

Institution: University of the Highlands and Islands
Unit of Assessment: 7 Earth Systems and Environmental Science
Title of case study: Change in deep-sea tailings placement practices in Papua New Guinea through deep sea research
<p>1. Summary of the impact (indicative maximum 100 words)</p> <p>Deep sea tailings placement (DSTP) techniques have been pioneered in Papua New Guinea (PNG): a mining reliant economy in a seismically active region, facing major environmental challenges in the safe handling and storage of mine tailings on land. Dr Shimmield's team researched impacts of DSTP on the marine environment specifically to inform and develop guidelines for the use of DSTP to reduce environmental impact, thereby lowering risk and increasing private sector investment. Guidelines have been established as regulation by the PNG Government providing reassurance to private investors, facilitating an increase in mining exports to 60% of total export (2010).</p>
<p>2. Underpinning research (indicative maximum 500 words)</p> <p>For more than 20 years UHI researchers have investigated deep ocean environments, including physical oceanography (Prof Sherwin), deep sea ecology⁴ (Dr Hughes) and sediment mobility⁵ (Dr Howe, Dr Shimmield and Prof Black) producing more than 120 peer reviewed publications. Over time the group's research has become increasingly focussed on understanding human impacts on the marine environment², specifically the redistribution of waste in the oceans by the physical environment. The research outputs include detailed knowledge of how different water masses are detected and mapped (Sherwin), transport and fate of particulate matter⁵ (Shimmield, Howe, Black) and the impact of human inputs on marine life forms (Hughes).</p> <p>This project history gave the researchers the experience and knowledge required to design and lead a comprehensive research programme to investigate the environmental impact of the deposition of mine tailings in the deep sea of Papua New Guinea (PNG) (2006-2010). The research programme formed part of the Mining Sector Support Programme (MSSP) of PNG, funded by the 8th European Development Funding Initiative.</p> <p>Mine tailings are the waste product resulting from the removal of target metals (e.g. gold) from mineral ore. Traditionally tailings are stored on land in 'tailings dams', however due to high incidence of seismic activity and frequent heavy rainfall, dams in PNG are at high risk of failure, causing catastrophic damage to the environment and human health. Consequently deep sea tailings placement (DSTP) techniques have been pioneered by mine operators, involving the discharge of tailings in deep water¹.</p> <p>Understanding and mitigation of mine-induced environmental impacts is essential to secure private sector investment for mining operations on which the economy of PNG relies. The objective of MSSP was to investigate how to mitigate mine-induced environmental impacts, including impacts of DSTP, therefore reducing risk and increasing private-sector investment.</p> <p>Dr. Shimmield's team researched the effects of DSTP at 2 PNG mines: Lihir Gold Mine which has been actively discharging tailings since 1996 and Misima Mine, closed in 2004 after discharging tailings for 15 years, allowing an assessment of the recovery of the marine environment after tailings placement¹. Research involved investigating ocean currents and mixing, the behaviour of metals³ and the effect of tailings on benthic communities⁴ including the risk of elevated metal contents entering the food chain.</p> <p>The research established a metal "fingerprint" of tailings compared to natural sediments¹, which enabled the transport of fine tailings within the deep ocean to be ascertained. Key findings of the research include:</p>

- Significant differences in biological assemblages present at DSTP and DSTP free areas, indicating a relative decline in species number at DSTP sites¹.
- Impacted sediments contain high concentrations of metals, including ecotoxic elements (e.g. Cu, Cd, As)^{1,3}.
- Evidence of post-operational recovery of deep sea benthic communities impacted by mining operations¹.
- Elevated arsenic levels in surface waters were not linked to DSTP but result from runoff of acid mine drainage at Lihir Gold Mine.¹

Research Outputs:

- Final Report: Independent Evaluation of DSTP in PNG¹
- Guidelines for the use of DSTP in PNG
- Specific Guidelines for the use of DSTP at Lihir Gold and Ramu NiCo mines.

3. References to the research (indicative maximum of six references)

1. **Tracy Shimmiel et al.**, SAMS, Final Report, Independent Evaluation of Deep-Sea Mine Tailings Placement (DSTP) in PNG, 2010.
<http://www.infomine.com/library/publications/docs/Shimmiel2010.pdf>
2. Kalantzis I., **Shimmiel, T.M.**, Pergantis, S.A., Papageorgiou, N., **Black, K.D.**, Karakassis, I., (2013) Heavy metals, trace elements and sediment geochemistry at four Mediterranean fish farms, *Science of the Total Environment* 444 128-137. (Journal Impact Factor: 3.258)
3. Law G, **Shimmiel TM**, Shimmiel GB, Cowie G, Breuer E and Harvey SM. 2009 Manganese, iron, and sulphur cycling on the Pakistan margin. *Deep-sea Research Part II-topical Studies In Oceanography* 56(6-7):pp305-323(19). (Journal Impact Factor: 2.243)
4. **Hughes, D.J.**, Levin, L.A, Lamont, P.A., Packer, M., Feeley, K. & Gage, J.D., 2009. Macrofaunal communities and sediment structure across the Pakistan Margin oxygen minimum zone, north-east Arabian Sea. *Deep Sea Research II, Topical Studies in Oceanography* 56: 434-448. (Journal Impact Factor: 2.243)
5. **Howe JA**, Wilson CR, **Shimmiel TM**, Diaz R and carpenter L. 2007. Recent deep-water sedimentation, trace metal and radioisotope geochemistry across the Southern Ocean and northern Weddell Sea, Antarctica. *Deep-sea Research Part II-Topical Studies In Oceanography* 54:1652-1681. (Journal Impact Factor: 2.243)

Peer reviewed Research Grants:

1. EU 8th EDF Funding Independent Investigation of Deep Sea tailings Placement in PNG, £1,538k

The following research funded grants provided skills and knowledge that were utilised in delivering the PNG work and hence the guidelines, regulation and policy used by the Papua New Guinean government to regulate the mining industry

1. NERC Arabian Sea Grant, Benthic processes in the Arabian Sea: mechanistic relationships between benthos, sediment biogeochemistry, and organic matter cycling, £360k
2. NERC Oceans 2025 Theme 3; Pelagic and benthic biochemical processes response to spatial variability in topographically controlled mixing. £550k
3. NERC Oceans 2025 Nuclear counting Equipment (capital funding). £68,375

4. Details of the impact (indicative maximum 750 words)

Research undertaken by Dr. Shimmiel's team to investigate the environmental impact of the deposition of mine tailings in the deep sea of Papua New Guinea (PNG) (2006-2010) informed the development, by the research team, of a set of 'Guidelines for the use of DSTP in PNG'². These

Impact case study (REF3b)

Guidelines were presented publically in 2008, published in 2009 and in 2012 these guidelines were formally adopted by the government of PNG^{3,8} (Mineral Resource Authority & Department of Mineral Policy and Geohazard Management) and established as regulation to control and manage mining impacts on the marine environment. The Guidelines outline international best practice for regulatory frameworks and environmental considerations including, initial mine development, preliminary site evaluation, environmental baseline surveys, mining operations, future mine closure plans and post-mining monitoring.

Dr. Shimmield also developed 'Specific Guidelines' for the use of DSTP at Lihir Gold and Ramu NiCo mines. Mine Specific Guidelines outline effective operational and environmental management plans for a specific site, based on data obtained during the research cruises and detailed study of local ocean currents and mixing, the chemical signature of the mine tailings relative to natural sediments, and the structure of deep sea communities in the area. Following publication of the research finds (2010), which detailed the link between elevated arsenic levels in surface waters and acid mine drainage at Lihir Gold Mine, Lihir Gold Ltd. changed the management of spoil heaps at the mine to prevent runoff of acid mine drainage reaching the marine environment⁹.

The research resulted in the development of regulatory and mine specific guidelines to regulate the impact of mining on the marine environment and has lowered the risk associated with mining operations in PNG, contributing to an increase in PNG's economic performance through mineral production and exports, specifically the export of copper and gold, from 3 billion Kina (£0.94 billion) in 2001 to 8 billion Kina in 2010 (£2.5 billion)⁸. Export trends will continue to increase as in 2011 Ramu NiCo were granted consent for a further \$8 billion mine following a court hearing in which Dr. Shimmield was an expert witness⁸. Dr. Shimmield outlined in court the research leading to the development of Guidelines which will enable effective environmental management of mine tailings, leading to the court finding in favour of Ramu NiCo⁸.

Additional Impacts

- **Change to Political Mind-set:** The research on the impacts of DSTP on the marine environment, and the development of 'Guidelines for the use of DSTP in PNG' created a fundamental shift in the government perception of the importance of understanding environmental impact. At the 2011 Annual PNG Mining Conference, the Acting Managing Director of the Mineral Resource Authority of the PNG Government, stated "*when a licence to mine was granted thoughts were on how to get the maximum amount of mineral out of the ground as quickly as possible now the first thing that is thought of is what will the environmental impact be of getting the minerals out of the ground, this is a huge cultural change on how we view mining in PNG and its effects on our environment*"⁸.
- **Improved Public Understanding:** The research team led a series of awareness campaigns with local villagers throughout the research project. These campaigns improved dialogue between the PNG public and the government by providing an independent (research team) body for the public to engage with and voice concerns. As a result villagers went on to attend the International Conference on DSTP Practices and Environmental Monitoring⁴, organised by the research team in PNG (detailed below). Research was widely publicised in the media^{6,7} to raise awareness and to facilitate better public understanding of DSTP practices and environmental impacts.
- **Stakeholder Engagement:** An integral part of the research project, was provision of an International Conference on DSTP Practices and Environmental Monitoring. This conference took place on 4th - 7th November 2008 in the Madang Resort, Papua New Guinea⁴. The conference presented and discussed all aspects of the work with over 250 delegates, including PNG landowners & villagers, government, lawyers, international scientists, NGO's and mining companies. This conference provided a platform to present results of the research and draft guidelines. Guidelines were discussed with all stakeholders at the conference. From this discussion and stakeholder input, the guidelines were finalised and published in 2009.

Impact case study (REF3b)

- **Implementation in other regions:** The International Marine Organisation (IMO) received a set of Guidelines which were presented as an information paper to the Scientific Group meeting of the London Convention/London Protocol in 2011 (London Convention Scientific Group 2011)⁵. The European Committee for Standardisation are using the basis of the guidelines to develop Sub-Sea Tailings Deposition Evaluation Guideline for Europe.

5. Sources to corroborate the impact (indicative maximum of 10 references)

1. Details of the research activities in PNG can be found on the website at <http://www.sams.ac.uk/tracy-shimmiel/an-independent-evaluation-of-deep-sea-mine-tailings-placement-in-papua-new-guinea>
2. General Guidelines for the use of DSTP in PNG. <http://ramumine.files.wordpress.com/2010/09/10-draft-general-guidelines-final-2-complete.pdf>
3. Confirmation of Guideline uptake by PNG Government <http://www.postcourier.com.pg/20110721/business03.htm>
4. A major part of the research programme was stakeholder engagement. Details of the International Conference on deep sea tailings placement, can be found at: <http://garamut.wordpress.com/2008/09/03/conference-on-deep-sea-mine-tailings-placement-dstp-madang-resort-4th-7th-november-2008/>
5. Information paper to the Scientific Group meeting of the London Convention/London Protocol in 2011 (London Convention Scientific Group 2011) (ramumine.files.wordpress.com) (Scottish Association for Marine Science 2010). http://www.imo.org/blast/blastDataHelper.asp?data_id=31114&filename=MineTailingsMarineandRiverineDisposalFinalReportNovember30.pdf
6. Media Publication: “An Alternative: Deep sea tailings placement” published in Mining Australia, May 2013. <http://www.miningaustralia.com.au/features/an-alternative-deep-sea-tailings-placement> and “Down to the Depths” Article published in Mining Magazine, June Issue, 2013, www.miningmagazine.com
7. Media Publication: A 30 Minute interview was given by T Shimmiel discussing DSTP on PNG National Television (EMTV News) for the national news programme. This was an important part of the stakeholder engagement aspects of the research programme, and provided a platform for public engagement to build upon.

The Following Organisations can provide corroboration of the claims made in this case study:

8. The Acting Managing Director, Mineral Resource Authority, Papua New Guinea, was a key figure representing the Government of PNG throughout this research and led on the implementation of Guidelines produced from the research as legislation. The Acting MD will also be able to give insight into the direct impact the research has had on the economy and environment of PNG, and the switch in Government priorities (putting environment at the forefront of new mine projects) as a result.
9. Lihir Gold Mine is owned by Newcrest. Impact of the research at specific mines can be corroborated by Lihir Environment Compliance and Research superintendent.
10. UHI research on deep ocean environments and human impacts on the marine environment gained recognition by international peers and in 2005, a senior figure in the Geomar Helmholtz Centre for Ocean Research, Kiel, recommended SAMS to the Chief Executive of the SYSMIN Project as having the skills and expertise to take forward an Independent Evaluation of Deep Sea Tailings Placement in PNG as part of the Mining and Sector Support Programme (MSSP). Following this recommendation, SAMS were invited to design a comprehensive research programme and were awarded funding to take forward and execute this programme in 2006.