CRUZ ENVIRONMENTAL

Report No. 16

Benthic Invertebrate Fauna associated with the Finger Jetty in Transnet Capital Projects Richards Bay Harbour Expansion Project

A report prepared for AECOM SA (Pty) Ltd, Westville, Durban

by

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TABLE OF CONTENTS

1. INTRODUCTION

1.1 BACKGROUND TO THE STUDY

The Final Scoping Report (AECOM 2014) for the developments proposed by Transnet Capital Projects (TCP) for the Richards Bay Harbour Expansion project (Option 3A) identified that several specialist studies needed to be undertaken as part of the Environmental Impact Assessment for the proposed developments. These included elements of both Terrestrial and Aquatic Ecosystems. In terms of the brief provided to CRUZ Environmental (CRUZ-E) three areas required Specialist Studies as part of project, the localities of these are shown on Figure 1.1 below.

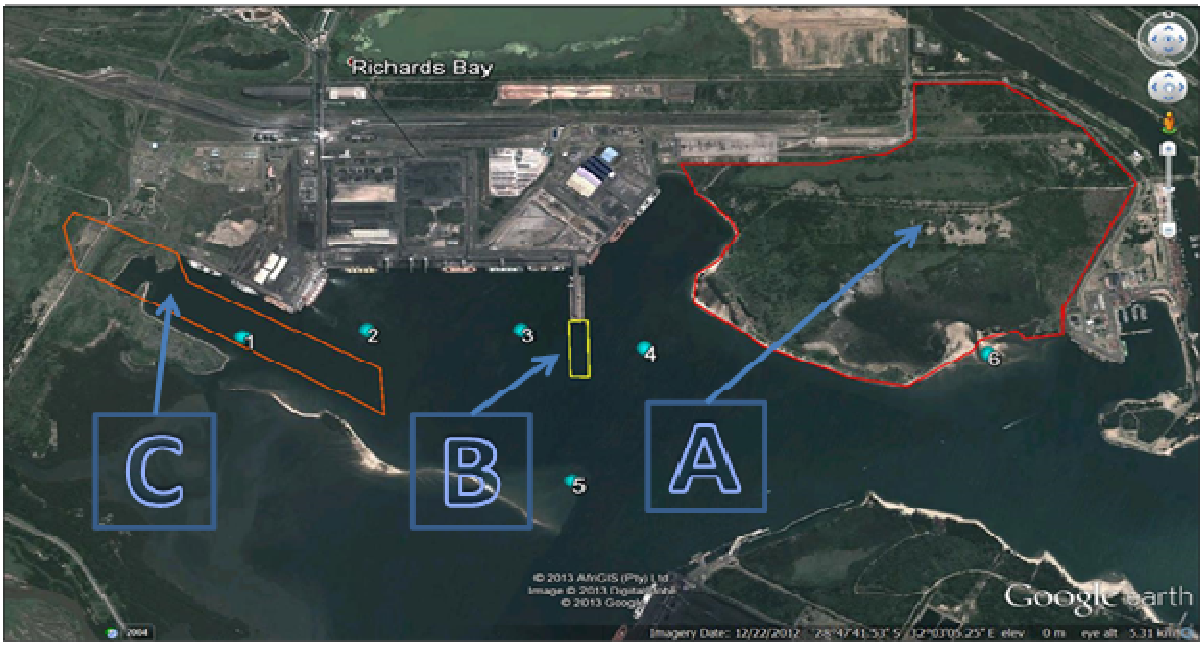

Figure 1.1 Sites associated with TCP Richards Bay Harbour Expansion Project, A = Rail Balloon, B = Finger Jetty Extension and C = Berth 600 Series Expansion.

The Benthic Invertebrate Fauna associated with the proposed extension of the Finger Jetty (Site B) (Figure 1.2), were identified as an important ecological component in the development of TCP Richards Bay Harbour Expansion project. This study focussed on the current status of the macrobenthic fauna associated with the proposed Finger Jetty development.

The Port of Richards Bay is the largest deep-water port in South Africa. The Port Development Framework (PDF) for the Port of Richards Bay recognised that any large-scale port expansion would involve alteration and environmental impacts to ecologically sensitive aquatic habitats within and adjacent to the port. Despite comprising large dredged deep-water areas with bulk shipping lanes and extensive port and rail infrastructure development, the Port of Richards Bay still serves as a fully functional estuary and contains ecologically highly important habitats for aquatic fauna. Richards Bay and the Mhlathuze Estuary have been shown to offer almost the complete range of habitat types found in tidal reaches of subtropical South African estuaries and as such comprise estuarine habitat of particular regional importance (Begg 1978). These habitats have retained much of their natural functioning, contributing importantly to the ecology of both port and nearshore marine waters. These include intertidal and shallow subtidal mudflats and sandbanks, deepwater basins and channels, reed and mangrove swamps. The port contains aquatic habitats which have been recognized as having national conservation importance (Turpie *et al.* 2002). The port plays an important role in the life histories of many marine fish and invertebrate species that show varying degrees of dependence on estuarine habitat at some stage in their life, be it as a nursery area for juveniles of these species or as a rich feeding grounds (Cyrus & Vivier 2009 & MER 2013).

Based on the results of the Final Scoping Report (AECOM 2014) for TCP, CRUZ Environmental identified macrobenthic invertebrates as an important ecological bioindicator of habitat disturbance in the area to be developed. Benthic macroinvertebrates are amongst the most sensitive biotic components of aquatic ecosystems and are thus useful for assessing ecosystem integrity and functioning of potentially affected estuarine habitats.

1.2 TERMS OF REFERENCE

The brief of the present study was to undertake a once off assessment of the physico-chemical water quality, sediment characteristics and macrobenthic invertebrate fauna of the area around the proposed Finger Jetty expansion site (Figure 2.1).

1.3 AIMS

The aim of the study was to determine the status of the macrobenthic fauna in the area around the proposed Finger Jetty expansion site and to assess any potential risks associated with the development on the macroinvertebrate faunal community.

2. STUDY AREA

2.1 INTRODUCTION

The study area incorporates two different habitat types in the port:

1. deepwater in-channel areas in close proximity to the proposed Finger Jetty expansion site.
2. off-channel shallow water areas adjacent to the Sand Spit and the Kabeljous mudflat.

2.2 MACROBENTHIC FAUNA SAMPLING SITES

Samples of the macrobenthic invertebrate fauna were collected at six sites (FJ1-6) in selected deepwater channel and shallow off-channel areas (Figure 2.1). The sites were selected to be representative of the development area and the ecologically important areas that could potentially be affected by the development. Site FJ6 on the Kabeljous mudflat was selected as a reference subtidal mudflat site.

The six sites were:

1. **FJ1: 28° 48' 10.30" S; 32° 02' 58.43" E**
2. **FJ2: 28° 47' 44.97" S; 32° 03' 08.79" E**
3. **FJ3: 28° 47' 45.56" S; 32° 02' 49.56" E**
4. **FJ4: 28° 48' 00.52" S; 32° 02' 30.49" E**
5. **FJ5: 28° 47' 48.30" S; 32° 02' 03.79" E**
6. **FJ6: 28° 48' 02.53" S; 32° 02' 54.65" E**

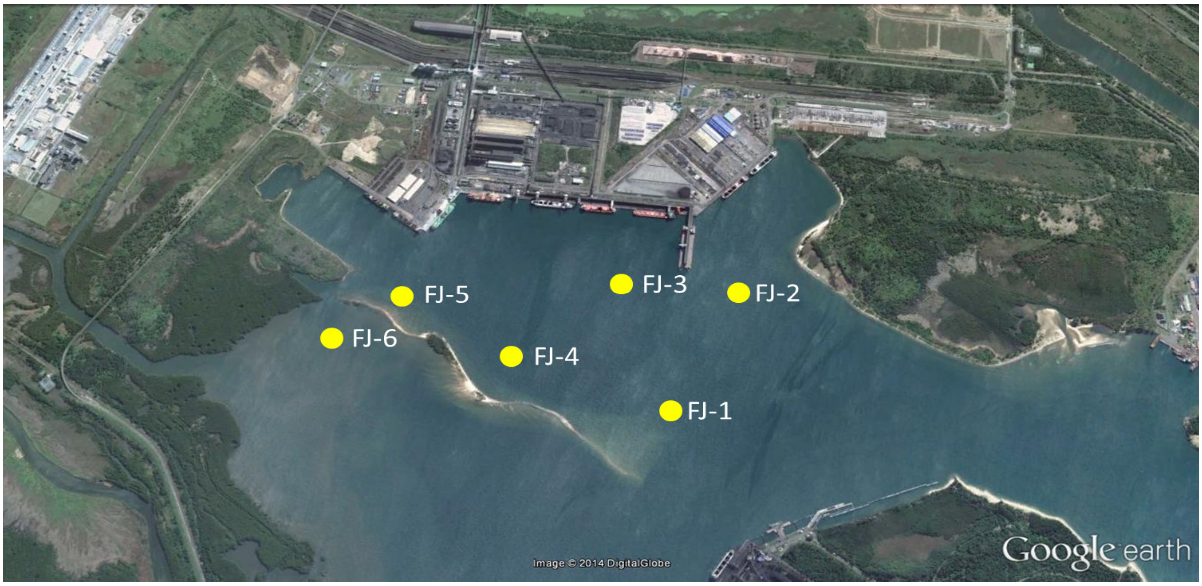

Figure 2.1 Macrobenthic sampling sites in the vicinity of the Finger Jetty in Richards Bay Harbour.

3. METHODS

3.1 INTRODUCTION

Only a once-off sampling of the selected sites in the vicinity of the Finger Jetty was conducted. A once-off sampling is far from ideal and creates constraints with regard to analysis and interpretation of macrobenthic community patterns (see Figure 2.1). However, historical data collected by CRUZ-E could however be used during the proposed monitoring phase to represent baseline data.

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3.2 METHODS

3.2.1 Benthic Invertebrate Sampling

Samples of the benthic fauna were collected at six sites (Sites 1-6) in the subtidal and intertidal zone adjacent to the Finger Jetty in the port (Figure 2.1). Two sets of sampling gear were used, depending on water depth. A Zabalocki-type Eckman grab, which samples 0.0236 m^2 to a minimum depth of 50 mm, was used to collect five replicate benthic samples from shallow sites, < 3m water depth. Deeper sites were sampled with a Van Veen grab. Samples were decanted five times through a 0.5 mm sieve to ensure extraction of at least 95% of the animals. Samples were preserved in a 10% formalin solution, and stained with the vital dye Phloxine B to aid sorting in the laboratory. Animals were identified to species level where possible, enumerated and densities calculated as no.m^{-2}. Sediment samples were also collected and analysed for grain size and organic content using standard techniques.

3.2.2 Sediment Grain Size & Organic Content

Bottom sediment was collected from each of the benthic sampling sites and sent to Environmental Management Service in Durban for Grain Size range and Organic Content determination.

3.2.3 Physico-chemical Parameters

Physical water quality parameters (water temperature, turbidity, salinity, pH, dissolved oxygen concentration, % oxygen saturation and depth) were measured at each site using a YSI 6920 Sonde (YSI Incorporated).

4. RESULTS

4.1 SEDIMENT & PHYSICO-CHEMICAL WATER QUALITY

The physico-chemical water quality parameters and sediment characteristics recorded at six sampling sites in the vicinity of the Finger Jetty are presented in Table 4.1.

Table 4.1: Physico-chemical water quality data and sediment characteristics at six sampling sites in Richards Bay Harbour in the vicinity of the Finger Jetty. See Figure 2.1 for sampling sites.

		Finger Jetty Sampling Sites											
Site		FJ1		FJ2		FJ3		FJ4		FJ5		FJ6	
		Top	Bottom	Top	Bottom	Top	Bottom	Top	Bottom	Top	Bottom	Top	Bottom
Temp (^{o}C)	(oC)	20.1	20.1	19.3	19.4	19.3	19.2	20.5	*	20.5	*	21.0	*
Conductivity	(mSm)	53.01	53.00	53.08	53.10	53.04	53.04	53.03	*	53.02	*	53.01	*
TDS	(mg/l)	34.45	34.45	34.50	34.52	34.48	34.48	34.47	*	34.46	*	34.45	*
Salinity		35.02	35.03	35.08	35.09	35.05	35.05	35.02	*	35.01	*	35.03	*
Dissolved Oxygen	(mg/l)	7.84	7.87	7.92	7.33	7.86	7.53	7.77	*	8.14	*	7.84	*
Oxygen Saturation	(%)	106.2	106.6	105.7	97.6	104.9	100.3	110.0	*	111.2	*	108.0	*
pH		7.70	7.69	8.00	7.92	7.96	7.94	7.95	*	7.78	*	7.65	*
Turbidity	(NTU)	2.4	2.6	1.9	3.1	1.8	2.6	3.7	*	4.1	*	3.3	*
Depth	(m)	-	0.8	-	21.8	-	21.6	-	0.7	-	0.7	-	0.8
Time		13h30		13h37		13h21		14h30		15h30		16h50	
Particle size	φ value	2.72		4.47		4.47		2.68		4.10		4.21	
	Category	fine sand		silt		silt		fine sand		silt		silt	
Sorting coefficient	Coefficient	0.46		0.54		0.32		1.08		0.85		0.98	
	Category	well sorted		moderate		very well sorted		poorly sorted		moderate		moderate	
% Organic content	%	0.38		1.78		2.15		0.41		0.92		1.21	
	Category	very low		moderately low		medium		very low		low		moderately low	

The area sampled was strongly marine dominated, given the marine salinities and conductivities recorded. Dissolved oxygen (mg/l) and oxygen saturation (%) were relatively high at all sites at the top and bottom of the water column. There was no sign of oxygen stratification in the water column and bottom oxygen concentrations were > 7mg/l at all sites, suggesting no anoxic conditions at any of the sites sampled. This was supported by pH levels ranging between 7.65 - 8.00, suggesting a strong marine influence. Water clarity was good throughout, at the top and bottom of the water column, with the highest turbidity of 4.1NTU being recorded on the shallow mudflat at Site 5. Even on the Kabeljous mudflat (FJ 6), a low turbidity of 3.3 NTU was recorded. The water quality recorded during this study was comparable to that recorded during the CSIR (2013) survey from sites close to the proposed Finger Jetty expansion site and the Sand Spit.

Sites 1 and 4 were characterised by fine sandy substrate with a very low organic content. In contrast, silty sediment occurred in the deep water areas of Sites 2 and 3, which also contained higher organic material in the sediment. Sites 5 and 6 were on the subtidal mudflat, with both sites showing silty sediment with relatively high organic content.

4.2 MACROBENTHIC FAUNA

The zoobenthic macroinvertebrates recorded at six sampling sites in Richards Bay Harbour in the vicinity of the Finger Jetty are presented in Table 4.2. A total of 28 zoobenthic taxa were recorded during the study, being dominated in terms of the number of taxa by polychaetes and molluscs. Highest benthic densities were recorded in muddy sand at Sites 1 and 6, whereas very low densities were recorded in the silty substrate at Sites 2 and 3. Site 6, the site chosen as a reference site on the Kabeljous mudflat, showed the highest densities. Similarly, highest number of taxa was recorded at Site 6 on the Kabeljous mudflat and in the muddy sand at Sites 1, 4 and 5, whereas the lowest number of taxa were recorded in the silty substrate at Sites 2 and 3.

Mean zoobenthic densities per site were generally low, with a mean CPUE = 662 organisms per m^{-2}, which can be regarded as low for a permanently open estuarine environment. This is particularly the case for Sites 2-3, as these low densities are very low for muddy estuarine habitat.

The macrobenthos was numerically dominated by small polychaetes e.g. *Mediomastus capensis* and *Ancistrocylis parva* and the bivalves *Dosinia hepatica* and *Tellina sp*, with these four taxa comprising 46% of the zoobenthic organisms in this area. It is noteworthy that the mud crab, *Paratylodiplax blephariskios*, was absent from the deep channel sites (Sites 1-4), but relatively abundant in shallower areas, notably on the Kabeljous Flats. These crabs are relatively large bodied compared to most other macrobenthic taxa and as such contribute substantially to the benthic biomass where they occur in abundance. The abundance of small spionid polychaetes is characteristic of muddy or silty areas where they feed on the abundant detritus and organic material.

Table 4.2: Zoobenthic macroinvertebrate taxa CPUE, mean CPUE per area and percentage contribution per area as recorded at six sampling sites in Richards bay harbour in the vicinity of the Finger Jetty. See Figure 4.1 for sampling sites. Dominant taxa (>4% of the total CPUE) are indicated in bold.

	FINGER JETTY SITES							
	FJ1	**FJ2**	**FJ3**	**FJ4**	**FJ5**	**FJ6**	**Total**	**% Contr**
NEMERTEA	59.0			16.9	59.3	84.7	178.0	**4.6**
TURBULARIA	8.5			25.4			33.9	0.9
ANNELIDA								
Naididae	8.5						8.5	0.2
Armandia intermedia	101.7			8.5			110.2	2.8
Ancistrocylis parva		152.5		42.4		76.3	271.2	**7.0**
Capitella capitata						67.8	67.8	1.7
Ceratonereis sp						33.9	33.9	0.9
Euchone sp	16.9			8.5			25.4	0.7
Glycera subaena			8.5	33.9		50.8	93.2	2.4
Mediomastus capensis	93.2	8.5		305.0	144.1	254.2	771.2	**19.8**
Magelona cincta	50.8						50.8	1.3
Notomastus aberans				16.9	25.4	67.8	110.2	2.8
Nephtyes sp			59.3				59.3	1.5
Nephtys sphearocirrata	93.2	8.5		84.7	76.3	59.3	322.0	**8.3**
Owenia fusiformis	161.0			25.4			186.4	**4.8**
Polychaete sp1			8.5				8.5	0.2
Prionospio cirrifera						84.7	84.7	2.2
Polydora sp		16.9					16.9	0.4
Tellina sp	237.3			118.6	16.9	8.5	381.4	**9.8**
Tharyx marioni	93.2	16.9			93.2		203.4	**5.2**
MOLLUSCA								
Dosinia hepatica	59.3	8.5	101.7		8.5	194.9	372.9	**9.6**
Eumarcia paupercula	25.4	25.4			8.5	42.4	101.7	2.6
Assimnea ovata			8.5				8.5	0.2
Nassarius kraussianus				8.5		42.4	50.8	1.3
CRUSTACEA								
Apseudes digitalis				8.5	42.4	59.3	110.2	2.8
Leptanthura laevigata		50.8	8.5				59.3	1.5
Mesopodopsis africanus			16.9				16.9	0.4
Paratylodiplax blephariskios				8.5	16.9	127.1	152.5	3.9
Total	1008.2	288.1	211.9	711.8	491.5	1254.2	3889.8	
No of taxa	13	8	7	14	10	15	28	

Figure 4.1 The mud crab, *Paratylodiplax blephariskios*, a numerically dominant component of macrobenthic densities and biomass in estuarine mudflats.

4.3 MACROCRUSTACEA FAUNA

No species of macrocrustacea were caught during the study.

5. DISCUSSION & CONCLUSIONS

5.1 MACROBENTHIC FAUNA

Limited data is available for the Port of Richards Bay with which to compare the macrobenthic faunal composition recorded during this study (Vivier & Cyrus 2009). To date, by far the most complete and detailed description of the macrobenthos of the harbour, with particular reference to subtidal mudflats and mangrove lined channel habitat, are contained in the reports by MacKay (2006), as part of a biomonitoring program for the dredging during construction of Berth 306 opposite the Kabeljous Flats at the coal terminal (RBCT).

A once-off macrobenthic survey conducted in 1996 indicated that muddy areas supported greater densities of benthic organisms than deep-water channel and sandy sediments, but with fewer species (Wepener et al. 1996). The polychaete *Prionospio sexoculata* was found to numerically dominate the mudflat macrobenthic fauna, particularly on the subtidal parts of the Kabeljous flats. It is noteworthy that this polychaete was not recorded during the current study, but has been found to be quite abundant in the mangrove lined Bhizolo Canal sediment (Wepener et al. 1996).

The 28 macrobenthic taxa recorded during the present study can be regarded as quite low for east coast subtropical estuarine environments. In the adjacent Mhlathuze Estuary, 86 macrobenthic taxa were recorded (Mackay & Cyrus 1999). MacKay (2006) recorded a total of 113 macrobenthic taxa during six two-monthly surveys on the subtidal mudflats of the Kabeljous Flats and in the Bhizolo canal. If the number of taxa per season (analogous to a once-off sampling such as was conducted during this study) is considered, the maximum number of taxa per season (N = 26) corresponds well with the number of taxa recorded during the present study (N = 28).

It is also interesting to note the variation in the number of taxa recorded between different habitat types. The mean number of taxa per sampling season recorded on mudflat areas (25-26 taxa) by Mackay (2006) was considerably higher than in muddy canal areas (14 taxa). These canal habitat values are comparable to the low number of taxa recorded in the deep-water channel areas (13 taxa; Sites FJ 2 & 3) during this study.

Macrobenthic densities recorded during this study were much lower than that reported in previous studies, with Mackay (2006) reporting mean seasonal benthic densities ranging from 1512 organisms.m^2 in summer to 5429 organisms.m^2 in spring. During the present study, the mean benthic density per site (excluding the reference Kabeljous mudflat site) was only 542 organisms.m^2. The mean density for off-channel sandy sites was 737 organisms.m^2, whereas the mean density for the deepwater mid-channel muddy sites was only 250 organisms.m^2. In contrast, a density of 1254 organisms.m^2 was recorded at the Kabeljous mudflat site.

Mackay (2006) noted that notable changes in the numbers of species of crustaceans and polychaete annelids have occurred between the pre- and post-harbour environment.

Previously, crustaceans dominated the benthic fauna in terms of both species richness and density, whereas during the 2006 survey, the system was significantly dominated (in terms of numbers) by bivalve molluscs. This suggested post-harbour changes in the benthic assemblage, mainly associated with changes in sediment distribution and anthropogenic input of contaminants related to the port activities.

As part of a Strategic Environmental Assessment (SEA) for the Port of Richards Bay, a study was done on the ecological significance and conservation importance of different habitat types within the port (CSIR 2005). Of the habitats assessed, intertidal mudflats were ranked as the habitat with the 2nd highest conservation importance, after intertidal sandflats. In contrast, deepwater sediments, such as the mid-channel areas in close proximity to the Finger Jetty development site, was rated as the habitat of least conservation importance. These findings highlight not only the importance of conserving the ecological integrity of the mudflat habitat (Kabeljous flats) during the development, but also the relatively low conservation importance afforded the deep-water channel habitat.

Even though the benthic diversity during this study was found to be relatively low, the system supports an important biomass of primary and secondary invertebrate consumers which can be regarded as a vital trophic link that sustains the role that the system plays as a nursery to estuarine dependent fish and prawn species. The macrobenthic community reported during the study also reflects the highly variable habitat within the system. Such diverse habitat has conservation significance as the organisms associated with each area will reflect the biodiversity of the system as a whole.

Benthic macroinvertebrates are sensitive and widely used bioindicators of habitat disturbance in estuarine monitoring studies. Their close association with aquatic sediment, coupled with their limited mobility, mean that they are closely associated with most physico-chemical processes in the aquatic environment. Due to their sessile nature and relatively long life cycles, benthic invertebrates are representative of the location being sampled, which allows monitoring of temporal and spatial changes in response to perturbation in the aquatic environment. Macrobenthos also form a central element of estuarine food webs, being an important food resource for many larger crustaceans, fish and birds, and can profoundly influence the abundance and species composition of these tertiary consumers.

5.2 OVERALL CONCLUSIONS

In terms of the macrobenthic faunal composition, it can be concluded that:

1. Extension of the Finger Jetty will have limited direct risk associated with the macroinvertebrate fauna in the deep-water environment other than the direct loss of the habitat under the footprint of the extended quay. The deepwater habitat was found to typically host a low diversity of macrobenthic fauna.
2. The off-channel muddy sand habitat to the south of the shipping channel revealed higher benthic densities and a higher number of taxa. Although not directly impacted on by construction of the Finger Jetty extension, the benthic fauna in these areas could be subjected to indirect toxicological impacts related to re-suspension of contaminated fine sediments during dredging.
3. Highest macrobenthic diversity was observed in the subtidal Kabeljous mudflats. Intertidal mudflats are regarded as of high conservation importance and should be the focus of concerted efforts to avoid any impacts during the development.
4. It is recommended that monitoring of the macrobenthic fauna at the sampling sites used in this study be continued before, during and after construction of the Finger Jetty.

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ABRIDGED CURRICULUM VITAE

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BSc (Zoology, Biochemistry)	**1987**
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PhD (Zoology)	**2010**

Experience: Twenty two years experience in estuarine ecological research on KZN rivers, estuaries and coastal lakes - mostly on zoobenthos, fish & water quality. Current fields of research include biology and ecology of estuarine zoobenthos and fish, and sediment toxicity bioassay procedure development for nearshore, estuarine and marine sediment and water. Have participated in many co-operative and contract research projects i.e. environmental biotic studies of Richards Bay Harbour and adjacent estuarine and wetland areas, environmental reserve for coastal lakes and estuaries, instream flow requirements for rivers,strategic environmental scan with reference to biotic components of the Richards Bay area, deign and monitoring of fishways in KZN, survey of water quality and biota of the Bivane and Phongola Rivers, ecostatus of the Phongolo river floodplain.

Specialisations: Zoobenthic & fish community ecology and water quality assessment of coastal lakes and east coast estuaries. Estuarine water and sediment pollution/quality surveys, including use and development of sediment toxicity assessments and assays.

Presentation of Research Findings:

Publications:	**Conference Presentations:**
22 reviewed journal publications, co-author of 38 consultancy reports.	10 National Conferences 9 International Conferences

Co-operative And Collaborative Research: Have participated in joint Unizul, Rhodes, UPE, CSIR & JLB Smith RDM projects on the Mhlathuze and Nhlabane Estuaries. Have collaborated with ORI scientists in a multi-disciplinary MCM funded survey of the drought related impacts on the fish community of St Lucia.

Membership of Scientific Societies: Member of the Southern African Society of Aquatic Scientists and the Consortium for Estuarine Research and Management.

2014-09-09

ABRIDGED CURRICULUM VITAE

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	BSc Hons (Hydrobiology)	**1978**
	MSc (*cum laude*) (Estuarine Ecology)	**1980**
	PhD (Estuarine Ecology)	**1984**
	Integrated Environmental Management - Theory & Practice	**1991**
	Offshore Marine Pollution	**1997**
	ISO 14001 Environmental Management Systems	**1998**
	Public Participation in EIA's – Theory & Practice	**2002**
Awards	**Southern African Society of Aquatic Scientists – Gold Medal**	**2011**

Academic Experience: Thirty three years' experience lecturing a wide range of Zoology related subjects as well a supervising numerous MSc and PhD students.

Research Experience: Forty years covering Estuarine, River, near-shore Marine and Coastal Lake environments. Have participated in numerous contract research projects such as the determination of the Environmental Reserve for Coastal Lakes and Estuaries, the effects of intrabasin transfer schemes in the area, A Strategic Environmental Scan with reference to Biotic components of the Richards Bay area and Instream Flow Requirements for Rivers. Involved with Freshwater Flow Requirements for Estuaries. Was part of the Scientific team that formulated the biological requirements for the South African Resource Directed Measures Legislation to determine Flow Allocations for Environmental Purposes for Estuaries & Rivers and the monitoring thereof.

Specialisations: Estuarine, River and Coastal Lakes Ecology. Flow Allocations for Environmental Purposes for Estuaries and Rivers based on Biotic component requirements. Fish Specialist. Also specialist in ornithological issues related to association of birds with Estuaries, Rivers and Coastal Lakes.

Environmentally Related Activities:	Have been involved in over 130 research projects concerned with Environmental Impact Assessments on the ecology of nearshore marine, estuarine and freshwater systems and project leader/senior author on some 90 of these. Fields include specialist biological surveys, ecological assessments, biomonitoring, specialist review consulting, Estuarine Flow Requirements and numerous studies on impacts of developments on aquatic environments. Have been involved with Reserve determinations for the Mkomaas, Mhlathuze, St Lucia, Siyaya and Nhlabane Systems as well as with the revision of the estuarine RDM Protocols, Thukela Intermediate EFR study and development of Estuarine Base line and long term Monitoring Protocols for RDM of Estuaries. Assessment of the Environmental Impacts of the development of the Port of Richards Bay over the next 40 years.
Presentation of Research Findings:	**Publications:** 146 Scientific Journal Publications (124 on Estuaries) 142 Environmental Project Reports **Conference Presentations:** 76 National Conferences 67 International Conferences
Co-operative and Collaborative Research:	Current and past involvement with the Universities of Natal (Durban & Pietermaritzburg) and Port Elizabeth, the SA Institute for Aquatic Biochemistry, KZN Wildlife, World Wildlife Fund - Conservation Division, National Ports Authority, Mondi Forests, Sappi Stanger Environmental Liaison Committee, CSIR, Institute for Natural Resources, Oceanographic Research Institute as well as three overseas based projects (University of Hull, UK & CSIRO, Australia).
Membership of Scientific Societies:	Southern African Society of Aquatic Scientists (SASAqS), Estuarine and Coastal Shelf Sciences Society (ECSA), Consortium for Estuarine Research and Management (CERM), Zoological Society of South Africa & Ornithological Society of South Africa (Bird Life SA).

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