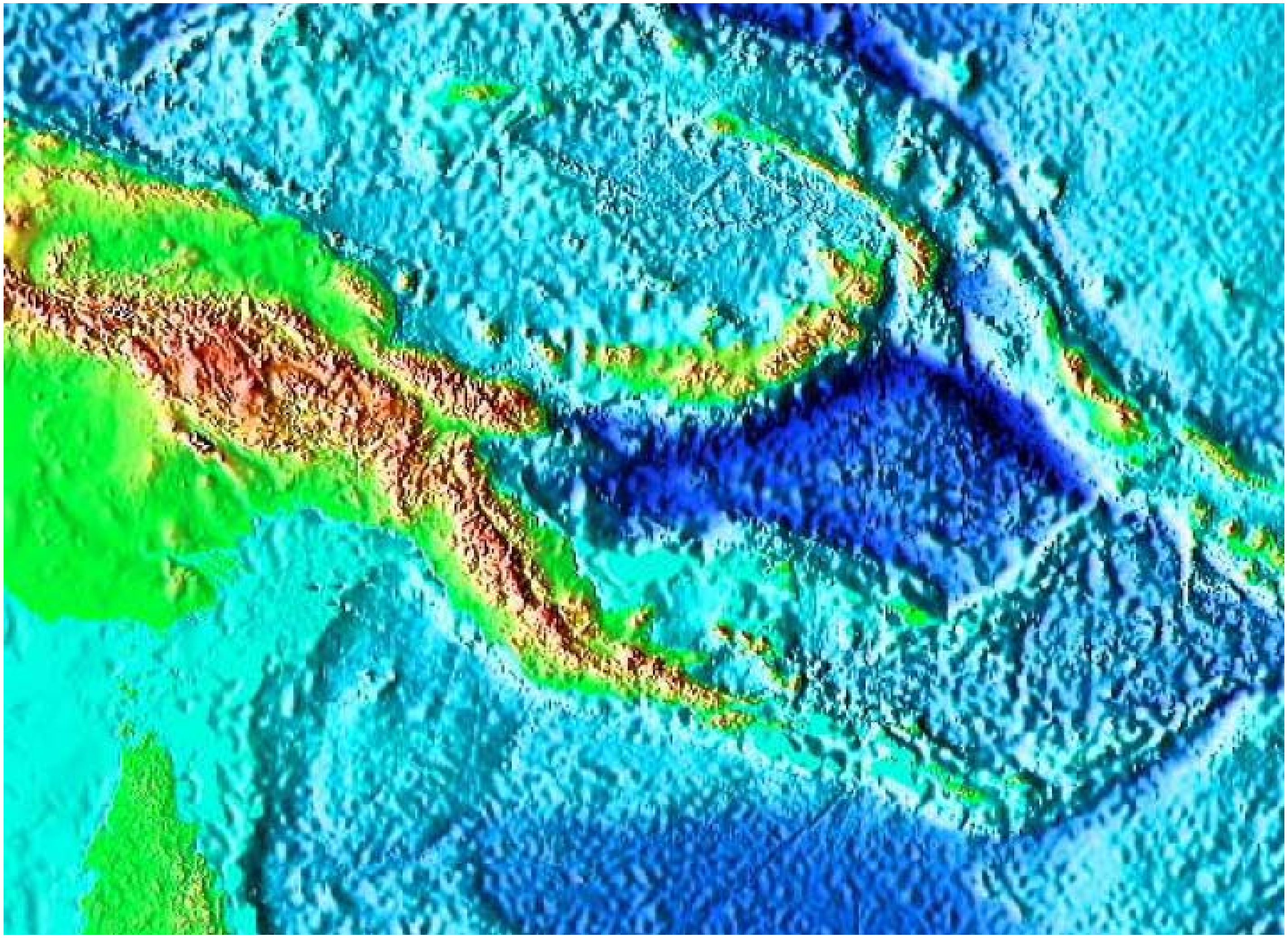
Scoping, Analysing and Managing Mining and Development Projects Impacts in Coastal Areas

Jeff Kinch

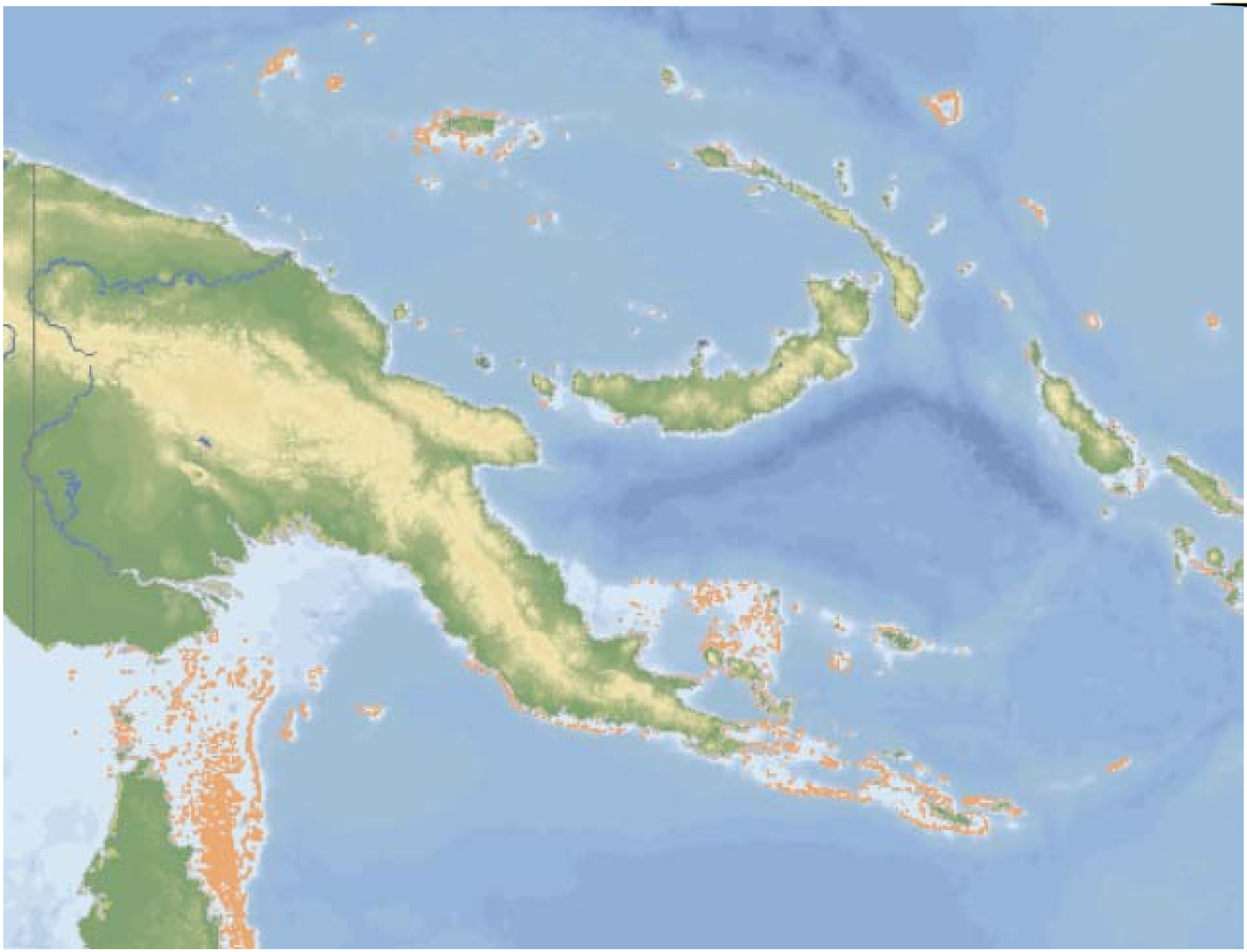
Statistics

PNG has an Economic Exclusive Zone (EEZ) of around 3,120,000 km^2, with a land area of 462,243 km^2 and a total coastline of approximately 17,110 km.

Coral reefs are estimated to cover an area of 40,000km^2.

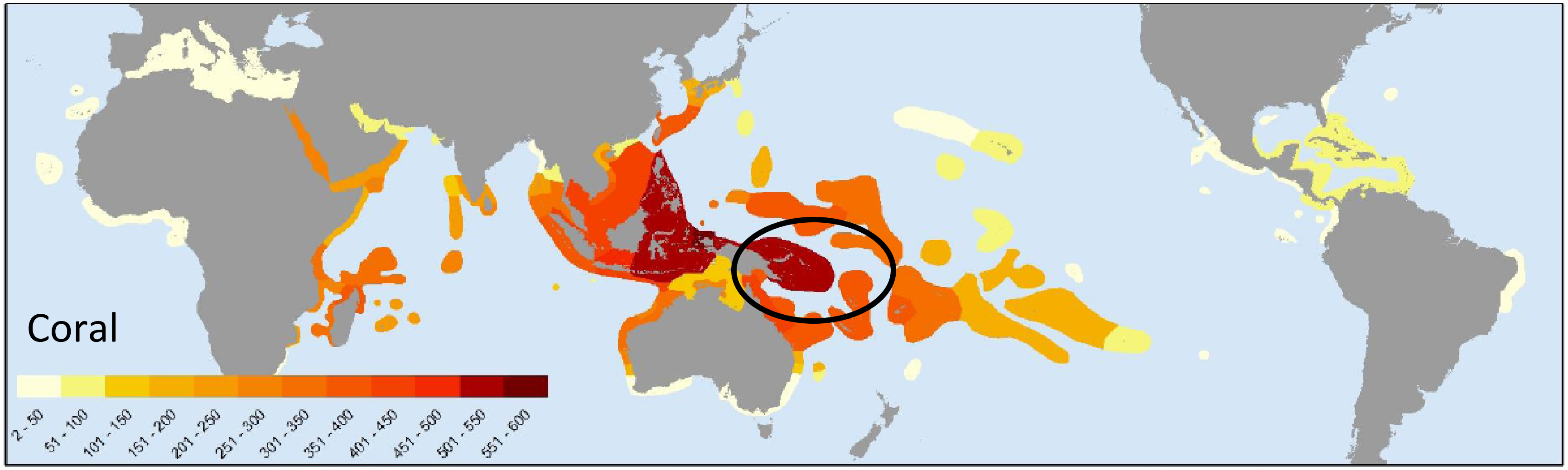


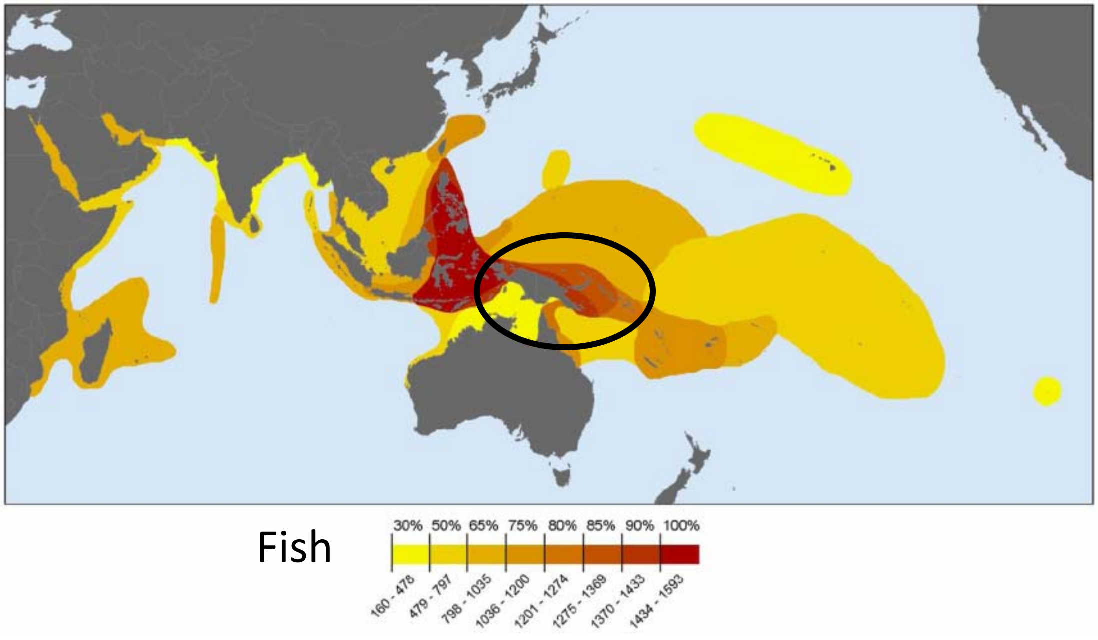
Bathymetry of PNG



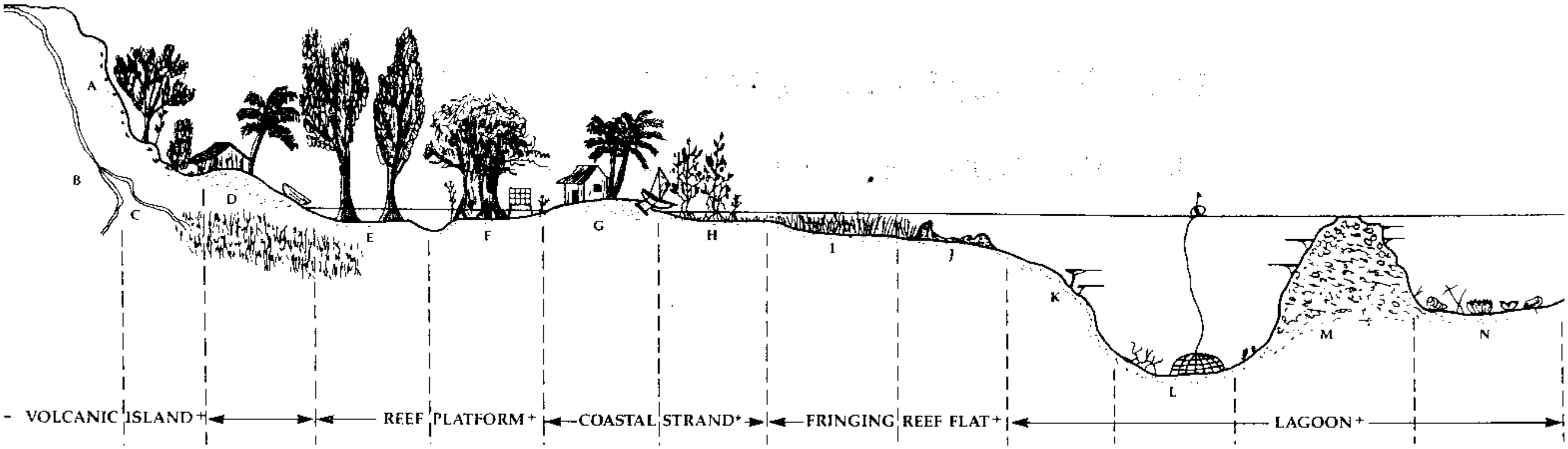
Coral reefs in PNG

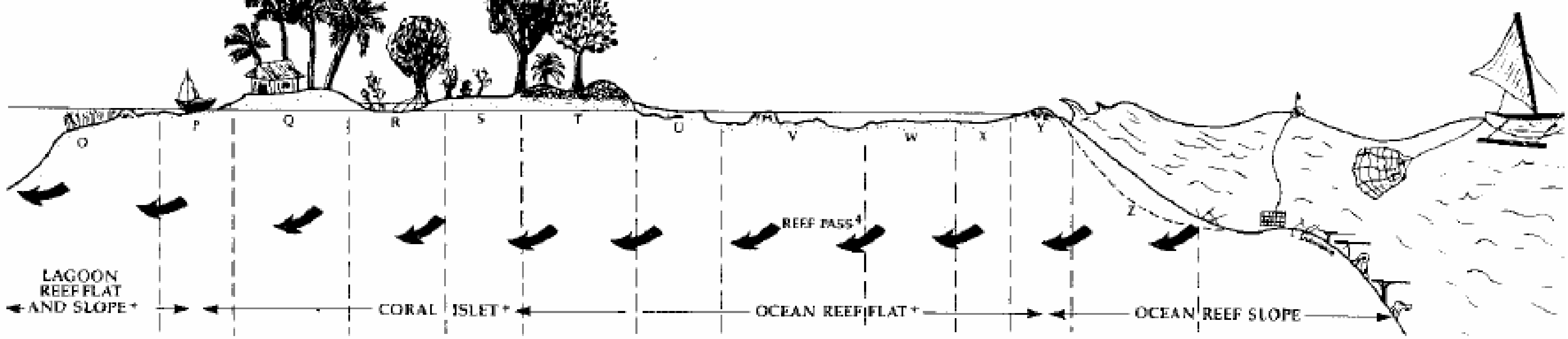
PNG is the centre of diversity for most marine species

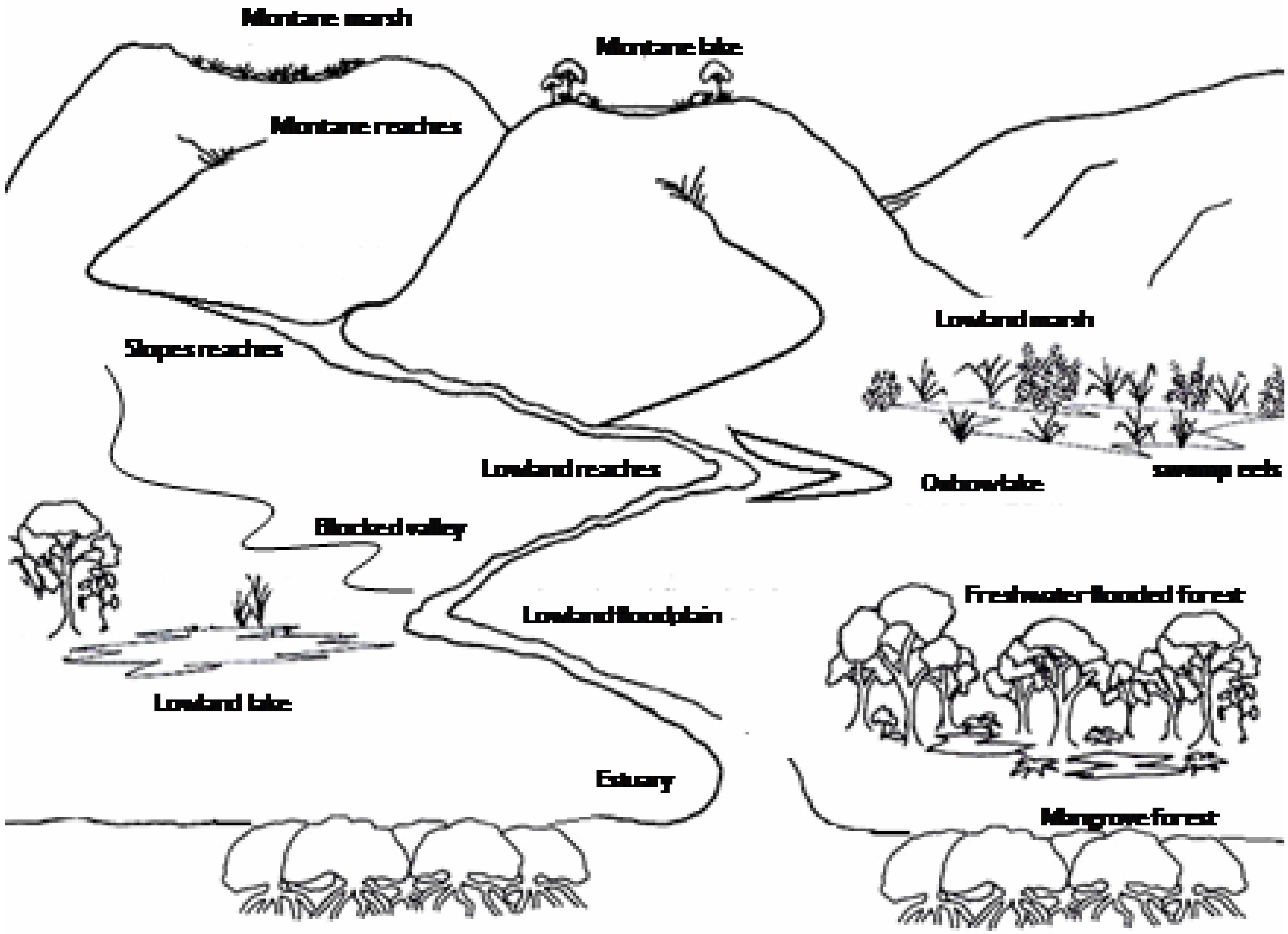


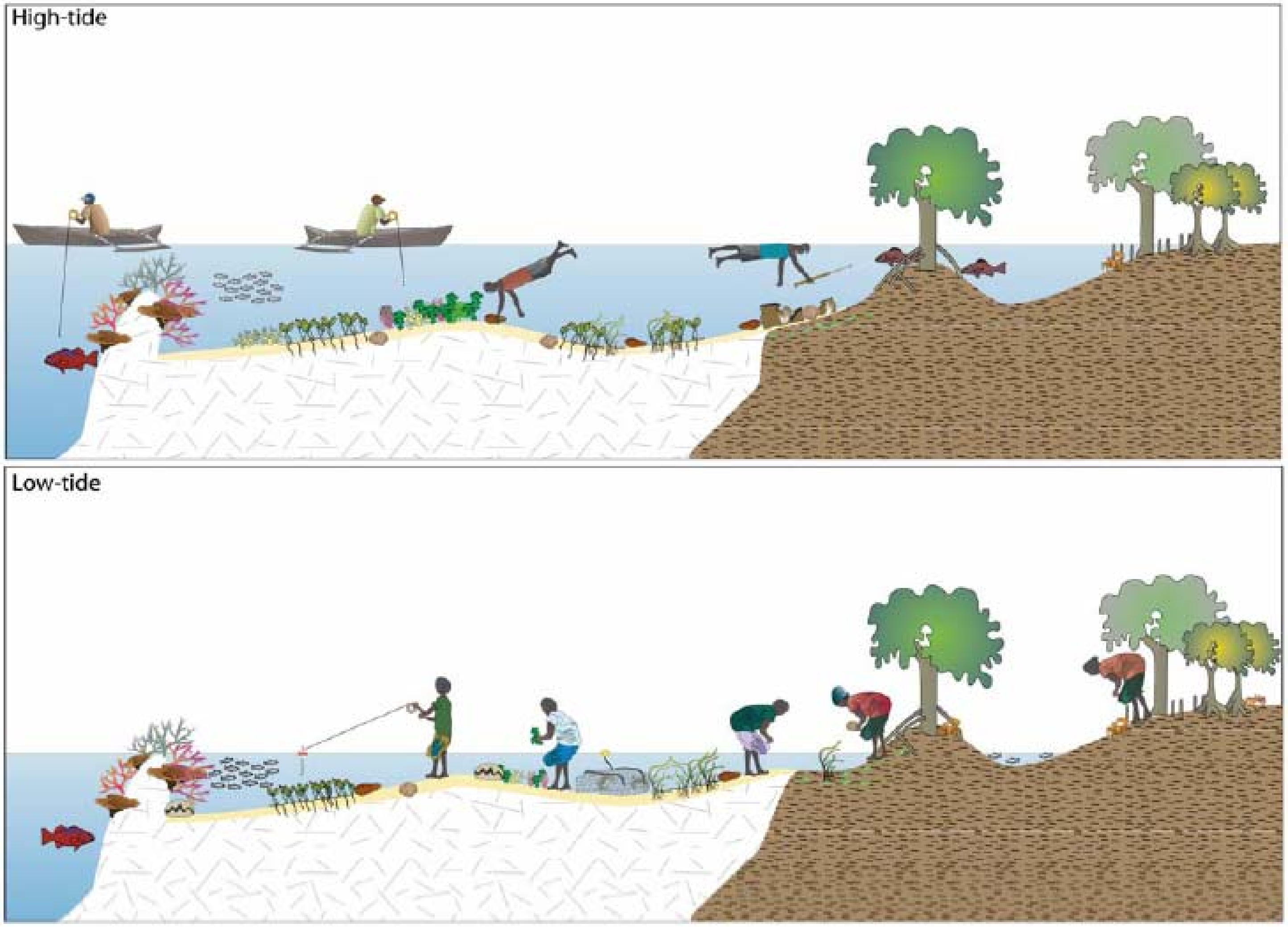


Coastal Areas

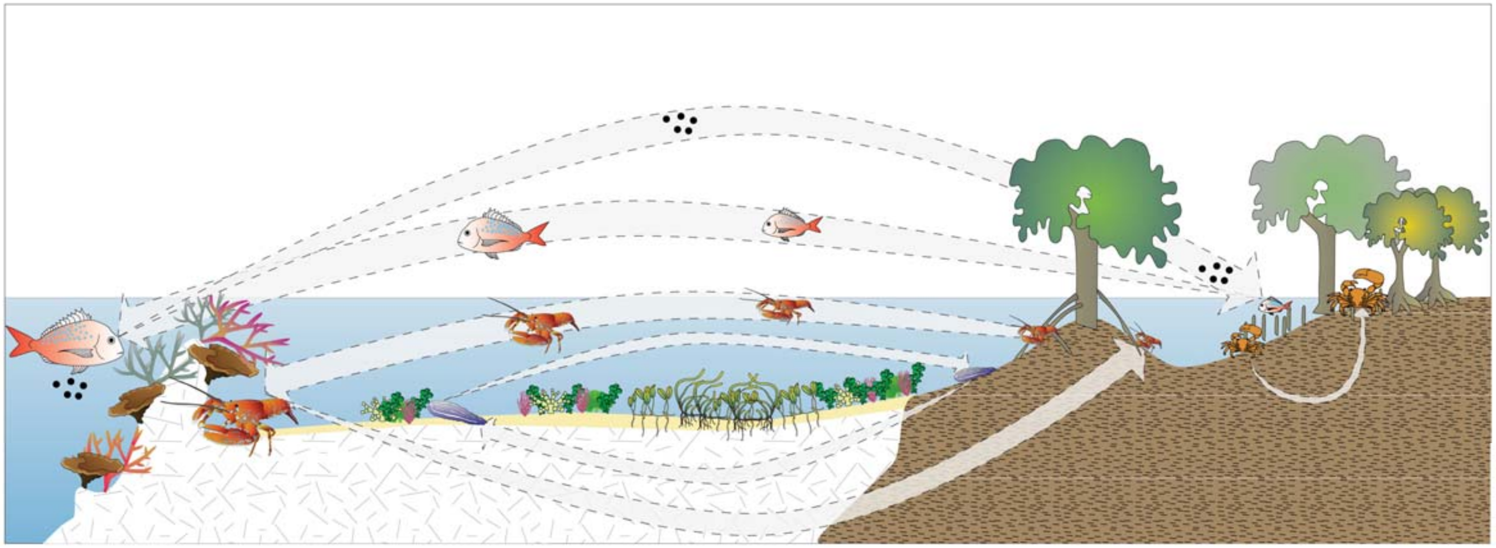




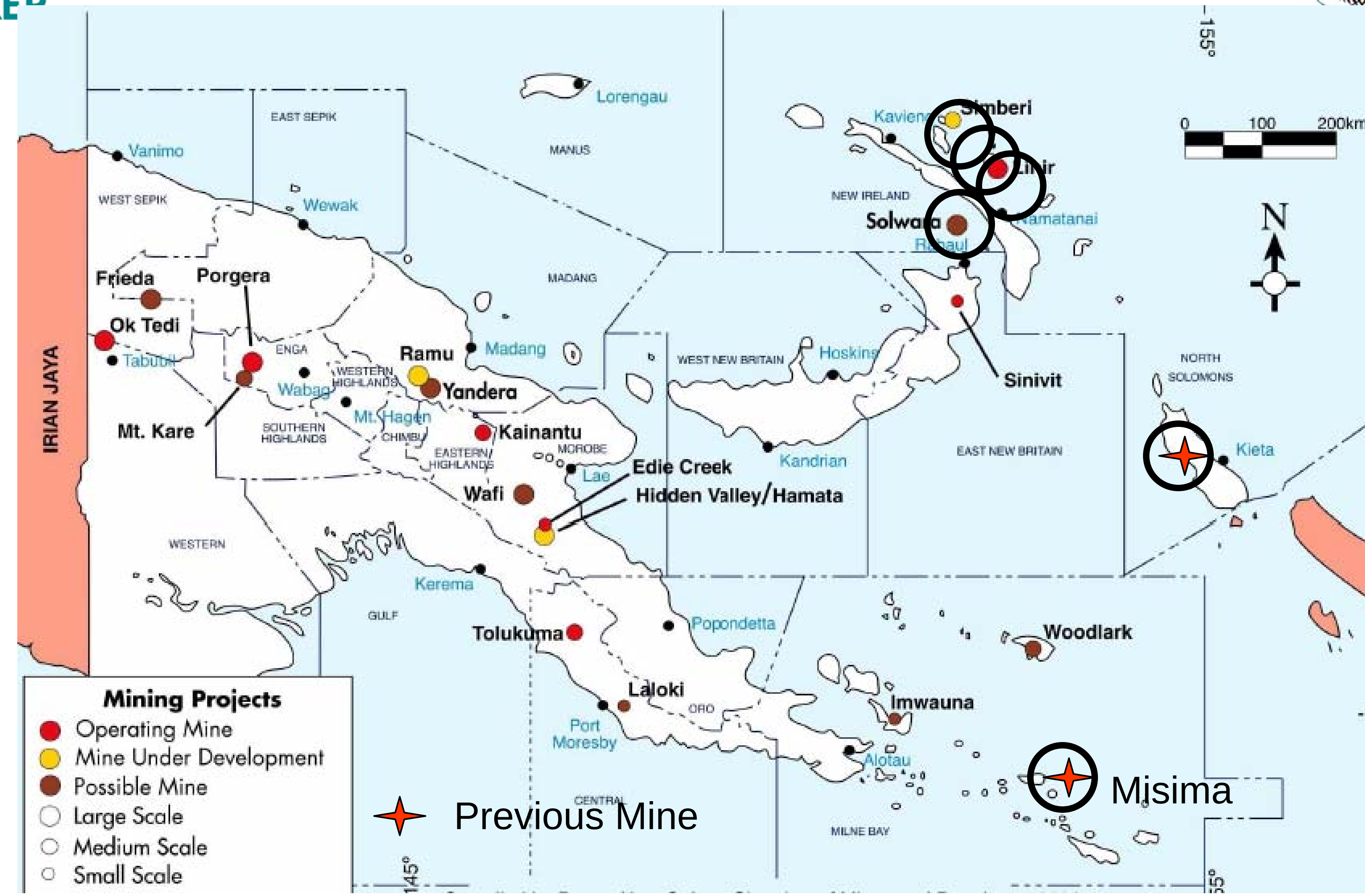

Montane marsh
Montane lake
Montane reaches
Lowland marsh
Slopes reaches
Lowland reaches
Oxbow lake
swamp eels
Blocked valley
Freshwater flooded forest
Lowland floodplain
Lowland lake
Estuary
Mangrove forest



Human use



Connectivity between/within habitats - lifecycles



Lorengau
Kavieng
Simberi
Lihir
Namatanai
Solwara
Rabaul
NEW IRELAND
EAST SEPIK
MANUS
Vanimo
WEST SEPIK
Wewak
MADANG
Frieda
Porgera
Ok Tedi
Tabubil
ENGA
Ramu
Madang
Yandera
WESTERN HIGHLANDS
Wabag
Mt. Hagen
SOUTHERN HIGHLANDS
CHIMBU
Mt. Kare
Kainantu
EASTERN HIGHLANDS
MOROBE
Lae
Edie Creek
Hidden Valley/Hamata
Wafi
WEST NEW BRITAIN
Hoskins
Kandrian
Sinivit
EAST NEW BRITAIN
NORTH SOLOMONS
Kieta
IRIAN JAYA
WESTERN
GULF
Kerema
Tolukuma
Popondetta
Woodlark
Laloki
ORO
Port Moresby
Imwauna
Alotau
Misima
CENTRAL
MILNE BAY
0 100 200km
N
155°
145°
Mining Projects
Operating Mine
Mine Under Development
Possible Mine
Large Scale
Medium Scale
Small Scale
Previous Mine

Mines in PNG

Habitats

Tidal floodplains and deltas have numerous tidal creeks, connecting channels, sandbanks, scour holes and overhanging riparian vegetation, which provide a wide variety of habitats for aquatic organisms.

Tidal floodplains are usually inundated by tides twice a day, with salinity varying greatly throughout the area, which allows for a rich diversity of freshwater, estuarine and marine fish fauna, as well as crocodiles, turtles and dolphins.

Dominant hydrodynamic processes include accretion but within this generally depositional environment, processes of erosion and accretion occur more-or-less continuously on the river bends and on the upstream/downstream areas in the deltaic islands.

Marine plants colonise several interconnected marine ecosystems including tidal wetlands, seagrass meadows and coral reefs.

Mangroves are extensive in some areas of PNG, which offer microhabitats for estuarine macro-invertebrates, as well as for fish, such as mudskippers and gobies; as well as important breeding habitats for a wide range of fish and other marine species.

Seagrass communities can be of ecological significance as nursery or feeding habitats for prawns, lobsters, crabs, fish, dugongs and turtles, as well as an aid in stabilising the substrate.

Coral reefs are massive limestone structures that provide food and shelter for marine life. Hard corals are responsible for much of the solid, limestone (calcium carbonate) framework of the reef.

Reef-building corals cannot survive without sunlight, since zooxanthellae, their symbiotic algae, require sunlight for photosynthesis.

Too many nutrients can upset the natural balance of life on the reef, creating conditions that favor other fast growing organisms such as marine plants and sponges.

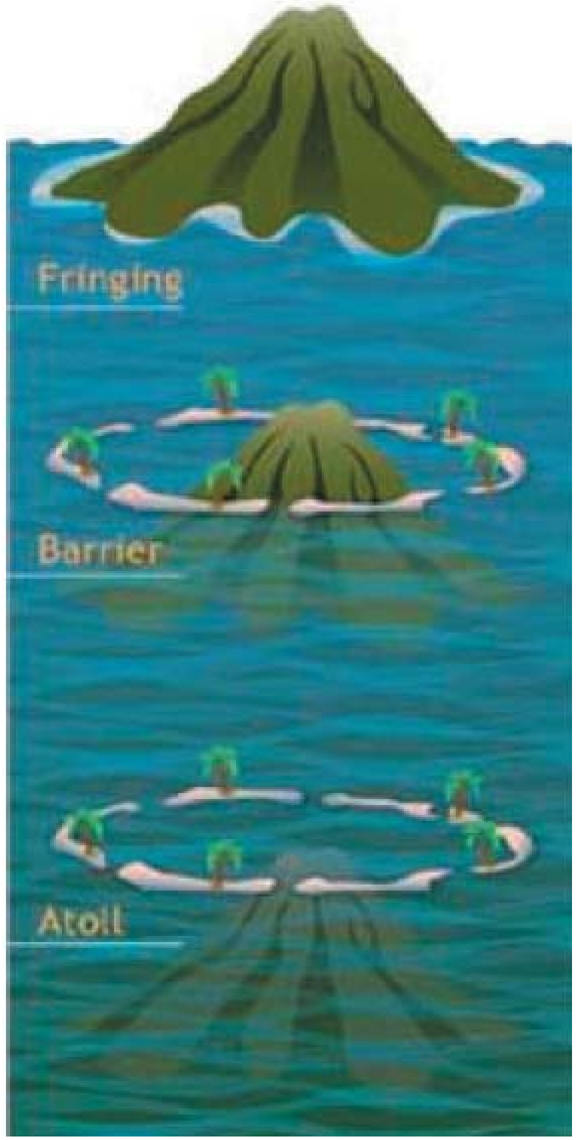
Corals prefer clear water with low levels of sediments (small particles of earth, rock and sand). Sediments can bury corals, blocking out needed sunlight and killing them.

Corals need a hard substrate or surface to attach to and cannot successfully colonize loose substrates such as rubble or sand. If the substrate is unstable, young coral colonies will be crushed and killed by wave action and storms.

Fringing reefs lie around islands and continents, and are separated from the shore by narrow, shallow lagoons. They usually parallel the coastline and at their shallowest point can reach the water's surface.

Barrier reefs also grow parallel to the coastline, but are separated by deep, wide lagoons. At their shallowest point, they can reach the water's surface, forming a "barrier" to navigation.

Atolls are rings of coral that create protected lagoons and are often located in the middle of the sea. Atolls usually form when islands surrounded by fringing reefs sink into the sea or the sea level rises around them (they are often the tops of underwater volcanoes). The fringing reefs continue to grow and eventually form circles with lagoons inside.



Deep Water Drop Off

Beyond 20 m, corals become patchy and are replaced with sponges, sea whips, sea fans and ahermatypic (non-reef building) corals that do not depend on sunlight. This area slowly descends into deep water.

Lower Reef Slope

The lower reef slope extends between 10-20 m and has the greatest diversity and abundance of life on the reef. Massive corals prevail, and extensive spur (high ridges of corals) and groove (sandy bottom channels) formations are found in this zone.

Reef Slope Wall

The reef slope wall has been created by past tectonic movement, resulting in a sharp angle wall that separates the upper and lower reef slopes.

Upper Reef Slope

The upper reef slope or reef front is on the seaward side of the reef crest, where the reef slope falls gradually (sometimes steeply) towards the seabed. In the shallowest areas there is intense wave action, with limited coral growth (mainly branching corals).

Reef Crest

The reef crest is the highest point of the reef facing the ocean, and is characterized by a line of waves that break along the edge. This area is often exposed at low tide and has an average width of 30-50 m. Constant wave action and exposure limits coral growth, but some small branching corals have adapted to this environment and coralline algae dominate.

Reef Flat

The reef flat is the shallow platform that extends outwards from the shore (0-2 m deep) and ranging from 60-100m in width. Exposure to harsh physical conditions limits coral growth, giving way to sand, rubble and encrusting algae.

Lagoon

The lagoonal area ranges from 3-10 m deep and is situated immediately behind the reef crest.

Other Ecological Factors

Tides

Tidal data is required for hydrodynamic modelling of sea of sea surface heights and sea tidal ranges, that is, the significant difference between successive high tides and successive low tides.

Currents

Oceanic circulation and current speed data is required for determining dominant patterns of tidal and wind driven currents, which then can be used to develop a hydrological model to assess the impacts of the marine structures on coastal currents and sediment transportation processes.

Upwellings

Waves

Severity of waves

SPREP

Papua New Guinea

Types of Impacts

Environmental impacts, both direct and indirect, on different environmental resources or values due to project location, as related to design, during construction and regular operation will be discussed and mitigation, offsetting or enhancement measures will be recommended.

Direct and Indirect Impacts

Direct impacts are generally those impacts occurring either within the project footprint (such as habitat disturbance) or as a direct consequence of a project activity (such as a waste discharge). Indirect impacts are those arising from project facilities or activities, but with a degree of separation in time or space (for example, the spread of marine pests). They are, by their nature, hard to predict except in broad terms.

Cumulative and Associated Impacts

A step further removed, are impacts arising from actions of third parties, which the presence of the project may enable or assist, and are expressed as scenarios based on speculative assumptions about the influence that the project may have on what other people may or may not do.

For example, in the marine environment, this might apply to increased boating or fishing activities, or development of other projects with incremental impacts on marine resources or habitats.

Environmental Impact Assessments

EIA is an important tool for incorporating environmental concerns at the project level. EIA should be carried out as early as the project planning stage as part of feasibility thus it can assure that the project will be environmentally feasible.

EIA is required to examine the project's potential impacts, and to recommend an environmentally sound project by comparing all possible alternatives. Public consultation must be undertaken at least twice during the EIA process, once during the early stage of the EIA field studies and after the draft EIA report has been prepared. The EIA should recommend mitigation measures for minimizing the adverse impacts and identify environmental monitoring requirements. The mitigation measures and proposed monitoring are to be incorporated into the Enviroment Management Plan (EMP).

EIA Objectives

The general objectives of the EIA study are to provide:
baseline information about the environmental, social, and economic conditions in the project area;

information on potential impacts of the project and the characteristic of the impacts, magnitude, distribution, who will be the affected group, and their duration;

information on potential mitigation measures to minimize the impact including mitigation costs;

to assess the best alternative project at most benefits and least costs in terms of financial, social, and environment. In addition to alternative location of the project, project design or project management may also be considered; and

basic information for formulating environmental management plan.

EIA requires an in-depth analysis because of the potential significance of environmental impacts from the project. EIAs demand:

comprehensive analysis of the potential impacts;

works to be carried out to formulate practical mitigation measures;

in-depth economic valuation of impact to screen and evaluate the best alternative; and

in-depth analysis to prepare an adequate environmental management plan.

Describing Environmental Conditions

Collection of baseline information on biophysical, social and economic aspects of the project area is the most important reference for conducting EIA study.

The description of environmental settings includes the characteristic of area in which the activity of proposed project would occur and it should cover area affected by all impacts including potential compensation area, and potential area affected by its alternatives.

Normally, information is obtained from secondary sources when there is a facility of maintaining database, or other existing documentation, and through field sampling.

Collection of baseline data should be designed to satisfy information requirements and should focused on relevant aspects that are likely to be affected by the proposed project. Therefore, the level of detail in this description of study area should be sufficient to convey to readers the general nature of environmental and social resources condition of the affected areas.

Assessing Potential Impacts

The ‘technical heart’ of the EIA process involves the prediction of changes over time in various environmental aspects as a result of a proposed project.

The prediction of the nature, extent, and magnitude of environmental changes likely to result from a proposed project is aided by various tools and techniques, the choice of which depends upon the impacts of concern, data availability or lack thereof, and the appropriate specificity of quantitative models.

However, the choice of the appropriate method for conducting an EIA can only be guided by certain criteria, but no single method will meet all the necessary criteria.

In addition, the prediction has to be based on established scientific knowledge.

Impacts during Construction

Activity	Consequence	Impact
Dredging	Turbidity, sedimentation, bethnic distruction	Water quality degradation, habitat destruction, species loss, toxicity
Blasting	Concussion, noise, seismic shock	Destruction of corals, fish kills, disturbance of endangered species
Site clearance	Denuded landscape, altered soil profile, altered topography	Soil erosion, water quality degradation, habitat destruction, species loss, increased run-off, increase risk of land slippage
Construction	Noise, fugitive dust, machine emissions, structural addition to coastal landscape, poisons and pesticide use	Disturbance of endangered species, habitat destruction, species loss, toxicity, water quality degradation, euthrophication
Labour importation	Immigrants, squatters, sewerage effluent	Water quality degradation
Shipping	Petroleum residues, sewerage effluent, anti-fouling compounds	Water quality degradation, habitat destruction, species loss, toxicity, changes in ecosystem structure

Activity	Consequence	Impact
Oil spills	Oil wastes, pollutants, detergents	Water quality degradation, habitat destruction, species loss, toxicity, changes in ecosystem structure
Coastline modification	Altered oceanography	Erosion and accretion, sand transport, changes in ecosystem structure, euthrophication, accumulation of wates
Run-off	Sedimentation., increased nutrification, toxicity	Erosion and accretion, sand transport, changes in ecosystem structure, euthrophication, accumulation of wastes
Land-use changes	Secondary developments, increased access	Urbanisation, increased fishing pressures, changes in ecosystem structure

Activity	Consequence	Impact
Waste disposal	Sewerage effluent, leaching from landfills, smoke and fumes from burning	Water and air quality degradation, habitat destruction, species loss, species entanglement
Sewerage effluent	Suspended solids, pathogens, chlorine, freshwater demands, toxicity	Water and air quality degradation, habitat destruction, species loss, euthropication
Harbour operations	Noise, congestion, hazardous materials	Disturbance of endangered species, habitat destruction, species loss

Potential Risks during mining

Rupture of slurry pipeline due to mechanical failure, seismic activity, volcanic activity etc.

Incompetent waste dumped in shallow water does not flow to deep ocean but remains in shallow water where it is repeatedly re-suspended.

Treated sewage discharge from accommodation area.

Accidental flushing of toxic chemicals in water draining from general refinery site.

Accidental flushing of toxic chemicals in water draining from bunded areas of refinery site.

Failure or overtopping of bunding, refinery buildings etc. (e.g. due to tsunami).

Fuel spillage from ships.

Impact Significance

The primary goals of such a monitoring and assessment program should be to:

understand and define the magnitude of the different environmental problems,

prioritize the problems for remediation, and

look for creative, cost-effective ways to help mitigate or remediate the problems.

Risk analysis involves environmental description, identification and characterization of contaminant sources, assessment of human and ecosystem exposure to the contaminants, assessment of contaminant effects, characterization of future risk, and risk management or remediation.

The risk assessment should also examine entire mining-environmental systems as a whole, and not just focus on selected parts.

Direct Impacts

In the marine environment, direct impacts include those that result from physical loss or removal of habitat once occupied by fauna, subsequently replaced by project infrastructure. This would apply to habitats in the areas proposed for the locations of structures, and activities such as trenching (for offshore pipelines) and dredging. Most of these direct effects are negative but can be positive, for example through the creation of habitat not previously present for colonisation by marine fauna and flora. Direct impacts would also apply to changes in access to resources (e.g. by people).

Indirect Impacts

Indirect impacts are those arising from project facilities or activities, but with a degree of separation in time or space, for example via changes to water quality or sedimentation. They are by their nature hard to predict, and in the marine environment, rely on modelling of dispersion and dilution.

Environmental impact significance can be expressed in a matrix of the value (or sensitivity) of a receptor and the magnitude of the impact. The method takes a range of factors into account, including extent, duration and severity of impact, and whether it is a positive or negative, direct or indirect impact.

	Sensitivity of Resource/Receptor				
Magnitude of Impact	**Very High**	**High**	**Medium**	**Low**	**Minimal**
Very High	Major	Major	Major	Moderate	Minimal
High	Major	Moderate	Moderate	Minor	Minimal
Medium	Moderate	Moderate	Minor	Minor	Minimal
Low	Moderate	Minor	Minor	Minor	Minimal
Minimal	Minimal	Minimal	Minimal	Minimal	Minimal
Positive	Positive	Positive	Positive	Positive	Positive

Matrix of significance

Magnitude of impact categories and descriptions: LNG marine facilities

Category	Description
Very High	Effect likely to have large impact on population, community or ecosystem survival and health, possibly even leading to local extinction or system collapse. Impact is widespread, affecting around 25% or more of a regional population (e.g., within all of Caution Bay). Recovery, if possible, is likely to take more than 10 years.
High	Effect likely to have severe negative impact on population, community or ecosystem survival or health. Impact is regional, affecting approximately 10% of a regional population. Recovery, if possible, is likely to take from 5 to 10 years.
Medium	Effect will be detectable but not severe; populations or the areal extent of communities may be reduced but unlikely to lead to major changes to population, community or ecosystem survival or health. Impact is local, generally occurring up to 2 km from impact site. Recovery is likely to take from 2 to 5 years.
Low	Effect may be detectable but is small and unlikely to have any material impact. Impact affects immediate surrounds of area of activity and extends for less than 1 km radius. Recovery is rapid - up to 2 years.
Minimal	Effect unlikely to be detectable.
Positive	Effect is likely to benefit the population, community or ecosystem.

Sensitivity of resource or receptor categories and descriptions: LNG marine facilities

Category	Description
Very High	A population of an ecologically or socially important species on an international level, or a site or habitat supporting such a species. A rare, threatened or vulnerable habitat or species and/or a breeding ground or feeding area that is critical to the survival of such species. Resource that provides the sole source food or income for local people.
High	A nationally designated site. A population of an ecologically or socially important species on a national level, or a site or habitat supporting such a species. Site supports 1% or more of national population. Resource upon which local people are frequently dependent for provision of food or income.
Medium	A population of an ecologically or socially important species on a regional level, or a site or habitat supporting such a species. Site supports 1% or more of regional population. Resource upon which local people are occasionally dependent for provision of food or income.
Low	Sites, populations or resources that generally enrich/maintain the local area. Resource upon which local people are rarely dependent for provision of food or income.
Minimal	No detectable ecological or social value or sensitivity.

Magnitude of impact categories and descriptions – LNG offshore pipeline

Category	Description
Very High	Effect likely to have large impact on population, community or ecosystem survival and health, possibly even leading to extinction or system collapse. Impact is widespread, affecting more than 10% of a regional population. Recovery, if possible, is likely to take more than 25 years.
High	Effect likely to have severe negative impact on population, community or ecosystem survival or health. Impact is regional, affecting up to 10% of a regional population. Recovery, if possible, is likely to take up to 25 years.
Medium	Effect will be detectable but not severe; populations or the areal extent of communities may be reduced but unlikely to lead to major changes to population, community or ecosystem survival or health. Impact is local, generally occurring within 10 km of impact site. Recovery is likely to take up to 7 years.
Low	Effect may be detectable but is small and highly unlikely to have any material impact. Impact is limited, affects immediate surrounds of impact area and extends for up to 2 km radius. Recovery is short term up to 3 years.
Minimal	Effect unlikely to be detectable.
Positive	Effect is likely to benefit the population, community or ecosystem.

Sensitivity of resource/receptor categories and descriptions – LNG offshore pipeline

Category	Description
Very High	A population of an ecologically or socially important species on an international level, or a site or habitat supporting such a species. A rare, threatened or vulnerable habitat or species and/or a breeding ground or feeding area that is critical to the survival of such species. Resource that provides the sole source of food or income for a local population.
High	A nationally designated site. A sustainable area of priority habitat. A population of an ecologically or socially important species on a national level, or a site or habitat supporting such a species. Site supports 1% or more of national population. Resource that provides a large portion of food or income for a local population.
Medium	A population of an ecologically or socially important species on a regional level, or a site or habitat supporting such a species. Site supports 1% or more of regional population. Resource that provides a medium portion of food or income for a local population.
Low	Sites, populations or resources that enrich the local area. Resource that provides a small portion of food or income for a local population.
Minimal	No ecological or social value or sensitivity.

Formulating Mitigation Measures

Once the impacts have been analyzed, their significance will be determined, i.e., whether they are acceptable, require mitigation, or are unacceptable. Subsequently, measures will be devised to mitigate anticipated environmental changes and consequential impacts during project implementation and operation, or further reduce the residual environmental changes inherent in the selected project design. They normally include technical, social, and institutional measures to be implemented as integral elements of the project.

LNG Marine mitigation and management commitments examples

Mitigation Item Number	Mitigation Measure	Relevant Phase	Responsible Party
M206	Consider discharging wastewater and brine in the same vicinity to assist with salinity dilutions.	Construction Operations	Operator Contractor
M207	Validation baseline monitoring of sedimentation will be undertaken during construction and will be similar in scope to that undertaken for the EIS characterisation baseline or expanded as required.	Construction Operations	Operator Contractor
M208	Limit marine habitat disturbance and mangrove clearing for Materials Offloading Facility/Jetty construction to the area within the perimeter fence (plus working buffer zone). Prohibit works from exceeding the design disturbance width and enforce boundaries through use of markers/tape and worker awareness.	Construction	Operator Contractor
M209	Establish an offshore spill response plan appropriate to the project phase and include staff training at induction to inform workers of their responsibilities under the plan.	Construction Operations	Operator Contractor
M210	Implement marine waste management (discharges to sea) procedures as part of the waste management plan complying with MARPOL standards and international port policies and procedures.	Construction Operations	Operator Contractor

Submarine Tailings Disposal, or STD

Countries proposed to have STD in the Indo-Pacific region: Indonesia (6), Papua New Guinea (5), New Caledonia (5), the Philippines (3), Fiji (1) , and the Solomon Islands (1),

Mine	Tailing (tonnes/day)	Mine life
Bougainville	135,000	30
Ok Tedi	60,000	30
Misima	15,000	10
Hidden Valley	10,000	10
Porgera	9,000	18
Wau	1,400	9
Mt Kare	3,000	3
Mt Victor	400	2

Volume of tailings disposals for selected PNG mines

STD in Theory

The theory surrounding the use of SDT is that ‘de-aerated’ tailings that are mixed with sea water are deposited by pipe below the ‘mixed surface layers’**,** and below the **‘**euphotic zone’, and below a ‘thermocline’ onto a sea bed with a ‘sufficient’ slope so that the tailings flow through gravity into the deep waters of the ocean, where there is little oxygen, then tailings will stay together in a ‘density current’ like toothpaste.

It is also thought that SDT will not be able to come back up above the thermocline, that they will not significantly leach out metals, and that they will not damage corals, and finally that they will not negatively affect marine organisms, in particular food fish.

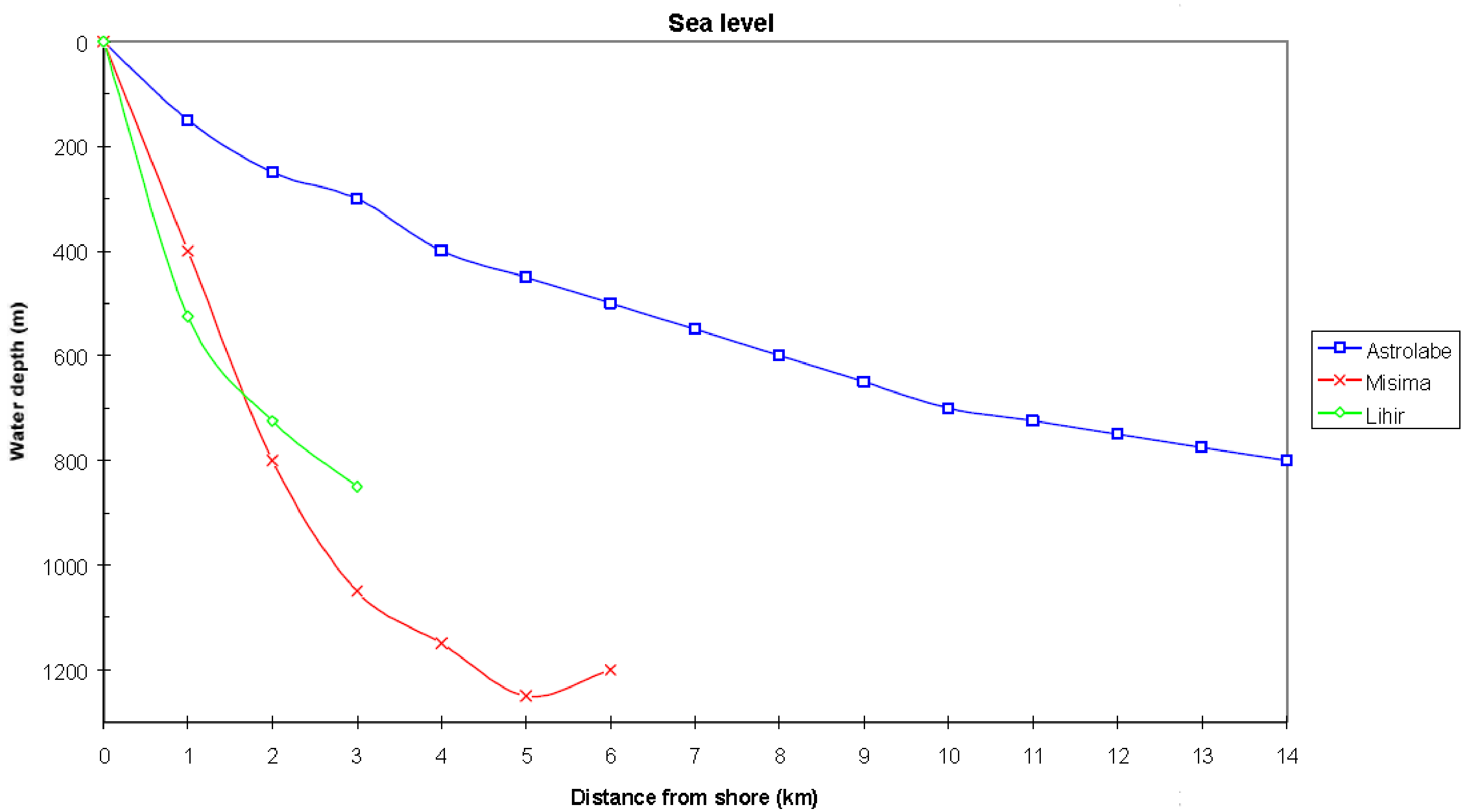
What can actually happen

SDT to get redeposited through upwelling, particularly where there is insufficient slope gradient of the seabed, internal waves, bottom currents on a sloping seabed, tidal flows, as well as more unusual events such as earthquakes at sea or tsunamis.

All STD systems smother benthic organisms in the planned deposition zone. As these areas of the deep sea are not yet well understood, it is as yet unknown what the ultimate effect will be of benthic smothering.

Both total and dissolved metals in the tailings may become bio-available through ingestion of whole tailings particles or through absorption of dissolved metals through gills tissue. Residual flotation chemicals and reagents enhance the solubility of metals in tailings.

Significant volumes of metals from tailings deposited at great depths may make their way up to higher seawater levels and into the human food chain through ‘vertical migration’,from the depths to higher layers, of plankton and fish that have absorbed tailings or leached metals, and by fish from the higher layers travelling down to the lower levels to feed.



Cross section of submarine slopes at three mine sites in PNG

Ramu Nickle

From the available evidence, it seems likely that the majority of tailings from the Ramu Nickle mine will accumulate in the nearshore canyons and inter-canyon platforms and be transported to the west towards Madang, in the New Guinea Under Current.

A proportion of the tailings will probably be re-suspended and enter the surface levels of the ocean in the vicinity of Basamuk Bay and the wider coastline. An additional quantity will separate from the main tailings flow and form plumes that will travel away from the outfall at the different levels in the water column.

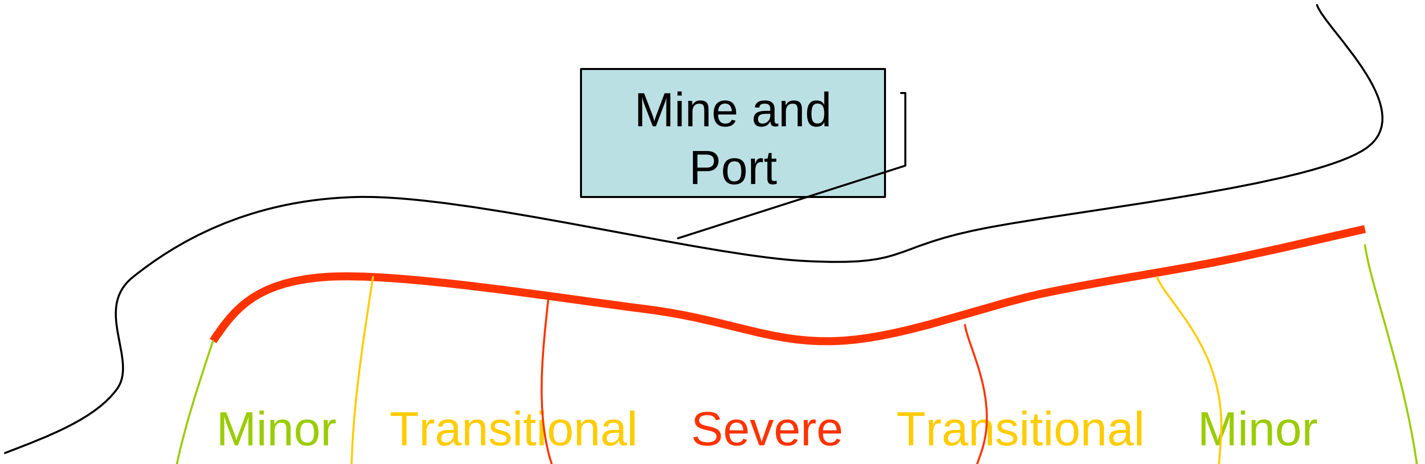
The dumping of waste rock and soils directly into the coastal bay will probably generate turbidity in the surface mixed-layer near shore.

Misima

At Misima, During construction from 1989-1994, **a**pproximately 53 million tonnes of soft waste rock and soil was dumped into the ocean over this period, smothering a coastal coral shelf over 1 km-long and having an extended impact on coastal reefs extending along 9 km of coast.

This dumping killed the corals in the immediate impact zone and wiped out the subsistence fish resource in that area. In a broader impact zone the dumping led to significant reductions in coral fauna diversity, reduced numbers and diversity of fish, significant reductions in subsistence fish yields, high suspended sediment concentrations, turbidity, and turbid plumes extending out into the ocean, particularly during the southeast trade wind.

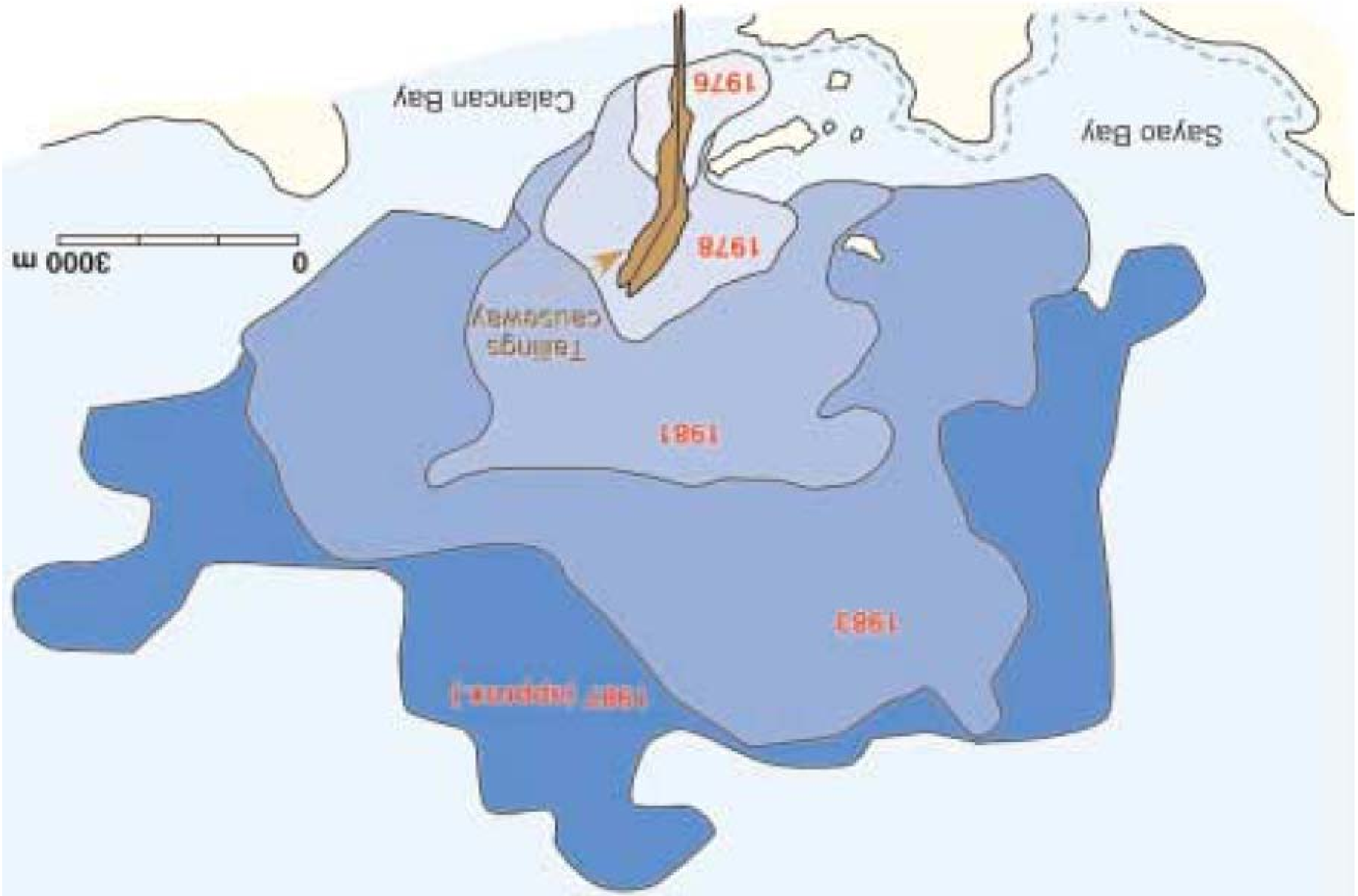
During mining, coastal impacts occurred for a distance of 5km on either side of the mine. The STD outfall terminus was at 118m depth and about 200m from shore on a steeply sloped >45º degree seabed. Tailings were rich in cadmium, copper, lead and cyanide.



Physical Impacts
Smothering of corals, seawater always turbid
Biological Impacts
Most corals dead, fish will die or move away
Effects on fishing
No fish caught or harvesting of marine resources

Physical Impacts
Moderate to severe damage of corals, seawater frequently turbid
Biological Impacts
Reduced coral and fish fauna and diversity
Effects on fishing
Reduced catches of fish and other marine resources

Physical Impacts
Minor damage of corals, seawater occasionally turbid
Biological Impacts
Reduced coral and fish fauna and diversity
Effects on fishing
Slightly reduced catches of fish and other marine resources



Map showing approximate extent of underwater tailings deposition over time in Calancan Bay, the Phillipines.

Risks associated with STD

STD smothering of benthos.
STD chemical effects.
STD food chain effects.
Slope may be too shallow to for STD waste to flow to deep waters.
STD rupture.
Re-suspension of SDT waste by upwelling.
Resuspension of SDT waste by bottom currents.
STD outfall depth not below actual maximum depth of surface mixed layer.
Resuspension of STD waste by abyssal storms and cyclones.
Resuspension of STD waste due to seismic activity (i.e. earthquake).
STD outfall material returned to surface layers of the sediment by biological activity.
STD outfall material returned to surface layers of the ocean by biological activity.
Sediment from DSTP may be different size to the natural sediments, so changing substrate type, and leading to change in biological communities.
STD may produce more waste than predicted.

What information is needed about STD to judge its suitability for the tailings disposal?

What are the sea-floor conditions and oceanographic conditions?

How do these conditions vary spatially across the ocean bottom and within the sea water column? How do these conditions vary with time (seasonally, and during storms or cyclones)?

What are the directions of sediment transport in the water column and on the sea floor? How do these directions vary with time, both seasonally and during storms or cyclones?

What are the forces that drive the primary physical processes (local wind, swell, tides, fluvial discharge)?

What are the high-energy events that affect the physical setting (riverine flooding, cyclones, earthquakes, tsunamis)?

What are the sea-floor conditions in the directions of sediment transport and at the anticipated site of tailings deposition?

What is the composition and size distribution of the waste material?

What are the proposed method, rates, and duration of waste emplacement?

Are offshore slopes sufficiently steep to maintain density flow to the basin floor?

Can the tailings discharge system be designed to withstand the impacts of storms? As storm induced failure of the piping discharge system could lead to catastrophic release of tailings in the near-shore environment.

What are the minerals in which heavy metals occur in the tailings materials? How soluble are these minerals in sea water and in the digestive tracts of marine organisms? Heavy metals residing in more soluble or reactive phases will be more readily taken up by marine organisms.

How readily will sulfides in the tailings oxidize in sea water?

What processing chemicals are present in the tailings fluids?

What chemical reactions will occur between the tailings solids, tailings fluids, and sea water?

If metals are dissolved from the tailings by sea water, what geochemical attenuation reactions with sea water will occur, and how far away from the tailings discharge outfall will these metals affect sea water quality?

What are all of the marine organism communities that could be affected by the tailings disposal, given the predicted area of impact?

What is the economic and ecological value of each of the marine biological communities identified in the disposal area?

How will physical processes (such as sedimentation) and geochemical processes (such as dissolution of metals from the tailings) affect each of the different aquatic marine communities?

What are the maximum chronic and acute toxicity concentrations of heavy metals in sediments and sea water for each type of marine organisms found in the areas affected by the tailings discharge, and will these levels be exceeded?

Biological Impacts

If sediment levels in coastal waters increase substantially through mining or SDT, there could be serious consequences for the fisheries stocks in the area, excluding many species that rely on clear water conditions from the area.

Large build-ups of sediment at shallow depths may provide the opportunity for catastrophic slumping leading to scouring of existing sediments, producing unexpected habitat changes.

Large tailings build-ups mean much deeper and more rapid burial of fauna leading to increased mortality that may even influence mobile fauna able to deal with slow burial by burrowing upwards.

Large repositories of sediment in relatively shallow water increase the danger of re-suspension of sediments due to upwelling, abyssal storms and turbulent, turbidity plumes generated by catastrophic slumping.

Retention of sediments in shallow waters transfers the impact of tailings disposal into the 100-400m depth range preferred by deep-water snapper, thereby impacting on these fisheries.

Octopus, squids and cuttlefish are top level predators which accumulate toxins by their mollusc, crustacean and fish prey; and these creatures will act as biological vectors in the transport of these contaminants to surface and coastal waters. These species are known to move between the inter-tidal zone to depths of 200 m.

At Misima, studies found that levels of lead, copper and zinc in shellfish (Turbo argyrostoma) were high and "may be attributable" to Misima Mine's activities. High levels of copper and lead were also found in the Common Rock Crab hepatopancreas tissue, also suggesting Misima Mine's activities were responsible.

"metal values in some edible seafood species exceed food standards and there is evidence that MML's activities may have caused increased metal levels in seafood at some potentially impacted sites compared to control sites. While there is a potential human health impact to villagers who consume any of the seafood types with elevated metal values, the potential exposures ranged from exceedingly low to very low in all cases….This may change however with mine closure and a return to a more traditional way of life based on a natural harvest."

Sedimentation is a leading cause of coral reef damage. Corals cannot thrive in water containing high levels of sediment which makes the water cloudy or turbid, blocking out sunlight, smothers and buries corals, and prevents planula larvae (juvenile corals) from finding a suitable substrate to colonize. Heavy metals such as copper suppress coral fertilization at concentrations of a few tens of parts per billion.

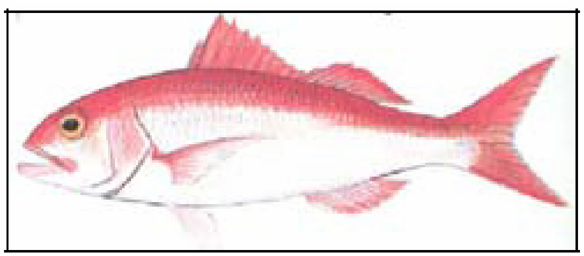
A range of metals can be taken up directly from the ingestion of sediments by some species of fish. For other species metals may be taken up from the water column over gill membranes, while in still other cases the most common route for metal uptake is via the food chain. Where concentrations are high enough, acute toxicity can occur, leading to death, and reproductive failure; but more subtle effects such as cell damage have been detected at lower levels of pollution.

Dredging, filling and other physical changes to habitats in the tropics have also been implicated as causes of increased incidences of ciguatera fish poisoning, which also impacts on human health.

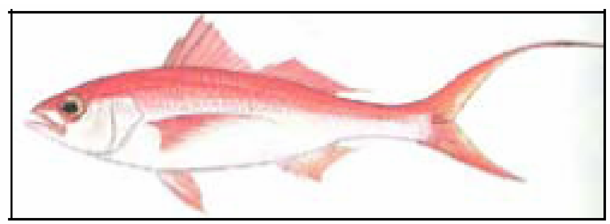
The Lihir gold mine has deposited both excavated overburden and processed tailings slurry into the coastal environment since 1997.

From 1999-2002, the CSIRO conducted an assessment of the abundances of fish species and trace metal concentrations in their tissues were compared between sites adjacent to and away from the mine.

Results of this study showed limited contamination in fish tissues caused by trace metals disposed as mine waste, although arsenic (several species) and mercury (one species) were found in concentrations above Australian food standards; and it appears fish are accumulating these metals mostly from naturally-occurring sources rather than the mine waste.



Short-tailed (Ruby) snapper
(*Etelis carbunculus* - ETA)



Long-tailed red snapper
(*Etelis coruscans* - ETC)

Losses of mangrove and other tidal wetland communities are mostly the result of reclamation for coastal development of estuaries (e.g. port infrastructure), and result in river bank destabilisation, deterioration of water clarity and loss of key coastal marine habitat. High nutrient levels may also alter faunal communities which might affect the vulnerable trophic links between mangrove trees and fauna.

Coastal seagrass meadows are characterized by small ephemeral species. They are disturbed by increased turbidity. Seagrasses accumulate metals from the environment by rapid uptake through the leaves under both chronic and pulsed exposure.

SPREP

Papua New Guinea

Mitigation

Conduct regular water quality sampling, as well as detailed ecological and eco-toxicological assessments of the marine environment.

Assess the potential long-term ecological impacts of the mining in the nearby terrestrial and marine ecosystems, and adjacent coastal areas, including an analysis of metal uptake by aquatic and terrestrial flora and fauna.

If the environmental assessment reveals substantial metal contamination from the mine site in drinking water supplies or food crops, a health assessment of local residents should also be carried out by metal screening in blood, urine, and hair of local residents who rely upon the local fisheries for food.

Other

Submarine Mining (e.g. Nautilus)

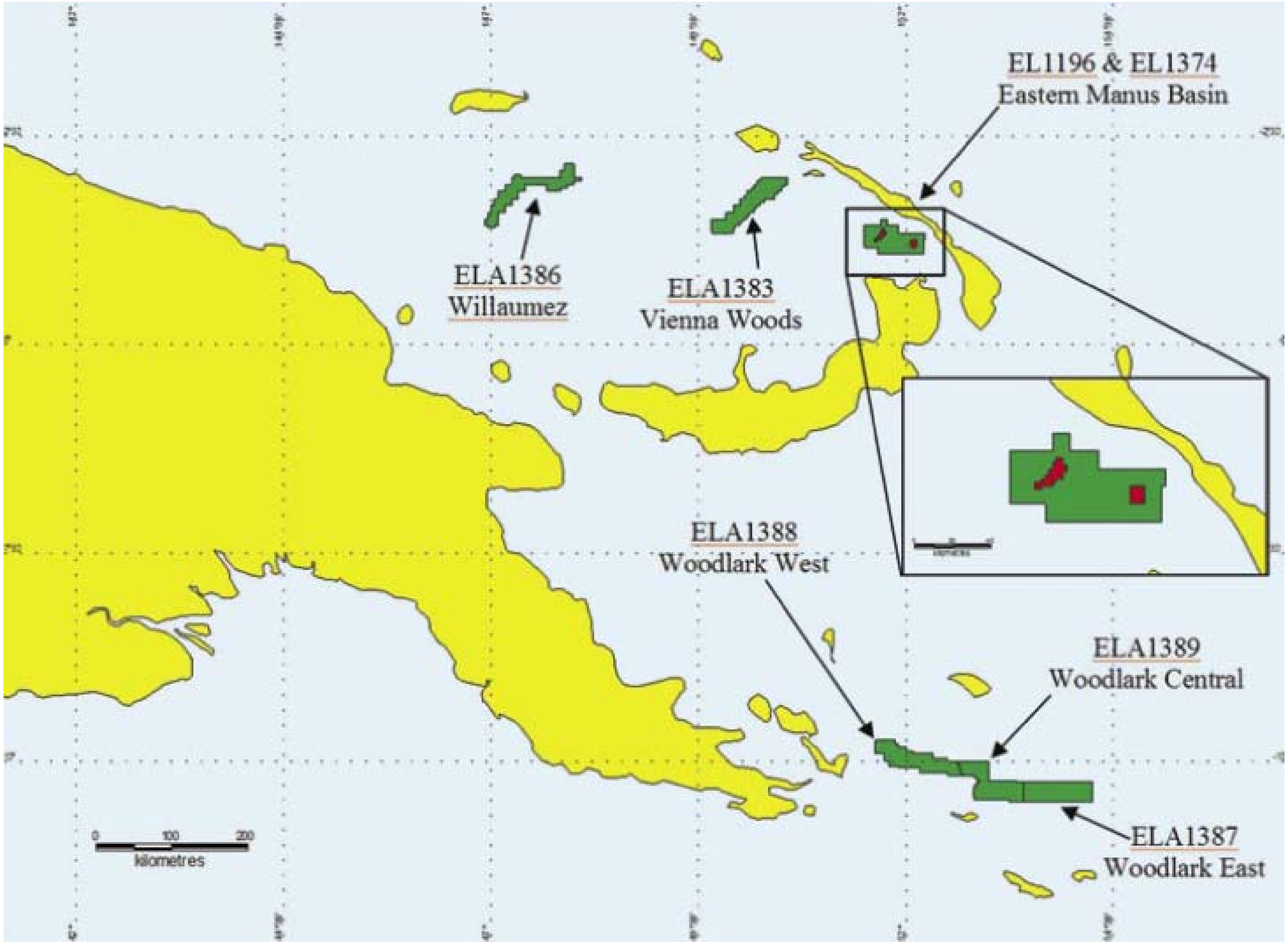
Ports and harbours (e.g. Lae Ports development).

Fish canneries (e.g. Vidar Marine Park).

Energy projects (e,g. Napanapa Oil Refinery and the LNG project).

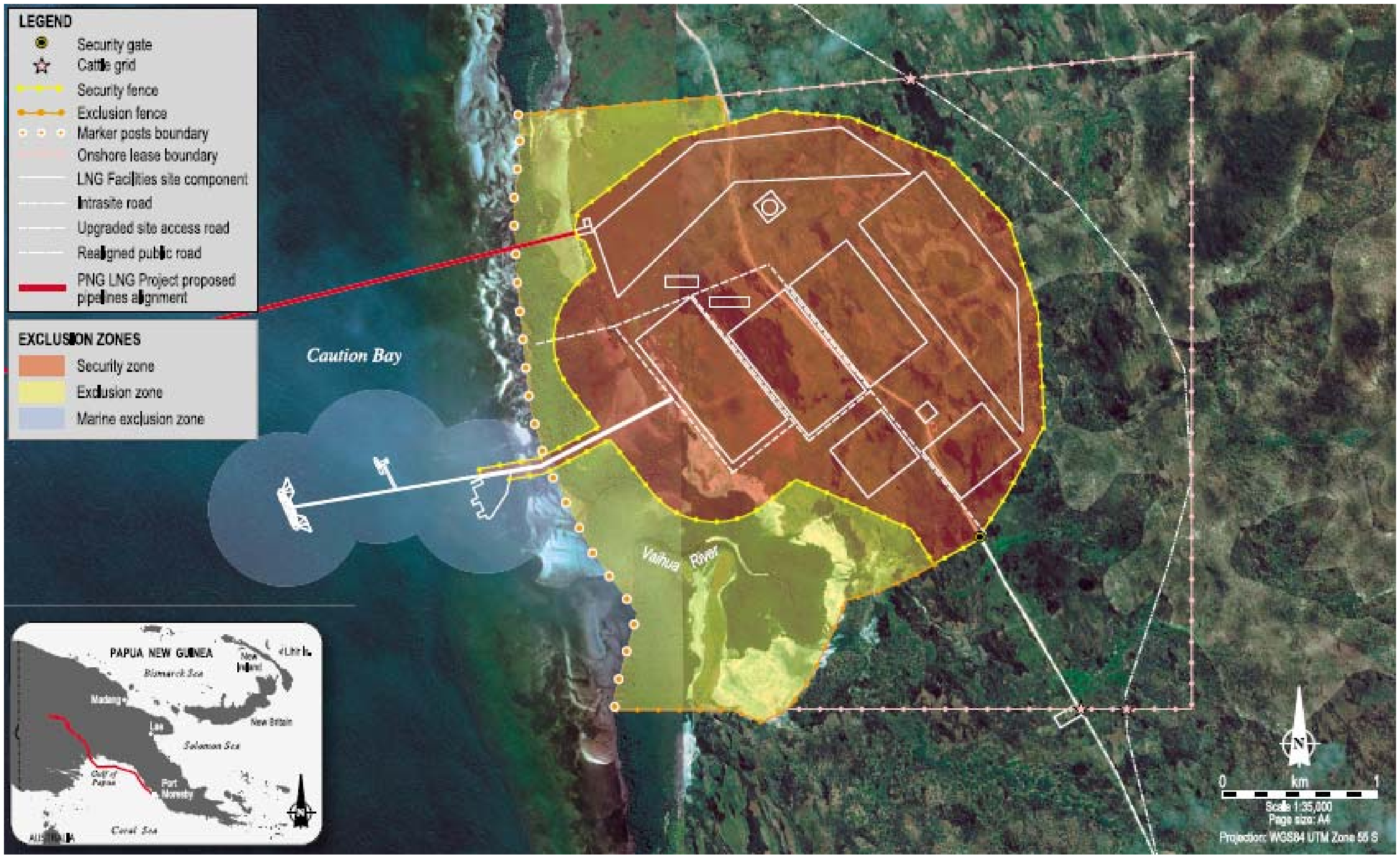
Tourism developments (e.g. Madang Resort).

Agriculture (e.g. Oil Palm development).



Submarine mining leases in PNG

Lae Port development



LNG Port Development

Fish Canning

Fish processing, like other food processing, produces a concentrated organic effluent that usually has the consistency of a loose slurry and is composed of a mixture of water, fish tissue, fluids and macerated body parts such as fish heads, bones, fins, scales and soft tissues such as the gut and liver.

This mixture is usually skimmed and screened to remove the larger floating and suspended solids before being discharged through a marine outfall.

SPREP

Papua New Guinea

If the outfall is not located beyond the influence of tidal or on-shore currents, the effluent plume may extend into shallow and tidal waters, where dispersion and dilution will be less effective in reducing concentrations to below significant impact levels.

In these circumstances, impacts on the water quality and biota may be severe enough to cause disturbance and damage to tidal and near-shore habitats and communities, and affect the recreational and fisheries use of these waters.

The closer the outfall is to the shore, the more thorough the baseline studies have to be to ensure that the degree of risk to shoreline users is acceptable.

Even then, there is the risk that further extension of the outfall may be required in the future or, alternatively, that additional treatment be installed prior to discharge if unanticipated levels of impact subsequently occur.

The End