotolithus senegalensis (Muscle) RHS	390	29.6	26.1
3	Pseudotolithus senegalensis (Muscle) RHS	550	35.2	28.1
4	Pseudotolithus senegalensis (Muscle) RHS	440	34.7	29.0
5	Pseudotolithus senegalensis (Muscle) RHS	500	34.6	28.0
6	Pseudotolithus senegalensis (Muscle) RHS	400	29.8	26.4
7	Pseudotolithus senegalensis (Muscle) RHS	390	29.8	26
8	Pseudotolithus senegalensis (Muscle) RHS	460	35.0	29.3
9	Pseudotolithus senegalensis (Muscle) RHS	540	35.0	28.0
10	Pseudotolithus senegalensis (Muscle) RHS	540	34.8	28.2
11	Pseudotolithus senegalensis (Muscle) RHS	390	29.8	26.0
12	Pseudotolithus senegalensis (Muscle) RHS	400	29.7	26.4
13	Pseudotolithus senegalensis (Muscle) RHS	400	29.8	26.3
14	Pseudotolithus senegalensis (Muscle) RHS	480	34.5	27.8
15.	Pseudotolithus senegalensis (Muscle) RHS	390	29.6	26.0

* RHS = Right Hand Side

4.4 ORGANICS, ORGANOCHLORINE PESTICIDES (OCPs), POLYCHLOROBIPHENYLS (PCBs) AND POLYAROMATIC HYDROCARBONS (PAHs)

The sediment samples were collected using a van Veen grab, subsampled in aluminium foil and deep frozen. The sediment samples were air dried in the laboratory to avoid loss of volatile organic components. After collection, the 15 fish samples (*Pseudotolithus senegalensis)* were washed with distilled water, packed in aluminum foils and kept at -20°C until analysis. Individual fish samples ranged in length 29.60-35.20 cm and had weights of 390-550 g. Water samples were collected from the Victoria Island end of the Atlantic Ocean. 500 ml purified glass bottles were filled with water from the different locations and stored at low temperature until ready for use.

Reagents

All chemicals and reagents were of analytical grade and of highest purity possible. Dichloromethane and n-Hexane used for the extraction were obtained from Koch light Laboratories Ltd England. Silica gel used for the cleanup of the extract was supplied by BDH Laboratories England. PAH standard mixture PM-525a (EA EPA method 525 PAH mixture) was obtained from Ultra Scientific, North Kingstown. The mixture contains 12 PAHs which are acenephthylene, anthracene, benz(a)anthracene, benzo(k)flouranthene, benzo(b)flouranthene, benzo(g,h,i)perylene, , pyrene, each at 1000 μg/ml in acetone. Organochlorine standards mixture containing 20 pesticides ,α-BHC, γ-BHC, β-BHC, σ-BHC, Heptachlor, Aldrin, HeptaChlor Epoxide, σ –Chlordane, 4,4'-DDE, α-Chlordane, Endosulfan 1, Dieldrin, Endrin, 4,4'-DDD, Endosulfan 11, Endrin, Methoxychlor Aldehyde , Endosulfan Sulfate, Endrin Ketone, was purchased from Restek Corporation. Aroclor standard mixture of 11 PCB congeners 28, 52, 49, 101, 149, 118, 153, 138, 170 and 194 was also purchased from Restek Corporation USA.

Sample Preparation

A separating funnel assisted liquid-liquid extraction using dichloromethane was performed on the water samples. Cold solvent extraction was performed on the sediment and fish samples using a mixture of Dichloromethane and acetone (1/1 by volume). 100 ml of water sample and 20 ml of dichloromethane were added in a separating funnel and shaken for 15 minutes. The mixture was allowed to settle for 10 minutes. The organic phase was removed and 20 ml of dichloromethane was added and the process repeated. All the organic layers were combined and the extract concentrated in a Buchi Rotary Evaporator apparatus until a volume of 0.5ml was obtained. 5g fish and sediment samples were homogenized with the same weight of anhydrous sodium sulfate and packed in a Kimax separating column. They were soaked in 30 ml mixture of Dichloromethane and acetone (1/1 by volume) and allowed to stand for 20 minutes after which extraction commenced. The process was repeated twice. The solvents were combined and concentrated in a rotary evaporator to 0.5 ml volume.

Cleanup

Kimax separating columns were used for sample cleanup. A 3 g portion of the deactivated silica gel was slurry packed into a glass column (1.0 cm i.d.) and covered with Na_2SO_4. The isooctane extract of the sample was placed on the silica gel column and the column was eluted with 60 mL hexane. The eluate was concentrated by rotary evaporation and by a nitrogen stream to 0.5 ml.

Apparatus

The HP 5890 Series 11 Plus GC used was equipped with flame ionization detector and (FID) and electron capture detector (ECD), a restrictor column (5A mole sieve, 80/80 mesh 1/8 '' x 1'SS), an analytical column (25m x320 µm x0.52 µm methylsiloxane capillary column) and a split injector. The Chemstation was supplied by Agilent USA. A high precision weighing balance was used. The carrier gas used was nitrogen, and the support gases were hydrogen and compressed air all supplied by BOC gases.

Analysis

The extract was analyzed in a HP 5890 Series 11 Plus GC. The injection volume was 1 µl. The GC oven temperature for PAH analysis was 50 °C for 2 minutes and ramped at 8 °C/min till it attained 290 °C and this temperature was maintained for 10 minutes. Carrier gas nitrogen was at 16 ml/min and air flow was at 450 ml/min, hydrogen gas was at 40 ml/min. The split inlet vent was at 100 psi while the split column head pressure was at 27 psi. The run time was programmed to 42 minutes and the retention time was the bases for quantification. The same GC conditions were employed in analyzing the standard mixture of PAHs used in this study.

Calibration graphs were obtained by preparing PAH standard solutions at different concentrations. Four concentrations 1, 2, 3, and 4 µg/ml were prepared by diluting the stock solution with n-Hexane. Linearity was found in all cases.

Aliquots were analyzed by GC-ECD for the determination of PCBs and organochlorine pesticides. The GC separation was performed on a Hewlett-Packard 5890 series II gas chromatograph equipped with one capillary column and one 63Ni electron capture detectors (ECD). The injector and detector temperatures were set at 220°C (splitless) and 300°C. Nitrogen was used as carrier gas at a head pressure of 0.9 bar. The packed column comprised CP-Sil 8/C18, 20% (4/5 5% phenyl, 95% methyl polysiloxane, 1/5 octadecylmethyl polysiloxane) and CP-Sil 2 (high molecular hydrocarbon similar to squalane). The column was of 50 m length, 0.25 mm internal diameter, and 0.25 μm film thickness. The GC oven temperature started at 60°C (1.5 min), then the temperature was ramped at 40°C/min to 180°C (2 min), then ramped at 2°C/min to 230°C (25 min), and finally at 10°C/min to 270°C (15 min). The total run time was 75.5 min.

RESULTS

Organochlorines in Water, Sediment and Fish:

Fifteen (15) water samples were analysed for 20 organochlorine pesticides namelyα-BHC, γ-BHC, β-BHC, σ-BHC, Heptachlor, Aldrin, HeptaChlor Epoxide, σ –Chlordane, 4,4'-DDE, α-Chlordane, Endosulfan 1, Dieldrin, Endrin, 4,4'-DDD, Endosulfan 11, Endrin, Methoxychlor Aldehyde, Endosulfan Sulfate, Endrin Ketone, The ΣOCPs in water samples ranged between 1.54 ng/l and 73.48 ng/l (Table 6).

The lowest level was observed in sample 4 and highest level in sample 2. The levels were generally very low. Endosulfan sulfate and Endrin Ketone were detected in all the samples. Dieldrin, DDT and Metabolites DDE and DDD were very prominent.

Table 6: Concentration of Organochlorine Pesticides in Water Samples ng/l

S/N	Pesticides	Stations and Dates					Stations and Dates					Stations and Dates				
		1 04/09	2 05/09	3 06/09	4 06/09	5 07/09	6 07/09	7 08/09	8 23/08	9 23/08	10 23/08	11 23/08	12 23/08	13 23/08	14 24/08	15 24/08
1	α-BHC	-	1.40	-	-	-	2.56	-	-	-	2.88	1.56	-	1.21	2.51	2.00
2	γ-BHC	2.21	-	-	-	1.15	-	-	-	3.00	1.59	-	-	-	3.28	-
3	β-BHC	1.76	1.56	-	-	3.27	1.38	1.56	-	2.42	-	4.65	-	2.28	-	3.12
4	σ-BHC	1.87	1.88	1.11	-	-	-	-	5.78	-	-	3.22	5.60	3.51	5.22	2.78
5	Heptachlor	-	2.33	1.32	-	1.02	0.98	2.90	1.34	-	3.34	1.78	2.56	-	4.55	1.56
6	Aldrin	-	2.09	1.80	-	1.08	-	1.58	-	4.44	1.56	-	-	4.44	-	-
7	HeptaChlor Epoxide	-	2.48	1.43	-	8.15	1.56	6.87	3.54	5.21	-	-	-	-	4.78	-
8	σ -Chlordane	1.80	6.20	1.85	-	1.29	1.98	-	-	-	2.28	2.87	1.34	5.66	4.88	-
9	4,4'-DDE	6.54	2.11	2.21	-	-		4.56	2.98	2.58	1.89	5.76	4.33	2.31	-	2.88
10	α-Chlordane	2.21	1.56	8.79	-	-		-	-	-	-	-	-	3.88	4.28	2.89
11	Endosulfan 1	-	1.17	1.66	-	2.17	3.54	5.21	-	-	6.98	-	2.98	-	4.00	3.90
12	Dieldrin	8.32	4.73	4.52	-	1.33	4.21	3.20	1.28	4.33	-	5.55	4.56	4.44	3.56	-
13	Endrin	2.53	3.53	2.17	-	1.21	-	1.56	-	2.54	-	4.89	1.44	1.25	-	-
14	4,4'-DDD	3.67	4.02	2.79	-	1.18	-	3.20	2.89	-	5.43	4.54	-	3.29	2.67	4.67
15	Endosulfan 11	-	2.63	2.03	-	8.41	5.60	4.28	3.56	2.87	-	-	3.04	-	6.42	3.66
16	4,4'DDT	2.58	9.19	6.38	-	9.88	6.58	-	2.66	-	-	3.90	1.99	2.67	-	4.89
17	Endrin Aldehyde	-	2.39	1.59	-	9.56	5.06	4.21	-	3.33	4.56	-	-	-	2.10	-
18	Methoxychlor	3.67	1.74	8.68	-	1.30	1.25	-	-	4.59	-	2.56	4.56	5.43	3.56	-
19	Endosulfan Sulfate	2.22	8.49	6.08	1.15	9.23	2.20	4.98	3.55	6.77	4.21	7.79	7.43	6.90	2.56	6.42
20	Endrin Ketone	6.89	6.50	5.60	1.42	4.17	1.22	2.58	4.89	2.91	7.54	8.54	8.98	4.89	4.98	5.43
21	ΣOCPs ng/l	46.27	73.48	52.11	1.54	61.24	38.12	41.93	32.46	44.99	47.69	57.61	48.81	52.16	59.35	44.20

Fifteen (15) sediment samples were also analyzed for OCPs. The ΣOCPs ranged between 4.28 and 68.63 µg/kg (Table 7). Lowest value was observed in sample 5 and highest value in sample 2. Fewer OCPs were detected in the sediment sample as a result of biodegradation. DDT and DDD were not detected in any of the samples analysed. Endosulfan sulfate and Endrin Ketone were detected in all the samples.

Table 7: Concentration of Organochlorine Pesticides in Sediment Samples µg/kg

S/N	Pesticides	Stations and Dates					Stations and Dates						Stations and Dates			
		1 04/09	2 05/09	3 06/09	4 06/09	5 07/09	6 07/09	7 08/09	8 23/08	9 23/08	10 23/08	11 23/08	12 23/08	13 23/08	14 24/08	15 24/08
1	α-BHC	-	-	-	-	-	-	-	-	-	-	-	3.54	2.23	1.15	2.20
2	Lindane	-	-	-	-	-	-	-	-	-	-	-	-	-	2.33	1.50
3	Beta-BHC	2.07	2.14	-	-	-	-	1.50	-	-	-	-	-	-	-	2.56
4	σ-BHC	-	-	-	9.31	-	-	-	4.67	-	2.30	-	-	-	-	4.20
5	Heptachlor	1.31	8.58	1.02	-	-	-	1.13	-	-	-	-	-	-	-	-
6	Aldrin	1.52	1.62	1.37	-	-	-	1.08	1.22	1.24	3.32	-	2.22	-	-	-
7	HeptaChlor Epoxide	8.35	8.55	8.11	3.04	-	5.74	6.41	-	2.88	-	-	-	5.43	-	-
8	Gamma Chlordane	-	9.08	-	-	-	-	-	3.54	-	4.40	-	-	-	-	-
9	α-Chlordane	-	-	-	-	-	-	-	-	-	-	-	3.45	2.43		-
10	4,4'-DDE	1.93	1.91	9.96	-	-	-	1.84	2.88	-	-	-	-	-	-	-
11	Endosulfan 1	1.14	1.62	-	-	-	-	1.28	-	-	3.56	6.78	5.68	-	2.43	-
12	Dieldrin	-	1.13	3.85	-	-	8.54	9.52	-	-	-	3.54	-	-	-	-
13	Endrin	-	9.01	-	-	-	-	8.27	-	-	-	-	-	2.20	-	-
14	4,4'-DDD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15	Endosulfan 11	-	1.27	8.67	-	-	8.99	9.71	-	6.45	-	2.54	-	-	-	1.23
16	4,4'DDT	-	-	-	-	-	-	-	-	-	-	-	-		--	-
17	Endrin Aldehyde	-	-	-	-	-	-		-	-	-	-	-	-	-	2.56
18	Methoxychlor	-	7.99	8.23	-	-	9.18	8.54	2.66	-	-	-	-		2.66	-
19	Endosulfan Sulfate	2.33	7.93	1.52	2.85	1.15	1.70	8.77	3.54	4.40	2.34	3.32	3.67	6.21	4.50	3.54
20	EndrinKetone	1.08	7.80	3.83	3.55	3.13	8.06	8.28	1.22	3.56	3.67	2.58	4.44	4.43	3.45	2.66
21	ΣOCPs	19.73	68.63	51.56	18.95	4.28	42.21	66.23	19.73	18.53	19.59	18.76	23.00	22.93	16.52	20.55

Fifteen (15) fish samples of *Pseudotolithus senegalensis* were analysed for 20 chloropesticides and related residues. The fish samples generally had low lipid content ranging between 0.35 and 1.25 % (see Table 11). The concentrations of ΣOCPs are shown in Table 8. In general, the concentrations were low based on wet weights (< 72 µg/kg ww) indicative of low level contamination in the environment. The ΣOCPs ranged between 7.72 µg/kg and 70.10. DDT and its metabolites DDD and DDE were detected in all the samples. Also detected in all the samples were β-BHC, gama-Chlordan, Endosulfan Sulfate and Endrin Ketone.

Table 8: Concentration of Organochlorine Pesticides in Fish Samples µg/kg fresh weight

S/N	Pesticides	Fish Samples					Fish Samples				Fish Samples					
		1 04/09	2 05/09	3 06/09	4 06/09	5 07/09	6 07/09	7 08/09	8 23/08	9 23/08	10 23/08	11 23/08	12 23/08	13 23/08	14 24/08	15 24/08
1	α-BHC	-	-	1.36	-	2.22	3.48	-	-	-	1.67	2.56	1.07	0.90	-	-
2	Lindane	-	1.52	3.55	1.56	2.88	-	5.32	1.11	3.42	3.78	2.24	1.80	1.50	2.30	1.80
3	Beta-BHC	-	8.32	6.55	3.26	2.20	3.35	4.44	2.75	3.58	1.96	2.54	2.33	1.39	3.36	4.21
4	σ-BHC	-	9.26	8.56	7.54	5.90	6.89	-	8.54	-	-	7.33	6.95	2.56	1.98	3.33
5	Heptachlor	-	8.26	7.56	-	6.35	4.99	-	-	-	3.67	4.44	3.88	2.78	4.01	2.99
6	Aldrin	-	1.67	2.25	2.67	1.89	2.56	2.11	2.98	2.77	5.86	3.38	4.50	3.90	4.12	3.21
7	HeptaChlor Epoxide	9.96	1.29	2.87	-	2.22	3.35	2.98	4.78	4.09	3.23	2.56	4.90	2.56	2.99	2.43
8	Gamma Chlordane	-	1.53	1.99	2.66	1.34	2.78	3.23	2.21	3.45	1.78	1.35	1.65	1.99	2.84	1.65
9	α-Chlordane	-	1.69	-	2.58	2.70	4.32	2.21	2.21	1.76	3.67	2.88	2.56	3.21	2.78	2.98
10	4,4'-DDE	-	8.86	2.25	4.86	2.20	3.21	1.19	3.33	2.86	2.56	8.29	1.98	2.20	2.19	3.35
11	Endosulfan 1	1.04	1.51	-	3.45	-	2.55	-	2.45	3.32	1.97	3.78	-	2.43	2.54	1.23
12	Dieldrin	-	1.30	3.33	3.67	-	2.22	3.56	3.66	5.76	3.77	2.43	2.56	1.56	2.55	2.88
13	Endrin	1.33	1.58	2.24	2.88	2.78	-	2.58	3.76	2.78	3.56	2.97	5.78	2.45	1.98	2.96
14	4,4'-DDD	9.81	2.27	1.98	8.77	7.26	-	4.68	3.88	2.44	3.76	-	7.90	3.55	3.55	3.58
15	Endosulfan 11	9.18	1.17	2.55	8.84	3.39	2.32	-	2.54	3.70	-	-	1.99	2.80	2.86	2.89
16	4,4'DDT	1.75	3.27	1.56	2.33	1.59	4.67	5.33	1.99	4.50	1.45	2.20	7.09	4.21	5.90	1.45
17	Endrin Aldehyde	9.86	1.34	-	1.88	2.28	2.78	-	-	2.90	2.56	5.98	-	-	-	2.22
18	Methoxychlor	1.16	4.88	-	2.45	2.56	1.58	-	2.21	1.45	3.30	4.56	-	-	-	1.98
19	Endosulfan Sulfate	8.49	4.93	4.56	2.78	1.78	2.78	4.66	3.48	5.98	4.90	3.89	4.32	5.87	2.88	3.36
20	Endrin Ketone	6.36	4.08	5.66	4.65	1.96	5.28	6.98	4.80	9.43	2.54	7.43	8.26	3.56	4.96	4.56
21	ΣOCPs	58.94	68.73	59.56	66.83	53.50	59.11	49.27	54.47	64.19	55.99	70.01	69.52	49.34	53.73	47.72

PCBs in Water, Sediment and Fish

Eleven (11) PCB congeners 28, 52, 49, 101, 149, 118, 153, 138, 170 and 194 were investigated. The ΣPCBs ranged between 2.45 and 4.49 ng/l in the water samples. The lowest value occurred in sample 13, while the highest value occurred in sample 1(Table 9). PCB levels were lower than OCP levels showing more impact of agricultural compared to industrial activities. High chlorinated PCB congeners, 153, 138, and 180 were detected in all the samples analyzed.

Table 9: Concentration of PCBs in Water Samples ng/l

S/N	Pesticides	Stations and Dates					Stations and Dates						Stations and Dates			
		1 04/09	2 05/09	3 06/09	4 06/09	5 07/09	6 07/09	7 08/09	8 23/08	9 23/08	10 23/08	11 23/08	12 23/08	13 23/08	14 24/08	15 24/08
1	PCB 28	0.54	0.33	-	-	-	-	-	-	0.33	-	0.35	-	-	-	0.25
2	PCB 52	0.63	-	0.98	-	0.88	-	0.38	0.43	0.25	-	-	0.21	-	0.54	-
3	PCB 49	0.56	0.54	0.66	-	-	0.56	0.88	0.44	-	0.32	0.45	0.54	0.23	-	0.33
4	PCB 101	1.45	0.32	0.58	0.56	0.61	0.21	-	-	0.45	0.43	-	-	-	0.86	-
5	PCB 149	-	0.25	0.54	-	-	-	-	0.35	-	-	-	-	-	-	0.24
6	PCB 118	-	0.78	0.25	-	-	0.33	-	-	0.44	-	0.56	-	0.32	-	0.21
7	PCB 153	0.56	0.86	0.60	0.56	0.42	0.56	0.36	0.28	0.34	0.21	0.43	0.32	0.38	0.54	0.33
8	PCB 138	0.25	0.24	0.39	0.89	0.35	0.78	0.54	0.53	0.65	0.45	0.56	0.43	0.58	0.48	0.98
9	PCB 180	0.60	0.56	0.58	0.34	0.28	0.39	0.94	0.76	0.33	0.89	0.28	0.28	0.66	0.46	0.43
10	PCB 170	-	-	-	0.22	-	-	0.32	-	-	-	-	0.86	-	0.23	-
11	PCB 194	-				-	0.22	-	-	-	0.34	-	0.76	0.28	0.52	-
12	ΣPCBs	4.49	3.88	4.00	2.57	2.54	2.83	3.42	2.79	2.79	2.64	2.63	3.40	2.45	3.63	2.77

Total PCBs in sediment samples ranged between 12.63 and 17.32 µg/kg. Lowest value occurred in station 14, and highest value occurred in station 5(Table 10). Higher values were recorded in the sediment samples compared to the water samples; however the levels were still very low. The trend was similar to the water samples where high chlorinated PCB congeners 153, 138, and 180 dominated in all samples. Low PCB concentrations found are consistent with no known use of these compounds during the last three decades.

Table 10: Concentration of PCBs in Sediment Samples µg/kg

S/N	Pesticides	Stations and Dates														
		1 04/09	2 05/09	3 06/09	4 06/09	5 07/09	6 07/09	7 08/09	8 23/08	9 23/08	10 23/08	11 23/08	12 23/08	13 23/08	14 24/08	15 24/08
1	PCB 28	1.34	-	1.28	1.22	1.35	1.67	1.87	-	1.36	1.43	1.35	1.43	1.87	-	1.25
2	PCB 52	-	1.76	2.55	-	1.88	-	-	1.49	1.25	-	2.22	1.88	-	1.54	-
3	PCB 49	0.96	2.84	-	2.58	-	1.26	2.58	2.55	-	2.32	1.58	1.54	3.26	-	1.33
4	PCB 101	1.38	-	-	2.59	3.68	2.71	1.32	-	1.45	1.46	-	-	-	2.86	-
5	PCB 149	-	1.26	1.94	-	1.98	-	1.57	1.75	-	-	2.56	-	1.58	-	2.24
6	PCB 118	1.65	1.78	2.25	-	-	1.30	-	-	1.58	1.65	1.78	-	1.32	-	1.21
7	PCB 153	2.36	0.96	2.80	2.66	1.48	1.50	1.66	1.28	1.44	2.27	2.22	2.32	2.38	1.54	1.33
8	PCB 138	1.95	1.24	1.29	1.89	1.39	2.88	1.74	2.51	1.68	3.85	1.56	1.43	1.58	1.48	2.98
9	PCB 180	3.80	1.51	1.81	1.34	3.28	2.39	2.94	1.66	2.53	1.84	2.28	2.28	1.66	1.46	2.43
10	PCB 170	-	-	-	2.25	-	1.55	1.32	-	-	-	-	1.82	-	1.23	-
11	PCB 194	1.94		2.38		2.28	1.28	-	2.30	-	1.44	-	1.56	1.28	2.52	-
12	ΣPCBs	15.58	11.35	16.30	14.53	17.32	16.54	15.00	13.54	11.29	16.26	15.55	12.70	14.83	12.63	12.77

Table 11: Concentration of PCBs in Fish Samples µg/kg

S/N	Pesticides	Fish Samples *Pseudotolithus senegalensis* Fish Samples *Pseudotolithus senegalensis* Fish Samples														
		1 04/09	2 05/09	3 06/09	4 06/09	5 07/09	6 07/09	7 08/09	8 23/08	9 23/08	10 23/08	11 23/08	12 23/08	13 23/08	14 24/08	15 24/08
1	PCB 28	-	-	-	-	-	0.08	-	0.06	-	0.02	-	-	-	-	-
2	PCB 52	-	-	-	-	-	-	-	-	-	0.03	-	-	-	-	-
3	PCB 49	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4	PCB 101	-	-	-	0.05	-	0.05	-	-	-	-	-	-	-	-	-
5	PCB 149	-	-	-		-	-	-	-	-	0.08	-	-	-	-	-
6	PCB 118	-	0.02	-	0.04	0.06	0.07	-	0.08	-	0.05	-	-	-	-	-
7	PCB 153	-	0.08	-	0.08	0.08	0.04	-	0.03	-	0.02	0.08	-	0.06	-	-
8	PCB 138	-	0.03	-	0.03	0.05	0.06	-	0.09	-	0.08	0.07	-	0.04	-	-
9	PCB 180	-	0.06	-	-	-	-	-	-	-	0.05	0.05	-	0.09	-	-
10	PCB 170	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11	PCB 194	-	-	-	-	-	-	-	-	-	0.02	-	-	-	-	-
12	ΣPCBs	-	0.19		0.20	0.19	0.28		0.26	-	0.35	0.20	-	0.19	-	-
13	% Fat	0.35	1.25	0.66	0.45	0.54	0.99	0.45	0.38	0.54	0.36	0.56	0.43	0.67	0.88	0.96

The ΣPCB in the fish sample were very low ranging between 0.35 and 1.25 μg/kg. The trend was different this time in the fish samples. High chlorinated PCBs congeners 153, 138, and 180 occurred in only 4 samples out of the 15 fish samples analyzed. Fewer PCBs occurred in the fish samples.

PAHs in Water, Sediment and Fish:

The ΣPAHs in the water sample ranged between 35 and 154 ng/l. Lowest level was observed in location 6 while the highest was observed in location 13 (Table 12). Higher values of PAHs were recorded compared to OCPs and PCBs. This could be as a result of the use of petroleum products in water ways in the area studied.

Table 12: Concentration of PAHs in Water Samples ng/l

S/N	Pesticides	Stations and Dates						Stations and Dates						Stations and Dates		
		1 04/09	2 05/09	3 06/09	4 06/09	5 07/09	6 07/09	7 08/09	8 23/08	9 23/08	10 23/08	11 23/08	12 23/08	13 23/08	14 24/08	1 2
1	Acenephthylene	12.55	6.54	6.88	3.78	4.78	-	2.54	3.56	6.66	7.98	12.09	18.54	⅔.28	3.70	3
2	Anthracene	7.86	16.89	10.25	7.45	-	1.87	2.31	8.56	4.78	2.59	10.54	9.34	14.59	9.54	1
3	Bez(a)anthracene	-	20.56	-	3.22	9.54	-	6.99	4.35	3.44	5.89	3.89	-	10.68	7.66	1
4	Benzo(k)flouranthene	6.87	-	3.99	-	3.56	8.54	9.34	5.87	-	4.68	-	3.44	24.89	8.56	3
5	Benzo(b)flouranthene	3.25	12.89	-	4.21	2.84	-	8.88	4.89	5.99	-	9.56	8.96	-	9.21	-
6	Benzo(g,h,i)perylene	-	5.90	4.56	1.89	1.78	7.87	7.43	3.98	4.32	8.56	4.09	-	16.54	-	4
7	Benzo(a)pyrene	5.98	6.67	6.58	2.58	-	-	5.32	7.88	2.89	3.52	11.56	12.98	8.88	5.66	7
8	Chrysene	1.98	3.25	-	-	4.90	9.32	-	6.59	9.22	8.45	9.54	11.22	6.67	7.88	4
9	Dibenzo(a,h)anthracene	2.45	6.99	3.98	3.67	3.21	-	1.58	6.58	6.98	6.44	-	13.87	-	8.96	5
10	Indeno(1,2,3-cd)pyrene	3.56	-	-	9.76	-	3.45	-	8.88	3.78	6.89	3.88	1.98	13.76	-	-
11	Phenanthrane	5.86	3.32	7.98	12.98	7.89	-	2.78	1.24	4.89	3.45	-	-	⅔.98	8.99	1
12	Pyrene	-	4.78	5.56	10.78	4.44	4.28	3.78	2.98	6.66	-	12.32	1.94	23.76	1.25	5
13	ΣPAHs	50.36	87.79	49.78	60.32	42.94	35.3	51.0	59.5	59.6	58.5	77.47	82.27	154.0	83.2	7

In the sediment samples the ΣPAHs ranged between 5.94 and 101.70 µg/kg. Fewer PAHs occurred in the sediment compared to the water samples (Table 13). The levels were comparatively lower as a result of biodegradation.

Table 13: Concentration of PAHs in Sediment Samples μg/kg

S/N	Pesticides	Stations and Dates						Stations and Dates					Stations and Dates			
		1 04/09	2 05/09	3 06/09	4 06/09	5 07/09	6 07/9	7 08/9	8 23/8	9 23/8	10 23/8	11 23/08	12 23/08	13 23/08	14 24/08	15 24/08
1	Acenephthylene	19.53	16.54	-	13.78	-	-	-	-	12.5	17.9	13.78	18.54	-	13.01	13.70
2	Anthracene	6.86	-	12.25	-	-	8.34	12.3	18.5	-	12.5	11.56	-	16.59	-	25.90
3	Bez(a)anthracene	-	22.66	-	14.54	19.24	-	-	14.3							
4	Benzo(k)flouranthene	12.87	-	13.32	-	-	8.54	19.4	-	-	-	-	13.44	14.89	18.62	13.40
5	Benzo(b)flouranthene	-	2.88	-	-	4.49	-	-	-	15.9	-	-	-	-	12.26	-
6	Benzo(g,h,i)perylene	-	15.70	-	11.84	11.78	7.87	6.48	13.9	14.3	18.5	14.09	-	18.54	-	-
7	Benzo(a)pyrene	15.34	16.67	3.58	-	-	-	-	17.8	12.8	-	-	14.98	-	5.66	17.90
8	Chrysene	11.54	13.25	-	-	4.60	19.3	-	-	-	15.3	-	13.22	16.67	-	-
9	Dibenzo(a,h)anthracene	7.29	-	13.58	13.67	-	-	12.8	-	18.0	8.25	-	-	-	18.93	15.40
10	Indeno(1,2,3-cd)pyrene	-	-	-	10.35	-	13.4	-	18.8	-	12.9	13.88	-	17.76	-	-
11	Phenanthrane	-	11.32	17.21	8.58	17.89	-	-	11.2	-	-	-	-	-	19.95	-
12	Pyrene	-	-	-	10.28	14.44	14.2	13.8		14.4	-	12.32	11.54	10.76	-	15.40
13	ΣPAHs	73.43	99.02	54.94	83.04	72.44	71.7	64.8	95.5	87.9	85.4	65.63	71.72	95.21	88.43	101.70

In the fish samples the levels ranged between 5.65 and 13.99 μg/kg. Very low levels of PAH were recorded in the fish samples (Table 14). Of the 3 matrices investigated, water, sediment and fish, the PAH levels were lowest in fish.

Table 14: Concentration of PAHs in Fish Samples µg/kg

S/N	Pesticides	Fish Samples *Pseudotolithus* Senegalensis Fish Samples *Pseudotolithus* Senegalensis Fish Samples														
		1 04/09	2 05/09	3 06/09	4 06/09	5 07/09	6 07/9	7 08/9	8 23/8	9 23/8	10 23/8	11 23/08	12 23/08	13 23/08	14 24/08	15 24/08
1	Acenephthylene	-	6.39	-	0.78	0.66	-	-	-	2.50	0.90	0.78	0.54	-	3.22	3.20
2	Anthracene	0.86	-	0.56	-	-	0.80	2.38	1.23	-	2.12	0.56	-	1.60	-	0.26
3	Bez(a)anthracene	-	0.66	0.34	0.54	0.49	-	-	0.45		-	-	-	-	-	-
4	Benzo(k)flouranthene	1.87	-	1.65	-	-	0.54	0.48	-	0.44	-	-	3.40	1.82	1.28	3.40
5	Benzo(b)flouranthene	-	0.58	-	-	1.20	-	-	-	-	-	-	-	-	0.99	-
6	Benzo(g,h,i)perylene	-	1.22	-	0.84	3.80	2.01	0.48	0.34	4.30	0.88	0.90	-	4.54	-	-
7	Benzo(a)pyrene	0.67	3.27	1.45	-	-	-	-	1.08	0.66	-	-	0.98	-	0.66	0.55
8	Chrysene	0.96		-	-	0.58	0.34	-	-	-	0.50	-	0.22	0.67	-	-
9	Dibenzo(a,h)anthracene	1.29	0.55	0.85	3.20	-	-	0.82	-	0.32	0.85	-	-	-	0.93	3.40
10	Indeno(1,2,3-cd)pyrene	-	-	-	0.78	-	3.40	-	0.83	-	2.90	3.88	-	0.76	-	-
11	Phenanthrane	-	1.32	2.21	2.51	0.25	-	-	1.29	-	-	-	-	-	0.95	-
12	Pyrene	-	-	-		1.54	220	1.38		1.60	-	1.36	1.54	0.76	-	0.95
13	ΣPAHs	5.65	13.99	7.06	8.65	6.98	9.29	5.54	5.22	9.82	8.20	7.48	6.68	10.15	8.03	11.76

4.5 SEDIMENT CHARACTERISTICS:

The initial particle size analysis of the sediment samples was essentially the rapid analysis of sediment outlined and recommended by Buchanan and Kain (1971). An accurately weighed 25g sample of oven-dried sediment from each station was pretreated with distilled water containing a sequestering agent (sodium hexametaphosphate or sodium oxalate) overnight or for 2-3 days until all lumps were broken. The sample was wet-sieved through a 63um sieve to separate the sediment into sand and silt/clay (mud) fractions. The retained material on the sieve was dried to constant weight at 80° C and agitated on a mechanical shaker for 15 minutes. Any remaining silt/clay fraction passed through the sieve. The percentage of silt-clay fraction was calculated by subtracting the weight of the fraction retained on the sieve after shaking from the initial weight of the oven-dried sediment sample.

Total Organic Matter (TOM) was determined as outlined in the course manual. The simple and rapid method provides a rough estimate of the total organic matter and shows a high degree of correlation with methods involving oxidation with a mixture of potassium dichromate and concentrated sulphuric acid (Loring and Rantala, 1977) and loss on ignition at 450°C (Rees and Walker, 1976).

RESULTS:

The stations sampled contained predominantly silty sand and sandy silt intermixed with varying degrees of clayey silt (Table 15). The percentage total organic matter was high in the silty sediments but considerably low in the sandy sediment. Only a few samples were thoroughly treated by the trainees.

Table 15: Sediment Characteristics

	Station Coordinates	Sand (%)	Silt Clay (%)	pH	Conductivity (mS/cm)	TOM (%)
1.	06°20.450N 003° 25.507E	0.18	99.82	7.94	9.32	25.6
2.	06°20.140N 003°27-022E	0.18	99.92	8.05	6.64	27.2
3.	06°21.484N 003°24.593E	2.10	98.90	7.82	8.20	25.3
4.	06°18.775N 003°28.275E	89.00	11.00	7.89	7.46	7.2
5.	06°20.00N 003°24.01E	0.05	99.95	8.15	3.75	21.4

4.6 MICROBIOLOGY:

The participants were familiarized with;

1. The major equipment used in the microbiology laboratory
2. Sterilizing glass wares used in microbial analysis
3. Different culture media, preparation and sterilization
4. Culture techniques-
   - preparing serial dilutions
   - inoculating plates of culture media and tubes
   - incubation of inoculated media
5. Identification of cultured organisms
   - Morphological characters
   1. Gram's reaction
   2. Shape, size and arrangement of organism.
   - Cultural characters
      1 shape
      2 size
      3 chromogenesis
      4 opacity
      5 elevation
      6 surface
      7 edge, etc

Laboratory investigations:

The samples were collected aseptically from different stations in sterile containers and analyzed between 3-6 hours.

Culture media:-
Peptone water, Nutrient agar, Lactose broth, Eosin methylene blue agar.

Procedure:

Water sample
0.1ml of the undiluted water sample was used for inoculation unto media plates.

Sediment Sample
Serial dilutions were made and 0.1ml of the 10^{-2} dilution were inoculated using the spread plate method. The total viable count was estimated using the pour plate method.

Fish Sample
The fish body and gills were swabbed using sterile swab sticks, and the swabs sticks put into peptone water and incubated at 37°C for 24hrs. Plates that had growths were then separated and the organisms identified using conventional microbiological identification methods.

Total Coliform
Lactose broth tubes were inoculated with undiluted water samples and incubated for 48hrs. The tubes that showed gas production were used to calculate the most probable number of coliform bacteria in the sample.

RESULTS:

Table 16: Bacterial count per milliliter of sample

I FISH MICROBIOLOGY

	Fish swab	Fish gills
CFU/ml	2.00×10^5	2.8×10^5

Key: cfu = Colony forming unit

Table 17: Bacterial flora of fish body swab and gill swab.

Fish body swab	Fish gills
Bacillus Moraxella Pseudomonas	Lactobacillus Bacillus Acinetobacter Flavobacteria

Table 18: Bacterial count/ml of sediment

	Stn	Stn	Stn	Stn	Stn
	1	2	3	4	5
Cfu/ml	3.0×10^4	5.2×10^4	5.4×10^4	5.0×10^4	1.3×10^5

II. SEDIMENT MICROBIOLOGY

Table 19: Distribution of the bacterial/fungal genera encountered in the study

Stations	Bacteria	Fungi
1.	Bacillus Alcaligenes Salmonella Escherichia coli	Mucor Agaricus Phytophthora
2.	Proteus Acinetobacter Listeria Flavobacteria	Gelasinospora, Rhizopus Alternaria
3.	Alcaligenes Moraxella Flavobacteria Pseudomnonas	Asspergillus Rhizopus Fusaruim
4.	Pseudomonas Flavobacteria Moraxella	Pythuin Phytophthora Alternaria
5.	Bordetella Lactobacillus Pasteurella Corynebacteria	Gelasinospora Fusaruim Peronospora

III **Water Microbiology**

Table 20: Total coliform count of the different study locations

	Stn	Stn	Station	Stn	Stn	Stn
	1	2	3	4	5	6
No of coliforms/ml	ND	250	60	ND	ND	ND

Key: ND = Not detected
Stn = Station

4.7 BENTHOS:

FIELD SAMPLING PROCEDURES:

On every sampling day, sediment samples were collected with the use of a van Veen Grab sampler ($0.5m^2$). The grab (attached to a wire rope) was deployed to the water depth and retrieved from a winch operated system (Plate 1). A successful grab was accepted if it was well closed and the content was at least 50% of the total volume.

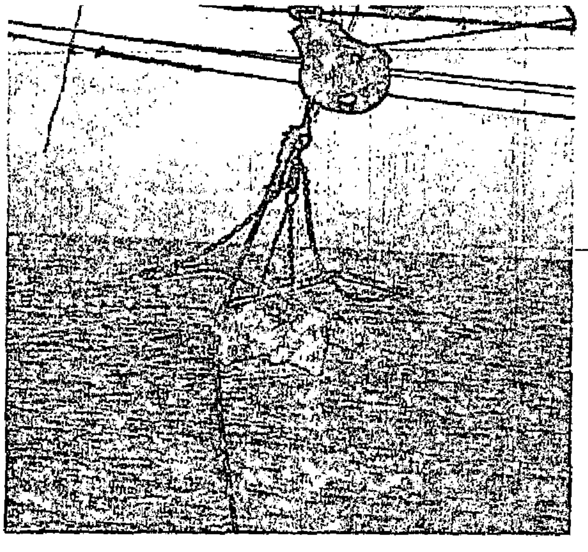

Plate 1: Grab being deployed to sea depth

On arrival on the deck, the content of the grab was emptied into a big plastic bowl (Plate 2) and such information as depth, colour, texture and also the presence of shells in the sediment were recorded in the benthos field data sheet (Table 21).

Samples for physico-chemistry, microbiology and heavy metal analysis were collected and the remaining was poured unto a sieving table (Plate 3).

Plate 2: Sediment poured into a plastic bowl

Plate 3: Sediment on sieving table and being washed through a 0.5mm mesh sieve

Table 21: Sample of Field report sheet

BENTHOS FIELD REPORT SHEET

PROJECT NAME________________________________

Sheet No.____________ Date________

Date	Sample_#	Grab		Coordinates		Depth	Sediment			Remark
		Time_in	Time_out	Latitude	Longitude		Colour	Texture	Shell Present	

Seawater was added from a low pressure water hose to dissolve the sediment and the slurry was allowed to fall by gravity unto two 0.5mm mesh size arranged at different heights below the table (Plate 2). During the sieving process, any animal observed were picked as soon as they were spotted in order to reduce damage to the organism.

After sieving, the content of the sieve was transferred into a well labeled plastic container and 10% formalin (with Rose Bengal stain) added as preservative (Eleftheriou and Holme, 1984). The preserved samples were kept in boxes for further laboratory analysis.

LABORATORY ANALYSIS:

Preserved samples from the filed were subjected to the following laboratory procedures:

a. WASHING: The preserved sampled were washed through a smaller mesh sieve (0.4mm) with fresh water to remove excess mud and to reduce turbidity. Also, to remove inhalation of the preservative (Formalin) during the sorting process

b. SORTING: Each washed sample was transferred onto well lit Petri dishes (on a white board - Plate 4) and was thoroughly examined with the aid of a hand lens and dissecting microscope for benthos species. Sorted samples were kept in separate containers and preserved with 5% formalin.

Plate 4: Some Participants sorting washed sample

c. IDENTIFICATION: Each animal was later identified as far as species level and the number of each species observed were recorded. Identification was done after Barnes (1975), Branch and Branch (2002), Branch, *et al* (2002), Dance, (1974), Edmunds, (1978), Hayward and Ryland, (1995), Kerkut, (1961), Smith, (1964), Yankson and Kendall, (2001) and Schreider, (1990).

DATA ANALYSIS:

All the data obtained were stored in excel spread sheet and the following analysis were performed:

- Numerical abundance and number of species
- Species distribution / occurrence per block
- Species Diversity using the Shannon-Weaner diversity index (Valiela 1995)
  Shannon-Weaner Index (H) = $-\Sigma P_i \ln P_i$
  Where H = diversity index, P_i = proportion of no of individuals in each species to the total no of individual of all species
- Margalef's Species Richness index (Valiela 1995)
  $d = (S - 1) / \ln N$
  Where S = no of species and N = Total no of individual of species

RESULTS:

General Overview:

A total of fifteen (15) samples were examined for the benthic macrofauna. Total number of species recorded per station (with their abundance and ecological indices calculated) is presented in Appendix II. Observations of the sediments sieved during the field sampling indicated that the area has a soft-bottom substrate.

Number of Species and Numerical Abundance

A total of fifty-two (52) macrobenthic species belonging to six major animal phyla were recorded from the total samples examined. The animal phyla recorded were Annelida, Mollusca, Arthropoda, Echinodermata, Sipunculida and Chordata. The percentage total number of individuals (numerical abundance) and total number of species recorded per major phyla is as shown in Figure 2.

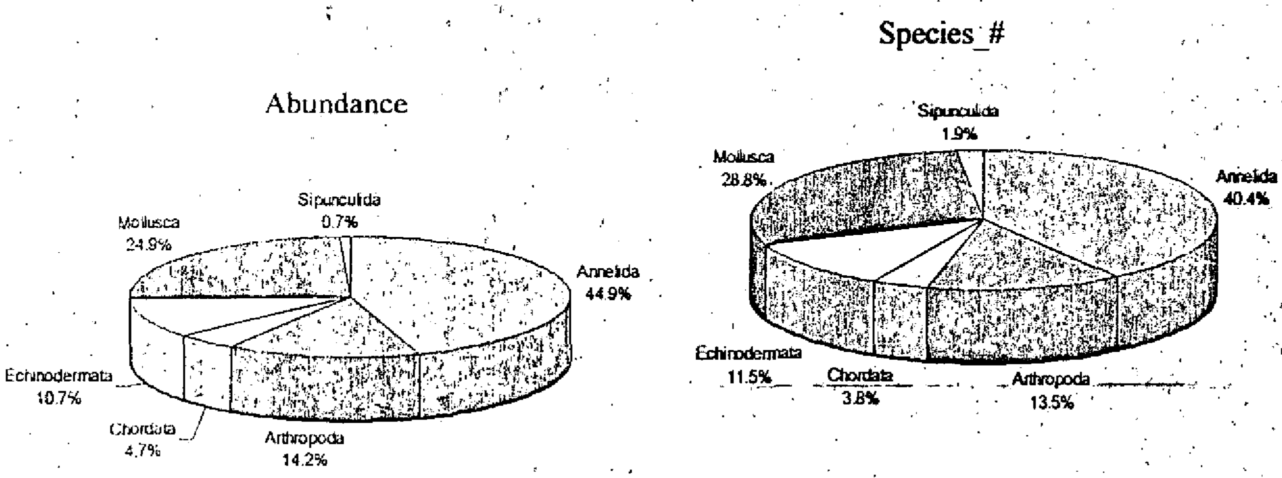

Figure 1: Percentage numerical abundance and number of species recorded per survey area

From the figure above, the phylum annelida (mainly polychaetes) had the highest number of species recorded (44.9%) from all the stations sampled. This was followed by the phylum mollusca (24.9%) and the crustacean arthropods (14.2%). The least number of species was recorded from the phylum sipunculida. Similar pattern was also observed for the numerical abundance of the species recorded for the area sampled (Figure 1). Figure 2 shows the number of species and the numerical abundance of species per station in the survey area.

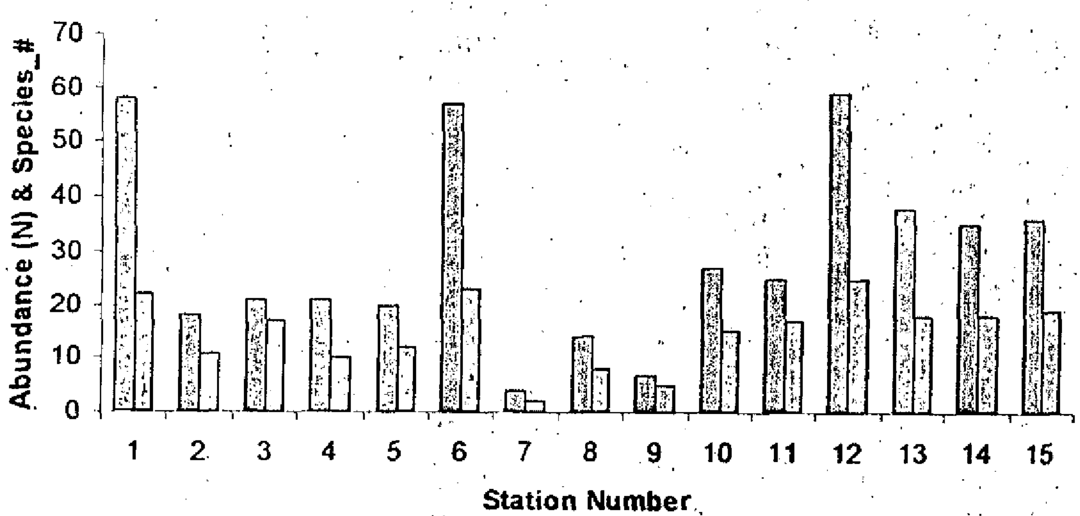

Figure 2: Total numerical abundance and species number recorded per station in the survey area

Between Stations, the highest number of individual species recorded was at station 12 (59) which was closely followed by station 1 (57) and Station 6 (respectively). The lowest numbers of individuals recorded were at Stations 9 and 7 respectively. Correspondingly, the highest number of species recorded was also at Station 12 (25) followed by Station 6 (23) and 1 (22) in that order. The least number of species were recorded at Stations 8, 9 and 7 respectively.

The numerical abundance of each species and their spatial distribution (occurrence per station) is presented in Table 22. *Nephtys incisa* (a polychaete) was the most abundant species recorded in the survey area and is followed by *Corophium sp* (a crustacean) and *Lumbrinereis sp, Nephtys sp* and *Pyrene sp* which are polychaetes respectively. Three species, *Sipunculus sp* (sipunculida), *Detalium longitrorsum* (a scaphopod) and *Ophelia sp.* (polychaete) were the least abundant species recorded.

Table 22: Numerical abundance and occurrence of species (spatial distribution) per station

Phylum	Class / Group	Species	Total Abundance	Occurrence
Annelida	Polychaetae	*Nephtys incise*	18	9
Arthropoda	Crustacea	*Corophium sp*	17	7
Annelida	Polychaetes	*Lumbrinereis sp.*	15	7
Annelida	Polychaetes	*Nephtys sp.*	15	8
Mollusca	Bivalvia	*Pyrene sp.*	15	9
Annelida	Polychaetae	*Scoloplos armiger*	14	8
Annelida	Polychaetae	*Glycera rouxi*	13	5
Mollusca	Bivalvia	*Macoma sp*	13	6
Annelida	Polychaetes	*Sabellaria vulgaris*	⅔	4
Mollusca	Gastropods	*Circineta callipyga*	11	6
Annelida	Polychaetae	*Terebella sp*	11	4
Arthropoda	Amphipods	*Aeginella sp.*	10	5
Mollusca	Bivalvia	*Dosinia sp*	10	5
Mollusca	Bivalvia	*Ensis sp*	10	7
Chordata	Pisces	Fish Larva	10	5
Annelida	Polychaetes	*Glycera dibranchiate*	10	4
Echinodermata	Ophiuroidea	*Ophiura textunata*	10	4
Chordata	Pisces	*Pytonichthys microphthalmus*	10	4
Echinodermata	Holothuroidea	*Trochostoma sp.*	10	5
Echinodermata	Echinoidea	*Echinocardium cordatum*	9	6
Annelida	Polychaetes	*Goniada maculate*	9	4
Annelida	Polychaetes	*Marphysa sp.*	9	3
Mollusca	Gastropods	*Neptunea sp.*	9	4
Annelida	Polychaetes	*Scoloplos fragilis*	9	4
Echinodermata	Asteroidea	*Asterina gibossus*	8	3
Annelida	Polychaetae	*Capitella sp.*	8	3
Annelida	Polychaetes	*Driloneries sp.*	8	5
Arthropoda	Tanaids	*Emplectonema sp.*	8	4
Annelida	Polychaetae	*Flabelligera sp*	8	4
Arthropoda	Mysids	*Heteromysis sp.*	8	6
Annelida	Polychaetae	*Harmathoe imbricate*	7	4
Arthropoda	Tanaids	*Leptochelia sp.*	7	3
Mollusca	Bivalvia	*Tellina radiate*	7	4
Annelida	Polychaetae	*Cirriformia afer*	6	3
Mollusca	Scaphopoda	*Dentalium sp*	6	5
Arthropoda	Cumaceans	*Diastylis sp*	6	4
Annelida	Polychaetes	*Pectinaria sp.*	6	3
Mollusca	Bivalve	*Aloides trigona*	5	2
Annelida	Polychaetes	*Arabella sp.*	5	2
Mollusca	Gastropods	*Cavolinia sp.*	5	4

Echinodermata		*Echiurus sp*	5	4
Arthropoda	Amphipods	*Gammarus sp.*	5	3
Annelida	Polychaetes	*Orbinia sp.*	5	3
Mollusca	Bivalvia	*Plectopecten sp*	5	4
Echinodermata	Ophiuroidea	*Ophiocomina sp.*	4	2
Annelida	Polychaetes	*Arenicola marina*	3	2
Mollusca	Scaphopoda	*Cadulus sp.*	3	1
Mollusca	Bivalvia	*Cobula sulcata*	3	2
Mollusca	Gastropods	*Natica sp.*	3	2
Aschelminthes	Sipunculida	*Sipunculus sp*	3	3
Mollusca	Scaphopoda	*Detalium longitrorsum*	2	2
Annelida	Polychaeta	*Ophelia sp.*	2	2

Spatial Distribution and Occurrence of Species per Station:

The occurrence of species at different stations is also presented in Table 22. From the observed result, two (2) species (*Nephtys incisa* and *Pyrene sp*) occurred in nine stations which show that they are more common and are well distributed in the study area than other species. Also, two polychaete species (*Nephtys sp. and Scoloplos armiger*) occurred in eight of the stations sampled. The species with the least occurrence in the area was *Cadulus sp* (Scaphopoda).

Species Diversity and Richness Indices

The species diversity of the study area per station is presented in Table 23 while the graphical representation is as presented in Figure 3.

Table 23: Species number, diversity and richness

Station Number	Species_#	Shannon-Weaner Index	Species Richness Index
1	22	3.03	5.17
2	11	2.3	3.46
3	17	2.78	5.26
4	10	2.19	2.96
5	12	2.44	3.67
6	23	3.04	5.44
7	2	0.69	0.72
8	8	1.97	2.65
9	5	1.55	2.06
10	15	2.6	4.25
11	17	2.78	4.97
⅔	25	3.07	5.89
13	18	2.72	4.67
14	18	2.76	4.78
15	19	2.84	5.02

The highest values of 3.07 and 5:89 for species diversity and richness respectively were observed at Station 12 while the lowest values of both indices (0.69 and 0.72 respectively) were observed at Station 7. Coincidentally, Station 12 recorded the highest number of species while Station 7 recorded the lowest number.

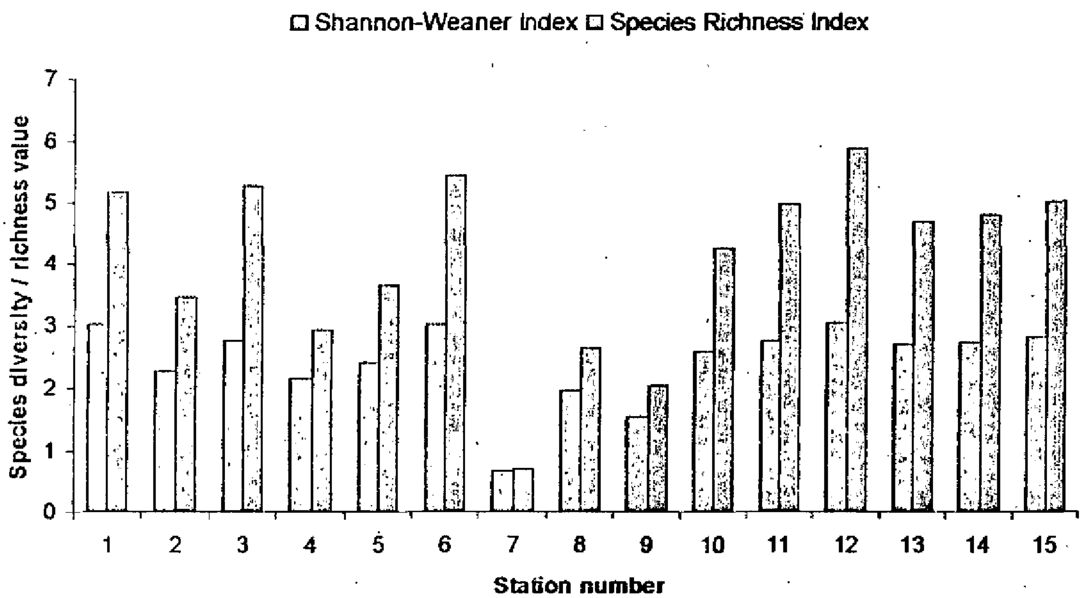

Figure 3: Species diversity and richness recorded per station in the survey area

DISCUSSIONS:

Physico-chemistry:

The values of physico-chemical parameters measured are typical for coastal waters along the Lagos coast for the wet season. The marked difference observable from additional data taken from measurements in the eastern flank of the country shows the variation along the Nigerian coastline especially with respect to distances offshore.

A period of significantly high dissolved oxygen concentration is usually associated with the peak rainfall season (March/April – October) when nutrients and debris are transported to coastal waters with the influx of fresh water from inland rivers. High dissolved oxygen concentrations often corresponded with low temperature season indicating an inverse relationship although oxygen concentrations and temperature may not correlate in all cases. This is expected since oxygen is also subject to biological processes e.g. photosynthesis and respiration. There was no indication of the influence of a pollution load during the period of study.

The pH (hydrogen ion index) ranged from 7 to 8 and varied little for the Lagos coastal area. The relatively small range would seem to depend largely on the salinity regime. The pH of the environment into which a pollutant is deposited may influence the chemical form, the solubility, and its toxicity to exposed biota (Sheehan, 1984). This is particularly so with toxic metals. pH changes can drastically affect the structure and function of the ecosystem both directly and indirectly.

Nutrients in the Gulf of Guinea:

Nitrate, Nitrite, Phosphate, Sulphate, etc are important nutrients required for optimal productivity in the marine ecosystem. They also serve as pollution indicator. Apart from their natural levels in marine water, they also gain ingress into through seepage or runoff. Their levels need to be monitored in the marine system.

Nutrients inputs to coastal, marine and freshwater ecosystems around the world have increased markedly during the past century due to increasing human activities that are altering global nitrogen (N) cycle and resulting in widespread coastal eutrophication (Vitousek, 1994; Galloway et al, 1995). The nutrient pollution of marine waters is primarily not a problem of the wide, deep open seas and oceans but of nearshore waters due to land-based inputs (Conkright & Levitus, 1999).

The values recorded for Phosphate were found to be higher in sediment samples than in water. This may be due to the relative insolubility of Phosphate in water; thereby increasing its depositional tendency.

The values for phosphate in the seawater samples were found to be higher than the value expected in natural marine water (0.01ppm) (Chika 2002). Also, phosphate values from selected wetlands in Ghana (Chika 2002) established some similarity with the values from this present work.

Due to the solubility of Nitrate in water, values recorded for Nitrate, were found to be higher in water than in sediment samples. Nitrite concentrations are generally much lower than nitrate in both water and sediment except in cases of pollution.

The values for nitrates in the seawater samples were found to be higher than the value expected in natural marine water (0.25ppm) (Chika 2002). Nitrate values from selected wetlands in Ghana also establish some degree of conformity with the values arrived at in this work.

The moderately low values recorded for all nutrients are indicative of a pollution free environment.

HEAVY METALS:

Marine Bottom Sediments

The range of metal concentrations in ($\mu g\ g^{-1}$ dry weight) recorded in all sediment samples analysed were:
Fe (6150 – 15,000), Cu (0.53 – 10.35), Zn (13.63 – 79.83), Cr (12.3 – 49.6), Pb (15.38 – 59.4), Cd (ND – 3.67), V (< 0.1 – 38.29), Ni (7.2 – 50.5), Co (5.82 – 17.67) and Mn (185 – 320). Following the classification of Prater *et al.*, 1977 on the pollutional status of sediments based solely on observed metals' concentrations, a general statement can not be made because the environment from which they were collected was non polluted with respect to some metals but polluted with respect o some others.

For example, the sediments could be said to come from an environment that is non – polluted with respect to Cu and Zinc because all measured values were < 25 μg Cu g^{-1} and < 90.0 μg Zn g^{-1}. On the other hand, with respect to Cr, Pb and Ni at some stations, some of the observed concentrations suggest that the environment was moderately polluted by Cr (25 -65 $\mu g\ g^{-1}$), Pb (> 40.0 $\mu g\ g^{-1}$) and highly polluted by Ni (> 30.0 $\mu g\ g^{-1}$). Riley and Chester (1977) gave typical near-shore values of some metals as Pb; 20$\mu g\ g^{-1}$, Cu; 20$\mu g\ g^{-1}$, Zn; 95$\mu g\ g^{-1}$, Ni; 55$\mu g\ g^{-1}$ and Cr; 100$\mu g\ g^{-1}$. Values recorded for Cu, Zn and Cr were less than these typical values while at some stations, the measured values for Pb and Ni was slightly above these typical values.

One interesting feature of the heavy metals distribution is the fact that sediments collected off Lagos (Stations 1-7) generally had higher metal concentrations than those collected off the Niger Delta (Stations 8 – 19). The only exceptions were Cu for which lower concentrations were recorded off Lagos and Vanadium for which much lower concentrations were recorded off Lagos. This raises the interesting question of the relative importance of petrogenic and industrial provenance at these locations and poses equally interesting future challenges to elucidate this observation. High Nickel-Vanadium ratios in the sediment are probably due to nickel contaminations related to non-petroleum pollution. For example, nickel is a known contaminant in domestic sewage.

Fish Samples

The ranges (in µg g^{-1}) observed in the specimens analysed were Fe; (2.9 – 4, 54), Zn; (1.12 – 1.64), Cr; (ND), Pb; (0.05 – 0.13), Cu; (ND – 0.10), Cd; (ND – 0.06), Ni; (ND), V; (ND), Ba; (ND – 2.18) and Mn; (ND – 0.01). All measured values were well below the WHO suggested limits in Fish and shellfish (e.g. Cd; 2.0µg g^{-1}, Cu; 30.0, Zn; 1,000.0, and Pb; 2.0). This suggests that with respect to heavy metals, the fish are very safe for human consumption with "safety margins" between 100 and 1000 fold. It was also interesting to note that for particular metals, variability in concentration was minimal possibly because all specimens belong to the same species and size class (and thus, presumably age bracket).

ORGANICS, ORGANOCHLORINE PESTICIDES (OCPs), POLYCHLOROBIPHENYLS (PCBs) AND POLYAROMATIC HYDROCARBONS (PAHs)

Concentrations of organochlorine compounds in inland and coastal waters of Africa are listed in Table 24. Inland waters are considered in this comparison because many rivers from inland flow into all the lagoons in this study. High levels of organochlorine pesticides were recorded in some inland waters in Africa.

Most of the literature data of organochlorine levels in fish are given in wet weight, making comparison with results based on lipid weights difficult. In Nile perch (*Lates niloticus*) from Lake Victoria, Kenya, sumDDT levels of 4510 µg/kg lw (460 µg/kg ww) were observed.

OCPs were determined in Tilapia, Alestes and Clarias from Lake Victoria Kenya and levels of 14.0-60 µg/kg ww of dieldrin and 10.0-25.0µ/kg ww p,p'DDT were recorded. These are higher than the values obtained in this study.

Table 24: Concentration of chlorinated hydrocarbon residue in fish from African inland and marine waters (µg/kg wet weight)

Country/Location/species	Dieldrin	a-HCH	HCB	y-HCH	p,p'DDE	p,p'DDD	p,p'DDT	sDDT	ΣPCB	Reference
Lake Victoria Kenya Nile Perch	-	-	-	-	-	-	-	460 4510*	-	Milema et al, 1990 [15]
Lake Mariut & Nozha Hydrodome Egypt Mugil species	-	-	-	-	-	3.1-820 3.0-1320	-	-	-	Marklad et al, 1984b [17]
Lake Nyumba ya Mungu Tanzania Tilapia species	3.33			0.33	4.67	1.33	2.0	8.0		Paasivirta et al, 1988 [18]
Cote d'Ivoire Pagellus belloti	n.d-2.1			0.1-2.2 (0.41)				0.4-12.9 (1.92)		Kaba, 1992 [23]
Lake Victoria Keny Tilapia. Alestes, Clarias	14.0-60.0			-	10.0-25.0					Koeman, et al, 1972 [16]
Malawi Clarias gariepinus								50.0 2700		Pickering et al, 1980 [19]
Ogun River, Oyo, Lagos Nigeria 40 Finfish		0.20-5.0 (1.8)	9.0-130 (⅔.7)	7.0-106 (25.6)	2.0-30 (3.40)	2.0-60 (7.8)	3.0-18 (4.9)	3.0-161 (20.6)	8.0-130 ()28.7	Amakwe, 1984 [20]
Ibadan, Nigeria 24 finfish	n.d-173 (68)	0.04-0.24 (0.15)	-	0.20-598 (248)	-	0.2-6.6 (3.0)	n.d-23 (7.0)	0.5-36 (15)	-	Osibanjo and Jensen, 198[illegible] [21]
Cross River, South East Nigeria, Finfish	n.d-173 (68)	0.20-7.4 (1.80)	-	0.6-13.0 (4.4)	n.d-4.20 (1.80)	n.d-8.0 (0.70)	-	2.5	0.70-14.0 (3.8)	Amakwe, 1984 [20]
Lagos lagoon, Nigeria Tilapia Hemichromis				0.31 0.59	0.75 3.43	1.29 4.48	0.94 2.20	1.98 10.61	0.17 0.29	Uyimadu, 200 [22]
Coastal waters of Nigeria 94 Finfish, marine species			.04-9.48	n.d-5.3				.15-18.6	11.0-225	Osibanjo et, al 1990 [19]

Two fish species were monitored in Lake Mariut, and the Nozha hydrodome, Egypt. The data of these fish, Tilapia and Mugil species indicated that DDT and its metabolites (DDE and DDD), HCH, and endrin where the major chlorinated pesticides detected. In the hydrodome fish, the level of DDE in Mugil species ranged from 3.1 – 820 and 3.0-1320 μg/kg wet weight in fish liver and muscle respectively. These results from the Noziha hydrodrome fish are very high compared to the results obtained in this study on wet weight bases.

Results of chlorinated pesticides and PCBs were described in one sample of (Tilapia) from a small Man made lake Nyumba ya Mungu in Tanzania. With the exception of dieldrin, the results did not differ much from the present study when DDT and metabolites are considered. The fish sample contained (per kilogram wet weight) 4.67 μg p,p'-DDE, 1.33μg p,p'-DDD, 2.0μg p,p'DDT, 0.33μg lindane, and 3.33 μg dieldrin. SDDT levels of below 50 μg/kg ww in muscle and high value in ovaries of 2700 μg/kg ww in *Clarias gariepinus* in Malawi have been reported . These levels for sDDT are higher than the levels in the present study, although sDDT were not determined in ovaries of the samples in the present study. DDT and metabolites, HCB, PCBs were detected in 40 fresh water fish samples colleted from various locations in Oyo and Ogun States in Nigeria whose rivers flow into the area under investigation. The concentration ranges with mean in parenthesis in μg/kg ww are shown in Table 24. The levels were lindane 7.0-106 (25.6), p,p'-DDE, 2.0-30.0 (3.40), p,p'-DDD, 2.0-60.0 (7.8), p,p'-DDT, 3.0-18 (2.9), sDDT, 3.0-161 (20.6), PCB, (Aroclor A 1250, 8.0-130 (28.7), HCB, 9.0-130.0 (12.7) and a-HCH, 0.20-5.0 (1.3).

Also nine OCPs were detected and quantified in fish from South Eastern Nigeria. The concentration ranges and mean in parenthesis μg/kg ww were a-HCH, 0.20-7.4 (1.8), Lindane, 0.6-13.0 (4.40). p,p'-DDE, n.d-4.2 (1.8), p,p'-DDD, n.d-8.0 (0.7), and PCBs, 0.7-14 (3.8). All these results are consistent with the results of the present investigation. The present study recorded very low ΣPCBs. The results from the work done around Ibadan in Western Nigeria are also consistent with the present study.

The analyses of 94 samples of 25 marine fish species over 1983-1985, from the Nigerian coastal waters agreed reasonably with the present investigation. The only area of disagreement was on the levels of ΣPCBs reported. The concentration ranges in μg/kg ww were found to be, HCB, 0.04-9.48, lindane, n,d-5.30, sDDT, 0.15-18.60 and ΣPCBs, 11.0-225.0. The work carried out in the Lagos lagoon in 1999 on two fish species *Tilapia guineensis* and *Hemichromis faciatus* recorded levels of OCPs in μg\kg ww of lindane, 0.31, p,p'-DDE, 0.75, p.p'-DDD, 1.29, p.p'-DDT, 0.94, sDDT, 1.98, PCB 153, 0.11, PCB 138, 0.06, ΣPCB, 0.17 in the former and lindane, 0.59, p,p'-DDE, 3.43, p;p'-DDD, 4.48, p,p'-DDT, 2.20, sDDT, 10.61, PCB 153, 0.18, PCB, 138, 0.11, ΣPCB, 0.29 in the later . This result agree completely with the findings in this work

Marine fish in Cote d' Ivoire recorded concentrations of organochlorine substances similar to the levels obtained in the present study. The ranges for the species analysed *(Pagellus bellotiii Epinephelus aeneus, Cynoglossus canariensis,Pseudotolithus senegalensis, Sphyraena sphyraena and Penaeus notialis)* which were similar species to the ones analysed in the lagoons of Western Nigeria in this work. The levels were, lindane < 0.10-2.40, dieldrin, n.d-2.1, sDDT 0.4-12.9 µg/kg wet weight.

Sediment characteristics

The sedimentary environment may be correlated with settlement characteristics enabling deposition in areas of low physical energy. High values of total organic matter associated with mud represents a food source for deposit-feeding organisms apart from its value as an indicator of pollution (Raman & Ganapati, 1983). The organic matter could be related to anthropogenic input in the coastal area and the depositional nature which is governed by the current flow and the fluxes due to tidal stream in the area.

Microbiology:

The total plate count of the fish body and gill swabs ranged between 2.00×10^5 and 2.80×10^5. These values lie within the acceptable limit of 10^6 recommended for fresh fish by the International Commission of Microbiological Standards for Foods (ICMSF, 1978).

The bacterial flora associated with the fish and also the bacterial/ fungal genera of the sediment are autochthonous.

The detection of the indicator organism *Escherichia coli* in some locations should not be of much concern, as bacteria from the intestinal tract generally do not survive in the marine environment. The die – out rate however depends on the water temperature, the effect of sunlight, the population of other bacteria present, and the chemical composition of the water.

The microbial load encountered in both the fish and sediment samples were within acceptable limits. The wide range of bacterial/fungal genera encountered in the various locations is typical of the environment.

Benthos:

The results of the macrofauna analysis of the 15 samples from the study area showed a benthic community typical of a soft sediment area (Sanders, 1968). The sediment type varied from mud to coarse sand in grain size composition with little organic debris in some areas.

Six major animal phyla were observed and annelida (comprising of only polychaetes) constitute the most abundant number of individuals with highest number of species. Mollusca (gastropod and bivalves) are the next groups with higher levels than the remaining groups observed. The reason for this observation may be due to the muddy nature of the sediment that favours burrowing and tube dwelling activity of these groups. Also, majority of the species in these groups are deposit feeders utilizing detritus and the organic matter in the sediment. Some species recorded had been reported by Ajao (1990), Brown (1991), Olaniyan (1968), Oyenekan (1975, 1983, and 1987) and Williams (1999).

Some fish larvae (juveniles) were recorded within the study area. The presence of a relatively high number of fish larvae in the samples may be that the period of sampling coincided with the spawning season of some demersal fish species in the study area.

Two macrobenthic species *Nephtys incisa* (polychaete) and *Pyrene sp.* (Bivalve) were the most widely distributed in the area occurring at nine stations out of the fifteen stations sampled. Other species in the area with high occurrence are the polychaetes (*Nephtys sp.*, and *Scoloplos armiger*) in eight stations. These species are known to be well adapted to live in soft sediments and are also deposit feeders.

One species of interest to pollution studies was the presence of a capitellid polychaete (*Capitella sp*). Some members of the family Capitellidae (e.g *Capitella capitata*) are known to inhabit and prefer a highly organically polluted area, hence it has been used as indicator organism for organic pollution (Ajao, 1990; Ajao and Fagade 1990; Oyenekan, 1981). The presence of this organism in the study area does not indicate that the area is organically polluted because it may be its natural environment but if it happens to dominate other organisms in the area this may lead to the conclusion that the area is organically polluted.

CONCLUSION:

It is pertinent to conclude this report with highlights from the field and laboratory-based exercise carried out under the training:

ORGANICS, ORGANOCHLORINE PESTICIDES (OCPs), POLYCHLOROBIPHENYLS (PCBs) and POLYAROMATIC HYDROCARBONS (PAHs)

The report presents data on the concentrations of organochlorine compounds, metabolites and polyaromatic hydrocarbons in 15 samples each of water, sediment and fish from Nigeria's coastal waters during the workshop cruise. 15 sediment, water and fish samples were analyzed for 20 chloropesticides and related residues, 11 PCBs and 12 PAHs. The ΣOCPs in the water, sediment and fish samples ranged between 1.54ng/l and 73.48 ng/l, 4.48µg/kg and 68.63 µg/kg, 47.72 and 70.10 µg/kg respectively. The ΣPCBs in the water, sediment and fish samples ranged between 2.45-4.49 ng/l, 12.63 and 17.32 µg/kg, 0.35 and 1.25µg/kg respectively. For the ΣPAHs in water, sediment and fish the ranges were between 35.30 and 154 ng/l, 54.94µg/kg and 101.70µg/kg, 5.65 µg/kg and 13.99 µg/kg. The concentrations of Endosulfan sulfate and Endrin Ketone were the most prominent OCPs observed. PCBs (PCB congeners 153, 138, 180 were very prominent and there was no discernable pattern in the case of PAHs. The concentration of PAHs was highest in the matrices followed by organoclorine pesticides and finally PCBs. The sequence of occurrence is PAHs>OCPs>PCBs. This ranking suggests greatest anthropogenic effects of petroleum exploration and exploitation followed by agriculture and lastly industry.

Microbiology:

The microbial load encountered in both the fish and sediment samples were within acceptable limits. The wide range of bacterial/fungal genera encountered in the various locations is typical of the environment.

Benthos:

The contribution of the benthic ecology in pollution studies can not be over emphasized. It is a useful tool in the understanding of the biological environment (diversity) and processes. The benthos, by the virtue of the habitat they live in, receives 'rain showers' of anthropogenic impacts of various types and from various sources. Many species are sessile and those that are even mobile are limited in distribution because they are sediment specific. Therefore, changes in the environment may mark and manifest on their diversity and relative abundance.

Environmental monitoring and Techniques:

The seaboard training on marine pollution monitoring techniques exposed the trainees to technical developments and data arising from environmental monitoring and assessment; the use of scientific principles in the design of monitoring systems at the local, regional and global scales; and the use of monitoring data in assessing the consequences of natural resource abuse and mismanagement.

The scope of the exercise focused on the use of monitoring in pollution assessment, and particular emphasis was given to the synthesis of monitoring data with toxicological, epidemiological and health data. The approach should assist trainees to develop the tools necessary to monitor and assess the status and trends of national ecological resources. It would also allow trainees to develop the scientific understanding for translating environmental monitoring data from multiple spatial and temporal scales into assessments of current ecological condition and forecasts of future risks to our natural resources.

The training also aimed at advancing the science of ecological monitoring and ecological risk assessment, guide national monitoring with improved scientific understanding of ecosystem integrity and dynamics, and demonstrate multi-agency monitoring through large regional projects. Trainees learnt that the results from the monitoring can, among other things, be used for:

- Feedback on national regulations;
- Early warning of aggravation of the environmental situation;
- The development of forecasts for the expected environmental condition;
- Verification of models for calculating the environmental risk as a function of the existing and expected discharges / input into the marine environment;
- Verification of laboratory-based research to increase the knowledge of possible environmental impacts of discharges / inputs to the marine environment;
- Evaluation of the risk for environmental damage and ecological effects.

In addition, the exercise is hoped to secure a standardized performance of environmental monitoring surveys in the GCLME in ensuring comparable results from one year to another, and between different countries using the same monitoring techniques. This will become increasingly important in view of the growing problems caused by environmental pollution as countries in the region become industrialized. There is therefore a justified interest in finding appropriate methods for monitoring the environment and detecting the level of environmental pollution. Consequently, the inherent limitations imposed on the information yielded by individual measurements of physical and chemical parameters, as well as practical difficulties associated with performing them, will indicate a need for periodic national and regional workshops and trainings, aimed at equipping researchers, and personnel involved in monitoring exercises, on the best techniques and approaches to marine pollution monitoring.

REFERENCES:

Ajao, E. A. & Fagade, S. O., (1990): A Study of the Sediments and Communities in Lagos lagoon, Nigeria. Oil and Chemical Pollution 7, 85 – 117.

Ajao, E. A., Oyewo, E. O., and Unyimadu, J. A. (1995): Ecotoxicological Studies on heavy metals in Nigerian Coastal waters. NIOMR 1995 Annual Report, 55pp

Ajao, E. A. (1990): The Influence of Domestic and Industrial Effluents on Populations of sessile and Benthic Organisms in Lagos lagoon. Ph.D Thesis, University of Ibadan, Ibadan, Nigeria. 413p.

Ajao, E. A., Oyewo, E. O., and Unyimadu, J.P. (1996): A review of the pollution of coastal waters in Nigeria. NIOMR Tech. Paper No. 107, 20p.

Barnes, R. D (1975): *Invertebrate Zoology*. Saunders College Publishing, USA.

Boesch, D. F. (1973): Classification and community structure of macrobenthos in the Hampton Roads Area, Virginia, Mar. Biol. 21: 226-244.

Branch, G. M and Branch, M. L (2002): The living shores of Southern Africa. Eight Impression Struik Publishers (Pty) Ltd, Cape Town. 272pp

Branch, G. M, Griffiths, C. L, Branch, M. L., and Beckley, L. E (2002): Two Oceans: A guide o the marine life of Southern Africa. Fifth Impression, David Philip Publishers, Cape Town, South Africa. 349pp

Brown, C.A. (1991): Community Structure and Secondary Production of benthic macrofauna of Lagos lagoon and Harbour. M.Phil. thesis, University of Lagos. 359pp.

Buchanan, J.B., and Kain, J. B. (1971): Measurement of physical and chemical environment: In: Methods for the study of Marine Benthos. IBP Handbook No. 16, Blackwell Scientific Publication, Oxford.

Conkright, M.E., Gregg, W.W., Levitus, S. (1999): Seasonal Cycle of phosphate in the open Ocean. NOAA, Natl Oceanog Data Ctr, Greenbelt, Md.Deep-Sea Research Part 1-Oceanographic Research Papers, Vol.47, No.2, pp 159-175. Publisher: Pergamon-Elsevier Sci. Ltd. Kidlington Oxford, UK.

Chika, N.U. (2002): Implementing innovative best environmental practises and policy approaches for reduction of nutrient pollution in transboundary waterbodies in western Africa: Contribution of UNIDO technical assistance programmes. Proceedings of the expert group on strategies for the management of pollution and sedimentation in the Nigerian inland waterways. pp 198 – 224.

Dance, S. P. (1974): *The encyclopedia of shells*. Blandford Press Limited, London. 288pp.

Edmunds, Janet (1978): *Sea shells and other molluscs found on West African shores and estuaries*. Ghana University Press, Accra. 148pp.

Eleftheriou, A. and Holme, N.A. (1984): Macrofauna techniques. p. 140-216. In: Methods for the study of marine benthos (N.A. Holm and A.D. McIntyre, (eds.) Blackwell Scientific Publications, 387 pp.

Fabino Consult Nigeria Limited (2003): Environmental Impact Assessment (EIA) of Edop C. E. OML 67 & 70 Project. A report submitted to Mobil Producing Nigeria Unlimited. Draft Final Report.

Fischer,W., Bianchi, G and Scott, W, B (1981): FAO species identification sheets for fisheries purposes. Eastern Central Atlantic: fishing areas 34, 47(in part). Food and agriculture Organization of the United Nations, Vol. 6,

Galloway, J.N., Schlesinger,W.H., Levy, H.V., Michaels, A. and Schnoor,

J.L. (1995): Nitrogen fixation: anthropogenic enhancement – environmental response. Glob. Biogeochem. Cy.9 (2), 235 – 252.

Gosner, K. L. (1971): Guide to identification of marine and estuarine invertebrates. Wiley-Intersciences, A division of John Wiley Inc. New York 693pp

Gosner, K.L. (1971): *Guide to Identification of Marine and Estuarine Invertebrates*. Wiley – Intersciences, a division of John Wiley Inc. New York 693pp. Hampton Roads area, Virginia. Mar. Biol. 21: 226 -244.

Hayward, P. J., and Ryland, J. S., (1995): Handbook of the marine fauna of North-East Europe. Oxford University Press, New York. 591pp

International Commission on Microbiological Specification for Food (1978): Microorganisms in Foods 2, Sampling for microbiological analysis. Principles and specific applications. University of Toronto Press, Canada, pp 92-104.

Jones, K. C., Burnett. V., Duarte-Davidson, R. & Water-house, K. S. (1991): DDT and the Metabolites in the *Environment. Chem. Brit*. May 435 – 440.

Kerkut, G. A., (1961): *The invertebrata: A manual for the use of students*. University Press, Cambridge. 821pp

Loring, D. H. and Rantala, R. T. T. (1977): Geochemical analysis of marine sediments and suspended particulate matter. Environment Canada fisheries and marine service Tech. report no. 700, 58pp.

Lekki EPZ Limited (2004): EIA for Port & Harbour Facilities. Draft Final Report.

Mathews. H. B., & Dedrick, K., (1984): Toxicity of DDT and related Compounds. *Pharmacal. Taxical.*. 24, 85-94.

McFarland, V. A., &.Clark, J. U., (1989): Occurrence, Abundance and Potential Toxicity of Polychlorinated Biphenyl Congeners: Consideration for a Congener Specific Analysis. *Environ. Hlth. Perspec.* 81, 225-229.

McIntyre, A.D., Elliot, J.M., and Ellis, D.V. (1984): Introduction: Design of sampling programmes. In: Methods for the study of marine benthos (N.A. Holme and A.D. McIntyre, eds.), pages 1-26. Blackwell Scientific, Oxford.

Muir, D. C. G., Norstrom, R. J. &, Simon M. (1988): Organochlorine Compounds in Arctic Marine Food Chain.Accumulation of Specific PCBs and Chlordane Related Compounds. *Environ. Sci. Technol..* 22, 1071-1079.

Olaniyan, C.I.O. (1961): Observations on the salinity and stratification of tidal currents in Lagos Harbour. *Nigerian J. West African Science Ass.* 7. 49 – 58

Olaniyan, C.I.O. (1968): *An Introduction to West African Animal Ecology.* Heinemann Education Books Ltd. 165pp.

Osibanjo, O., Biney. C., Calamari,D., Saad, M.A.H., (1994): Review of Chlorinated Hydrocarbon Substances in the African Aquatic Environment. FAO Fish Rep. 502, 7-45.

Osibanjo, 0., and Jensen, S.,(1980): In proceedings of First National Conference on Water pollution and pesticide residue in food, University of Ibadan, Nigeria, pp 206

Oyenekan, J. A. (1983): The Polychaetes of Lagos lagoon and Harbour. *Nig. J. Sc. and Tech.* 7(2): 181 – 185.

Oyenekan, J. A. (1975): A survey of the Lagos lagoon Benthos (with particular reference to the Mollusca). M.Sc. Thesis, University of Lagos. 137pp

Oyenekan, J. A. (1981): Community structure and production of the Benthic Macro-infauna of Southampton Water. Ph.D. Thesis,University of Southampton, Southampton, Britain. 351pp

Oyenekan, J. A. (1987): Benthic macrofauna communities of the Lagos lagoon, Nigeria. *Nig. J. of Sci.* 21: 45 – 51

Pickering, G.B, Cox. J. R., and Donegan, L. (1980): Organochlorines in Fish Tropical Products Institute, Overseas Development administration. 87p

Raman, A. V., and Ganapati, P. N. (1983): Pollution effects on Ecobiologyof Benthic polychaetes in Visakhapatnam harbor (Bay of Bengal). Mar. Pollut. Bull. 14, 46 -52.

Rees, E.I.S., and Walker, A. J. M. (1976): Monitoring study of benthos at the spoil ground (1973) In: Out of Sight, out of mind: Report of a working party on sludge disposal in Liverpool bay, Vol. 4, Appendix 1, HMSO London, pp173 – 182.

Risebrough, R. W., Reich, P., Peakall, D. B., Herman, S.G. & Kirven, M. N. (1968): Organochlorine Pesticides and Biphenyls in the Global Ecosystem, *Nature*, 1098 - 1102.

Sanders, H. L. (1968): Marine benthic diversity: A comparative study. Am. Nat. 102:243-282.

Schreider, W. (1990): *Field Guide to the Commercial Marine Resources of the Gulf of Guinea.* FAO, Rome 268pp.

Smith, R. I. (1964): *Keys to invertebrates of the Woods Hole Region.* Contribution 11 / Systematics-Ecology Program, Marine Biological Laboratory, Massachusettts, USA. 208pp

Steinwandter, H, and Schluter, H. (1978): A simple Micro Method for the Determination of Organochlorine Pesticides. Dtsch. Lebensm.Rundsch. 74, 134-14

Štirn, J. (1981): Manual of methods in aquatic environment research. Part 8. Ecological assessment of pollution effects. FAO Fisheries Technical Paper 209: 71 pp.

Unyimadu, J. P. (2000): In proceedings 21st annual conference, chemical society of Nigeria, Ibadan.20th-24th September.

Valiela, I. (1995): *Marine Ecological Progress*. Springer-Verlag, New York.

Vetter, W., and Luckas, B. (1995): Determination of Organochlorine Compounds in Codliver. *J. High. Resolut. Chromatogr.* 18, 643-646.

Vitousek, P.M. (1994): Beyond global warming: ecology and global change. Ecology 71, 1861 – 1876.

Webb, J. E. (1958): Ecology of Lagos lagoon I & II. *Phil. Trans. Roy. Soc. Bull. 241*: 224 – 332

Williams, A. B. (1999): Ecological studies of macrobenthic fauna of the Light House Creek and Oworonsoki areas of Lagos lagoon. M. Sc. thesis, University of Lagos. 97pp

Yankson, K. and Kendall, M. (2001): A student guide to the sea shore of West Africa. Darwin Initiative Report 1, Ref. 162/7/451. 132pp

ANNEX I

SHIP-BOARD TRAINING ON MARINE POLLUTION MONITORING TECHNIQUES LAGOS, NIGERIA, 4-9 SEPTEMBER, 2006

Time	Sunday 03	Monday 04	Tuesday 05	Wednesday 06	Thursday 07	Friday 08	Saturday 09
08.00 09.00 09-00 - 10.00		Registration of participants Opening Ceremony	Field Monitoring G.1 Laboratory Work G.2	Field Monitoring G.1 Laboratory Work G.2	Field Monitoring G.2 Laboratory Work G.1	Field Monitoring G.2 Laboratory Work G.1	Field Monitoring G.2 Laboratory Work G.1
10-00 10.30	Coffee/Tea Break						
10.30 12.30	Arrival of participants	Flag off Research Vessel	Field Monitoring G.1 Laboratory Work G.2	Field Monitoring G.1 Laboratory Work G.2	Field Monitoring G.2 Laboratory Work G.1	Field Monitoring G.2 Laboratory Work G.1	Field Monitoring G.2 Laboratory Work G.1
12.30 13.30		Lunch					
13.30-15.30		Field Monitoring G.1 Laboratory Work G. 2	Field Monitoring G.1 Laboratory Work G. 2	Field Monitoring G.1 Laboratory Work G. 2	Field Monitoring G.2 Laboratory Work G. 1	Field Monitoring G.2 Laboratory Work G. 1	Evaluation of the training
15.30-16.00	Coffee/Tea Break						
16.00 18.00	Objective/ Safety briefing	Field Monitoring G.1 Laboratory Work G. 2	Field Monitoring G.1 Laboratory Work G. 2	Field Monitoring G.1 Laboratory Work G. 2	Field Monitoring G.2 Laboratory Work G. 1	Field Monitoring G.2 Laboratory Work G. 1	Closing Ceremony
18.00	Adjournment						

APPENDIX II

Species abundance, number, diversity, richness and other sediment characteristics observed per station

Station Number	Phylum	Class / Group	Species	Abundance
1	Mollusca	Gastropods	*Cavolinia sp.*	3
1	Arthropoda	Cumaceans	*Diastylis sp*	3
1	Arthropoda	Mysids	*Heteromysis sp.*	4
1	Arthropoda	Amphipods	*Aeginella sp.*	3
1	Annelida	Polychaete	*Arabella sp.*	2
1	Annelida	Polychaete	*Capitela sp.*	3
1	Annelida	Polychaete	*Cirriformia afer*	2
1	Arthropoda	Crustacea	*Corophium sp*	4
1	Mollusca	Bivalvia	*Ensis sp*	3
1	Annelida	Polychaete	*Glycera dibranchiata*	2
1	Annelida	Polychaete	*Glycera rouxi*	2
1	Annelida	Polychaete	*Goniada maculata*	1
1	Annelida	Polychaete	*Harmathoe imbricata*	3
1	Annelida	Polychaete	*Lumbrinereis sp.*	3
1	Annelida	Polychaete	*Nephtys sp.*	2
1	Annelida	Polychaete	*Nephtys incisa*	2
1	Annelida	Polychaete	*Pectinaria sp.*	3
1	Mollusca	Bivalvia	*Pyrene sp.*	1
1	Chordata	Pisces	*Pytonichthys microphthalmus*	2
1	Annelida	Polychaete	*Scoloplos armiger*	2
1	Annelida	Polychaete	*Terebella sp*	4
1	Echinodermata	Holothuroidea	*Trochostoma sp.*	4
			Total Number of Individuals	58
			Number of Species	22
			Shannon-Weaner Index	3.03
			Species Richness Index	5.17
2	Mollusca	Scaphopoda	*Cavolinia sp.*	3
2	Mollusca	Gastropods	*Circineta callipyga*	1
2	Arthropoda	Tanaids	*Emplectonema sp.*	1
2	Annelida	Polychaete	*Marphysa sp.*	3
2	Arthropoda	Amphipods	*Aeginella sp.*	1
2	Echinodermata	Echinoidea	*Echinocardium cordatum*	1
2	Annelida	Polychaete	*Goniada maculata*	2
2	Annelida	Polychaete	*Nephtys sp.*	2
2	Annelida	Polychaete	*Nephtys incisa*	1
2	Mollusca	Bivalvia	*Plectopecten sp*	1

2	Annelida	Polychaete	*Scoloplos armiger*	2
			Total Number of Individuals	18
			Number of Species	11
			Shannon-Weaner Index	2.3
			Species Richness Index	3.46
3	Mollusca	Gastropods	*Circineta callipyga*	1
3	Mollusca	Bivalvia	*Cobula sulcata*	1
3	Arthropoda	Cumaceans	*Diastylis sp*	1
3	Arthropoda	Tanaids	*Emplectonema sp.*	2
3	Arthropoda	Amphipods	*Aeginella sp.*	2
3	Annelida	Polychaete	*Cirriformia afer*	1
3	Arthropoda	Crustacea	*Corophium sp*	1
3	Echinodermata		*Echiurus sp*	1
3	Chordata	Pisces	Fish Larva	1
3	Annelida	Polychaete	*Lumbrinereis sp.*	1
3	Annelida	Polychaete	*Nephtys sp.*	2
3	Annelida	Polychaete	*Nephtys incisa*	2
3	Mollusca	Bivalvia	*Plectopecten sp*	1
3	Mollusca	Bivalvia	*Pyrene sp.*	1
3	Annelida	Polychaete	*Scoloplos armiger*	1
3	Aschelminthes	Sipunculida	*Sipunculus sp*	1
3	Echinodermata	Holothuroidea	*Trochostoma sp.*	1
			Total Number of Individuals	21
			Number of Species	17
			Shannon-Weaner Index	2.78
			Species Richness Index	5.26
4	Echinodermata		*Echiurus sp*	1
4	Mollusca	Bivalvia	*Ensis sp*	1
4	Chordata	Pisces	Fish Larva	3
4	Annelida	Polychaete	*Lumbrinereis sp.*	3
4	Mollusca	Bivalvia	*Macoma sp*	1
4	Annelida	Polychaete	*Nephtys incisa*	2
4	Mollusca	Scaphopoda	*Cadulus sp.*	3
4	Mollusca	Gastropods	*Neptunea sp.*	3
4	Annelida	Polychaete	*Ophelia sp.*	1
4	Annelida	Polychaete	*Scoloplos armiger*	3
			Total Number of Individuals	21
			Number of Species	10
			Shannon-Weaner Index	2.19
			Species Richness Index	2.96
5	Mollusca	Gastropods	*Circineta callipyga*	2
5	Arthropoda	Mysids	*Heteromysis sp.*	2

5	Arthropoda	Crustacea	*Corophium sp*	1
5	Mollusca	Scaphopoda	*Dentalium sp*	1
5	Echinodermata	Echinoidea	*Echinocardium cordatum*	2
5	Annelida	Polychaete	*Flabelligera sp*	2
5	Annelida	Polychaete	*Nephtys incisa*	1
5	Annelida	Polychaete	*Nephtys sp.*	2
5	Mollusca	Gastropods	*Neptunea sp.*	1
5	Echinodermata	Ophiuroidea	*Ophiura textunata*	2
5	Annelida	Polychaete	*Scoloplos armiger*	2
5	Mollusca	Bivalvia	*Tellina radiata*	2
			Total Number of Individuals	20
			Number of Species	⅔
			Shannon-Weaner Index	2.44
			Species Richness Index	3.67
6	Mollusca	Gastropods	*Cavolinia sp.*	2
6	Arthropoda	Tanaids	*Emplectonema sp.*	4
6	Arthropoda	Amphipods	*Gammarus sp.*	3
6	Arthropoda	Mysids	*Heteromysis sp.*	4
6	Arthropoda	Tanaids	*Leptochelia sp.*	4
6	Mollusca	Gastropods	*Natica sp.*	2
6	Annelida	Polychaete	*Sabellaria vulgaris*	4
6	Annelida	Polychaete	*Scoloplos fragilis*	1
6	Arthropoda	Amphipods	*Aeginella sp.*	3
6	Annelida	Polychaete	*Capitela sp.*	4
6	Annelida	Polychaete	*Cirriformia afer*	3
6	Arthropoda	Crustacea	*Corophium sp*	2
6	Mollusca	Scaphopoda	*Dentalium sp*	1
6	Mollusca	Bivalvia	*Ensis sp*	1
6	Chordata	Pisces	*Fish Larva*	1
6	Annelida	Polychaete	*Flabelligera sp*	2
6	Annelida	Polychaete	*Glycera rouxi*	3
6	Annelida	Polychaete	*Harmathoe imbricata*	2
6	Mollusca	Bivalvia	*Macoma sp*	2
6	Echinodermata	Ophiuroidea	*Ophiocomina sp.*	3
6	Mollusca	Bivalvia	*Pyrene sp.*	2
6	Annelida	Polychaete	*Scoloplos armiger*	1
6	Annelida	Polychaete	*Terebella sp*	3
			Total Number of Individuals	57
			Number of Species	23
			Shannon-Weaner Index	3.04
			Species Richness Index	5.44
7	Annelida	Polychaete	*Arenicola marina*	2
7	Annelida	Polychaete	*Lumbrinereis sp.*	2

			Total Number of Individuals	4
			Number of Species	2
			Shannon-Weaner Index	0.69
			Species Richness Index	0.72
8	Mollusca	Bivalvia	*Dosinia sp*	3
8	Mollusca	Gastropods	*Natica sp.*	1
8	Echinodermata	Asteroidea	*Asterina gibossus*	3
8	Mollusca	Bivalvia	*Ensis sp*	1
8	Annelida	Polychaete	*Glycera rouxi*	1
8	Mollusca	Bivalvia	*Macoma sp*	2
8	Annelida	Polychaete	*Nephtys sp.*	1
8	Annelida	Polychaete	*Orbinia sp.*	2
			Total Number of Individuals	14
			Number of Species	8
			Shannon-Weaner Index	1.97
			Species Richness Index	2.65
9	Annelida	Polychaete	*Driloneries sp.*	2
9	Echinodermata	Echinoidea	*Echinocardium cordatum*	1
9	Annelida	Polychaete	*Lumbrinereis sp.*	2
9	Annelida	Polychaete	*Pectinaria sp.*	1
9	Aschelminthes	Sipunculida	*Sipunculus sp*	1
			Total Number of Individuals	7
			Number of Species	5
			Shannon-Weaner Index	1.55
			Species Richness Index	2.06
10	Mollusca	Scaphopoda	*Cavolinia sp.*	1
10	Mollusca	Gastropods	*Cavolinia sp.*	2
10	Mollusca	Bivalvia	*Cobula sulcata*	2
10	Arthropoda	Cumaceans	*Diastylis sp*	1
10	Mollusca	Bivalvia	*Dosinia sp*	3
10	Annelida	Polychaete	*Driloneries sp.*	1
10	Arthropoda	Amphipods	*Gammarus sp.*	1
10	Annelida	Polychaete	*Marphysa sp.*	3
10	Annelida	Polychaete	*Sabellaria vulgaris*	2
10	Mollusca	Bivalvia	*Ensis sp*	1
10	Annelida	Polychaete	*Goniada maculata*	3
10	Mollusca	Bivalvia	*Macoma sp*	2
10	Annelida	Polychaete	*Nephtys sp.*	3
10	Mollusca	Bivalvia	*Pyrene sp.*	1
10	Mollusca	Bivalvia	*Tellina radiata*	1
			Total Number of Individuals	27
			Number of Species	15

			Shannon-Weaner Index	2.6
			Species Richness Index	4.25
11	Mollusca	Bivalvia	*Dosinia sp*	1
11	Annelida	Polychaete	*Driloneries sp.*	2
11	Arthropoda	Tanaids	*Emplectonema sp.*	1
11	Arthropoda	Mysids	*Heteromysis sp.*	1
11	Arthropoda	Crustacea	*Corophium sp*	1
11	Echinodermata	Echinoidea	*Echinocardium cordatum*	2
11	Chordata	Pisces	Fish Larva	2
11	Annelida	Polychaete	*Lumbrinereis sp.*	2
11	Mollusca	Bivalvia	*Macoma sp*	1
11	Annelida	Polychaete	*Nephtys incisa*	1
11	Mollusca	Gastropods	*Neptunea sp.*	1
11	Mollusca	Bivalvia	*Plectopecten sp*	2
11	Mollusca	Bivalvia	*Pyrene sp.*	2
11	Annelida	Polychaete	*Scoloplos armiger*	1
11	Mollusca	Bivalvia	*Tellina radiata*	2
11	Annelida	Polychaete	*Terebella sp*	2
11	Echinodermata	Holothuroidea	*Trochostoma sp.*	1
			Total Number of Individuals	25
			Number of Species	17
			Shannon-Weaner Index	2.78
			Species Richness Index	4.97
12	Mollusca	Scaphopoda	*Cavolinia sp.*	1
12	Mollusca	Scaphopoda	*Detalium longitrorsum*	1
12	Arthropoda	Cumaceans	*Diastylis sp*	1
12	Mollusca	Bivalvia	*Dosinia sp*	2
12	Arthropoda	Mysids	*Heteromysis sp.*	4
12	Arthropoda	Tanaids	*Leptochelia sp.*	1
12	Annelida	Polychaete	*Sabellaria vulgaris*	4
12	Annelida	Polychaete	*Scoloplos fragilis*	4
12	Arthropoda	Amphipods	*Aeginella sp.*	1
12	Mollusca	Bivalvia	*Aloides trigona*	4
12	Annelida	Polychaete	*Arabella sp.*	3
12	Arthropoda	Crustacea	*Corophium sp*	4
12	Annelida	Polychaete	*Flabelligera sp*	3
12	Annelida	Polychaete	*Glycera rouxi*	3
12	Annelida	Polychaete	*Nephtys sp.*	1
12	Annelida	Polychaete	*Nephtys incisa*	3
12	Mollusca	Gastropods	*Neptunea sp.*	4
12	Echinodermata	Ophiuroidea	*Ophiocomina sp.*	1
12	Echinodermata	Ophiuroidea	*Ophiura textunata*	1
12	Annelida	Polychaete	*Orbinia sp.*	1

12	Annelida	Polychaete	*Pectinaria sp.*	2
12	Mollusca	Bivalvia	*Plectopecten sp*	1
12	Mollusca	Bivalvia	*Pyrene sp.*	2
12	Chordata	Pisces	*Pytonichthys microphthalmus*	4
12	Echinodermata	Holothuroidea	*Trochostoma sp.*	3
			Total Number of Individuals	59
			Number of Species	25
			Shannon-Weaner Index	3.07
			Species Richness Index	5.89
13	Mollusca	Scaphopoda	*Cavolinia sp.*	2
13	Mollusca	Gastropods	*Circineta callipyga*	1
13	Annelida	Polychaete	*Driloneries sp.*	1
13	Arthropoda	Mysids	*Heteromysis sp.*	3
13	Annelida	Polychaete	*Sabellaria vulgaris*	2
13	Mollusca	Bivalvia	*Aloides trigona*	1
13	Echinodermata	Asteroidea	*Asterina gibossus*	3
13	Mollusca	Scaphopoda	*Dentalium sp*	1
13	Annelida	Polychaete	*Glycera dibranchiata*	3
13	Annelida	Polychaete	*Harmathoe imbricata*	1
13	Annelida	Polychaete	*Lumbrinereis sp.*	2
13	Mollusca	Bivalvia	*Macoma sp*	5
13	Annelida	Polychaete	*Nephtys incisa*	3
13	Annelida	Polychaete	*Ophelia sp.*	1
13	Echinodermata	Ophiuroidea	*Ophiura textunata*	5
13	Mollusca	Bivalvia	*Pyrene sp.*	1
13	Chordata	Pisces	*Pytonichthys microphthalmus*	1
13	Mollusca	Bivalvia	*Tellina radiata*	2
			Total Number of Individuals	38
			Number of Species	18
			Shannon-Weaner Index	2.72
			Species Richness Index	4.67
14	Mollusca	Bivalvia	*Dosinia sp*	1
14	Annelida	Polychaete	*Scoloplos fragilis*	1
14	Annelida	Polychaete	*Arenicola marina*	1
14	Echinodermata	Asteroidea	*Asterina gibossus*	2
14	Annelida	Polychaete	*Capitela sp.*	1
14	Arthropoda	Crustacea	*Corophium sp*	4
14	Mollusca	Scaphopoda	*Dentalium sp*	1
14	Echinodermata	Echinoidea	*Echinocardium cordatum*	2
14	Echinodermata		*Echiurus sp*	2
14	Mollusca	Bivalvia	*Ensis sp*	2
14	Annelida	Polychaete	*Flabelligera sp*	1
14	Annelida	Polychaete	*Glycera dibranchiata*	2

14	Annelida	Polychaete	*Glycera rouxi*	4
14	Echinodermata	Ophiuroidea	*Ophiura textunata*	2
14	Annelida	Polychaete	*Orbinia sp.*	2
14	Mollusca	Bivalvia	*Pyrene sp:*	4
14	Annelida	Polychaete	*Terebella sp*	2
14	Echinodermata	Holothuroidea	*Trochostoma sp.*	1
			Total Number of Individuals	35
			Number of Species	18
			Shannon-Weaner Index	2.76
			Species Richness Index	4.78
15	Mollusca	Scaphopoda	*Detalium longitrorsum*	1
15	Annelida	Polychaete	*Driloneries sp.*	2
15	Arthropoda	Amphipods	*Gammarus sp.*	1
15	Arthropoda	Tanaids	*Leptochelia sp.*	2
15	Annelida	Polychaete	*Marphysa sp.*	3
15	Annelida	Polychaete	*Scoloplos fragilis*	3
15	Mollusca	Scaphopoda	*Dentalium sp*	2
15	Echinodermata	Echinoidea	*Echinocardium cordatum*	1
15	Echinodermata		*Echiurus sp*	1
15	Mollusca	Bivalvia	*Ensis sp*	1
15	Chordata	Pisces	Fish Larva	3
15	Annelida	Polychaete	*Glycera dibranchiata*	3
15	Annelida	Polychaete	*Goniada maculata*	3
15	Annelida	Polychaete	*Harmathoe imbricata*	1
15	Annelida	Polychaete	*Nephtys sp.*	2
15	Mollusca	Bivalvia	*Pyrene sp.*	1
15	Chordata	Pisces	*Pytonichthys microphthalmus*	3
15	Annelida	Polychaete	*Scoloplos armiger*	2
15	Aschelminthes	Sipunculida	*Sipunculus sp*	1
			Total Number of Individuals	36
			Number of Species	19
			Shannon-Weaner Index	2.84
			Species Richness Index	5.02