Independent Review of the Environmental Impact Statement for the proposed Nautilus Minerals Solwara 1 Seabed Mining Project, Papua New Guinea

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Conducted for the ***Bismarck-Solomon Seas Indigenous Peoples Council***
Madang, Papua New Guinea

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I. Introduction

The Nautilus Minerals Solwara 1 seabed mining project proposed in the Bismarck Sea off Papua New Guinea (PNG) is defined as a Level 3 activity under the PNG Environment Act 2000, requiring an Environmental Impact Statement (EIS) to be submitted to the PNG Department of Environmental Conservation (DEC). Accordingly, Nautilus and its contractor Coffey Natural Systems, submitted to DEC the Phase I EIS in September 2008, seeking approval and receipt of mining lease in the first quarter of 2009. The independent review of the EIS presented here was conducted at the request of the *Bismarck-Solomon Seas Indigenous Peoples Council* (BSSIPC). The review was based on the main EIS report (Volume A) with figures / plates as posted on the Nautilus Minerals website, but not Volume B (the technical reports in appendices). The author requested access to the technical reports / appendices via an email to Nautilus, but at the time of writing had not been provided with these. However, as the EIS states that it summarizes all of the technical reports in the appendices, the review presented here is assumed to have been based on all relevant information regarding the Solwara 1 Project.

II. Summary of Findings

The Solwara 1 project proposes to commercially exploit gold and copper deposits associated with deep-sea hydrothermal vents at a depth of 1,500 in the Bismarck Sea off Papua New Guinea. As the Project would represent the first large-scale, human-induced, site-specific disturbance to the deep ocean basin anywhere in the world, it must be considered with exceptional deliberation and caution. Scientists only first discovered these deep-sea hydrothermal vents and their exotic chemosynthetic ecosystems in 1976, and these extraordinary ecosystems remain poorly understood today. Deep-sea hydrothermal vents, found along mid-ocean ridges and back-arc basins (such as the Manus Basin in the Bismarck Sea), support one of the rarest and most unique ecological communities known to science. Organisms derive their energy from sulfide chemicals in hot (350 C), mineralized vent fluids rather than directly or indirectly from photosynthesis as in other biological communities, and/or from endosymbionts in their tissues. Most species discovered at vents are new to science, and the vents support communities with "extremely high biomass" relative to other deep-sea habitats. Some scientists suggest that such deep-sea hydrothermal vents systems may be where life first evolved on Earth.

The proposed Solwara 1 mining project would destroy an extensive patch of productive vent habitat, including tens of thousands of vent chimneys, killing virtually all of the attached organisms. The EIS states that: "The extent of the impacts to vents and other seafloor habitats directly mined will inevitably be *severe* at the site scale," and that "it may be *many years* before development of chimneys returns to pre-mining conditions (emphasis added)." And mining is expected to alter venting frequency and characteristics on surrounding seafloor areas as well, thus affecting the ecological communities of a much broader scale than just the mined site.

Although the Solwara 1 EIA / EIS makes a significant contribution to deep-sea vent science, it is clear that the EIS does not present sufficient information with which the PNG government can effectively judge the project's expected impacts. Thus the EIS is judged as not fit-to-purpose. Many risk contingencies are poorly analyzed, some are not analyzed at all, and many of the baseline studies necessary to understand potential impacts have yet to be completed.

For instance, studies of the taxonomy and genetic relationships of macro-invertebrate species found at Solwara 1, South Su (upstream about 2 km), and Solwara 8 (downstream about 45 km) have not been completed, and thus the degree of genetic variability and endemism of organisms between sites is not yet known. It is likely that several rare and endemic (found only at the site) macro-invertebrate species that are yet to be described by science exist at Solwara 1. As a result of the 2007 study at the mine site, "at least 20 new species have been added to the species list at active vent sites." This is a high rate of discovery of species new to science, and species encounter rates of the studies predict that there are likely many more species yet to be identified at the site. Such species would likely become extinct due to the mining project, even without having yet been identified or described. This alone constitutes an unacceptable risk. Bioethics dictates that resource development should not knowingly put species at risk of extinction, be they well-known charismatic macro-fauna (tigers, gorillas, whales, etc.), or poorly known deep-sea invertebrates.

While Nautilus conducted extensive studies of the deep-sea *benthic* (bottom dwelling) communities at the site, no systematic study was conducted on the deep-sea *pelagic* (water column) community that would be impacted immediately overlying the seafloor. Further, there was an inadequate assessment of risks associated with sediment and waste rock disposal, toxicity of the dewatering plume to deep-sea organisms, effects of increased light and noise in the deep ocean environment, and potential accidents on seafloor equipment or surface vessels. Regarding impacts to the *nearshore* ecosystem, one of the greatest risks from the project is the potential loss of tow or power of an ore shuttle barge in route to Rabaul (the EIS projects 3-9 barge trips per week, with 6,000 tons of toxic ore onboard each transit), or of one of the 25,000 ton bulk ore freighters (3-6 trips per month from Rabaul), and the barge or freighter then drifting ashore spilling its toxic cargo and fuel onto the coastal reef system. Yet, this risk was not considered at all in the EIS. Much of the EIS is simply too general in nature to determine impacts, and many of the mitigations proposed rely upon Environmental Management Plans and procedures that have yet to be developed by Nautilus, and thus the effectiveness of these cannot be judged at present.

It is likely that the project would result in severe, prolonged, and perhaps region-wide impacts to a globally rare and poorly understood biological community, and it is clear that the EIS does not adequately assess many of these impacts. Further, the benefits to local people or the economy of PNG seem disproportionately low compared to the scale and risk of the project.

While the Project could gross almost $1 billion USD in its 30-month lifetime, it expects to provide only $41 million in total taxes and royalties to the government, a $1.5 million development fund, and a few dozen jobs at most to PNG nationals.

Given the above concerns, **it is respectfully recommended that the government of PNG not approve the project on the basis of this EIS.**

III. Project Overview

Nautilus Minerals Inc. is applying for permission to develop in the waters of Papua New Guinea (PNG) in the southwest Pacific Ocean the first commercial deep seafloor mining project in history. Nautilus, headquartered in Toronto, is jointly owned by several of the largest mining companies in the world – Barrick Gold Corporation, Anglo-American, Teck Cominco, and Epion Holdings. And the government of PNG has a legal right to acquire up to 30% equity in the project. Nautilus currently holds 51 exploration licenses in the Bismarck Solomon Seas in the southwest Pacific, covering 107,917 km2, as well as 37 exploration license applications, covering another 88,906 km2. As well, they hold exploration licenses in Tonga and the Solomon Islands, and have pending applications in Tonga, Fiji and New Zealand.

The Solwara I project proposes to extract gold and copper ore from Seafloor Massive Sulfide (SMS) deposits at 1,600 m – 1,200 m water depth on the seafloor of the Bismarck Sea, New Ireland Province, Papua New Guinea. The SMS deposits are associated with deep-sea hydrothermal vent systems and their unique chemosynthetic (relying on chemicals from vent fluids rather than photosynthesis) ecosystems that have only recently become known to science.

The Project proposes to mine ore from a large Seafloor Massive Sulfide deposit at Solwara 1, including areas of active and inactive hydrothermal vent chimneys and their associated ecosystems. The sulfide mound deposit is on the northwest shoulder of the active North Su submarine volcano, and stands approximately 200 m above the surrounding seafloor and stretches about 2 km in diameter. The area hosts some 40,000 hydrothermal vent chimneys over 0.25 m in height. Nautilus proposes to mine five mineralized areas covering approximately 11 hectares (0.112 km2) of seafloor, recovering an estimated 2.17 million tons of ore to yield an estimated 435,000 ounces of gold and 157,000 tons of copper. The projected mine life is 30 months (at a maximum production of 5,900 tons of ore / day), but could “extend up to 5 years and beyond depending upon discoveries of additional mineralization at Solwara 1.”

During the mining operation, approximately 130,000 tons of unconsolidated sediment (6 m deep over some of the deposit) and 115,000 tons of waste rock will be removed and pumped onto deeper nearby seabed areas down-slope.

The ore will be collected using a Seafloor Mining Tool (SMT) weighing 250 tons out-of-water, and standing 8 m tall, 17 m long, 13 m wide, with a 2-meter diameter drum cutter-suction head extended from a hydraulic boom on the front. The SMT, powered by 6 electric-hydraulic power units, will move across the mining bench of 2.5 m to 3.5 m in height, cutting 2-meter vertical and horizontal swaths of the seafloor deposit with its cutter head, down to a maximum depth of 220 m below the current seabed surface. The dislodged ore will be collected by a suction hood and pipe behind the drum cutter head. Two remotely operated vehicles (ROVs) will be used to assist the process, including removal of sediment overburden with a suction pump and discharge pipeline.

The SMT will be remotely operated via a fiber-optic/electric umbilical cable from a Mining Support Vessel (MSV) surface ship 160 m long, that will be kept dynamically positioned over the mine site. The ore slurry will be pumped to the surface MSV via a riser and lift system (RALS), and dewatered once at the ship with separated water returned to near the sea bed for discharge. The ore will be loaded onto 3-9 shuttle barges per week, each of 85 m long, for transport 50 km south to shore for temporary storage at the Port of Rabaul on north New Britain Island. In Phase I of the project, the ore will be exported from Rabaul via 3-6 ore bulk carriers (160 m LOA and 25,000 DWT) per month to a foreign processing facility and smelter. Phase II will build a concentrator onshore in PNG, and the ore concentrate will be exported to foreign smelters.

The project will have approximately 140 employees, most being technically skilled expatriates. It expects to contribute a total of $41 million USD in taxes and royalties, a Community Development Fund of about $1.5 million USD, and total direct economic benefit to PNG estimated to be $142 million USD. Start up was expected in 4th quarter of 2010, but this has been delayed indefinitely due to the current global financial situation and unstable markets. In December 2008, Nautilus suspended its contracts and purchase orders, including its order for the MSV, and laid off about 30% of its employees. At today's market prices and resource estimates for the deposit, Solwara 1 production would generate about $370 million USD in gold and $530 million USD in copper, for a total of $900 million in revenue.

IV. Overview of impacts projected in EIS

Concerns regarding Project impacts summarized in the EIS include: "loss of habitat and degradation of water quality; loss, regional or wider scale loss, of endemic or rare species; decreased diversity of species or higher taxonomic levels; and loss of knowledge or of future opportunities (i.e., what we do not know)." It is highly likely that all of these will occur.

The ecological footprint of normal operation of the project will be significant. An 11-hectare area of the sulfide mound at Solwara 1, all of its associated organisms, and tens of thousands of vent chimneys would be removed and destroyed by the mining process, down to a maximum depth of 220 m below the existing seafloor.

It is expected that mining will impact venting frequency, location, and intensity at areas surrounding the mined area, and thus impact these nearby biological communities. Recruitment of vent species at other vent sites downstream from Solwara 1, including Solwara 8 approximately 45 km to the northwest, will likely be reduced. The 245,000 tons of waste rock and unconsolidated sediment overburden will be disposed down-slope, and extend 2 km or more from the discharge site. The suspended sediment from mining operations and disposal of waste will settle over an extensive area of seafloor habitat, resulting in the smothering of benthic communities. The discharge plume from the dewatered ore with 6,000 mg/L suspended solids, increased metals leached from the ore, and elevated temperatures up to 11 C, will be discharged 25 m – 50 m above the seabed, and will exert detectable impacts 10 km from the site. At the expected discharge rate of 0.3 m3 / sec, over 10 million tons / year of contaminated effluent will be discharged into the deep-sea environment.

Underwater noise from the Project is expected to be audible 600 km from the site, and could induce masking effects in cetaceans 15 km from the site, and behavioral response much farther. And 1.44 million m3 (tons) of ballast water from bulk ore carriers, potentially contaminated with exotic invasive species, will be discharged into nearshore waters off New Britain. Project impacts are expected to be regional in extent (extending more than 10 km from site), prolonged in duration (lasting beyond 1 year), and have high degree of severity (severe negative impact on populations, community or ecosystem survival or health). The relative impact of the proposed Project on the globally rare and unique habitat found only at deep-sea hydrothermal vents would be proportionately far greater than, for instance, impacts of terrestrial mines on global forest habitat.

Further, the footprint of the Project would be considerably more extensive and severe if accidents occur. The accident scenario of most immediate concern is that of the loss of an ore shuttle barge, with 6,000 tons of toxic ore, fuel, and other hazardous material onboard, or a bulk ore carrier with 25,000 tons of ore and fuel onboard, in the nearshore environment off New Ireland or New Britain.

V. **Specific Comments** (with corresponding page number from EIS)

1. *Introduction*

1-3 The EIS states that: "The Project is consistent with the Fourth National Goal and Directive Principle of the Constitution of PNG which states: 'We declare our Fourth Goal to be for Papua New Guinea's natural resources and environment to be conserved and used for the collective benefit of us all, and be replenished for the benefit of future generations.'" As support for this, the EIS refers to the potential economic benefits of the project "over the nominal Project life and beyond." It is difficult to see just how this project satisfies the Fourth National Goal of the Constitution of PNG.

Clearly, the project is not sustainable, as it exploits a relatively finite mineral deposit, lasts only 30 months, contributes a relatively small amount of money to PNG, severely damages the benthic habitat for a rare deep-sea sulfide mound ecosystem, and poses risk to other marine resources in the region.

1-4 The EIS states that: "The Project proposes the first-ever attempt to commercially develop SMS deposits, including small areas of active mineralized chimney habitats and their associated colonies of hydrothermal vent fauna. Understanding the impacts of mining on these biological communities is the fundamental environmental issue for the Project." Note, this refers to the biological communities associated with hydrothermal vent systems, which include the off-bottom (bathypelagic) organisms as well as the on-bottom (benthic) organisms at the site. The EIA process did not methodically examine the bathypelagic community at all, and thus the EIS fails its own charge. As well, it is difficult to accept the premise that the Project will mine the active vent communities. It is strongly recommend here that *no active sites be mined*, and exceptional care be given to avoid these areas. This would dramatically reduce the impact on these unique vent-specific communities, which otherwise is correctly deemed to be "severe."

1-4 The EIS states that: "the offshore location of the Project has necessarily shifted the consultative focus from landowner issues (as there are no direct impacts) to the more international scientific input described above." They imply that consultation with local people is less essential, but that they will conduct some anyway. This ignores the substantial stewardship coastal peoples in PNG feel for the marine environment as a holistic entity, and one with considerable spiritual value. This includes valuation and inferred tenure for the marine resources outside of their immediate use for subsistence purposes, including presumably such systems as the deep-sea hydrothermal vents. That coastal peoples in PNG do not live at or directly utilize the offshore mine site should not be interpreted to mean that they do not value and/or exert ownership and tenure over such areas. Many PNG people express a strong spiritual connection to all components of the ocean environment, including deep-see hydrothermal vent systems that they have never seen.

1-5 The EIS states that: "The offshore components of the Project have no impacts to landowners." It is clear that the EIS did not adequately assess potential risks to landowners, but such risks do nevertheless exist. For instance, shoreline risks include potential accidental impacts such as an ore shuttle barge in transit to Rabaul losing its tow (or power) in heavy weather, or a bulk ore carrier losing engine power, drifting ashore, and spilling its entire load of heavily mineralized and toxic ore and fuel onto nearshore coral reef ecosystems. These are very real risks, were not addressed at all by the EIS, and will be discussed below in the shipping accident risk section.

2. *Viability of Project*

2-5 In again purporting that the Project is consistent with the Fourth National Goal of the PNG Constitution, the EIS states that the mining will be conducted with methods that are "environmentally responsible, socially acceptable, technologically achievable and economically viable." The last two terms here – "technologically achievable and economically viable" - are objectively quantifiable. The first two however - "environmentally responsible and socially acceptable" – are subjective and open to interpretation. It is clear that there are many coastal residents in PNG who do not feel that the proposed project will be either environmentally responsible or socially acceptable.

3. *Policy, Legal, and Administrative Framework*

3-2 EIS states that Environment Act 2000 authorizes the PNG Department of Environmental Conservation to act as follows: "The Director, while assessing the EIS, may refer the EIS to a number of bodies, such as an *environment consultative group* or a *public enquiry committee*. If a provincial environment committee has been established, the Director must refer the EIS to the committee for its comments."

It is unclear whether the DEC Director has established such levels of additional review for the EIS, but as this is such a novel project with such potential consequence, and which will likely set the stage for many future development proposals in the PNG, it is strongly recommended that the DEC Director establish both an *independent technical consultative group* and a *public enquiry committee* to review the EIS as prescribed by the Environment Act 2000. As the project has been delayed indefinitely due to the global financial situation, this provides additional time to conduct a more thorough examination of the project impacts and ways to mitigate such impacts. See discussion of stakeholder consultation below.

3-7 EIS states that: "No PNG legislation exists to address the impacts of in-water noise as it affects marine animals, particularly cetaceans. Therefore the Australian Government Environment Protection and Biodiversity Conservation Act Policy Statement 2.1 – Interaction Between Offshore Seismic Exploration and Whales (DEWR, 2007) has been adopted." Standards related to offshore seismic surveys are likely not very useful in predicting or mitigating impacts from noise generated by the deep-sea mining project proposed here. The EIA/EIS did not adequately address the underwater noise issue.

3-7 EIS states that: "Nautilus will endeavor to comply with Equator Principles where appropriate and concomitantly comply with all relevant IFC performance standards." It is noted here that "will endeavor to comply" and "where appropriate" give unnecessary flexibility to Nautilus to decide just how compliant to be. This should read: "Nautilus *will* comply with all Equator Principles and IFC performance standards," and they should identify a performance monitoring mechanism.

4. *Stakeholder Consultation*

4-1 The Project's stakeholder consultation, as described in the EIS, is insufficient and must be strengthened. It relies on passive consultation, rather than active engagement. Simply giving a presentation about the Project to a local group does not necessarily constitute "engagement." Legitimate engagement is a deliberate process where all stakeholders are informed, have time and technical resources with which to assess the information and respond, and then enter into dialog to resolve outstanding issues of contention. The EIS presents no evidence that such legitimate engagement has occurred. Nautilus was informed of such an effective stakeholder engagement model over a year ago – the Regional Citizens Advisory Councils in Alaska – yet the EIS makes no reference to such mechanisms. Just this past summer, the *Bismarck-Solomon Seas Indigenous Peoples Council* (BSSIPC) was incorporated, and seeks to represent the views and concerns of coastal indigenous peoples of the region in all matters regarding the environment, exploitation, and sustainability of the Bismarck-Solomon Sea region. In August 2008, BSSIPC sent Nautilus a letter with their concerns regarding the Solwara seabed mining project, yet the EIS does not reference the BSSIPC or its concerns at all.

As the BSSIPC represents an integrated, cohesive, comprehensive, and continuing mechanism for consultation and engagement across the region, it is strongly recommended that Nautilus and the Government of PNG recognize and consult BSSIPC on any and all aspects of proposed activities in the region. It is in the interest of commercial operators, the government, and the people of PNG for the BSSIPC to flourish. Accordingly, it is recommended that substantial and stable financial resources be dedicated (by government, industry, philanthropic and/or other NGO community) to support BSSIPC, at least for the lifetime of any/all offshore mining projects in the region. The government can and should make the funding of BSSIPC a stipulation of the approval of the lease application from Nautilus (or any other applicant). This funding must be sufficient for BSSIPC to support a full time staff and central office, communications with local counselors, travel for counselors from across the region to meet regularly, funding to commission their own scientific studies, and so on. Further, it is recommended that BSSIPC be allowed to place an observer onboard the MSV or other project vessels during any and all future operations.

4-7 The EIS states that: "A number of well-attended meetings (Table 4.2) were held on Bagabag Island (Madang Province), in Kavieng, etc.…The majority of attendees were generally positive while not expressing full support." This is a dramatic misrepresentation of the results of the Bagabag meeting. The author visited Bagabag in 2007 shortly after Nautilus representatives held their meeting there, and was told that the overwhelming sentiment expressed by Bagabag residents to Nautilus was in strong opposition to any seabed mining proposals. This should be honestly reflected in the EIS, but isn't. This misrepresentation calls into question other such representations of community support in the EIS.

4-11 The EIS states that: “Consultation will continue prior to and during operations of the Project.” Again, without a fully functional BSSIPC, this will be difficult.

5. ***Description of the Proposed Development***

5-1 The EIS states that: “A 500-m exclusion zone will be put in place around the Mining Support Vessel (MSV) to minimize the risk of collisions with non-Project vessels, in accordance with accepted international shipping and oil and gas facility procedures.” However, there is no discussion regarding how Nautilus intends to enforce this exclusion zone. Do they anticipate using active force to deter incursions into the zone? And, the governmental authority to grant the exclusion zone needs further clarification here.

5-6 The Seafloor Mining Tool (SMT) would be a very large piece of equipment, weighing 250 tons in air, and 190 tons in water. It is designed to operate at depths to 2,500 m, and in water temperatures of 0 C – 35 C. There is no discussion of how the operator intends to recover the SMT if its umbilical cable is severed (although likely the ROVs will assist in this), what would occur if the SMT is directed into active vents that exceed the thermal maximum for the unit (35 C), and how much hazardous material it has on board (e.g. hydraulic fluids, etc.) that could spill at depth directly into the vent habitat. There are several sensors designed into the SMT (depth, pressure, temperature, onboard equipment, etc.), but apparently no sensor with which to detect toxic spills of hydraulic oil, etc. This should be remedied.

5-8 The Riser Transfer Pipe (RTP) connecting the SMT to the RALS system will be fitted with floatation collars to keep it off the bottom, designed for 80-130 meter range horizontally and 10-60 m vertically. Given the potential sea states in which the MSV might operate on the surface, and the possibility of periodically losing its dynamic position over the RTP and seabed operation, these tolerances seem too small. It seems that additional range of flexibility in the RTP should be designed.

5-9 The Mining Support Vessel (MSV) is a 14,200-ton ship, with 2,000 m3 fuel capacity. Although this is not mentioned in the EIS, it would enhance safety if the fuel tanks were protectively ballasted (ballast tanks outside the fuel tanks), double hulled, compartmentalized, and/or lined to prevent outflow of fuel in the event of a rupture. Such a fuel tank rupture could occur from collision with a support vessel, shuttle barge, or vessels acting in an intentionally hostile manner (ramming) toward the MSV.

5-10 The MSV will be refueled at sea once every month or more often, and no discussion is found in the EIS regarding the fuel transfer procedure and equipment, weather restrictions, and spill prevention and response specific to fuel transfer operations. As these operations present serious risk of spillage to offshore surface waters, this operation must be designed and managed with caution.

5-13 The plan to translocate some aggregations of vent organisms, including aggregations of *Ifremeria* and *Alvinoconcha*, from areas to be mined to areas already mined, is an interesting idea. However, it is unclear that relocated organisms will survive. If these communities are disconnected from the hydrothermal system that provides the sulfidic trophic base upon which they depend, it seems unlikely they will survive. It is also unlikely that a significant portion of the total active vent communities at the site can be relocated in this way. The idea deserves a try, but no one should feel confident that this technique would be an effective mitigation strategy that would significantly reduce the severe impact to the sulfide mound ecosystem.

5-14 The transfer of toxic ore from the MSV onto shuttle barges presents risk of ore spills and contamination of surface waters. It isn't clear from the EIS that prevention of this risk has been thoroughly addressed. For instance, it should be possible to install a neoprene (polymer) liner beneath the conveyor similar to those proposed beneath the onshore storage piles at Rabaul, between the two vessels to catch spilled ore and any contaminated water, much as a cargo net is deployed in typical ship-to-ship loading / offloading operations. This should be addressed by project engineers and ship masters.

5-15 The elevated discharge temperature of the dewatered effluent from the RALS is of concern in producing impacts to the deep-sea environment. The EIS projects that, based on a surface time of 12 minutes during which the ore is dewatered, and another 6 minutes for the effluent to return to the sea floor for discharge, the effluent temperature is expected to be 5.8 C – 11.4 C. This elevated temperature may have measurable effects on the bathypelagic fauna, but this is not addressed sufficiently. Further, if there is a delay in the ore dewatering process at the surface (due to equipment malfunction or other cause), then the time exposed to surface heating will increase and the discharge temperatures could be even further elevated. This was not addressed in the EIS.

5-15 The transit of 3-9 shuttle barges per week from Solwara 1 to Rabaul, each with 6,000 tons of toxic ore, fuel, and other hazardous materials onboard, is likely the riskiest component of the entire project to near shore ecosystems. Any one of these transits could result in the tug losing its tow of the barge in heavy weather, and the barge then drifting onto shore or fringe reefs, spilling its entire load of ore and fuel into the water. This scenario was not addressed in the EIS, and the PNG government should consider this a significant oversight that needs to be rectified.

5-16 Similarly, the export bulk ore carriers represent a considerable risk to he near shore environment as well. The project anticipates transits of some 3 – 6 ore bulk carriers / month from Rabaul, each with approximately 25,000 tons of ore cargo and several thousand tons of fuel. The EIS contains no discussion of routing agreements, navigational considerations (shoals and reefs), specifications for these bulk carriers, or contingency plans for loss of power, propulsion, or foundering along route.

Each of these bulk carrier transits presents significant risk to the near shore environment, yet the EIS does not consider this at all. Again, the PNG government should consider this a significant oversight that needs to be rectified.

5-16 As is seen throughout the EIS, the plans for the transport of hazardous materials to Rabaul and from Rabaul to the MSV have yet to be developed. This includes loading procedures, spill prevention, spill contingency plans, etc. Until these plans are developed, with a complete listing of all hazardous materials to be used by the Project and in what volumes, it is impossible to judge the risk or potential impacts of this component of the project.

5-18 The workforce anticipated by the Project is a total of 140 personnel, of which most will be offshore, and most likely skilled expatriates. Relative to other mining projects in PNG, this is a minimal workforce. Thus, the suggestion that this project will provide significant employment for local people is not born out by these projections.

5-19 The EIS states that: "Operations at the Port of Rabaul are expected to cease prior to completion of mining activities at Solwara 1, i.e., when Phase 2 of the Solwara Project commences, all onshore operations will be transferred to the yet-to-be-determined location of Phase 2 operations." This calls into question the advisability of separating the two phases of the project for the purposes of EIS review. It is clear that Nautilus intends to build the onshore ore concentrator as part of the Project, and this will significantly alter and shift the environmental footprint of the project. That this is not considered at all in this EIS seems a significant problem. It should be apparent where the most probable locations for the Phase 2 concentrator may be, and these should be identified in this EIS process.

6. *Development Timetable*

6-1 The Development Timetable needs to be updated, as the project has recently been delayed by Nautilus due to the global financial situation and softening of commodity markets. The timetable had projected first ore in last quarter of 2010, but as Nautilus has recently suspended purchase orders and contracts, this will obviously be delayed indefinitely. Fortunately, this delay will allow time for baseline studies to be completed, and a more sufficient EIS to be prepared.

7. *Description of the Existing Environment*

7-1 The EIS states that: "Applying water or sediment quality criteria or toxicity protection limits developed for surface organisms is not relevant for these vent organisms." Yet, there was no attempt made in the EIA to conduct toxicity testing on the vent organisms themselves. It is stated in the EIS that vent organisms will not survive transport to and maintenance on the surface vessel or laboratory, thus making it difficult to conduct toxicity tests.

However, until a reliable toxicity testing procedure is developed for these unique deep-sea vent organisms, it will be difficult to assess the potential impact of dewatered effluent streams from the RALS, or from turbid plumes from mining or sediment / waste rock disposal at depth.

7-24 – 7-26 The EIS discusses the bathypelagic ecosystem above the proposed Project site only in very general terms. The EIA did not conduct a systematic study of the bathypelagic communities overlying the mining site, but reported only opportunistic observations from the ROV. For instance, the EIS states that: "It was not practicable to sample fish from the areas around the vents and non-venting habitats of Solwara 1 and South Su," but does not discuss why. This should have been a straightforward exercise. A full characterization of the bathypelagic environment at the site is essential in order to understand the potential impacts of the Project. Such a comprehensive study would include a characterization of the bathypelagic plankton community (including planktonic larva and juveniles of upstream vent organisms), and nekton including fish, crustaceans, and pelagic mollusks. Additionally, the seasonality in species composition of this community needs to be understood. The EIS discusses very general information derived from studies elsewhere, and infers that the species composition and structure of the bathypelagic community at Solwara 1 is similar to our general understanding of such systems elsewhere in the world ocean. This is insufficient, and represents a significant oversight of the EIA / EIS process that should be rectified.

7-26 – 7-29 Similarly, the EIS discusses the mesopelagic and epipelagic ecosystem in only general terms as well. These regions host an important diversity of marine organisms that might be impacted by the project (although certainly less so than the communities on and just above the sea floor at the mining site), including plankton, cetaceans (whales and dolphins), fish, cephalopods, dugongs, crocodiles, sea turtles, sea snakes, and sea birds. The EIS reports some literature on these communities, as well as some anecdotal observations at the site, such as that "squid occur in high concentrations above Solwara 1 at 400 m water depth in the early hours of the morning," and that the critically endangered Beck's petrel and vulnerable Heinroth's shearwater may occur in the Project area. But there was no systematic study of these biological communities at Solwara 1, and this again is a significant oversight that needs to be rectified.

7-33 – 7-34 The EIS discusses the initial biological sampling from the SuSu Knolls in the Manus Basin in 2000, which indicated several new, endemic, and un-described species of macro-invertebrate species in the region. These include tube worms, mussels, snails, and perhaps the bamboo coral. The EIS goes on to state that additional sampling and detailed taxonomic studies and DNA studies would be necessary to determine whether different species exist at the site, and that "the study also highlighted the generally poor understanding of the macrobenthic fauna of inactive hydrothermal sites." This question needs to be adequately addressed before any active mining is allowed to commence at the site.

7-35 The EIS reports the existence of three ecological zones moving outward from active host vents that are characterized by dominant species *Alvinoconcha, Ifremaria*, and *Eochionelasmus*. However, the basis for this zonation (fluid chemistry, temperature, etc.) is inferred from vent systems elsewhere, as it has yet to be definitively established at Solwara 1. This is a fundamental scientific question regarding the vent ecosystems at Solwara 1 that should be determined before these vent communities are destroyed by mining.

7-35 The EIS reports considerable variation between the communities at Solwara 1 and South Su, 2 km southeast of Solwara 1. Of the 49 species observed from both sites, 23 were common to both, 16 were observed only at South Su, and 10 were observed only at Solwara 1. And species diversity indices were significantly different (in the *Ifremaria* zone) between sites. Also, South Su had a much greater abundance of the limpet *Lepetodrilus*, and the mussel *Bathymodiolus* and the tube worm *Alaysia* were found only at South Su. Given these significant differences in the two sites then, it is surprising that the EIS concludes that: "South Su is a suitable control [by which measure impacts of mining at Solwara 1 against] insofar as it shares the same faunal elements and densities found at Solwara 1." Having described the different densities, abundance, and occurrence of several species between sites, this is particularly puzzling. It is doubtful that impacts at Solwara 1 can be definitively determined using South Su as a control, as the EIS proposes. Permanently protected control sites at Solwara 1 itself may provide better understanding of mining impacts.

7-35 The EIS states that: "at least 20 new species have been added to the species list at active vent sites" by the studies conducted by the EIA. This indicates a high rate of encounter of new, un-described species in the area, and suggests that there may be a high risk of species extinction due to the proposed Project. This is clearly an unacceptable risk. At very least, before the Project is approved, additional study should be conducted at the site to identify any / all species that are new to science, reference samples collected, and a better understanding of their life histories should be developed. This may be the most significant shortcoming of the proposed Project to date, and clearly needs to be rectified before the site, and its new species, are destroyed by mining.

7-36 On the *inactive* hard surfaces away from the active vents, sampling found a similar disparity between the South Su site and Solwara 1. From these inactive hard sites, 91 species were collected, 26 observed only at South Su, and 33 observed only at Solwara 1. These included amphipods, stalked barnacles, hydroids, carnivorous sponges, limpets, squat lobsters, and bamboo coral. This further questions the logic of using South Su as a control for understanding the impacts of mining at Solwara 1.

7-37 The EIS states that: "Given the dynamic and variable nature of venting activity, attempts at clear differentiation of zones with or without venting influences is not practicable."

However, it seems that with more time and study, this differentiation is not only possible, but it would be essential to provide a basis to fully understand the potential impacts of the proposed Project. Further, that species effort curves had not yet leveled off in the studies conducted to date suggests an "incomplete characterization of the lesser abundant species." Also "it is unlikely that all of the more rare species will be observed," and "more species would be found with increased effort," suggesting that more intensive study would continue to reveal the more rare, possibly new and endemic species. Clearly, it is in the interest of science that such intensive investigation, on both inactive hard surfaces and the active vent systems, be conducted before any mining activity is approved on the site. Further, it was not clear from the EIS that intensive sampling was conducted at the specific seafloor sites where waste rock and sediment overburden will be dumped. Clearly, this needs to be conducted in order to predict impacts from smothering etc. to these communities.

7-35 – 7-36 The EIS states that: "some colonies of bamboo coral (Keratoisis sp.) have been estimated at being over 100 years old," and that some of the ones at Solwara 1 may be different species, suggesting that there is much still to learn about this genus of deep-sea organism. The EIS also states that: "Characterizing the degree of endemism of these bamboo corals and their taxonomic relationship with those from other areas is currently difficult and beyond the scope of this EIS." However, as the bamboo corals are "prominent biogenic features of the 'inactive' hard surfaces" at Solwara 1, it would seem necessary to more completely understand their taxonomy and ecology before destroying them in the mining Project.

7-38 – 7-40 In the sediment macrobenthos sampling effort, only 35 push-core samples and 16 scoop samples were collected. This is a very limited sampling effort, and should be expanded. Some of the organisms collected are of species new to science. Regarding the bivalve *Prionospio* sp., the EIS states that: "it is likely that the species collected at Solwara 1 and South Su are undescribed." Likewise, at least three species of isopods collected at Solwara 1 were undescribed: *Notoxenoides* sp., *Janirella* sp, and *IIyarachna* sp.. And those species present in the Manus Basin "are likely to be new species of more widely abundant genera and families." Clearly, these new macrobenthic sediment species need to be fully identified and better understood before they are destroyed by the Project. The EIS even states that: "more extensive sampling of these sediments would be necessary to capture all of the rarer species."

7-40 Sampling of sediment meiobenthos (small invertebrate organisms living within soft bottom sediments) resulted in collections of organisms, mainly nematodes and harpacticoid copepods, that were identified only to major taxonomic level (family, order, etc.). The EIS states that: "identification to genus or species level requires considerable effort and, in the case of samples form deep water, the majority of animals are likely to be species that are undescribed."

And although the EIS then states that "statistical comparisons of community composition and diversity can still be achieved," without knowing the species of organisms present, this is categorically not so. It is recommended that all the sediment invertebrates at Solwara 1 be identified to species level before the Project commences.

7-43 The genetic study conducted on 126 individuals collected from the Project site provided a first glimpse of genetic variability and potential endemism at the site. But these studies are far from complete, and should be expanded. Further, the EIS states that the data-base of gene sequences (GenBank) maintained at the U.S. National Center for Biological Information to date contains "very few gene sequences for hydrothermal vent species," making it impossible to compare vent species from different areas of the world ocean. It would be prudent to dramatically expand the number of gene sequences for hydrothermal vent species at GenBank, thus allowing a better understanding of the zoogeographic distributions of many of the species that will be impacted by the Project.

7-45 The EIA did not conduct any scientific baseline investigations of ambient underwater sound or light at the Project site. In particular, there is need to have a better characterization of actual ambient noise, including frequency spectrum and energy levels, and its propagation characteristics at the site, as a significant impact from the actual mining operation itself will be noise. Such information could be collected with Passive Acoustic Monitoring (PAM) sensors deployed on the seafloor. This would give a better understanding of the ambient noise levels, in particular that generated by the vents and North Su volcano themselves. In addition, the discussion of cetacean sounds in the EIS is only general, and no field data was collected at Solwara 1. In order to understand the full impact of the project, it will be necessary to have a baseline for biologically-generated sounds that may be masked by noise from the MSV dynamic positioning thrusters, ore loading, etc.

7-50 The description of the ecological community of the near shore environment is woefully insufficient, simply stating that: "There is a high diversity of marine species in and around Simpson Harbour." Surely, this cannot pass as an adequate basis upon which the potential impacts of the near shore component of the Project are assessed. In order for the government to understand what may be affected in the nearshore environment, the EIS needs to give a far more detailed characterization of the ecosystems there.

7-51 The EIS states that current vessel use of the Port of Rabaul is about 12 ships / month. The Project is projected to add 3-6 barge trips into the Port each week, and 3-6 bulk ore carrier calls / month, thus increasing vessel traffic by about 25% - 50%. This represents a substantial increase in risk of vessel casualties and increase in vessel noise in the near shore marine environment. Further, the EIS states that shipping routes "are poorly defined and companies operate largely without charts or navaids [navigational aids] and rely on the local knowledge and skill of their ships' masters."

The vessel traffic situation off Rabaul need to be further detailed, such that it may be clear to what extent the additional traffic from the Solwara 1 Project increases risks such as collision or grounding in the region. At very least, the Project should be required to enhance the navaids on approach to Rabaul as appropriate. Further, contingency plans for vessel casualties should be detailed.

8. ***Socioeconomic Environment*** – no comments

9. ***Environmental Impacts and Mitigation Measures***

9-3 – 9-10 The potential impacts on water quality are understated. For instance, the EIS does not evaluate the risk of loss of an entire barge load of ore at the surface, which would generate a major impact on surface waters. Regarding the SMT operation at the seafloor, the statement that: "no plumes are expected to be generated at the cutter head" seems implausible, regardless of the effectiveness of the suction mechanism. In the return water process, if there is a delay in the surface dewatering process and extension of time on surface, then there will be greater oxidation and heating of the effluent to be discharged at depth. This contingency was not evaluated. Also, the EIS states that Environmental Management Plans to prevent water quality impacts "will be implemented," but as these have yet to be developed, it is impossible to judge how well these will mitigate impacts. These should be developed and submitted with the EIS, prior to approval. Further, such EMPs will require constant compliance monitoring by government officials on site.

9-5 – 9-9 Estimates for metal concentrations in effluent plume suggest that within 85 m of the point of effluent discharge, water quality standards will be reached through dilution. The sediment in the discharge plume will achieve TSS standards "a short distance from the point of discharge," and that the plume "will be no more than 175 m thick and will stay between 1,300 and 1,475 m water depth." The EIS reports that the plume is expected to be detectable as far as 4km - 5 km from the point of discharge, and will periodically cover an area of 11.6 km2. Another section of the EIS states that sediment will "settle on the seafloor approximately 5-10 km to the west and northwest of Solwara 1." This bathypelagic habitat that will be impacted in the mixing zone of the effluent discharge was not sampled during the EIA / EIS process. Thus, predicting impacts in the mixing zone is problematic. Also, the plume generated by disposal of sediment overburden and waste rock is projected to deposit within 1 km of the point of discharge, covering an area over 2.3 km2. Water quality monitoring during operations should receive careful oversight by government representatives.

9-9 – 9-10 With regard to the toxicity of effluent plumes, the EIS states that: "the toxicity assessment used surrogate species, as no tests using local species from Solwara 1 were available or practicable, i.e. animals living at Solwara 1 do not survive for very long under conditions found at the surface."

The EIS then goes on to question the validity of the assumptions behind use of surrogate species in this case, as "species that exist at Solwara 1 have both differing exposure pathways (e.g. water versus food) and sensitivity to metals." It is not clear why toxicity tests and procedures could not be developed for species found at Solwara 1, perhaps using test tanks in hyperbaric chambers. The tests with crushed chimney samples on the surrogate surface species (the algae *Mitzschia* and copepod *Acartia*) resulted in *high toxicity* to both. Before concluding that discharges will have "negligible overall effects," toxicity tests on vent species and bathypelagic species should be devised and conducted.

9-11 – 9-12 The EIS states that: "make-up water (for optimal pumping will be added pre-discharge to the return water leading to some oxidation and temperature increase." However, this section fails to mention that contaminated wastewater collected from ore storage piles at Rabaul will be "returned to the MSV for combination with the dewatering plant discharge at depth after treatment." The addition of warm, oxidized, acidic wastewater from the ore stockpiles at Rabaul, into the return water discharge at depth at Solwara 1 has not been considered in the impact analyses, and should be. Depending on the volume and chemistry of this additional waste stream, the toxicological effects at depth could be significantly magnified.

9-13 The toxicity tests for sediment toxicity likewise used surrogate shallow water species, the amphipod *Melita plumulosa*, and showed very high toxicity results to the mineralized sediments. As with the bathypelagic species discussed above, it would useful to devise and conduct such toxicity tests on sediment organisms from active and inactive vent regions at the SuSu Knolls.

9-14 In issues to be address regarding potential interactions between the project and protected whales, turtles, dugongs, and seabirds, the only risk mentioned is that of the extremely low risk that animals could collide with the MSV or the transport barges. This is certainly one risk, but so is the potential impact of vessel noise, as well as noise from the mining operation itself, which will certainly be audible to acoustically sensitive species such as whales. Further, the risk of fuel and/or ore spills from any of the vessels is real, and must be addressed when considering Project risks to these protected species.

9-15 With respect to dissolved metals in the effluent, the EIS reports that: "there is the potential for some bioaccumulation through the food chain via uptake by plankton and subsequent predation by small fish/crustaceans and larger fish." This needs further detail and modeling, particularly as the EIS finds that there is considerable uncertainty ("moderate confidence") regarding the bioaccumulation of dissolved or particulate metals in the bathypelagic ecosystem.

9-16 The EIS cites one study that suggests that the critically endangered Beck's petrel is not known to be attracted to vessels. However, the MSV will represent a relatively stationary presence for several years, well illuminated at night, in an area where the Beck's petrel is thought to forage.

Thus, it is possible that this will represent a risk different than that of passing ships. The Project should develop a contingency for the attraction of one of these birds to the MSV, and it becoming injured in the lights or on deck (and seabirds are known to do).

9-16 That "a shipboard marine pollution Emergency Response Plan will be implemented to combat accidental spills or non-routine discharges of pollutants" gives no basis upon which to judge the efficacy of such a mitigation effort.

9-17 The EIS states that the 30 amp electric current generated through the umbilical cable between the MSV and the SMT during the exploration phase of the Project has not had "adverse impacts to fauna." However, they did not report any monitoring program of this project component from which they derive this conclusion.

9-18 The EIS states that: "there will be no significant or sustained source of input to the offshore or inshore marine environment…and no prolonged detectable impacts to biota." However, as discussed above, they do not consider the very real risks of an ore barge or bulk carrier grounding or otherwise spilling their load into the near shore environment.

9-18 The EIS states that: "there will be no risk of any adverse interference with species reliant on bioluminescence in the mesopelagic zone or bathypelagic zone shallower than 1,300 m." This does not rule out impacts to bathypelagic species deeper than 1,300 m, that are in the mixing zone of the discharge, and this needs to be discussed.

9-19 The EIS states that: "diminished recruitment may occur at equivalent habitats downstream of Solwara 1," but that "relative impacts to Solwara 8 are likely to be diminished given the distance from the Solwara 1 and similar distance from the unaffected South Su." This hypothesis however does not consider the fact that benthic sampling identified some 33 species on inactive hard substrates and 10 species from active vent systems that were found *only* at Solwara 1, and not at all at South Su. If these species do not occur at South Su, then South Su will not contribute to recruitment of those species at downstream sites such as Solwara 8. Reduced recruitment of vent species at sites downstream of Solwara 1 is a very real risk, and has yet to be adequately assessed. A full characterization of Solwara 8, and a bathypelagic plankton study focusing on early life stages of vent species, should be completed before any disturbance commences to Solwara 1.

9-20 The EIS states that: "Noise from the SMT cuter head has not been modeled, in absence of details of likely source spectra and frequencies. However, low frequency sound is likely and would be expected to be audible for considerable distance. However, natural background noise from the erupting North Su volcano is likely to mask the sound of the SMT to a considerable extent and it is not considered further." This is insufficient treatment of this significant impact of the Project.

To predict impact of this loud source of underwater noise, the noise needs to be modeled, and field / tank tests should be conducted. There will certainly be very loud, low frequency sound generated by the cutter head and other operations of the SMT and removal of waste rock and sediment overburden at the site. Many of the characteristics of this noise, such as decibel levels, frequencies, propagation routes, etc. can be predicted. It is likely that this noise will be audible to cetaceans at the sea surface passing through the area, resulting in behavioral deflection from preferred migration routes, feeding areas, and/or masking of hearing or vocalizations. This needs to be methodically addressed in the EIS.

9-21 Regarding use of surface species as surrogates for toxicity tests, the EIS states, again, that: "There are no standard tests or established ways to allow for different tolerances of deep-water species, particularly those adapted for life at hydrothermal vents," and then draws the conclusion that the mixing zone criteria applied are "extremely conservative." This is an unconvincing argument. Vent species may be tolerant to certain forms of some metals, but not others. And, as the EIS states: "the same logic cannot necessarily apply to species located in sediments or hard surfaces away from direct influence of vents." Certainly, non-vent (inactive hard substrate or sediment) species may have different tolerances to dissolved and particulate metals in the effluent plume from dewatered ore. As stated above, Project scientists should devise an effective procedure for conducting toxicity tests on vent and non-vent deep-sea species, including their larva and juvenile stages. It is possible that the dewatering effluent plume may be toxic to the larval stages of vent species, and thus affect downstream recruitment at other vent sites. This deep-sea toxicity issue needs to be resolved before any understanding of actual toxic effects on vent and non-vent species can be predicted with any confidence.

9-22 The use of South Su as a control site, and a site from which recolonization of Solwara 1 may occur, is questionable, as discussed above. The species composition at the two sites is significantly different, as there are dozens of species found at Solwara 1 that have not been found at South Su. Thus, the applicability of this site as a control or source for recolonization seems in doubt. Permanent set-asides at Solwara 1 would provide better control with which to measure mining impact. As well, it would be useful for the Project to attempt to characterize the faunal communities at the North Su volcano itself.

9-22 The suggestion that South Su, North Su, and "temporary refuge areas" will be left as mitigation, seems somewhat disingenuous at best. Mining can only be conducted by the one SMT on the seafloor at any one time, and thus of course other areas will serve as refugia from mining. Also, the standard for recovery seems to be that a "mined out area meets specified criteria that the major community elements (i.e., the three biomass dominant species) have re-established." Other than this, the EIS does not state what the "specified criteria" are with which to conclude that a mined vent area has "recovered."

Re-establishment of some individuals of just the three dominant species cannot be used as a standard for complete recovery, as there are many other species associated with the vents that may have very different recovery trajectories. The EIS confirms that the recolonization of some species, such as the bamboo coral *Keratoisis*, is thought to take considerably longer than other species. A more precise definition of recovery for both active and inactive habitats should be developed.

9-23 As discussed above, the transplant by ROV of clumps of vent animals away from areas to be mined, and artificial substrates are certainly worth a try as mitigation measures. However, if these clumps are disassociated from their vent fluids, it is difficult to imagine that they will survive. Until it is proven, this mitigation cannot be considered as substantive mitigation.

9-24 The dewatering effluent will be filtered to 8 *u*m particulate size, but clearly a finer filter size would reduce sediment in the discharge accordingly. It is recommended that the Project examine the possibility of reducing this filter size as much as possible, so that sediment in effluent at depth will be reduced. As well, the Project should explore the possibility of refrigerating / cooling the surface dewatering process on the MSV, such that return water temperatures and the amount of thermal pollution from the effluent plume at depth are reduced. Further, the EIS should more closely examine the potential for RALS system anomalies that may result in spills of contaminated process water or ore at or near the surface, such as failures of hose connections, etc. The impacts of such an event need to be thoroughly evaluated and presented in the EIS.

9-24 The entrainment of plankton and small nekton into the water pumped with ore from the SMT will kill a large number of organisms. There should be some effort to document any / all of these in the dewatering process. Thus, a biological sampling program of the decanted water at the MSV should be incorporated into the Project monitoring design.

9-24 The Project should consider different spectra of light at the SMT and alternative lighting scenarios that may reduce the attraction of organisms at depth to the SMT, thus exposing them to risk at the cutter-suction head. For instance, it may be possible to light the mine face with an ROV more distant from the suction head, or place the light source further aft (away from the suction hood) on the SMT, thus reducing the risk of entrainment of organisms.

9-24 The EIS states that: “The risk of major losses of equipment or spills of ore or fuel oils due to accidental events will be extremely low with the implementation of vessel and equipment maintenance procedures, navigational procedures, safety plans, environmental management plans, and emergency response plans.” Yet there is no risk assessment presented for any of these important issues. For such a suite of significant risks from the Project, this is an inadequate assessment.

That ‘plans will be developed’ provides no means whatsoever by which government authorities can truly assess the level of risk or the effectiveness of proposed mitigation. These many risks need thorough documentation, and the mitigation plans need to be developed and presented for analysis prior to project approval.

9-25 Regarding mining impacts to species at Solwara 1, the EIS correctly notes that: “the immediate loss at local scale will be severe.” As discussed above, the EIS’ optimistic projections for the recolonization of fauna from mined areas is not persuasive. The proposed mitigations may be ineffective. Relocated clumps may not survive, and as South Su does not currently support many species that will be lost in mining at Solwara 1, it cannot be relied upon as an effective recolonization source. The EIS projects that within 1-3 years, post-mining: “populations characteristic of active sulfide mounds will return and reorganize to a condition of biomass and diversity that resembles the pre-mining state.” It does not however predict *full* recovery rates for the affected communities. For full recovery of pre-mining species composition, community structure, and function to recover, it may take decades, if it is possible at all. If endemic species are lost to the mining process, as seems likely, then full recovery will never occur. The EIS states that: “At the inactive sedimentary areas, natural recolonization is expected to be slow.” The issue of recolonization of active and inactive sites needs considerably more analysis and discussion than is found in the current EIS.

9-26 The EIS states that: “Overall, assuming successful outcomes of the mitigation measures proposed, the ecological impacts are expected to be moderate.” But as discussed above, the mitigation measures are unlikely to be entirely successful. Given the measurement standards elucidated on page 9-2, the overall ecological impacts of the Project should be anticipated to be “severe.” First, as the Project may affect recolonization 45 km away at Solwara 8, sediment plums will extend for 11 km, and noise generated by the project will transmit for hundreds of km, the geographic *extent* of impact would likely be *regional*. As recolonization may not occur for many years, the *duration* of impact will be *prolonged*. And as species may go extinct due to the Project, the *severity* of impact should be considered *high*.

9-27 The EIS states that: “Over the mining period, there will be a progressive reduction of larval production from Solwara 1,” which “may affect recruitment at any downstream areas dependent on Solwara 1 as a source.” This may include Solwara 8, but genetic studies to establish this link are yet to be completed. Before approval of the Project, results from these studies should be made available, so that potential impacts of Solwara 1 mining on recruitment at Solwara 8 can be predicted.

9-27 The EIS contains many typographical errors that are relatively insignificant. However, the one at the bottom of p. 9-27 may be significant, depending upon just what is the correct language.

Regarding noise from the SMT cutter head, the EIS states that: "Details of this source and likely decay rates are not known well enough to model at this stage but will be modeled *during prior* to operations (*italics* added to typo)." It is significant to know whether the noise from the SMT will be modeled *prior* to operations, or *during* operations, and it cannot be determined from this statement which of these is the intent. As discussed above, the noise from the SMT can and should be understood *prior* to approval of the Project, as this may represent a very significant impact from the Project. It is also possible to conduct tank testing of the SMT cutter operation, to generate acoustic data for modeling.

9-28 With regard to deck lights from the MSV, the EIS states that: "this will not be materially different from lighting associated with other vessels transiting the area and no adverse impacts to flora and fauna are therefore predicted." However, as discussed above, the MSV will be stationary source of light for several years, and thus will not be similar to lights from ships simply transiting the area. The stationary nature of the light (and noise) from the MSV may result in different behavioral response of seabirds, cetaceans, and sea turtles, and should be considered.

9-28 The underwater noise discussion in the EIS needs further development. The propagation of noise generated by dynamic positioning thrusters should be modeled, and potential affects on marine mammals and other organisms should be discussed in more detail. The EIS states that: "the sound may be audible (e.g. to whales) at up to 600 km (a similar range as with other large ocean going vessels), but at long ranges the sound will not be greatly above that of background ocean noise depending on sea surface conditions." This should be further detailed. For instance, there should be shutdown protocols established for noisy equipment operation if cetaceans enter prescribed acoustic safety zones near the MSV, which can extend out to 15 km from the vessel. This was not discussed in the EIS. As well, the underwater noise generated by ore shuttle barges and bulk ore carriers will constitute an additional impact to the coastal environment, but was not discussed in the EIS. This noise may represent a significant impact to reef sharks, and shark calling conducted by coastal peoples of the region. Further, the 130 dB level of exposure, which extends out to 15 km from the MSV, may be effective to prevent behavioral impacts in adult cetaceans but not for calves. Exposure levels of 120 dB should be established for shutdown of noisy operations for female whales with calves, and the distance for this propagation should be determined and monitored. Note, the area ensonified at 120 dB will be exponentially larger than the 15 km from source for 130 dB. The underwater noise issue is a significant shortcoming of the EIS that needs to be rectified prior to Project approval.

9-31 The EIS discusses in a very general way the issue of ship traffic, but does not detail specific mitigations that can reduce risks from this Project component. There is no Oil Spill Contingency Plan (OSCP) for the vessels, no specific routing lanes for transits established, vessel casualty scenarios developed, rescue contingencies, etc.

All of this needs to be sufficiently resolved before the government authorities can feel comfortable that these risks have been adequately addressed.

9-31 Ore carriers for the Project will discharge up to 1.44 million m3 of ballast water into the coastal environment in the Project area each year. The potential introduction of exotic, invasive species through ballast water of these vessels was discussed in the EIS, and the proposed mitigation for this problem was simply that "vessels will adhere to MARPOL requirements (IMO, 1973/1978) to exchange ballast in mid ocean." However, mid-ocean exchange does not remove all of the risk of invasive species introductions. The concept of building a ballast water treatment facility at the Port of Rabaul was not discussed, and should be. Such ballast water treatment facilities exist at shore facilities throughout the world, and provide a mechanism for ships in ballast to offload all of their contaminated ballast water for treatment, before discharge into the local environment.

9-37 As discussed above, that "emergency (spill) response procedures will be developed" does not provide a basis upon which government authorities can assess the adequacy of these mitigation measures. The general discussion of spill prevention and response preparedness found in the EIS is not sufficient. The conclusion drawn by the EIS that: "Given the management measures described above, it is considered unlikely that a hydrocarbon or chemical spill will occur," cannot be supported without review of prevention and response plans. As well, spill prevention and response planning must be considered for *all* vessels involved with the Project, including supply vessels, the MSV, shuttle barges, and bulk ore carriers. This should include a rigorous review of ship vetting procedures for chartering or contracting the ore barges and ore carriers.

9-37 The EIS states that the MSV will discharge "treated sewage and macerated kitchen wastes into offshore waters, " but does not report the expected volumes or chemical/ biological characteristics of this waste stream.

9-38 As discussed above, the EIS proposes that acidic waters with toxic levels of copper and zinc that leach beneath ore storage piles at Rabaul will either be treated and discharged into Simpson Harbor, "or returned to the MSV for combination with the dewatering plant discharge at depth after treatment." This additional source of contamination in the effluent at depth at Solwara 1 was not sufficiently considered in the EIS.

10. ***Socioeconomic Impacts and Mitigation Management***

10-1 The EIS generally discusses the potential negative effects caused by the Project to "social organization, in terms of conflict over the distribution of benefits or between people in the areas adjacent to the Project and those living outside," and the conflicts caused by the inevitable in-migration of people looking for jobs with the Project.

As with any such new mine development in PNG, news will travel far and wide, and it is likely that many people will migrate to Rabaul or Kavieng seeking employment with the Project. However, as the Project only anticipates about 140 jobs in total, with most of those going to skilled expatriates, the problem of regional in-migrants not finding satisfactory employment could be particularly severe with this Project. This should be more thoroughly addressed by the EIS.

10-4 The EIS states that: "Total tax, duties, and royalty receipts are estimated at approximately US $40.8 million over the nominal life of the Project." For a project that could potentially earn $1 billion in revenues, this seems to be an exceptionally small take for the government. One problem seems to be that due to costs incurred: "it is expected that no company tax will be payable during the life of the project." The government revenue collection on this project should be reassessed, and increased at least 2-fold.

10-5 The EIS states that a Community Development Fund (CDF) will be established, and that "Nautilus will pay PGK 2 per tonne of ore mined into the trust, which will be managed by Nautilus." At projected production volume of 2,170,00 tons of ore for the Project, this would equate to PGK 4,340,000, or approximately $1.5 million USD. Again, considering that the Project could gross $1 billion USD, this is a nominal amount for the Community Development Fund. It is recommended that contributions to the CDF be increased 10-fold, to 20 PGK per tonne of ore mined. This would result in a more realistic $15 million CDF over the life of the Project. Further, it is recommended that the CDF be managed not by Nautilus, but by local government authorities in New Ireland and East New Britain.

10-5 The EIS states that: "It is anticipated that PNG nationals will be trained and receive skills development, with an expectation that the number of PNG nationals employed by the Project will increase over time." However, there is no detailed discussion for how or where this will be done, nor any quantitative goals for level of local employment (e.g. 50% by year 2, etc.). It is likely that at most a few dozen PNG nationals will gain employment by the Project. This should be more thoroughly discussed by the EIS.

10-6 The EIS states that due to the Project's offshore location: "no adverse effects due to interference with subsistence fishing vessels is anticipated," and further that there will be no impact from mining on "nearshore coral reefs, including traditional reef fishing and shark calling." As discussed above, the EIS does not consider the potential for an ore barge of bulk ore carrier to ground or founder, spilling its ore and fuel onto nearshore reefs, or noise from vessels.

10-7 The EIS states that: "The implementation of the mitigation measures described above will ensure that the disruption to marine traffic from Project activities will be kept to a minimum. Overall impact on marine traffic from the Project is anticipated to be low."

However, as discussed here, the mitigation proposed is 'plans to be developed,' and thus one cannot draw such a conclusion. Further, the Project is expected to increase ship traffic to Rabaul by 25%- 50%, and this constitutes a significant increase in traffic. This issue needs further detail in the EIS.

11. ***Accidental Events and Natural Hazards***

11-1 – 11-2 Extreme weather contingencies at the Project site and on-route to Rabaul need to be more completely identified. Suspending operations at sea state 5 (significant wave height up to 3.5 m) leaves open the question of whether all operations will be continued *up to* this sea state. It is questionable that ore loading, with a barge along side, can be safely sustained even at lower sea states. And there is no discussion regarding the tie-up and fender system that will be used between the ore barges and the MSV, and how these will be secured at successively higher sea states.

11-4 With regard to the potential to induce volcanism through the mining of the vents, the EIS states that: "It is unlikely that the gradual removal of low density porous material to a depth of 20 m below the seafloor will depress magma at 1 km." However, the EIS estimates that 40% of the deposit will be mined to depths greater than 20 m. The EIS states that material will be removed "to a maximum depth of 220 m." Thus, an assessment of the potential for induced volcanism needs to take this greater mining depth into account.

11-5 A tsunami at the Port of Rabaul could deposit ore from the stockpile inland and/or into the harbor and nearshore environment. And as the EIS states: "Wetting of the high-sulfide-content oxidized ore by a tsunami wave may result in acidic runoff with elevated metal concentrations, i.e. acid rock drainage, which may damage vegetation and contaminate soils." The only proposed mitigation for this is "good port operating and maintenance procedures." Given the high degree of seismicity in the region, additional tsunami protections at the Port should be explored. These may include harbor breakwaters, or the use of steel storage tanks within which to store the ore, or tsunami barriers built around the open stockpiles. Storage tanks would reduce the risk of toxic contamination from ore mobilized from the ore stockpiles during tsunami events.

11-6 As discussed above, there is need for much greater specificity in the EIS with regard to the issue of fuel handling, particularly in bunkering offshore. All such transfer should be boomed, to prevent the spread of any fuel spills.

11-7 The EIS states that: "compared to coastal areas, the open ocean lacks environmental sensitivities that could be impacted by a hydrocarbon spill." It may be true that coastal spills present greater risk, but this understates the risk to the offshore environment in the Project area. While a spill nearshore may be "more visible,' as noted by the EIS, the offshore region is rich in marine life, all of which is vulnerable to hydrocarbon and other hazardous material spills.

11-8 – 11-9 As discussed above, the assessment of vessel casualty risk in the EIS is incomplete, as it essentially ignores potential for casualties of ore barges and bulk ore carriers.

12. ***Greenhouse Gas Emissions and Climate Change***

12-1 It is recommended that the Project seek to include solar voltaic panels in its power generation regime at all surface locations (MSV and Port of Rabaul), to reduce its overall carbon footprint.

13. ***Environmental Management, Monitoring and Reporting***

13-1 As discussed above, the preparation of the Environmental Management Plans (EMPs) has yet to be completed, and thus the potential impacts and effectiveness of mitigations cannot be assessed at this point. These EMPs should be submitted for government approval, prior to Project approval.

13-2 It is recommended that, to monitor compliance with all laws, regulations, and permit stipulations for the Project, a PNG federal authority be represented onboard the MSV at all times. Further, as mentioned earlier, an observer from BSSIPC should be onboard at all time as well.

13-7 In proposed monitoring and mitigation, all of the proposed baseline studies should be completed prior to approval of the EIS and the Project. Any assessment of potential impact relies upon the results of these studies, and thus government authorities cannot make reasoned judgments regarding the potential impact of the Project without the results of these studies. For instance, studies on the DNA flow between Solwara 1 and Solwara 8 will demonstrate the affinity or lack thereof of the two sites, thus giving a clearer idea of the extent of impact to recolonization of Solwara 8 by any mining activity at Solwara 1. As well, more intensive sampling at sediment habitats downslope at Solwara 1 is necessary to predict impacts of the disposal of the estimated 239,000 tons of waste rock and unconsolidated sediment overburden removed from the mining area. The bathypelagic ecosystem needs to be studied, including downstream recruitment studies with sampling of planktonic larva.