Marine Phosphate Mining in Namibia: The Truth of the Matter

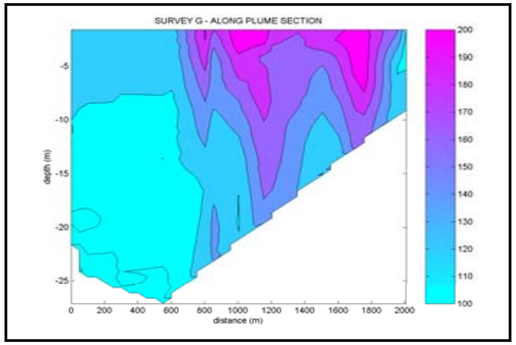
Talk by Grant Rau at the Scientific Society of Namibia

10th November 2016

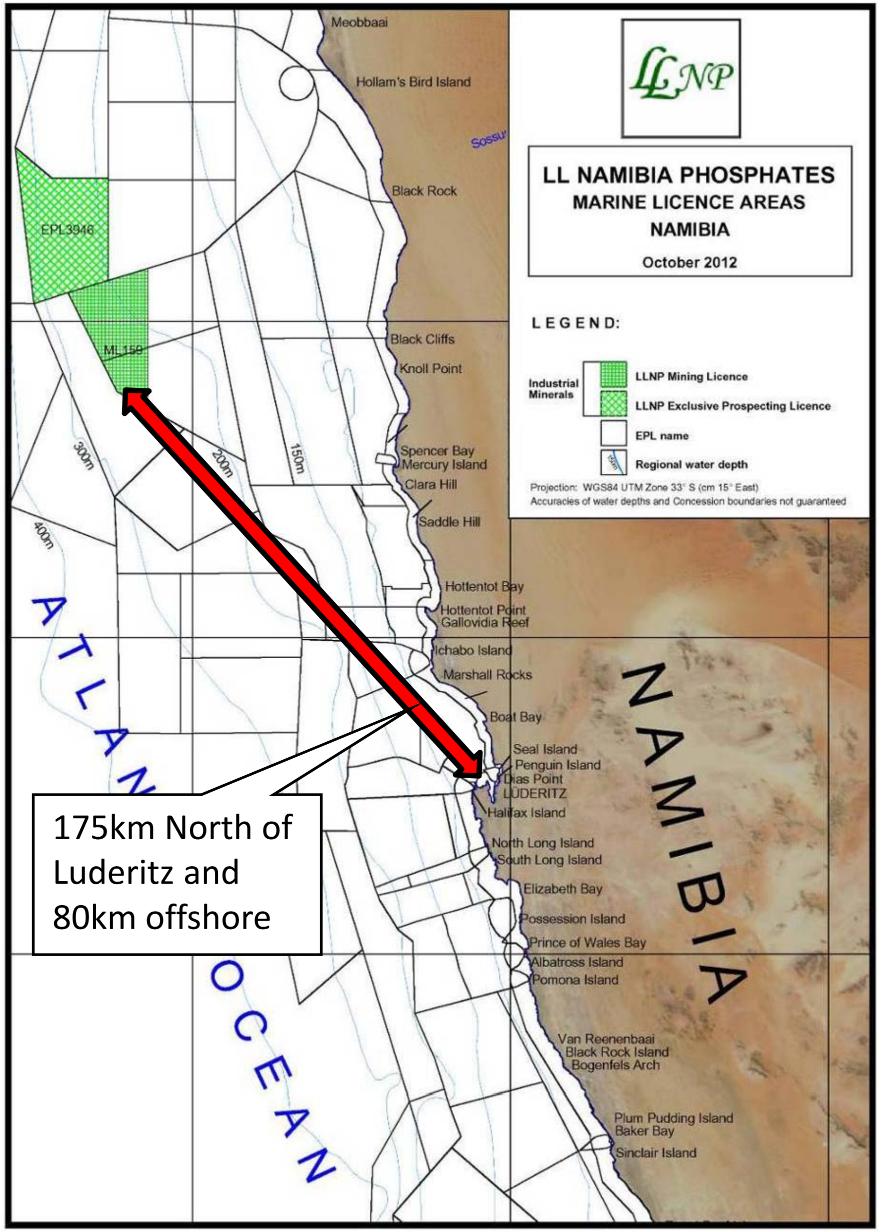
- I’m sad to inform you that tomorrow a large asteroid is going to impact and destroy the earth, what thoughts go through your head?

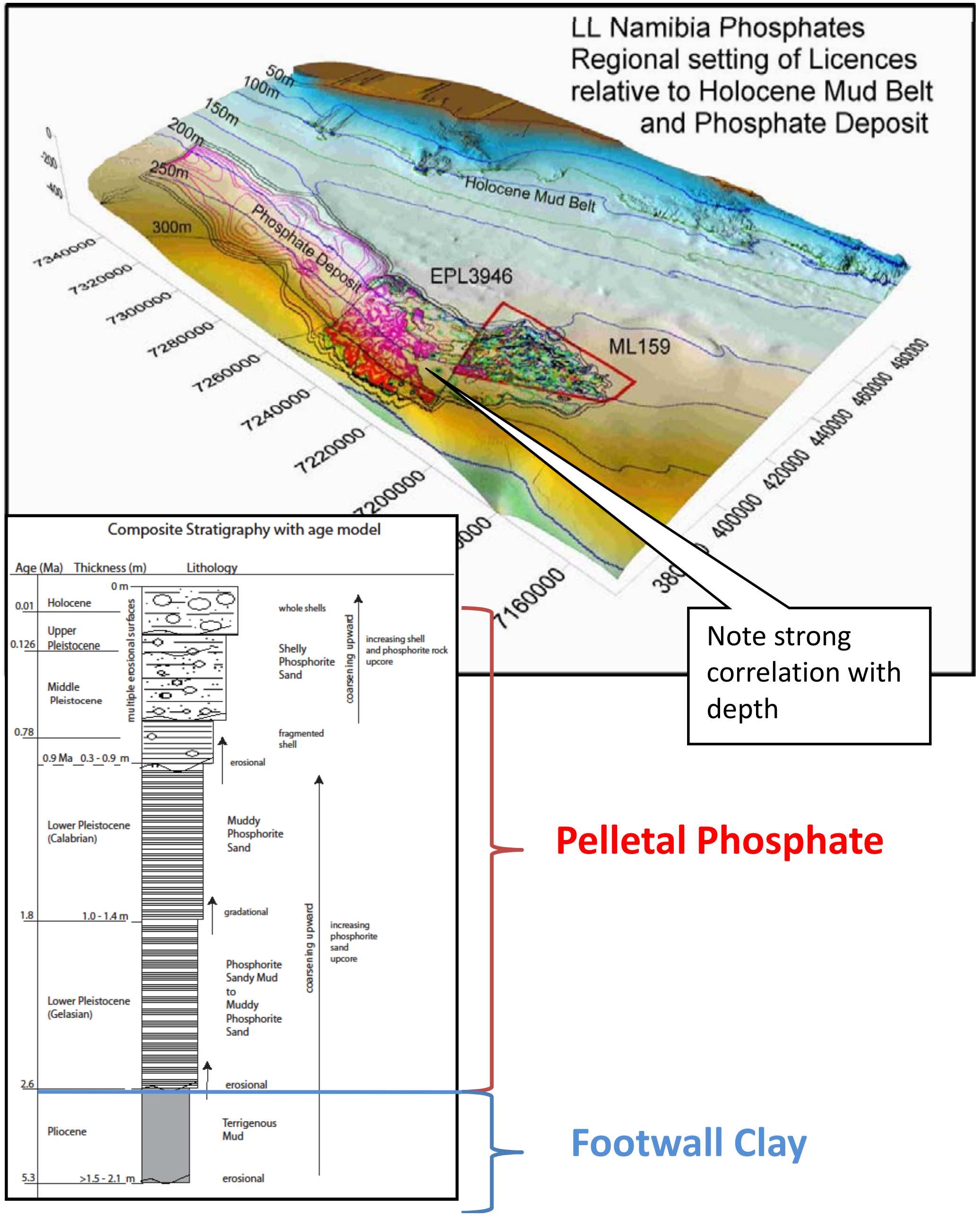
WHAT SCIENTIFIC PROOF DO YOU HAVE TO BACK UP THIS ALLEGATION?

Environmental Considerations: Phosphate Mining and the Marine Ecosystem

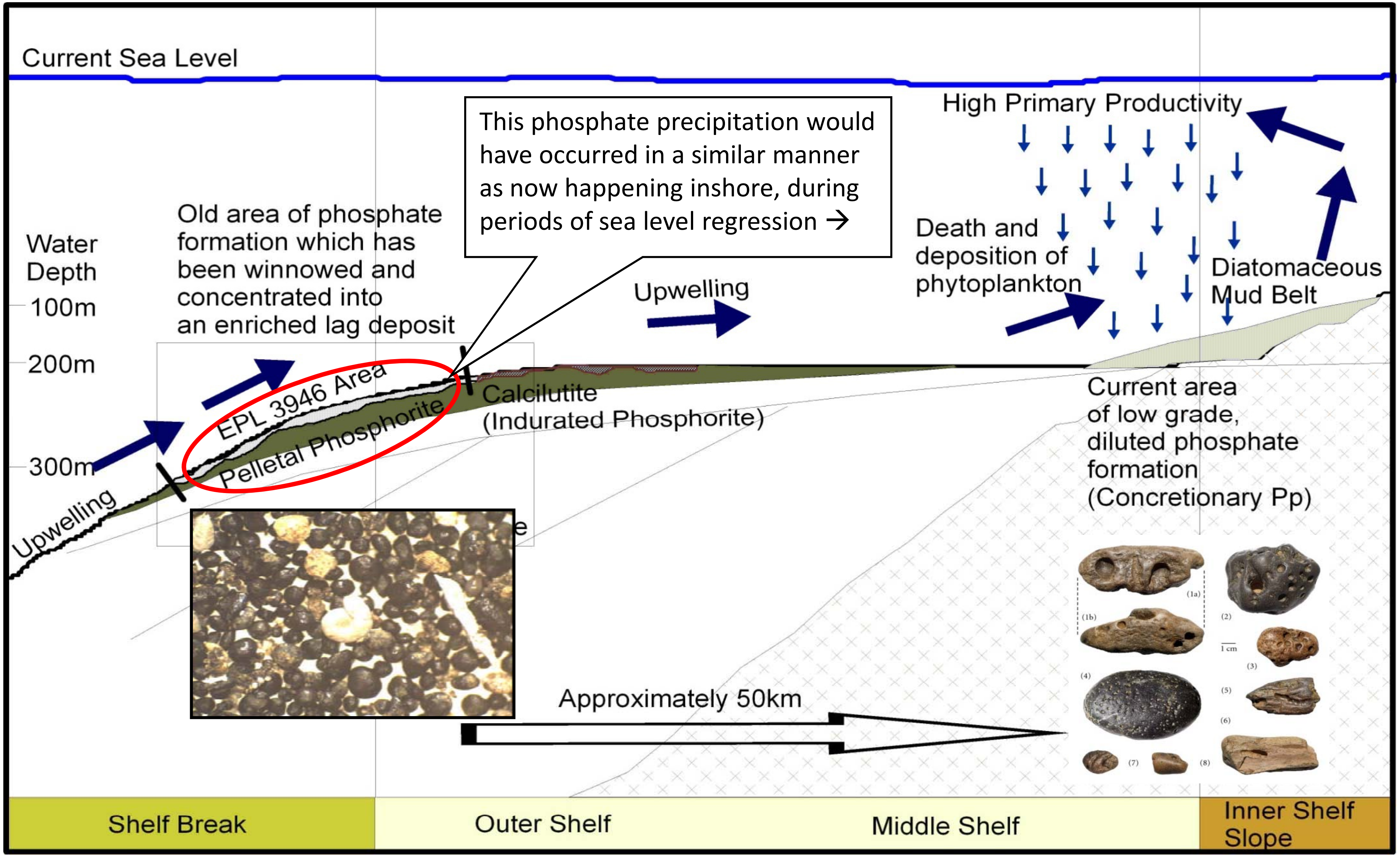


LLNP Deposit



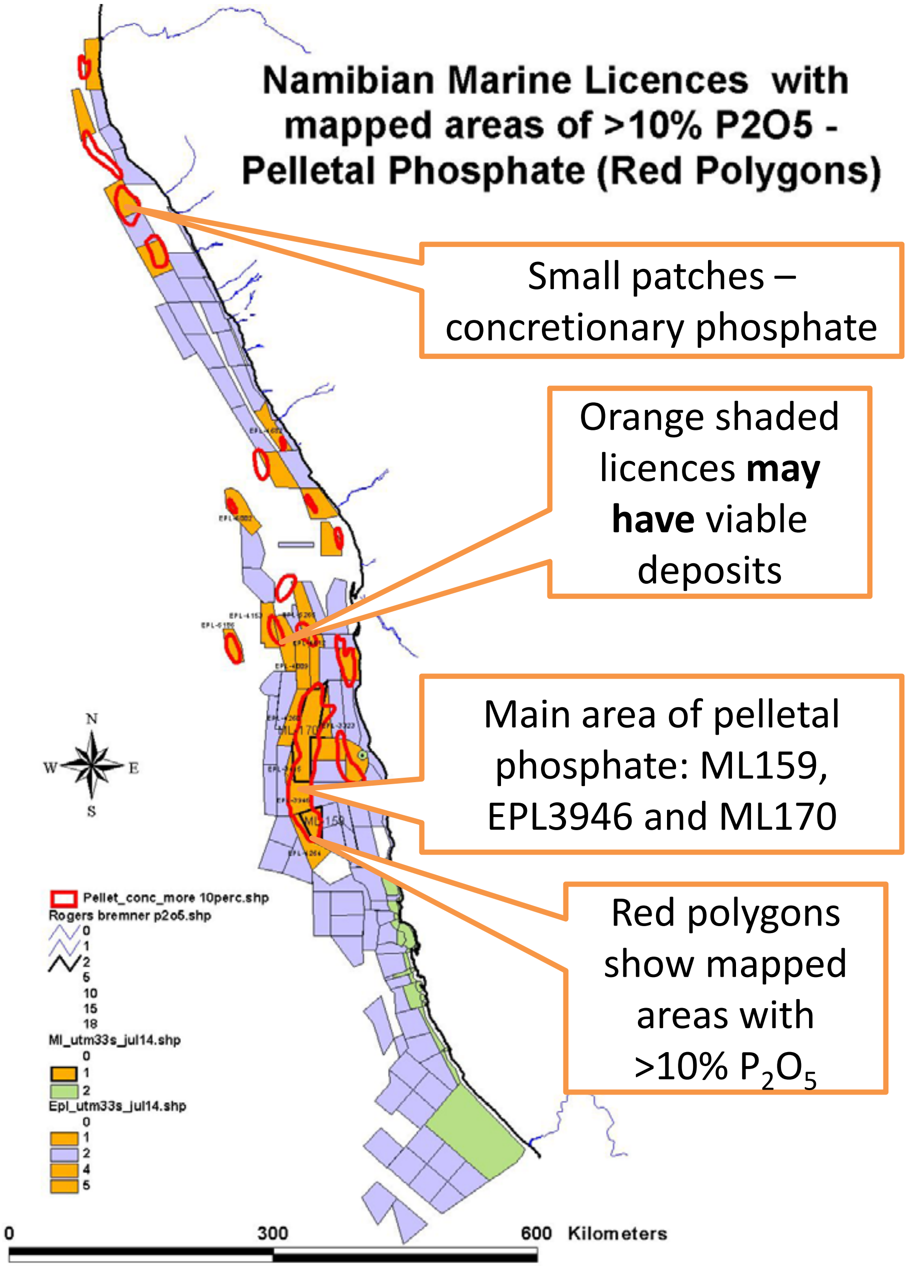


Phosphate Deposition Formation



Schematic diagram showing phosphate formation model for Namibian west coast.

Phosphate Licences - Distribution



Rogers and Bremner in their PhD's mapped the Namibian west coast sediments. From their research **areas of >10% P_2O_5** (red polygons = cut-off grade) could be mapped. This research was enhanced by the detailed sampling programmes by LLNP and NMP in the central Namibian section.

Thus the licences shown in **orange shading indicate the maximum extent of viable marine phosphate licences on the west coast (8 530km² of 225 700km²** - 3.7%). Only small portions of some of these licence areas will eventually be mined (<0.5%).

LLNP Baseline Studies completed



Environmental Baseline Studies

Biological Baseline Survey of the Benthic Macrofauna Communities in the Phosphate Licence Blocks EPL 3946 and ML 159

April 2012

LL Namibia Phosphates (Pty) Ltd

Steffani Marine Environmental Consultant
October 2012

BASELINE REPORT: BENTHIC MACROFAUNA COMMUNITIES IN – EPL 3946 & ML 159

PREPARED FOR

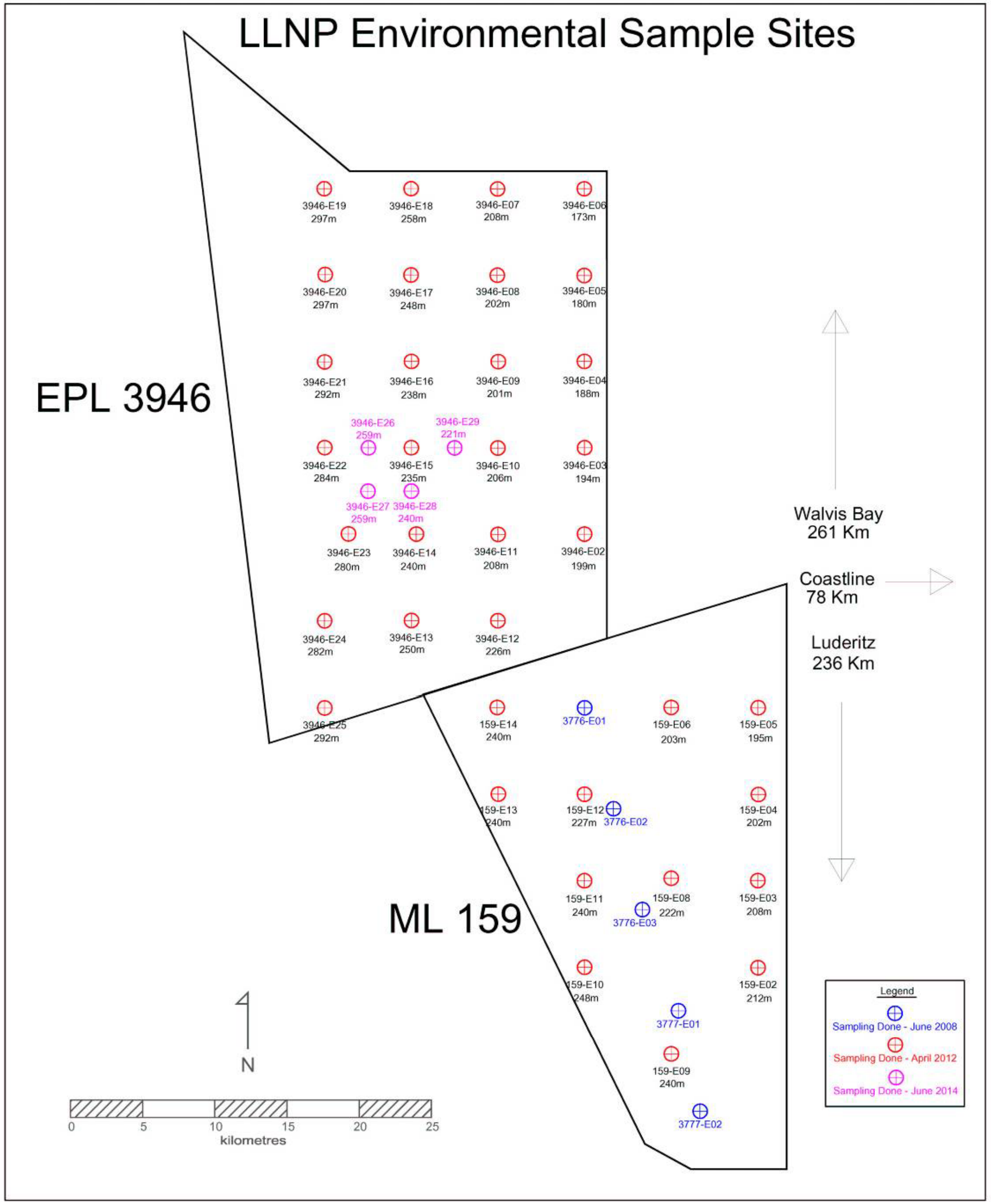
LL NAMIBIA PHOSPHATES (Pty) Ltd.

February 2015

Sam Mafwila

CENTRE FOR ENVIRONMENT AND NATURAL RESOURCES P.O.Box 96063, WINDHOEK, Namibia

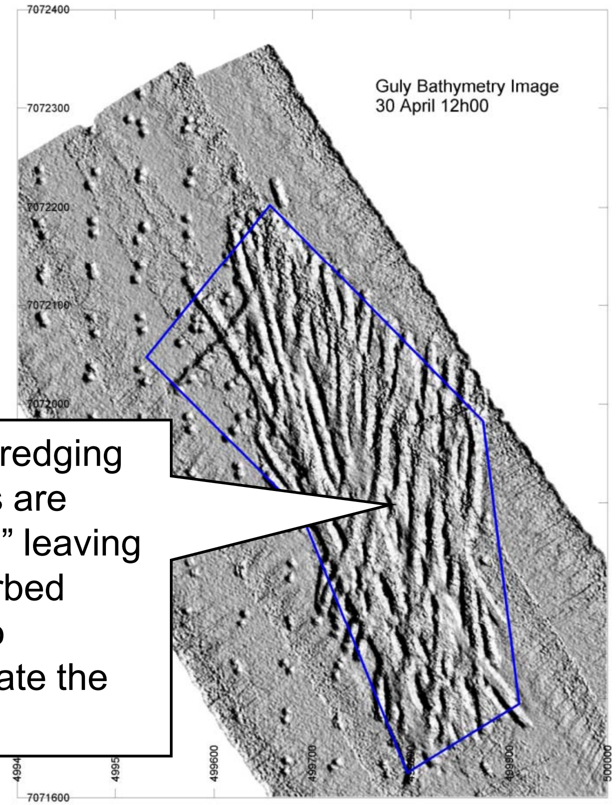
Environmental Sampling



<u>Environmental baseline survey results - macrofauna (Steffani Marine Environmental Consultant)</u>
"Overall species richness of the benthic macrofauna assemblages was relatively low and strongly dominated by **polychaetes (69% of species),** followed by crustaceans, molluscs and a number of taxa belonging to a variety of other phyla.

"All of the identified species found in the study area have a larger geographical distribution and/or have been recorded elsewhere from the Namibian and/or South African west coast".

Photographic gallery of some of the common polychaetes, molluscs and crustaceans:

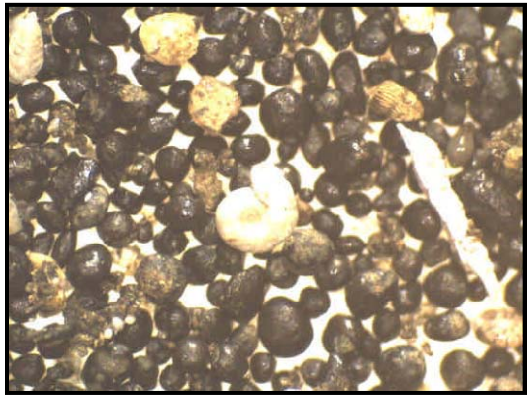


When dredging portions are "missed" leaving undisturbed fauna to repopulate the area

Main Environmental Factors to Consider – Phosphate Mining

1) Heavy metals, H_2S - water column impacts
2) Nutrients and anoxia
3) Impact on commercial fisheries and fish spawning
4) Seafloor Sediment Removal – pertinent points to know
5) Are there other similar mining operations in other 1st world countries?
6) Why did they not approve the Environmental clearance in New Zealand?
7) Onshore beneficiation – environmental facts you should know?

1. Heavy Metals, Hydrogen Sulphide (H_2S) and Uranium/Thorium.



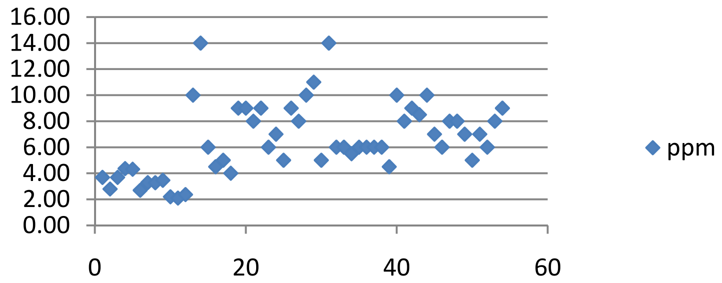
Points to Ponder

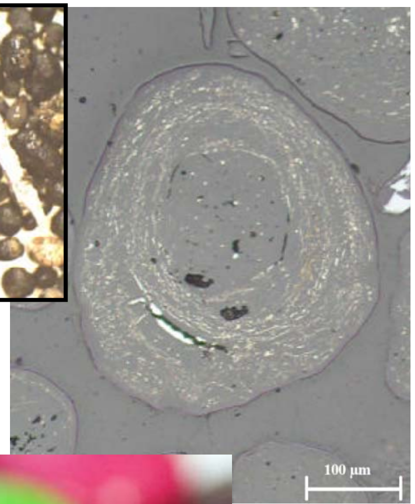
Some Points to Consider:

1) No phosphate mining has been done to date
2) The monkfish and sole bury themselves in these phosphate sediments – if the Cd, As, Pb, U and Th were bio-available why are the fish of the Namibian west coast not contaminated or glowing with radioactivity?
3) The bottom trawling industry have been disturbing the seafloor for decades, over very large areas, were these heavy metals bio-available why have these activities not already caused the ecosystem to crash?
4) If the underlying footwall clay unit were dangerous/ poisonous why has it not affected the ecosystem in the thousands of square kilometers where it is not covered by the P_2O_5 sand to the east, west, north and south of the deposit?

	Unit	Raw Namfos rock	Beneficiated Namfos rock
P_2O_5	%	23.00	42.00
CaO	%	44.30	33.60
SO_4	%	3.86	<0.05
F	%	3.00	0.60
Cl	%	0.10	0.01
Fe_2O_3	%	2.57	0.91
Al_2O_3	%	1.02	0.17
SiO_2	%	3.64	0.26
MgO	%	0.85	0.04
Na_2O	%	0.94	0.05
K_2O	%	0.98	0.04
Cd	ppm	6	0.18
As	ppm	65	8.90
Pb	ppm	8.9	3.70
Zn	ppm	20	5.70
Ni	ppm	41	13.00
Cu	ppm	12	1.00

Figure 8: LLNP: Cd ppm - Raw Ore



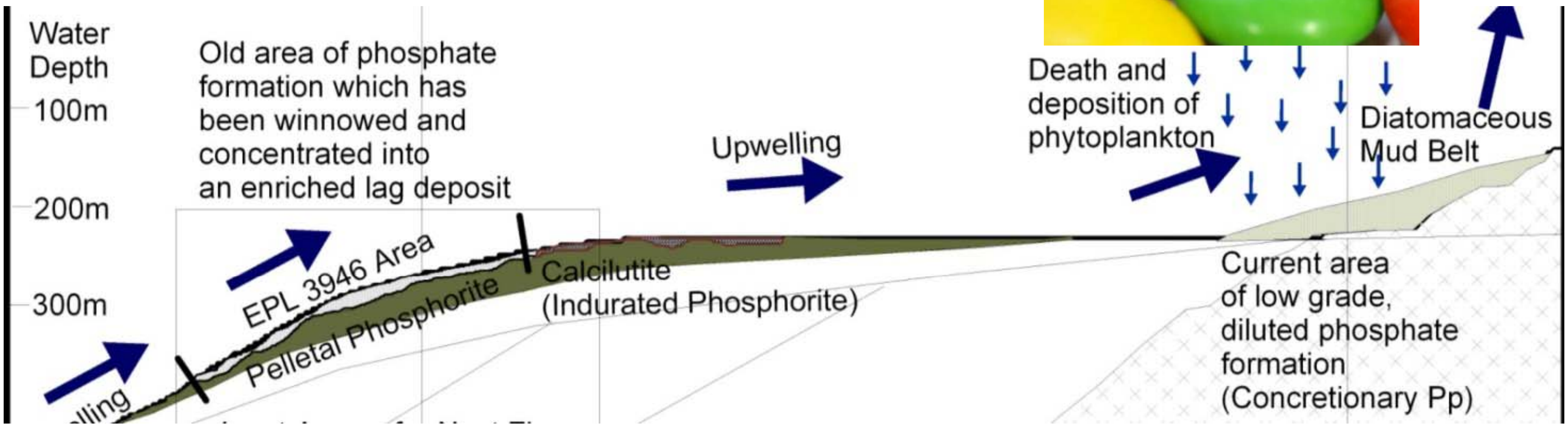


Answers to these Points

1) Phosphate is a great scavenger and attracts heavy metals, U and Th that substitute for ions in the crystal lattice of the Francolite mineral.

2) Namibia pelletal phosphate is like a "smartie" it has a dormant organic coating. The P and the HM's are locked up inside. It took us 3 years to find a method to "crack" it out. It is not a "smartie"!

3) The Pliocene terrigenous mud underlies the deposit. Where it "sticks out" it is in direct contact with the water column with no impact detected.



Answers continued

ELEMENT	LLNP Level (µg/L)	USA EPA (µg/L)	Comments
Cadmium	1.7	8.8	
Arsenic	16.4	36	25µg/L limit for Canadian drinking water
Lead	<0.5	12	
Mercury	<1	0.94	1µg/L detection limit
Uranium	24.8	30	

ELEMENT IN PELLET	LLNP (ppm)	Comments
Cadmium	6.5	5 - 510 ppm is the global range for phosphates
Uranium	148	Rossing (270 ppm), Langer Heinrich (550 ppm), Husab (390 ppm)
Thorium	35.5	Ilmenite (275 ppm), Rutile (200 ppm)

Materials Safety Data Sheets do not class phosphorite as a hazardous chemical; it may be handled, stored and transported by any person, is not corrosive and has low toxicity and irritant tendencies.
Studies (NMP) done on phosphate sand's radioactivity show that the radionuclides of interest do not bio-magnify and that phosphate mining operations posed <u>little risk to humans consuming seafood or the ecosystem</u>.

So where on the west coast are these heavy metals, radio-active elements and gases that the scientists opposed to phosphate mining keep talking about and the media keep referring to?

Studies have already been conducted on H_2S:

Dynamics of methane and hydrogen sulphide in the water column and sediment of the Namibian shelf

Volker Brüchert [1], Bronwen Currie [2], Kay-Christian Emeis [3], Rudolf Endler [4], Thomas Leipe [4], Kathleen R. Peard [2], Thomas Vogt [5], 2009

[1] Max-Planck Institute for Marine Microbiology and Research Center Ocean Margins, Bremen
[2] Ministry of Fisheries and Marine Resources, Namibia
[3] Institute of Biogeochemistry and Marine Chemistry, University of Hamburg
[4] Institute for Baltic Sea Research, Warnemünde
[5] Geoscience Department University of Bremen

Max-Planck-Gesellschaft

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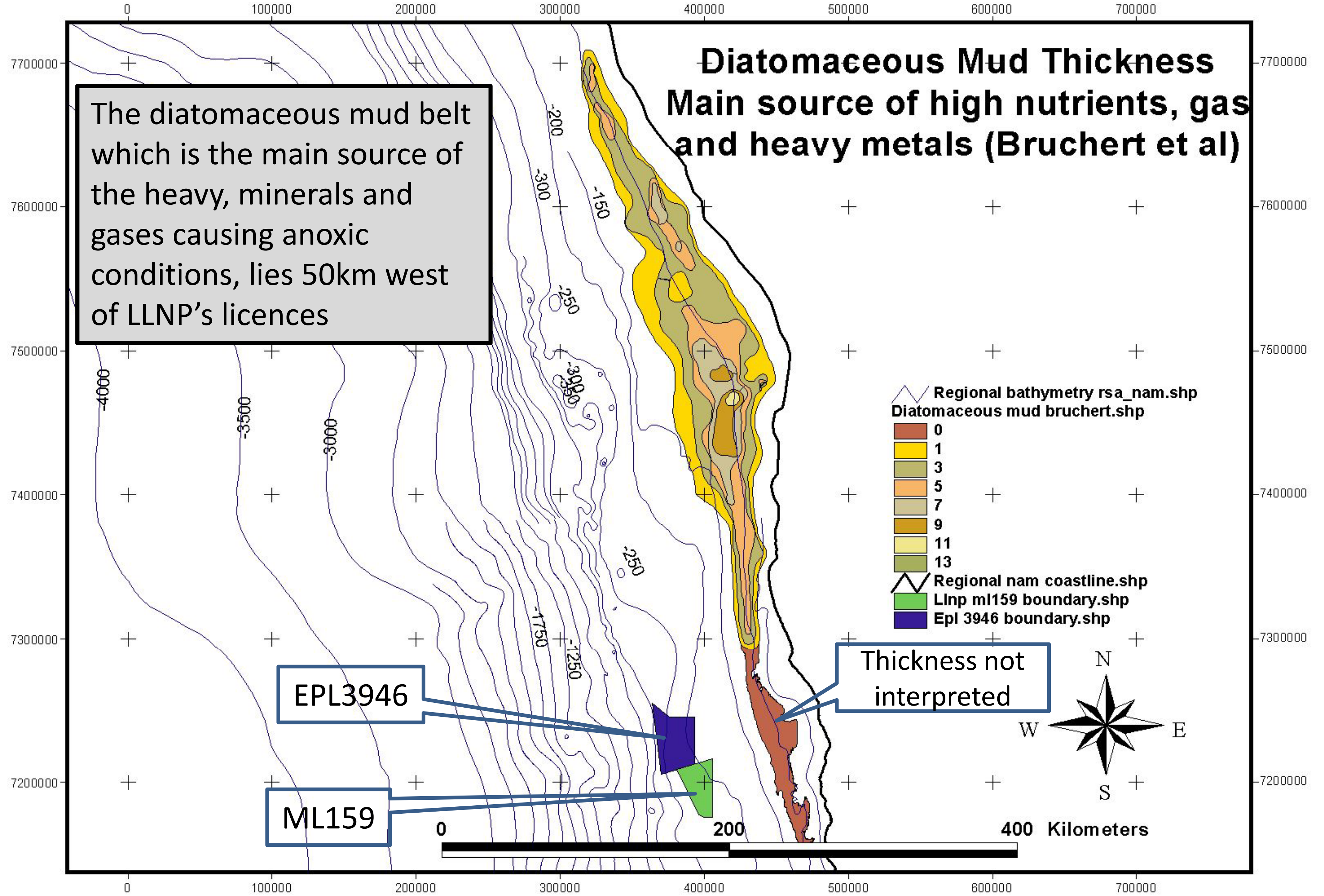
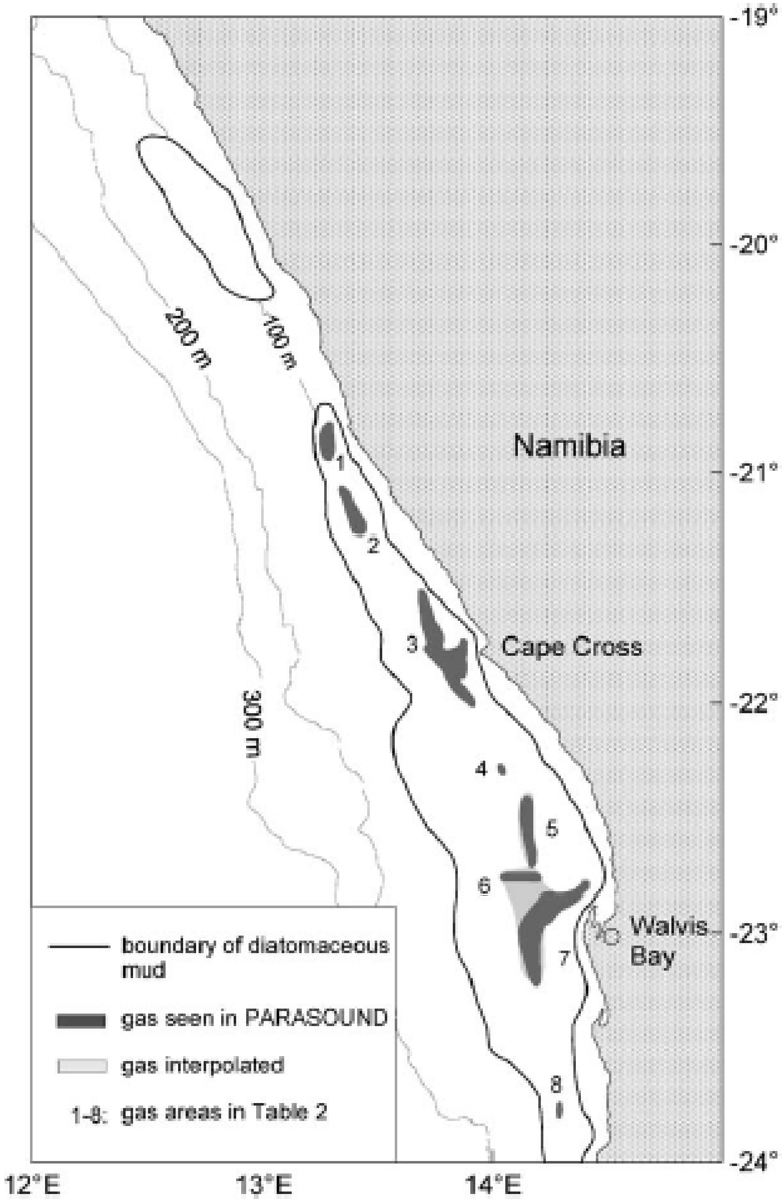
International Research - H_2S

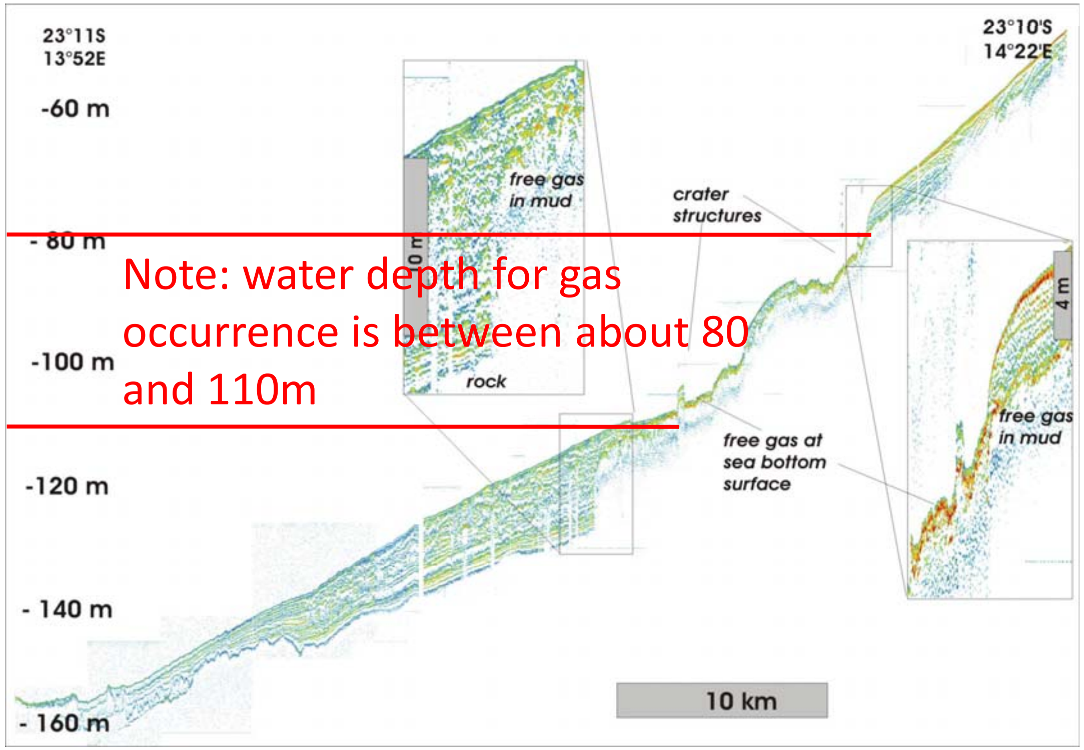


International Research - H_2S, Anoxia



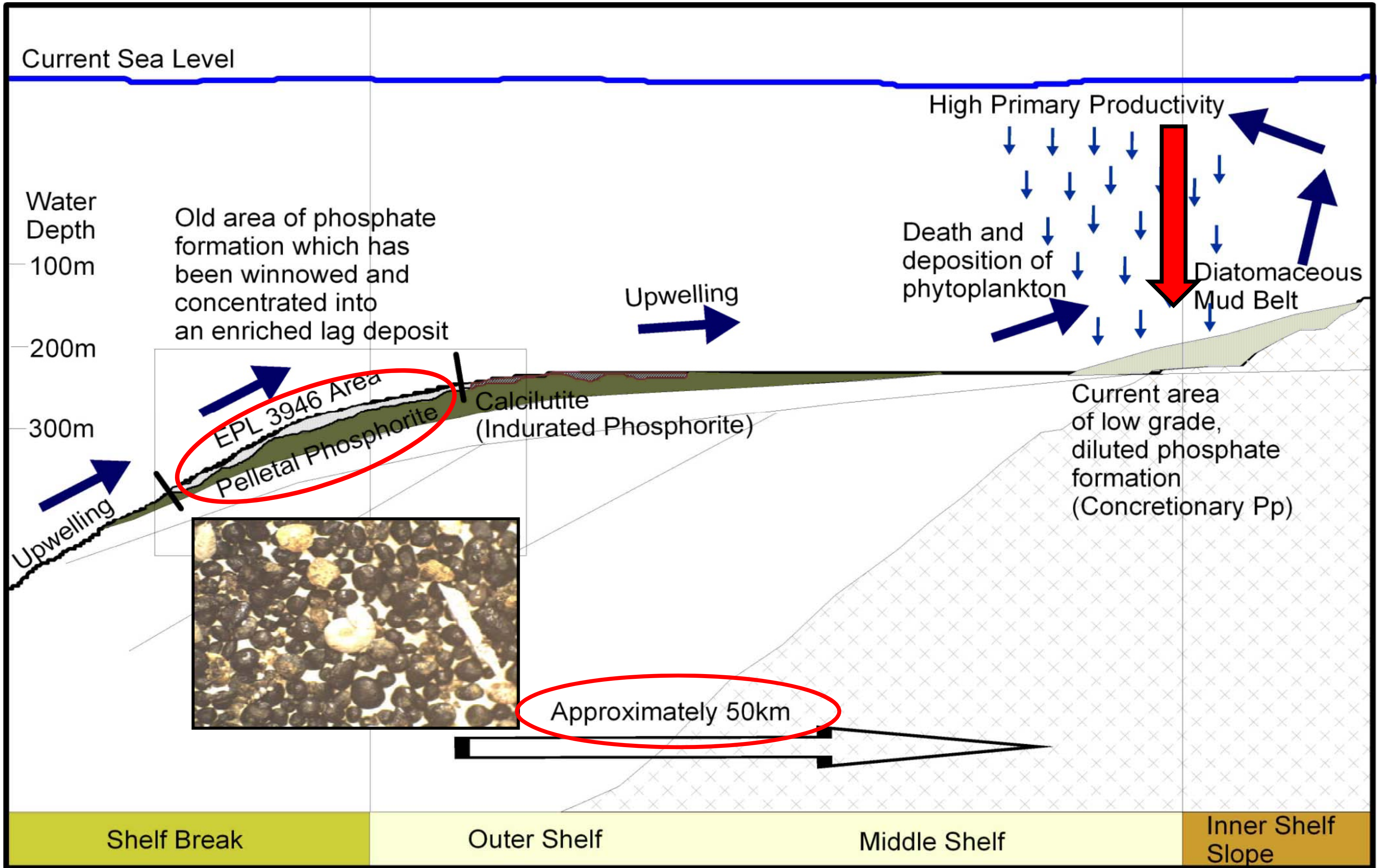
Areal estimates:

Diatomaceous mud: 17900 km^2
Gas-filled sediments: 1357 km^2
Sea floor -pockmarks and sediment craters: 380km^2



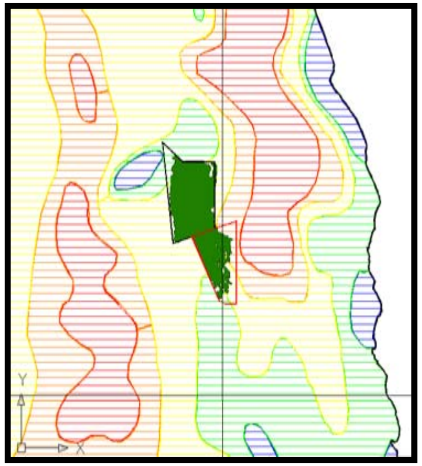
Note: water depth for gas occurrence is between about 80 and 110m

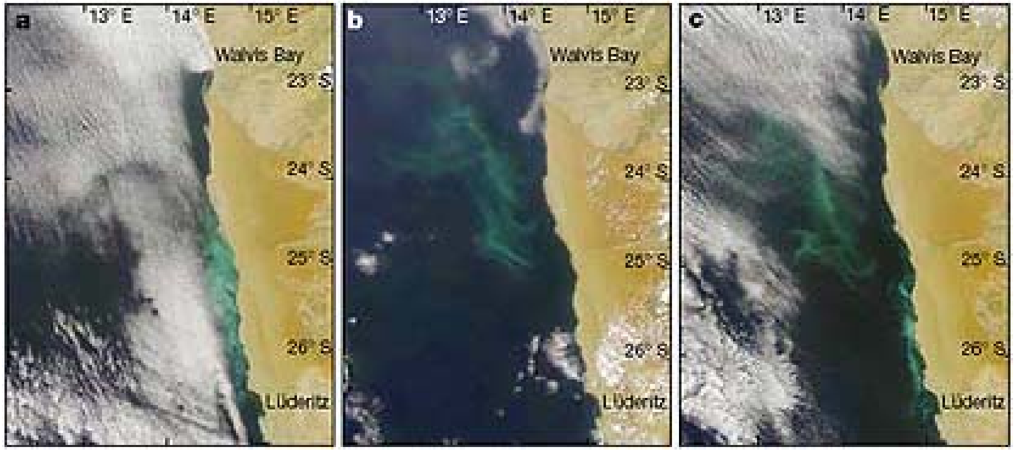
International Research - H_2S



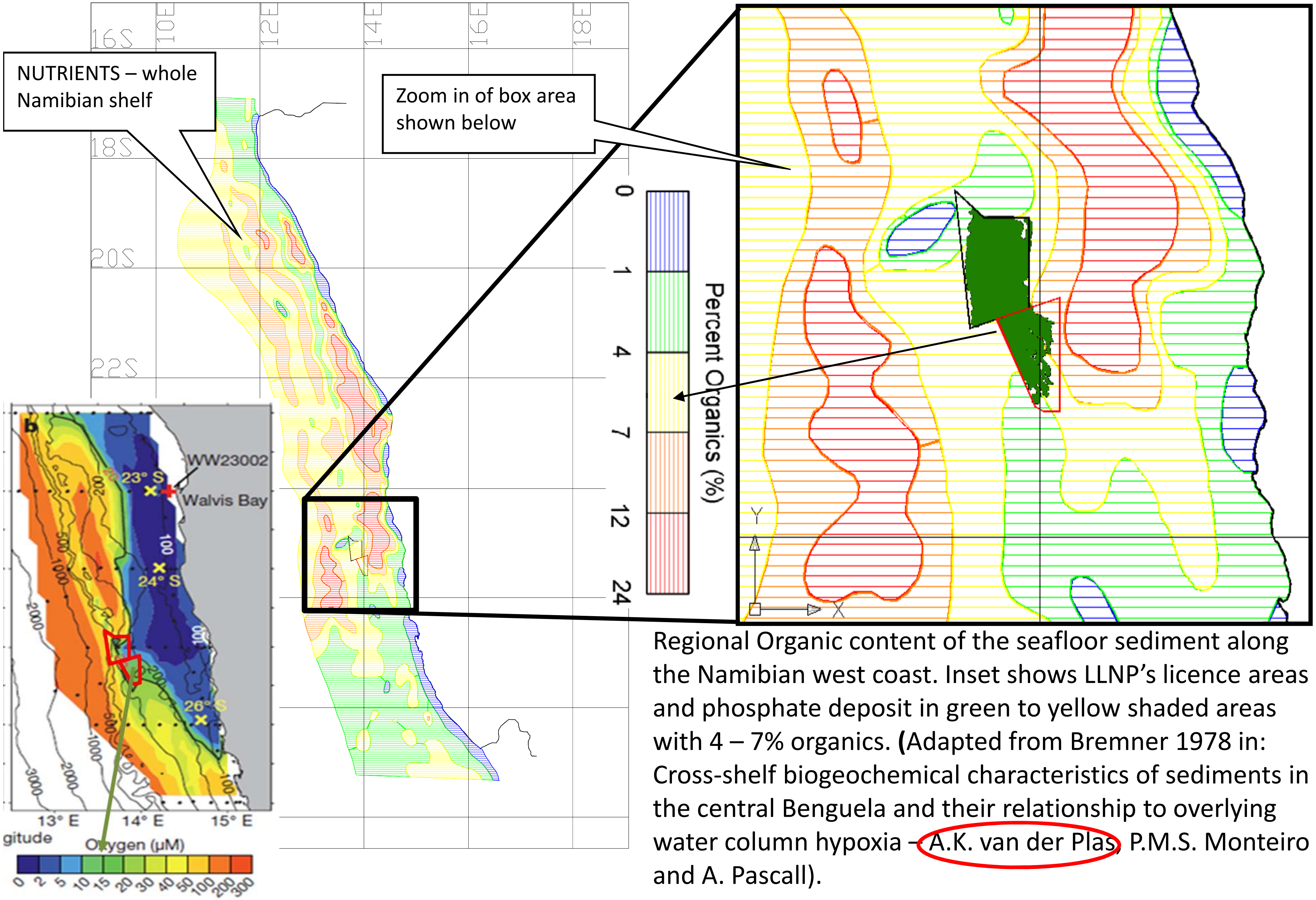
Red arrow indicates area mapped by international and MFMR scientists with high H_2S%

2. Nutrients and Anoxia





Namibian Studies – Nutrients, Anoxia



Regional Organic content of the seafloor sediment along the Namibian west coast. Inset shows LLNP's licence areas and phosphate deposit in green to yellow shaded areas with 4 – 7% organics. (Adapted from Bremner 1978 in: Cross-shelf biogeochemical characteristics of sediments in the central Benguela and their relationship to overlying water column hypoxia – A.K. van der Plas, P.M.S. Monteiro and A. Pascall).

Oxygen Uptake Study - Namibia

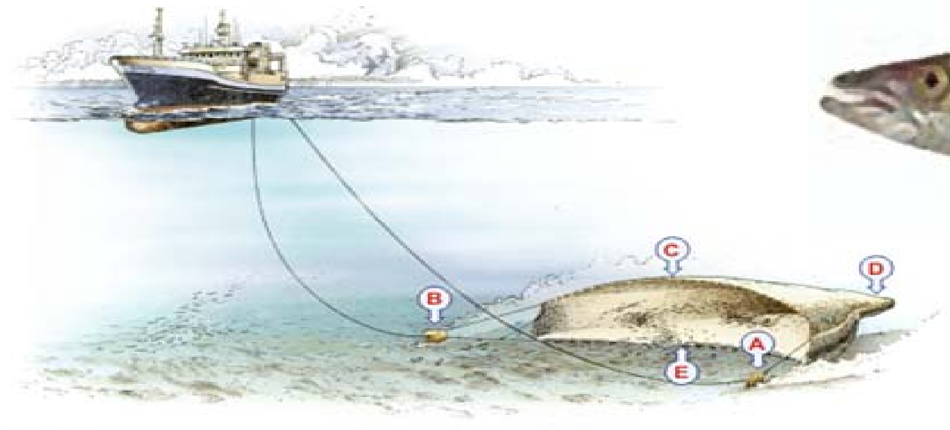
Oxygen uptake by plume sediments for the west coast. (From Stark, M, 2000. BSc (Hons), Unpubl. Supervisor: Prof. Compton. J)

- It is possible to estimate the oxygen uptake by the water column due to plume sediments if plume volumes, Total Organic Carbon and SO_3 percentages are known, using oxygen demand calculations.
- The calculations show that only 0.07% of the oxygen in the total seawater volume available is needed for the lower zone and 0.21% of the upper zone to account for these oxygen uptake reactions from mining sediment plumes.
- This calculation shows a maximum possible amount, as oxygen uptake will already have mostly taken place within the dredge hopper on contact with the atmosphere.

LLNP O_2 uptake Calculation	**GSI Israel Report**	**GSI Israel Report**
Grain Size Fraction	**TOC**	**S as SO_3**
>300µm	1.2	7.5
150-300µm	1.5	7.4
<150 µm	2.4	4
	Univ-Liege	**Univ-Liege**
	C_Org	**S**
Phosphate Pellets	1.06	3.3

Vol. re-suspended sediment/hr (m3)	6.8	6800
	Organic Carbon	**Sulphur Trioxide**
Average Weight %	2.4	4
SG of phosphate material/deposit	1.89	1.89
Mass (g)	308 448	514 080
Moles	25 681.10	16 065.03
Moles O consumed	25 681.10	30 121.86
Total Moles O consumed/hour	55 802.96	
	Upper Zone	**Lower Zone**
Percent Oxidation	100	100
Depth (m)	0-40	40-250
Plume area (km^2)	5	10
Plume Volume (m^3)	200 000 000	2 100 000 000
Seawater oxgen content ml/L	3	0.8
Seawater oxgen content mole/L	0.0001338	0.00003568
Volume seawater needed to supply oxygen demand L/hr	417 062 510	1 563 984 412
Volume seawater needed to supply oxygen demand m^3/hr	417 063	1 563 984
Volume seawater needed/hr as percentage of total available	**0.21**	**0.07**
	Plume more concentrated - fines	Plume more disseminated

3. The Commercial Fishery and Fish Spawning

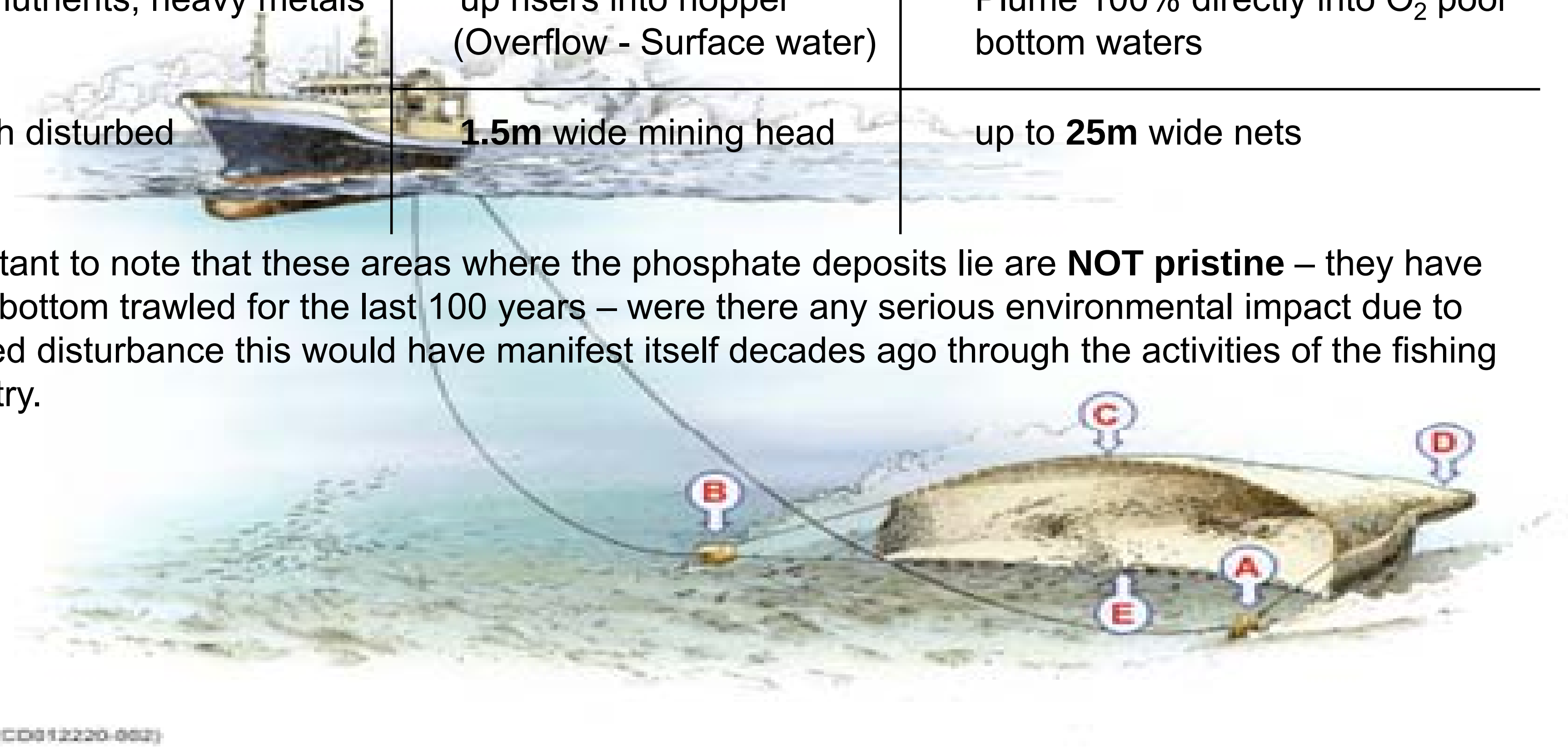


Fishing Industry

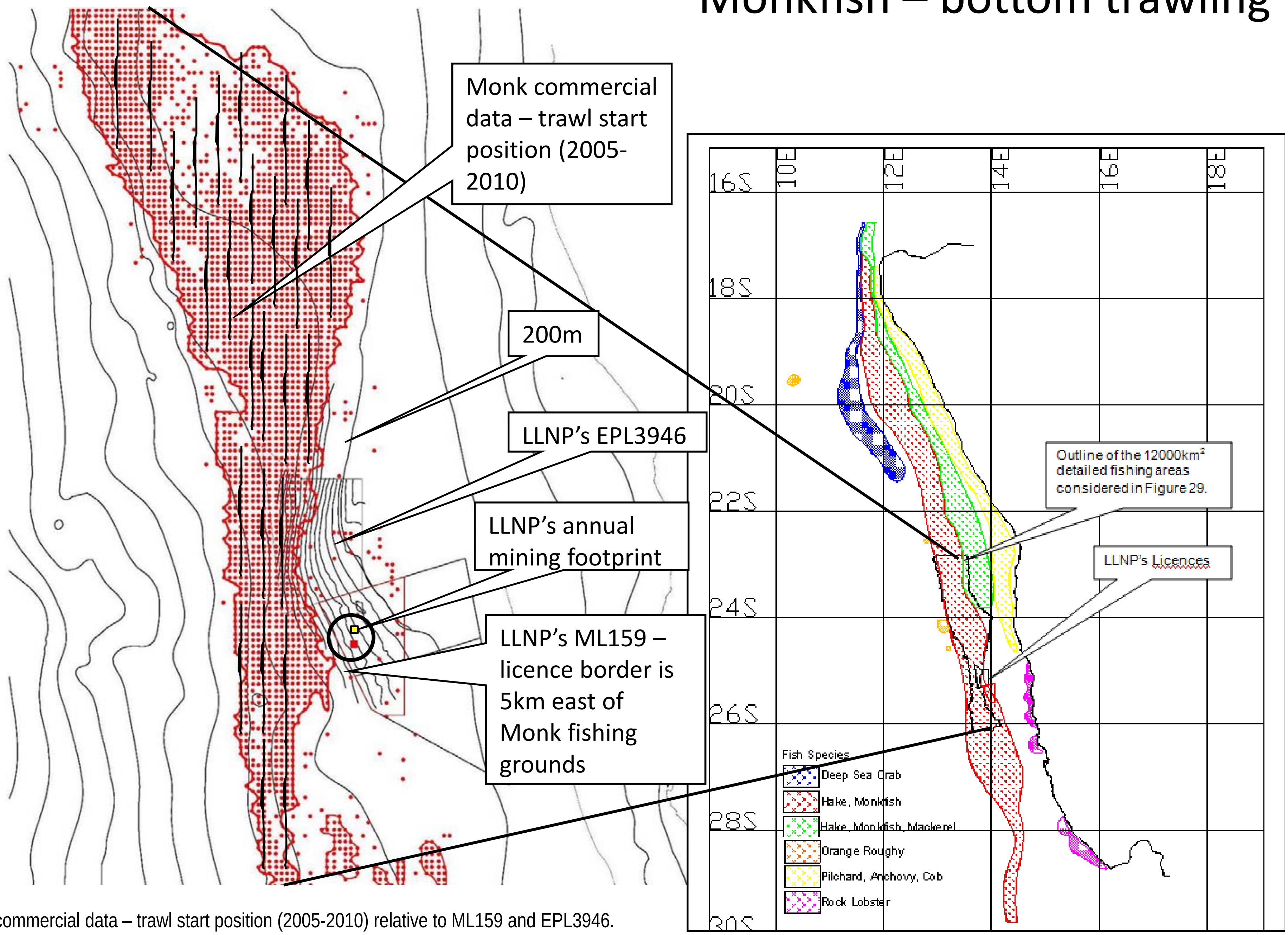
Scale of environmental impact of phosphate mining vs fishing - put into perspective

	Phosphate Mining	Fishing
1) Footprint	~**4**km^2	33000km^2 (up to 5km^2 per day)
2) Seabed disturbance	37cm cut	similar depth soft sediment disturbed
3) H_2S, nutrients, heavy metals	up risers into hopper (Overflow - Surface water)	Plume 100% directly into O_2 poor bottom waters
4) Swath disturbed	**1.5m** wide mining head	up to **25m** wide nets

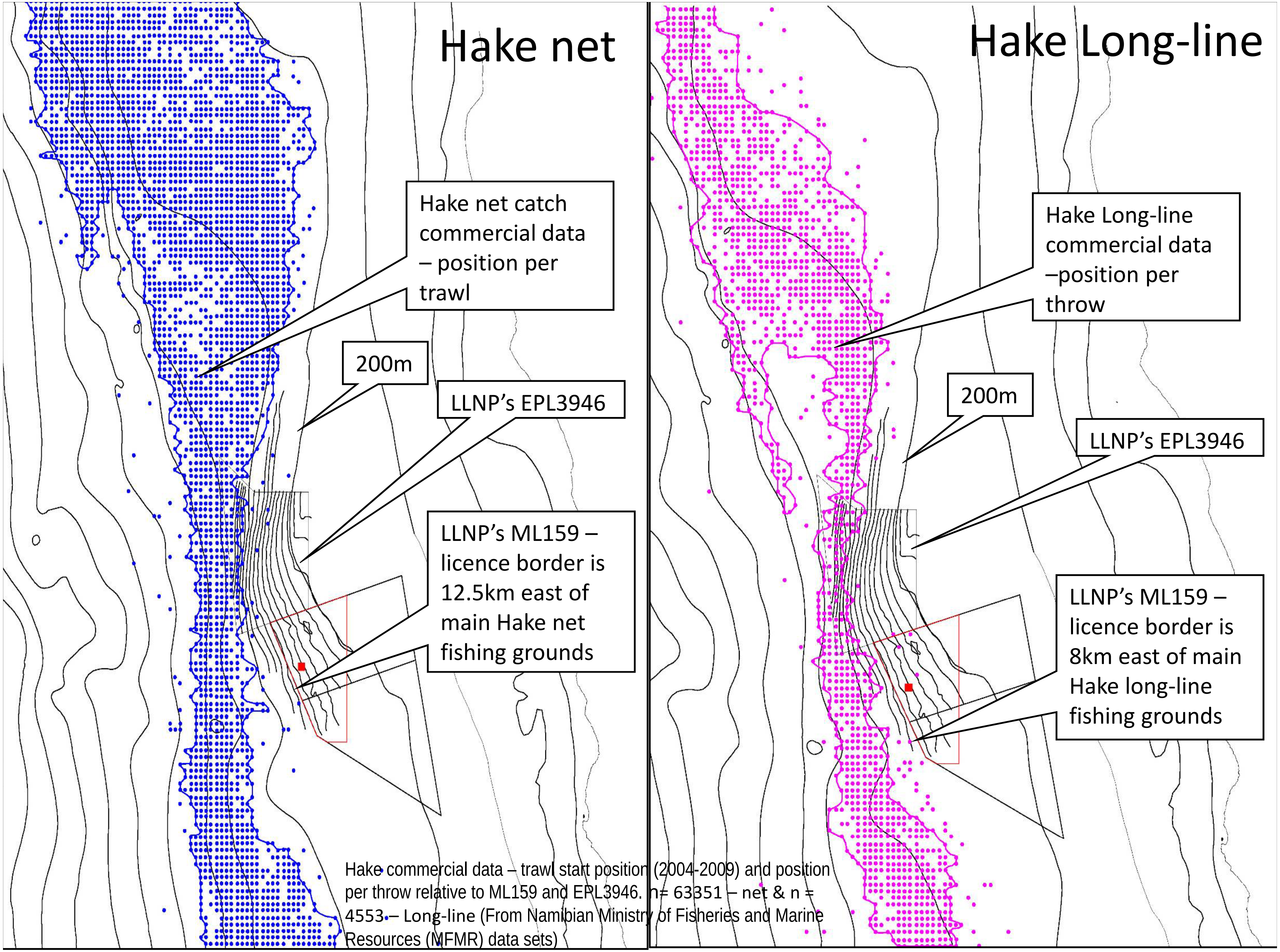
It is important to note that these areas where the phosphate deposits lie are **NOT pristine** – they have been bottom trawled for the last 100 years – were there any serious environmental impact due to seabed disturbance this would have manifest itself decades ago through the activities of the fishing industry.



Monkfish – bottom trawling

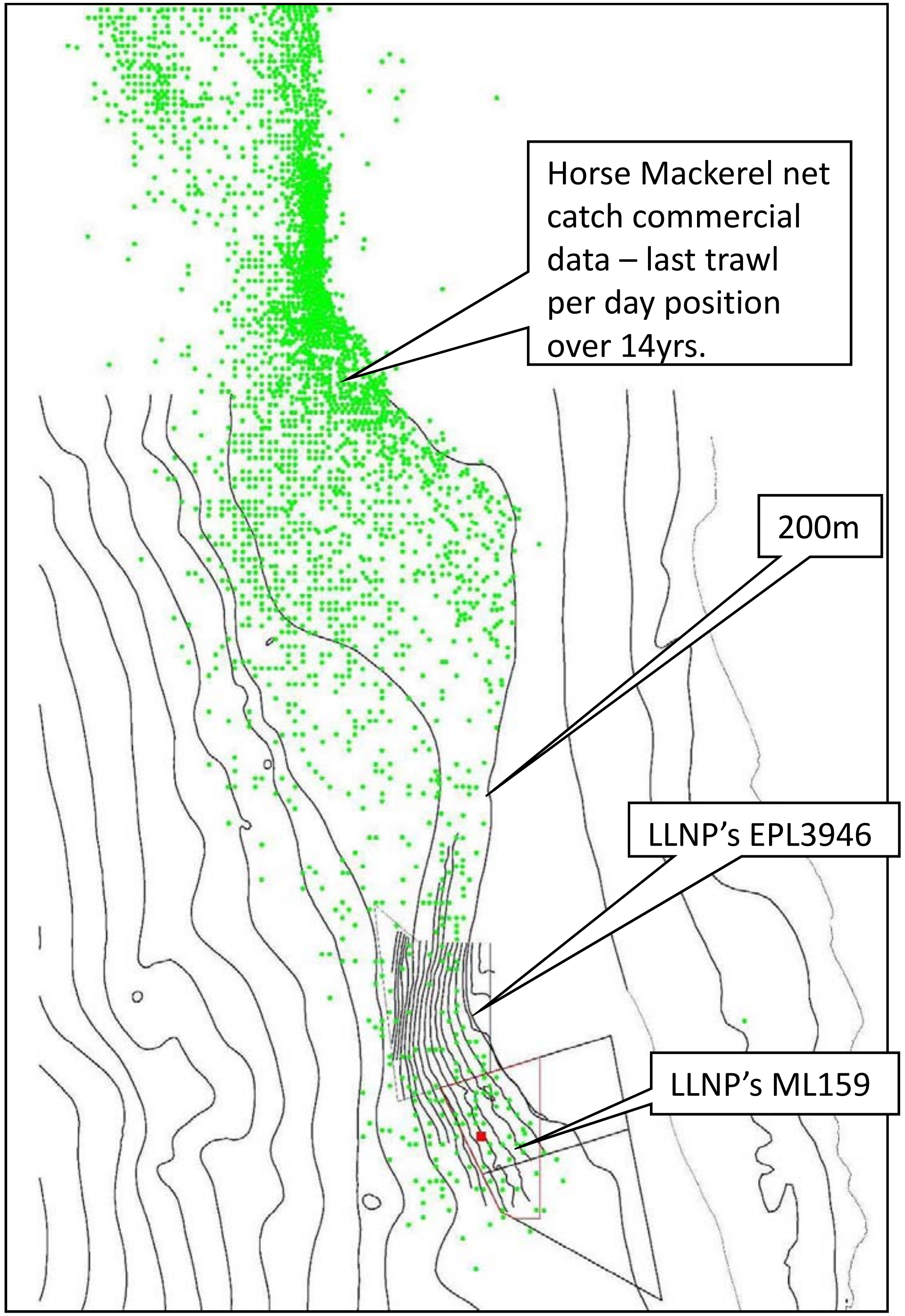


Monk commercial data – trawl start position (2005-2010) relative to ML159 and EPL3946.
n = 36798 (From Namibian Ministry of Fisheries and Marine Resources (MFMR) data sets)

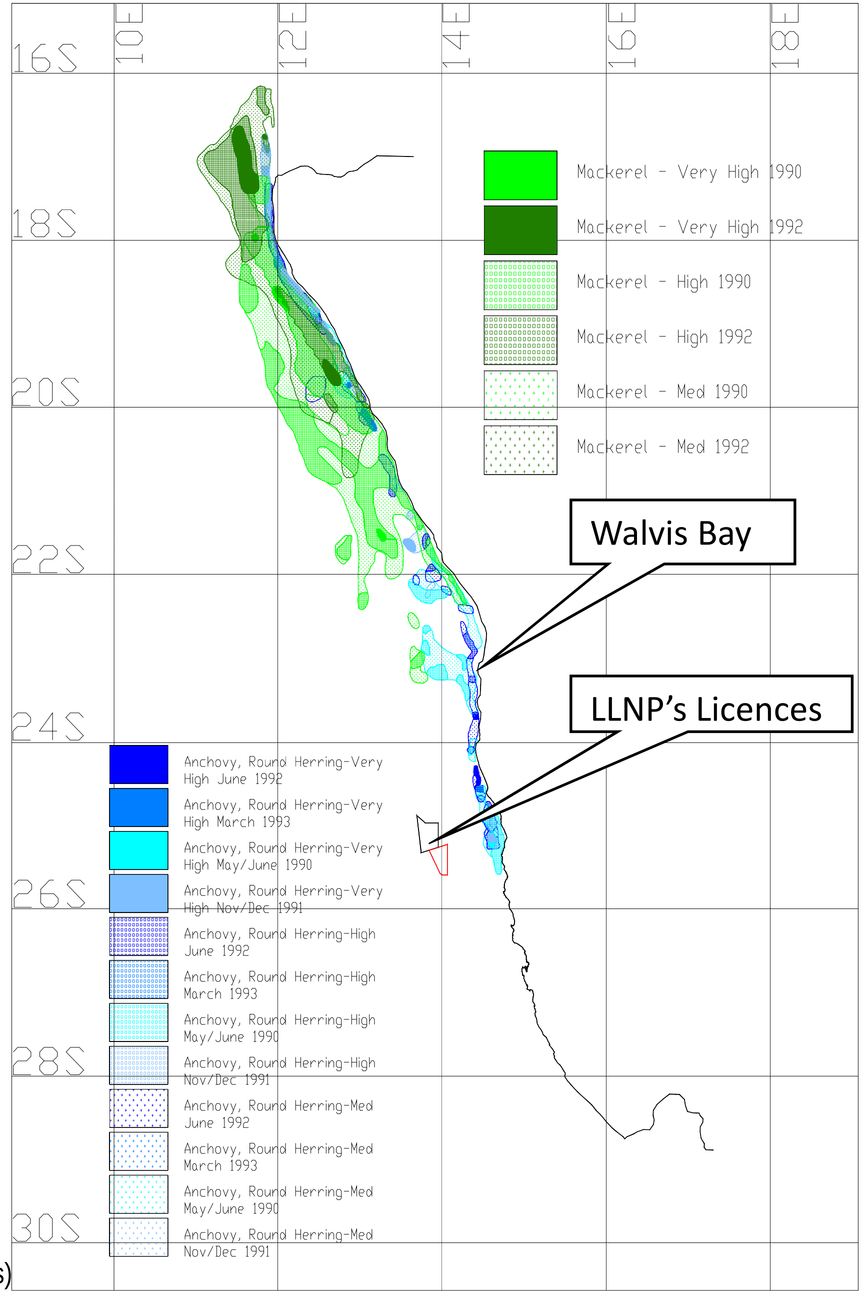


Hake commercial data – trawl start position (2004-2009) and position per throw relative to ML159 and EPL3946. n= 63351 – net & n = 4553 – Long-line (From Namibian Ministry of Fisheries and Marine Resources (MFMR) data sets)

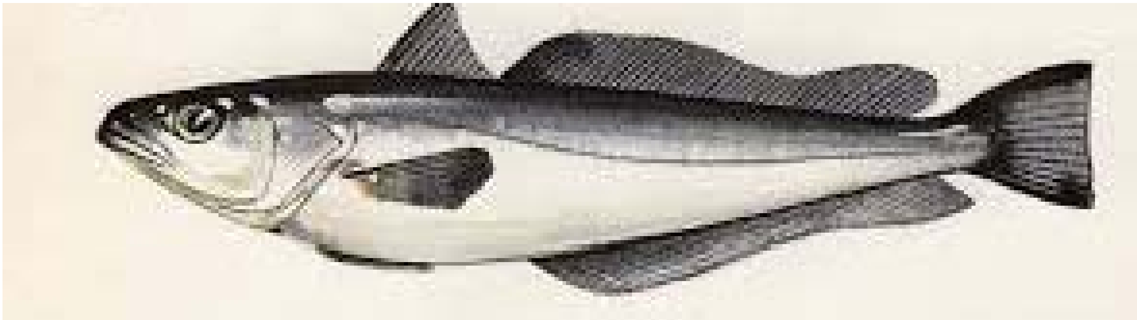
Mackerel, Anchovy and Herring



Horse Mackerel commercial data – last trawl per day (1997-2011) relative to ML159 and EPL3946. (From Namibian Ministry of Fisheries and Marine Resources (MFMR) data sets)



3. Fish Spawning



Hake Spawning

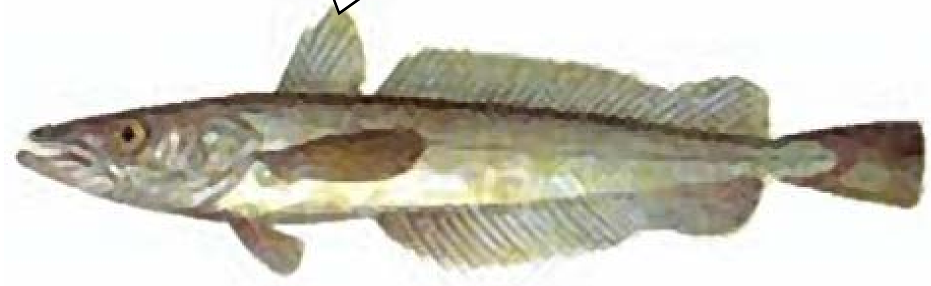
Merluccius capensis spawn in Namibian waters, but do *M. paradoxus*? P Kainge, OS Kjesbu, A Thorsen & AG Salvanes, *African Journal of Marine Science 2007, 29(3): 379–392.*

***M. paradoxus generally* don't spawn in Namibian waters – they spawn in SA.** This is backed up by the Kainge *et al. (*2007) study.

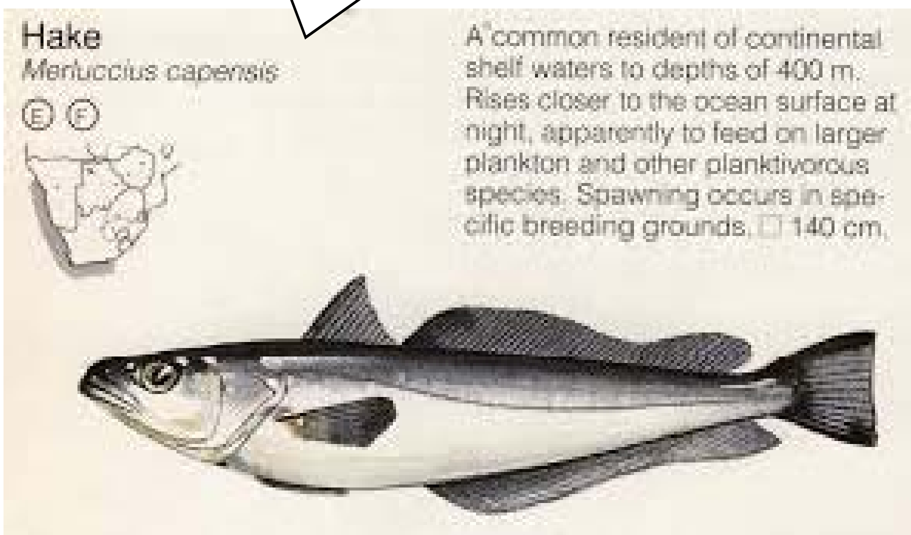
The dominant current system causes some early life stages of M. *capensis* to be transported northwards from SA to Namibian water (Orange River area), where they subsequently recruit to the fishery (MFMR 2001). **Therefore phosphate mining will also not disrupt *M. capensis* early life / spawning stages.**

Stenevik *et al.* (2008) found highest concentrations of *M. paradoxus* larvae in the 50-100 m depth interval and of *M. capensis* in the upper 50 m – you know the phosphate mining takes place on the seafloor? How will the eggs be impacted even if they do spawn in the licence area?

Merluccius paradoxus



Merluccius Capensis

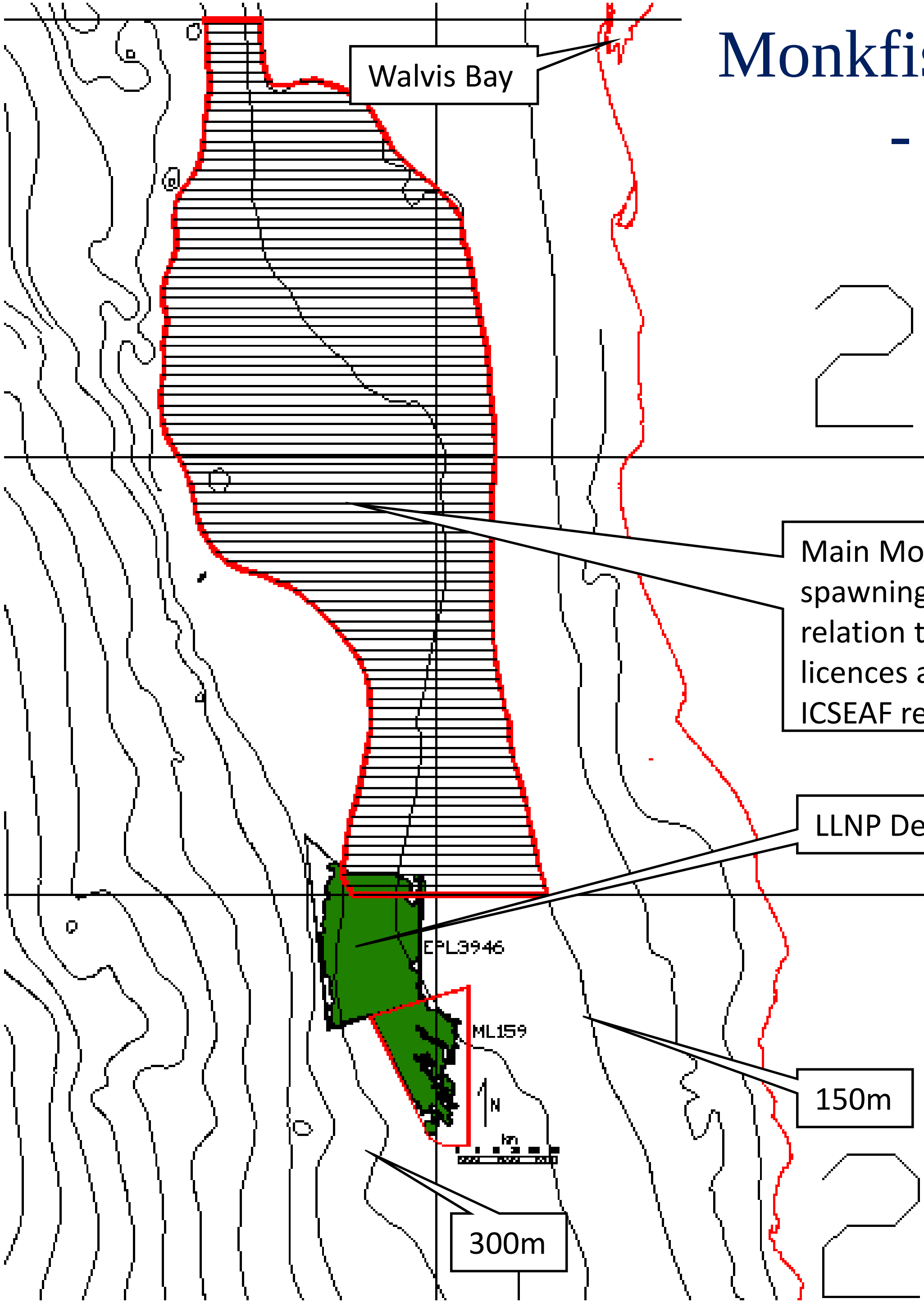


In: **AN ASSESSMENT OF THE MONKFISH RESOURCE OF NAMIBIA: PhD - RHODES UNIVERSITY** by **LIMA MAARTENS,** November 1999.

Monkfish Fishery - Spawning

MONKFISH SPAWNING AREA

The International Commission of the Southeast Atlantic Fisheries (ICSEAF) and in particular Spanish researchers identified two separate recruitment areas, **the first being off Walvis Bay (23°S - 25°S) at depths between 150 and 300 m** and the **second near the Orange River** (28°35'S) at depths between 100 and 300 m (ICSEAF, 1984a; 1985).

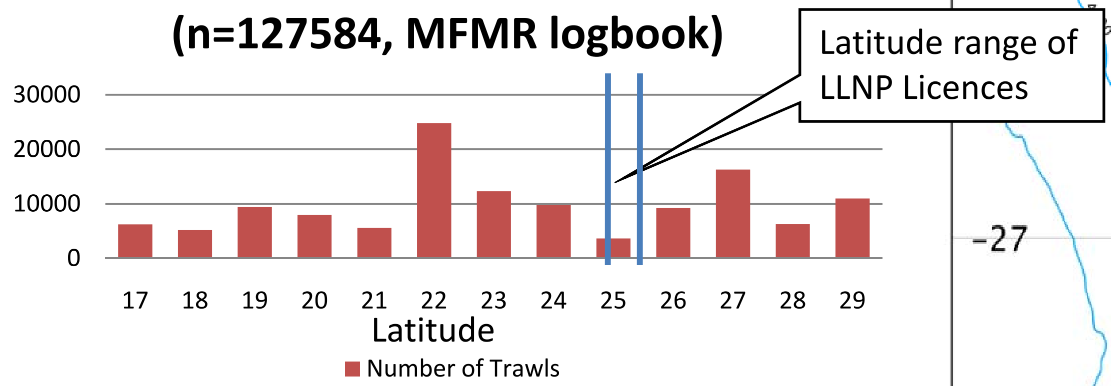


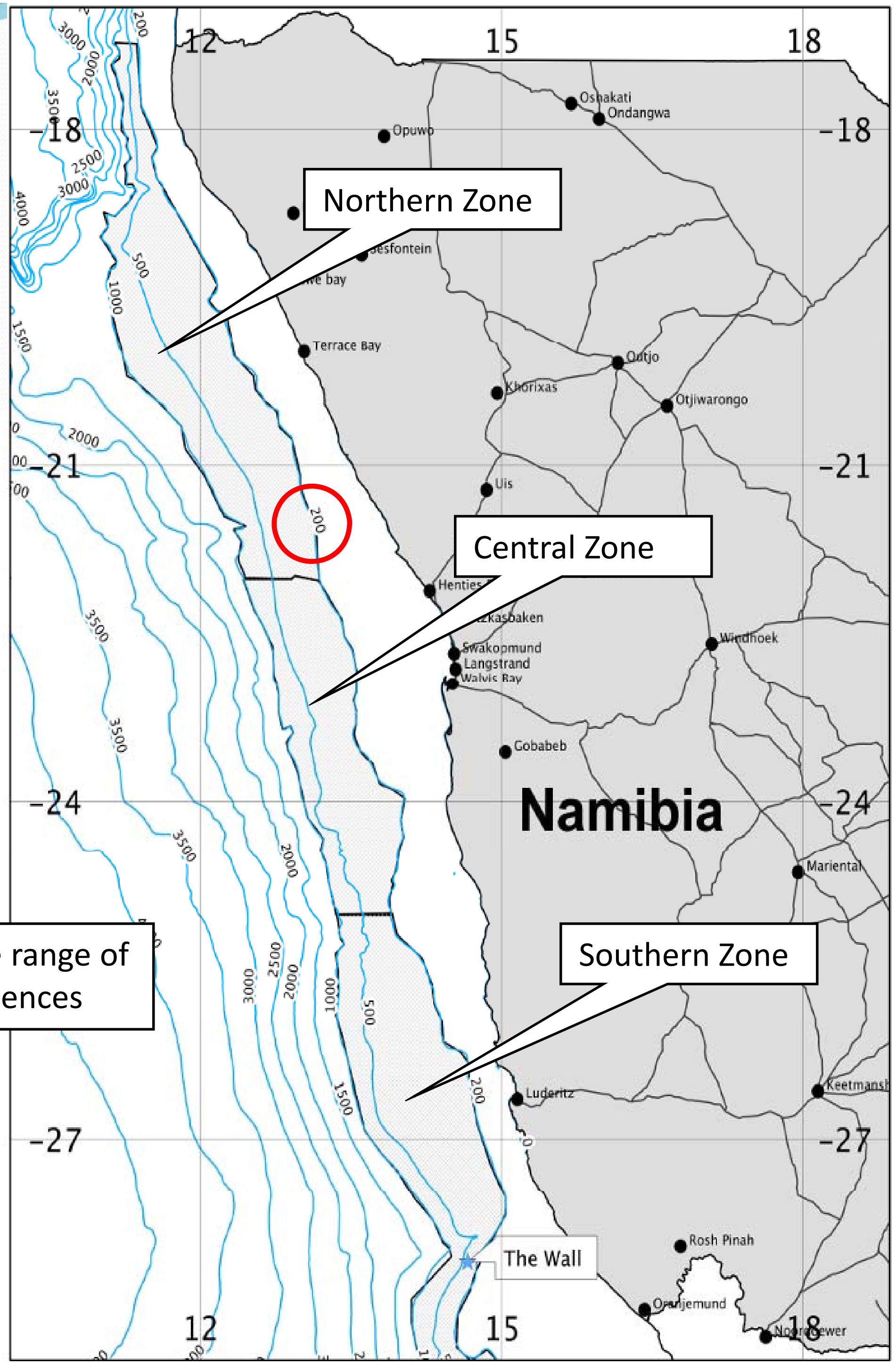
Demersal (bottom) trawling and its impact on the seabed

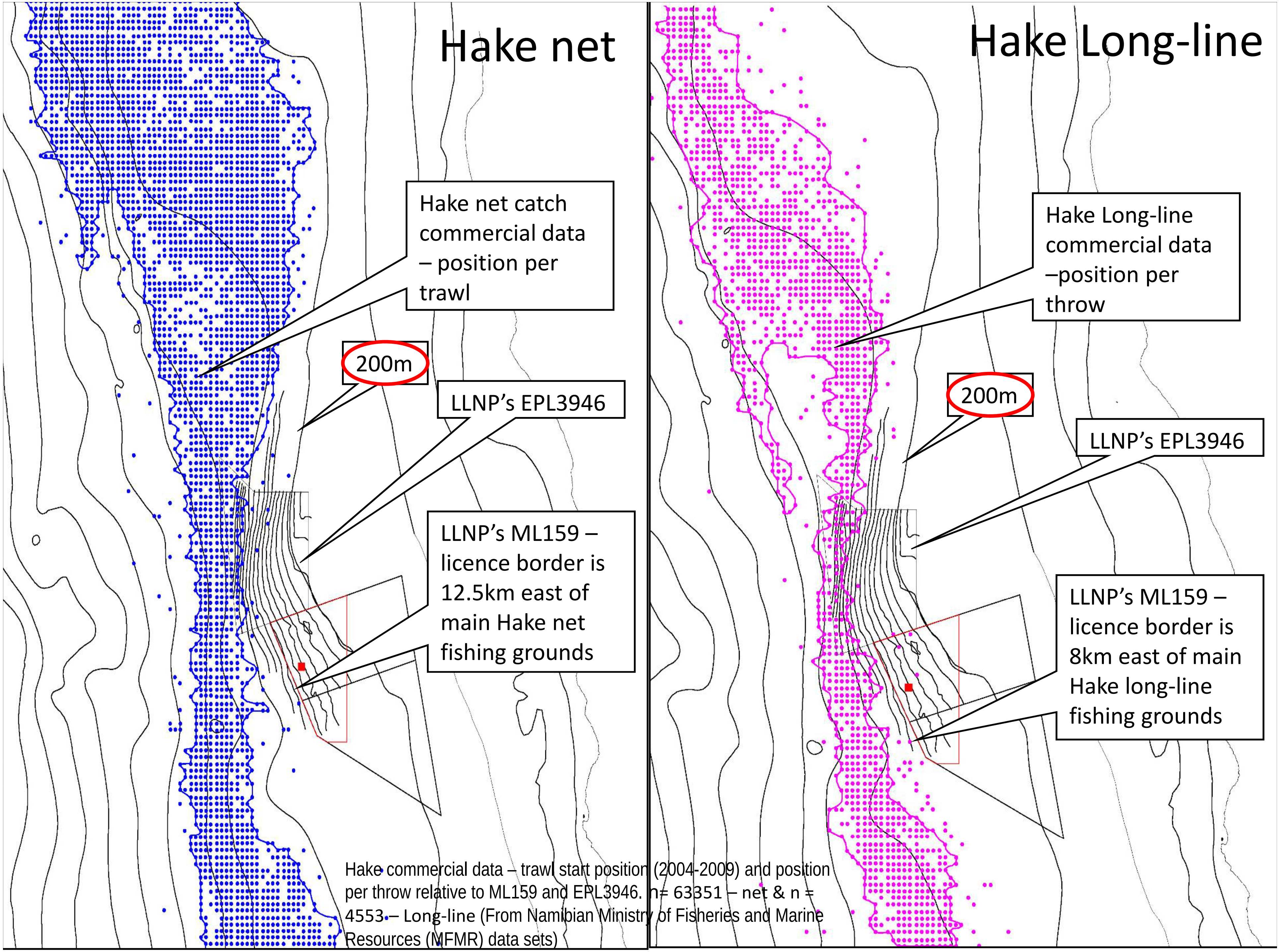
- Hake and monkfish trawlers impact the sea bottom, but trawl gear meets international standards
- No trawling may occur inside the 200 metre depth restriction to protect juvenile fish stocks

Talk presented by Matti Amukwa Chairman – Confederation of Namibian Fishing Associations

Number of Hake Trawls vs Latitude (2003 - 2005) (n=127584, MFMR logbook)







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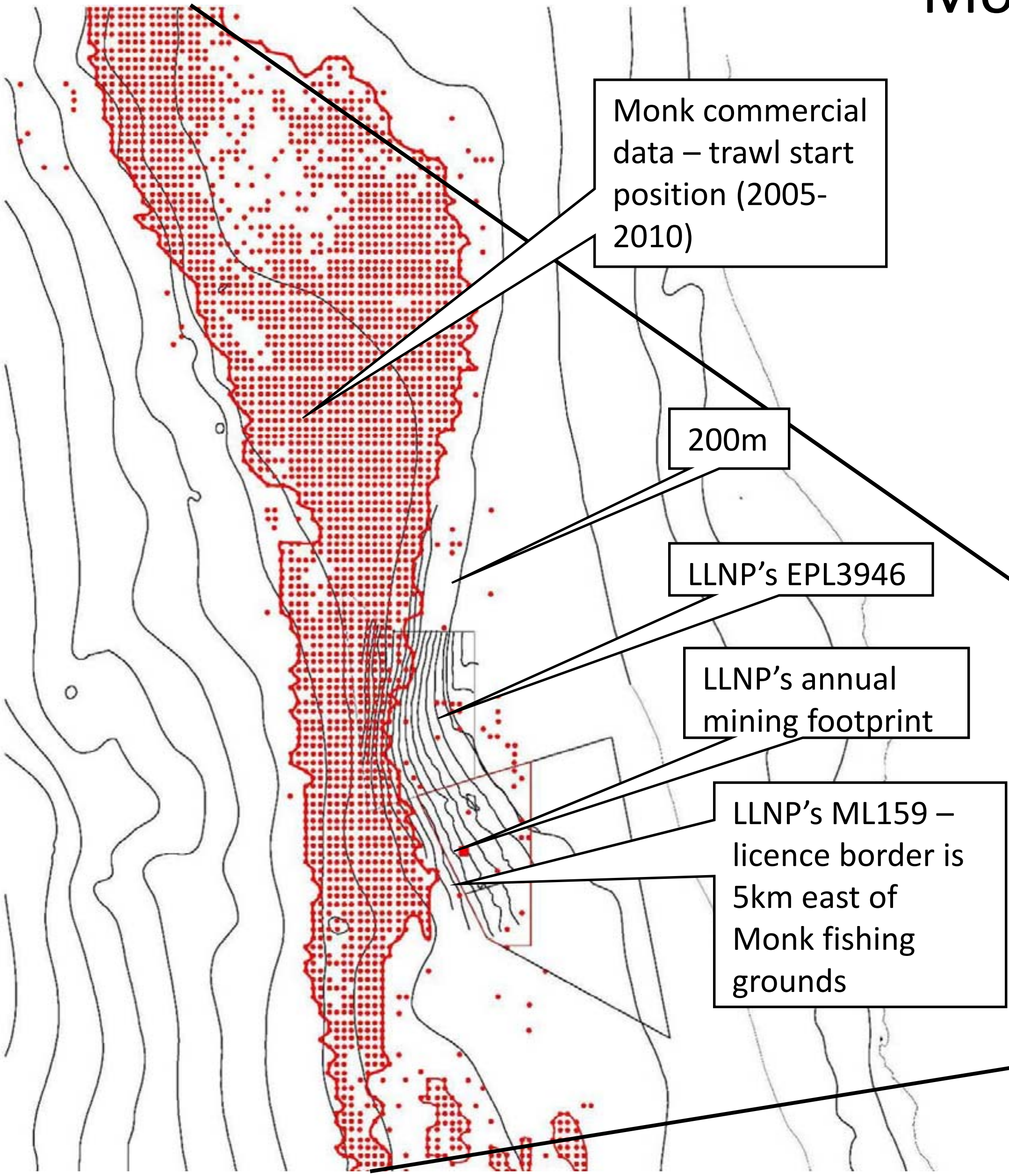
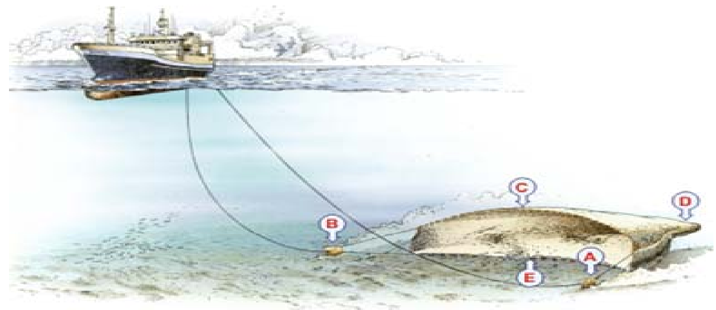
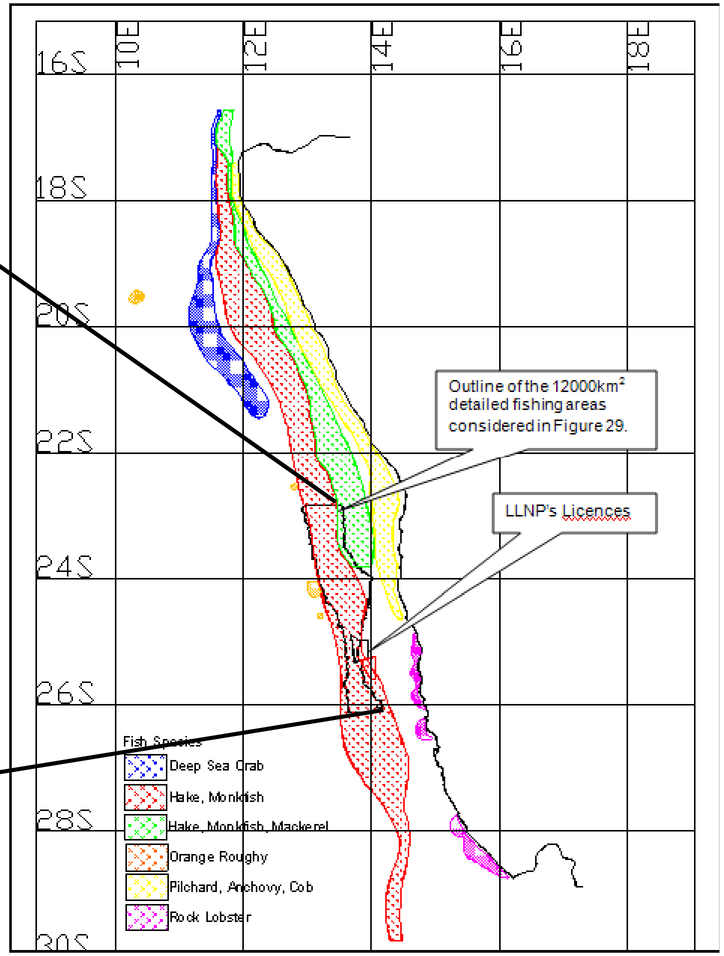
Monkfish – bottom trawling







Monk commercial data – trawl start position (2005-2010) relative to ML159 and EPL3946. n = 36798 (From Namibian Ministry of Fisheries and Marine Resources (MFMR).data sets)

Conclusion: The Commercial Fishery and Fish Spawning

Site specific information on phosphate mining impact to the fisheries and fish spawning is covered in great detail in Namibia Marine Phosphates Verification Report which is available to the public at MET and MFMR offices. You are welcome to go read the verification report for yourself, in full, and not be dependent on other scientists interpretation and rendition of the facts.

In conclusion on this topic I say that many groups and individuals are trying to mislead the public into believing phosphate mining and fishing is an "either or" scenario. **This is not true**.

The top environmental consultants on the Benguela ecosystem as well as the independent panel of peer review experts of the NMP EIA and Verification Study state that: **"the clear consensus of independent expert opinion is that, at the scale of the proposed operations, the project can be safely developed and also be well managed within the existing Namibian mining and environmental regulations without impact to fishing resources and in co-existence with the Fishing Industry"**.

I'm sure Dr's Brown and Tarr will cover this again next week and therefore I'm not going to delve deeper into this tonight.

4. Seafloor Sediment Removal
Pertinent Points to Know

Sediment Removal

What do you need to know about removal of phosphate sand from the seabed?

1) Will the benthic fauna be impacted where LLNP dredge? **YES** – no mining can take place, anywhere in the world, with ZERO impact!

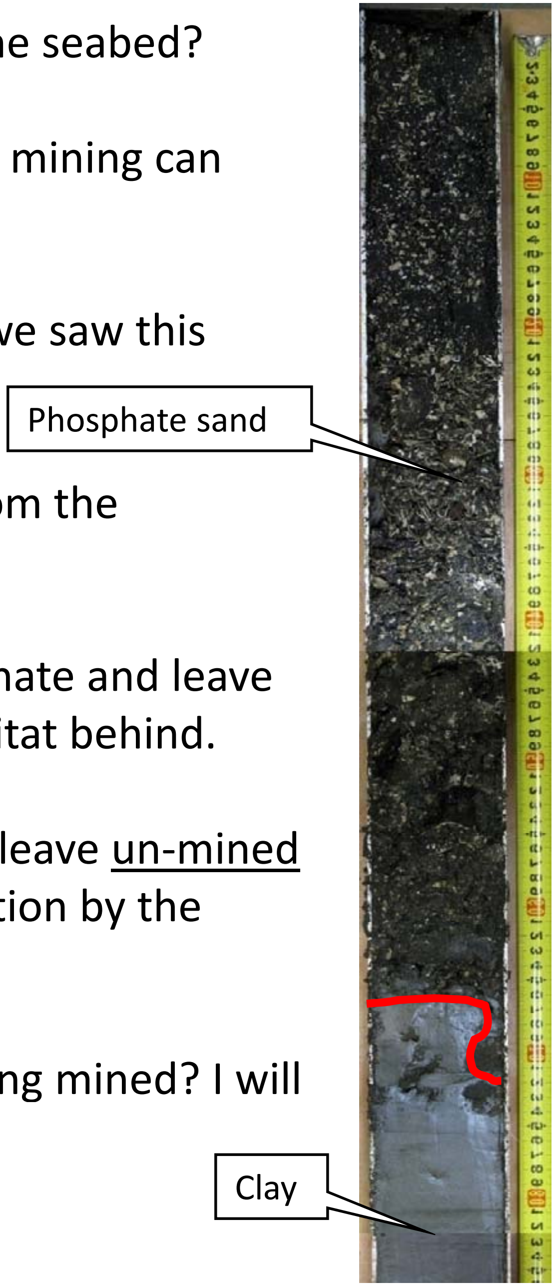
2) Are there any unique, endangered species in our licences? **NO** – we saw this from our baseline studies – mostly polychaetes (70%).

3) What has the biggest impact when removing marine sediment from the seafloor?

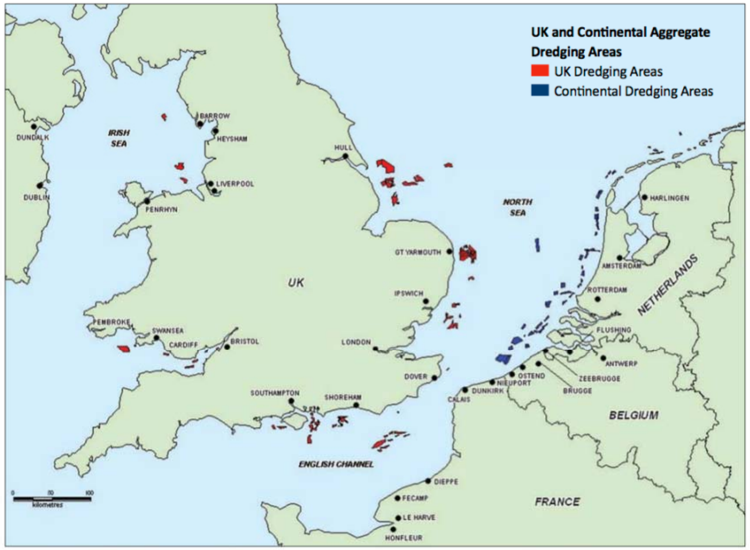
   a) To change the seafloor habitat. That is to remove all the phosphate and leave the clay behind. LLNP with take a 37 cm cut leaving the same habitat behind.

   b) To cover 100% of the seafloor area in a mining block. LLNP will leave un-mined strips behind – this allows for quick re-colonisation and rehabilitation by the benthic fauna from these un-mined strips.

4) Typically how long does it take for the seabed to recover after being mined? I will answer this shortly!



5. Are there other Similar Marine Mining Projects in the World?



Who did the Research?

AGGREGATE DREDGING AND THE MARINE ENVIRONMENT:

an overview of recent research and current industry practice



Marine Environment Protection Fund Steering Group Members

British Marine Aggregate Producers Association (BMAPA)

Centre for Environment, Fisheries and Aquaculture Science

Department for Environment, Food and Rural Affairs

English Heritage

Joint Nature Conservation Committee

Marine Management Organisation

Natural England

The Crown Estate

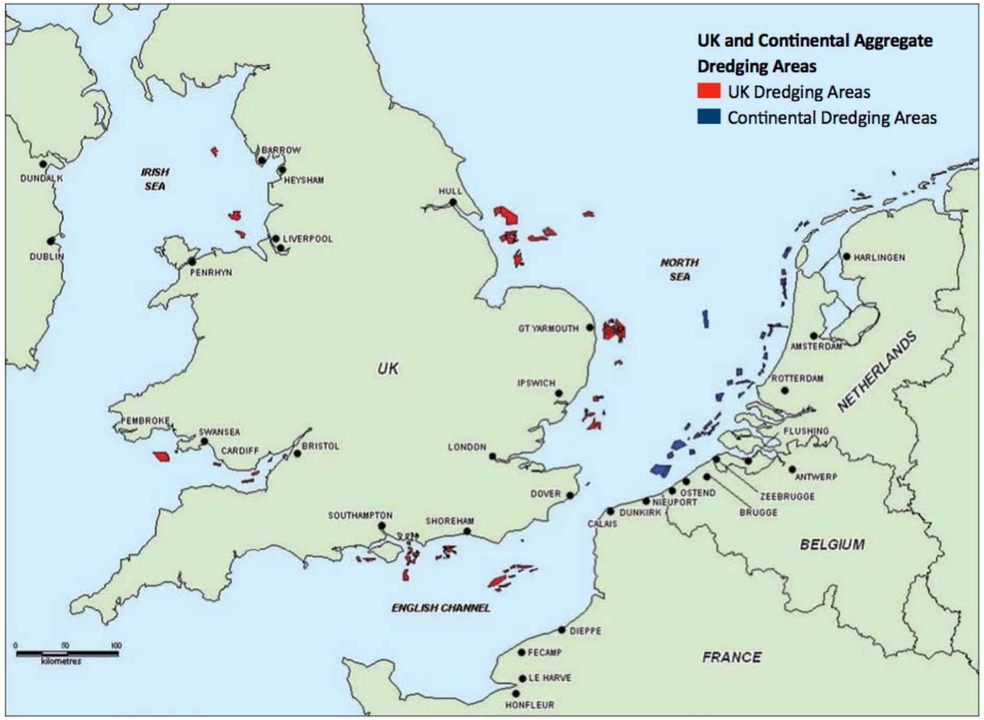
June 2013

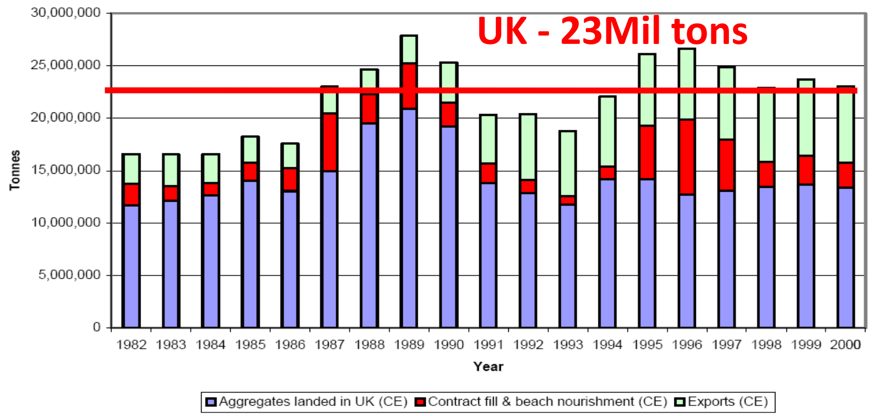
Aggregate Dredging

Various parties would like you to believe that seabed mining is unique and that LLNP's phosphate mining will be a "world first experiment". But this is misleading because:

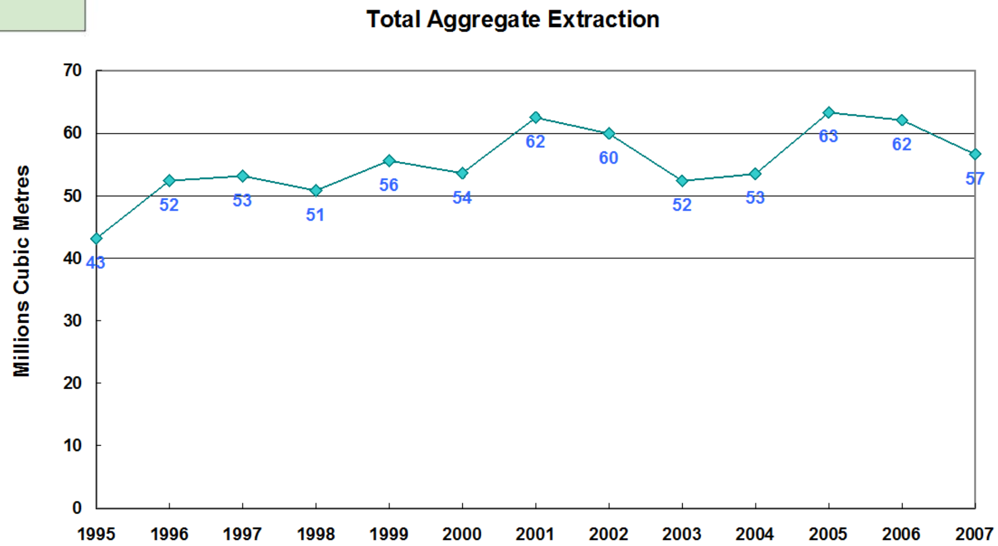
1) Dredging can be described as the process of removing part of the seabed or its overlying sediments with the aim of deepening the area (i.e. same effects as mining)
2) Namibia's offshore marine diamond mining has been active since the 1960's, at a scale larger than that proposed by the phosphate mining, with no scientifically recorded negative impacts to the Benguela ecosystem – many studies have been done!
3) The international aggregate dredging industry has been operative for decades. They also remove a layer of the seabed and often even screen the material on board.

Scale of Aggregate Dredging





Since 1995, an average of 56 million m^3 per year (~100 Mil tons) has been extracted from the seabed of the North-East Atlantic vs LLNP - 2.3 Mil tons



Total marine aggregate extraction in the OSPAR maritime area (in million m^3). Data from: ICES, 2005, 2006, 2007, 2008, 2009 (OSPAR 2009).
(i.e. Denmark, France, Germany, the Netherlands, and the United Kingdom)

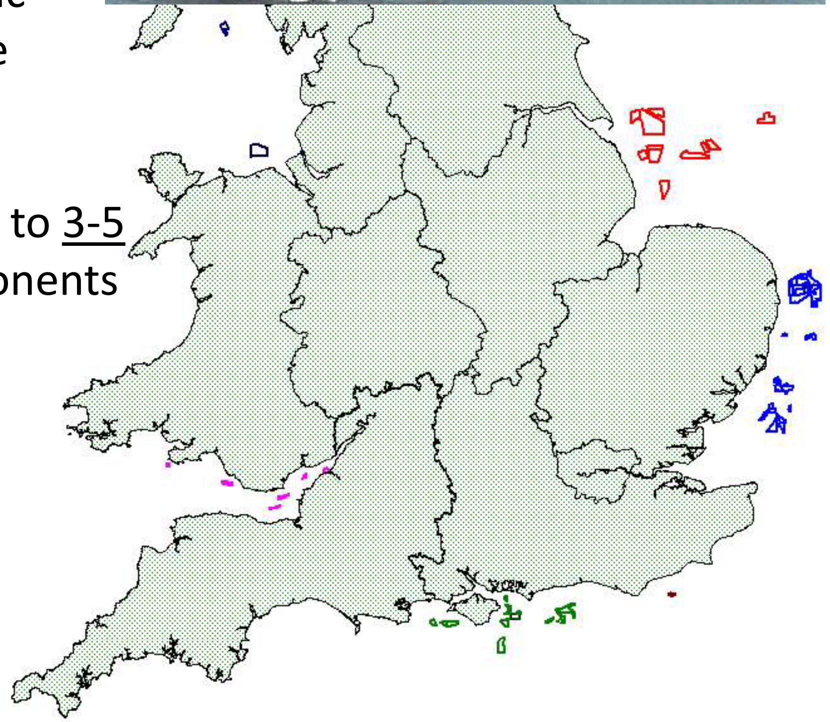
International Dredging – EIA Results

<u>Impacts and Recovery</u>

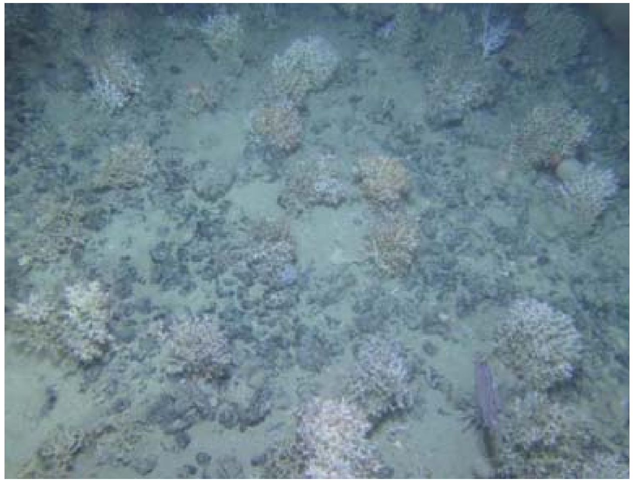
- Removal of the seabed sediments can result in a 40-80% reduction in population density and biomass of benthic invertebrates within the very small area of seabed that is under the path of the draghead.

- If the deposit sediment remains <u>similar</u> in composition, post dredging, then recovery of a benthic community is by recruitment and settlement from the plankton and by lateral invasion of mobile species.

- The 'recovery' time of dredged areas is generally up to <u>3-5 years</u> in sandy deposits, but the most common components of the seabed community can recolonise and grow to maturity well within this time (i.e. weeks to months).

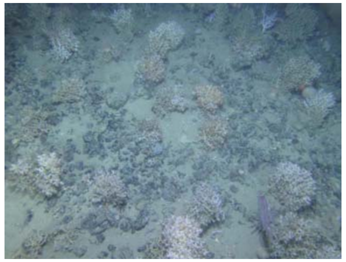


6. Comparison of Differences between Chatham Rock Phosphate (CRP) & LLNP Projects



Chatham Rock Phosphate(CRP) Decision

The main factors given by the DMC of the EPA for the CRP refusal of consent:



1) CRP mining would cause significant damage and permanent adverse effects to existing benthic environment. They elaborated that it was a **Benthic Protected Area (BPA)** which included some communities **dominated by protected stony corals** (photo RHS) and other species which are potentially **unique to the Chatham Rise and form a rare and vulnerable ecosystem**.

1a) **LLNP will be mining in an area previously disturbed by decades of bottom fish trawling. During environmental baseline studies no protected fauna, flora or unique ecosystem characteristics were observed within LLNP licence areas.**

2) CRP destructive extraction process effects, coupled with the **potentially significant impact of the deposition of sediment on areas adjacent to the mining blocks and on the wider environment, cannot not be mitigated.**

2a)

Mining Comparison	**CRP**	**LLNP**
Mined tons	10	2.3
Phosphate produced (t)	1.5	1.4
Screened tons returned	8.5	all-in cargo

3) Economic benefit to New Zealand of the CRP proposal would be modest at best.

3a) **LLNP's project will provide sustained economic benefit to Namibia for generations to come (LOM >500years).**

7. Separation and Demonstration Test Facility

Separation Test Facility

Separation plant in Lüderitz, Namibia

The Separation plant was used for the mechanical and gravitational spiral concentration of the phosphate pellets from the shell and fines. This stage of the project is complete for this phase.

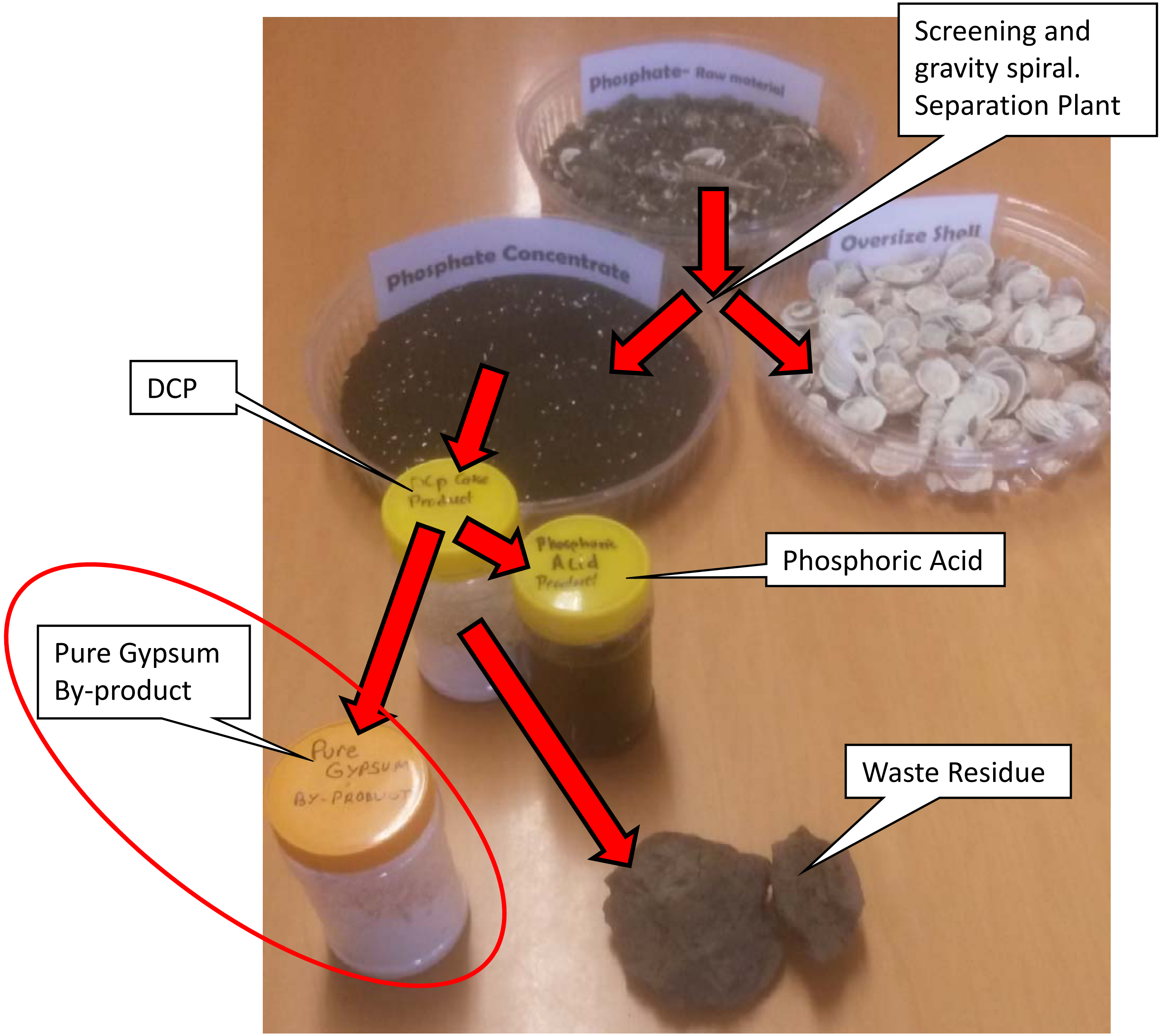
Demonstration Plant

Demonstration Test Facility

LLNP's N$200 Mil Demonstration facility was built to test the technical and environmental aspects of the project on a **1:500 scale** so that this information can be fed into the design of the industrial facility. A 10 day trial was completed in mid 2015 and after optimisation a further test will be conducted in Q2, 2017.

All emissions and waste products will be sampled and analysed and any mitigation measures required can be incorporated into the planning stages of the full facility.

Basic Flowchart



Gypsum byproduct

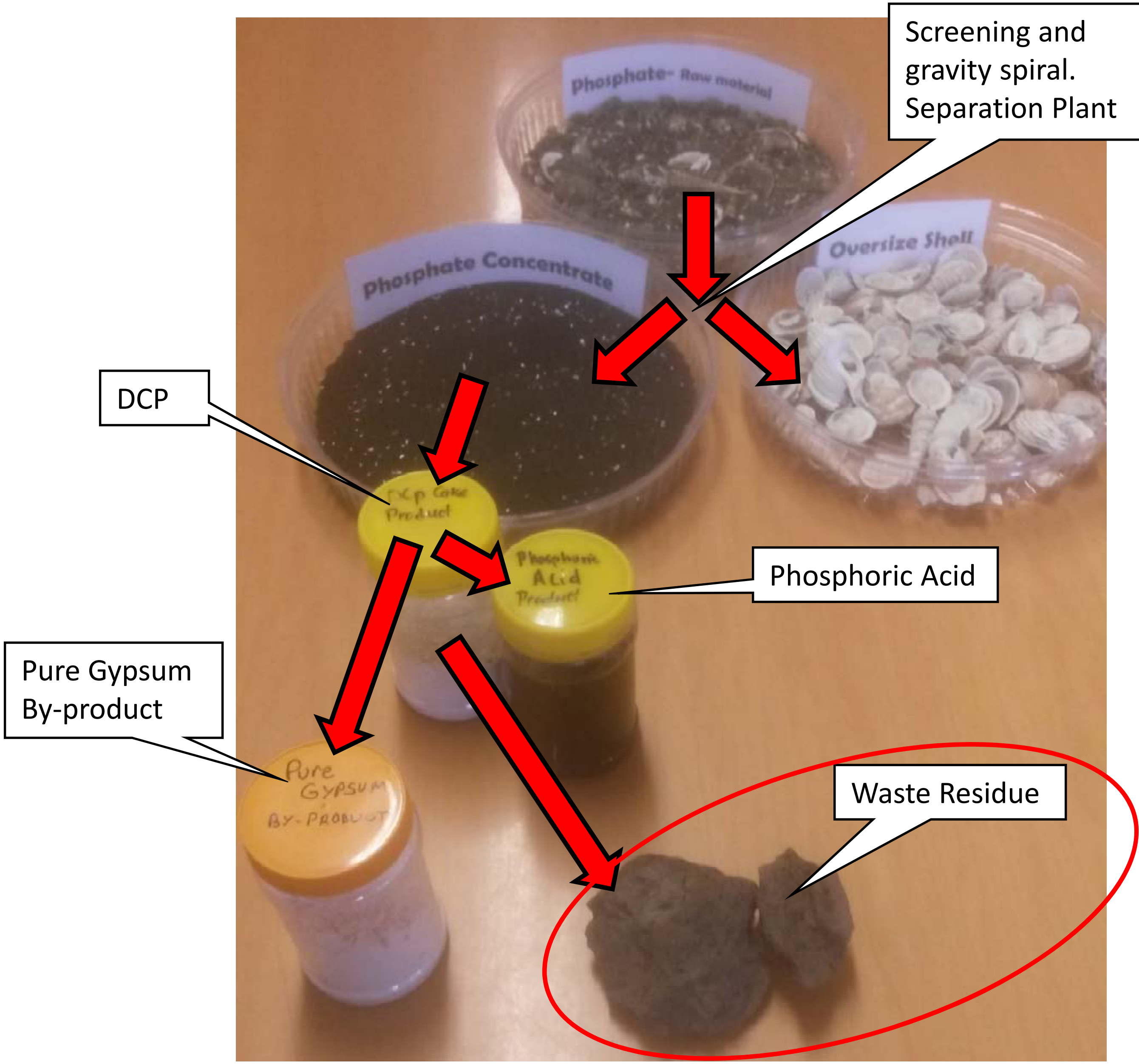
LLNP is using an environmentally friendly technology that produces pure gypsum as a by-product and **NOT** the traditional old technology **phosphogypsum**. Grenzebach BSH finished their lab test with LLNP's gypsum sample and concluded: "The purity is about 98,8% - very high" and "we can summarize that the gypsum sample sent is suitable for further processing into gypsum products including plasterboards".

Trace metal content of natural gypsum compared with U.S. EPA Part 503 pollutant concentration limits for Gypsum bio-solids vs LLNP Gypsum.

Pollutant(ppm= mg kg^{-1})	Natural gypsum	US EPA Part 503, limits	LLNP Gypsum
Arsenic	< 0.52	41	0.14
Cadmium	< 0.48	39	< 0.1
Chromium	1.38 (0.32)	1200	N/A
Copper	1.33 (0.30)	1500	0.19
Lead	2.92 (0.30)	300	2.60
Mercury	< 0.26	17	N/A
Molybdenum	1.28 (0.04)	75	N/A
Nickel	1.42 (0.23)	420	0.98
Selenium	< 1.45	36	N/A
Zinc	0.91 (0.49)	2800	< 1

Compound	Unit	Gypsum
P_2O_5	%	0.03
CaO	%	31.9
SO_4	%	55
F	%	<100
Cl	%	<100
Fe_2O_3	%	0.00025
Al_2O_3	%	0.001
SiO_2	%	0.07
MgO	%	0.0004
Na_2O	%	0.03
K_2O	%	0.0004
Cd	ppm	<0.1
As	ppm	0.14
Pb	ppm	2.6
Zn	ppm	<1
Ni	ppm	0.98
Ti	ppm	<0.1
Cu	ppm	0.19

Basic Flowchart



Waste Residue

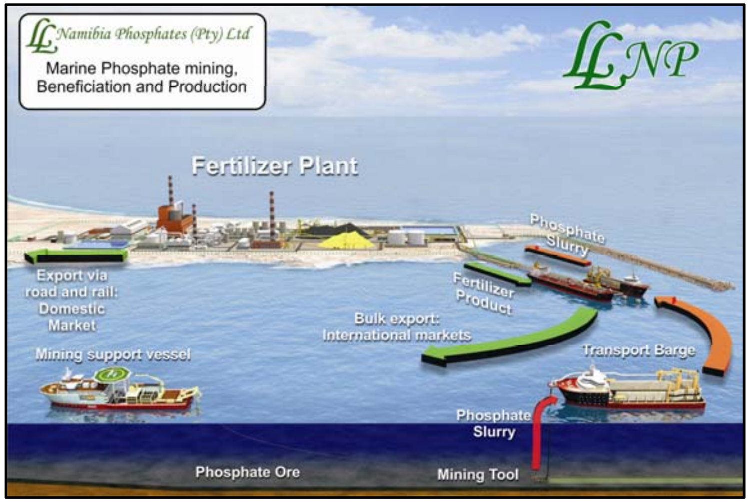
LLNP is using an environmentally friendly technology for beneficiation but as with all mining there is a waste product. One cannot get these elements people are talking about to disappear into thin air. So what happens to them?

This waste residue contains the heavy metals, uranium, thorium at the levels that necessitates tailings dump management. This waste residue cake will need to be dry stacked in a lined tailings dump and managed. This is done at mines all over the world and is not unique to LLNP's project.

I will not eat this residue cake! I've done the analysis and know what is in it!

Compound	Unit	Residue Average
P_2O_5	%	1.6
CaO	%	25.5
SO4	%	25.8
F	%	2.4
Cl	%	0.8
Organics	%	2.6
Fe_2O_3	%	4.2
Al_2O_3	%	1.3
SiO_2	%	5.4
MgO	%	1.8
Na_2O	%	1.2
K_2O	%	0.6
Cd	ppm	12.7
As	ppm	130.1
Pb	ppm	17.2
Zn	ppm	63.0
Ni	ppm	167.8
Ti	ppm	141.9
Cu	ppm	35.2

Conclusion


Namibia Phosphates (Pty) Ltd
Marine Phosphate mining, Beneficiation and Production
LLNP
Fertilizer Plant
Phosphate Slurry
Export via road and rail: Domestic Market
Fertilizer Product
Bulk export: International markets
Transport Barge
Mining support vessel
Phosphate Slurry
Phosphate Ore
Mining Tool


NAMFOS FERTILIZERS (PTY) LTD - LÜDERITZ PROJECT
MODEL OF JETTY AND BENEFICIATION PLANT
NamFert

MFMR Studies

- MFMR's proposed an 18 month moratorium which was approved by Cabinet on 17th September 2013 in order to conduct environmental studies using an independent institution.
- The aim of this Strategic Environmental Study (SEA) was to investigate potential impacts of the phosphate mining industry and to make sure that the two industries can co-exist without harming one another. The phosphate industry welcomes these studies by MFMR.
- Their studies can easily be carried out in parallel with those of the industry.
- However no actual research has been done in the 3 year period the Cabinet allocated to them. Mining is unlikely to start within the next 3 years giving MFMR additional time to complete their study. I'm certainly interested to see if they will do anything!

Way Forward

- The new Environmental Management Act, 2007 (EMA) is adequate to ensure that phosphate miners comply environmentally and to stop their operations, if they note serious impacts or are not compliant.

- MET renews the ECC every three years and therefore provisions already exist within the established legal system to stop a company's activities should environmental impacts be noted that could damage the Benguela ecosystem or the fishing industry.

- I hope that I was clear in explaining the environmental factors and presenting the information to you in a manner that you are now able to understand what phosphate mining entails and for you to draw your <u>own conclusions</u> on the many issues that have been raised.

- In future when reviewing the articles in the press and on social media, remember to ask: **What proof do you have to support your allegations?**

THANK YOU

Extra

Trace Elements- Separation Slimes

Once the Separation Plant operation was complete the slimes at the base of the tailings pond was sent away for analysis. LLNP's slimes material was disposed of at the municipal dump in a fenced off area allocated to them.

Table 1. Regulatory limits on heavy metals applied to soils (Adapted from U.S. EPA, 1993).

Heavy metal	Maximum concentration in sludge (mg/kg or ppm)	Annual pollutant loading rates		Cumulative pollutant loading rates		
		(kg/ha/yr)	(lb/A/yr)	(kg/ha)	(lb/A)	**LLNP**
Arsenic	75	2	1.8	41	36.6	**28**
Cadmium	85	1.9	1.7	39	34.8	**9**
Chromium	3000	150	134	3000	2,679	**280**
Copper	4300	75	67	1500	1,340	**64**
Lead	420	21	14	420	375	**9**
Mercury	840	15	13.4	300	268	**0.12**
Molybdenum	57	0.85	0.80	17	15	**19**
Nickel	75	0.90	0.80	18	16	**72**
Selenium	100	5	4	100	89	**88**
Zinc	7500	140	125	2800	2500	**114**