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Report on the **Strategic Environmental Assessment Oil Spill Incident USS Mississinewa** Ulithi Lagoon, Yap State, Federated States of Micronesia

18th September 2001

For the Government of Yap State,
Federated States of Micronesia

by
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Executive Summary

A State of Emergency had been declared in Yap State, Federated States of Micronesia following a significant oil spill from a sunken WWII US warship/oil tanker in Ulithi Lagoon. A compete ban on fishing within the lagoon area had also been imposed by the Environment Protection Agency and Marine Resources Department of Yap State. The spill had occurred over a 2 month period between July and August 2001. A request for assistance to South Pacific Regional Environment Programme was made by the President of FSM for an independent study on the wreck and environmental impacts of the recent oil spill from the WWII USS Mississinewa in Ulithi Lagoon.

The objectives of the Strategic Environmental Assessment was to:

- To confirm if all oil leaks from the sunken USS Mississinewa refueling oil tanker has ceased.
- To determine the resources at risk in the area of the spill and any ecological damage.
- Document the oiling and physio-ecological character of the shorelines of Ulithi lagoon.
- To assess extent of remaining oil on shorelines with particular focus on the environmentally sensitive islands known as the "turtle islands", to the south east of the lagoon.
- To determine if the oil that had reported to have impacted Fais Island 50nm was from the USS Mississinewa spill.
- To cross check existing information on environmental sensitivities and clarify observations from previous surveys.
- To determine priorities and requirements for any shoreline cleanup actions or restoration.
- Observe and assess the impacts of oil on any wildlife in the region.
- Document any ecological constraints on spill response or cleanup operations.
- To provide an overall recommendation on any necessary actions related to the remaining oil on the USS Mississinewa.
- To provide environmental, technical and spill response advice to the Yap government and agencies.

Summary of Conclusions & Recommendations

The prime consideration in my recommendations to the Yap Government is the conservation of the marine environment of Ulithi lagoon and its associated natural resources, which are essential for the maintenance of the health and standard of living for the population of the atoll. No economic assessment, nor cost benefit analysis, was performed in this study for implementation of stated recommendations.

Section 1 Assessment of Wreck, Response Options and Actions

There is major doubt and uncertainty in my mind as to the structural integrity of the vessel in the long term. I believe it is not a case of "if" the next oil leaks occurs from the USS Mississinewa but "when".

In my assessment of the wreck I believe the stated 9,600,000 gallons of oil remaining on the USS Mississinewa represents a "grave and imminent danger" of a pollution hazard to the government of Yap State, FSM and related interests.

The magnitude of the worse possible case scenario is between 400 and 500 times the amount of oil already spilt.

From a spill responders standpoint the most efficient and cost effective response option is to "control at source" any potential marine pollutant.

The magnitude of the risk, the likelihood of extensive environmental damage, and common sense dictates that the most responsible option would be to tap the fuel oil tanks of the vessel and drain any remaining oil under controlled conditions from the deteriorating wreck.

The wrecks extensive oil cargo poses an unacceptable and ever present risk to the marine environment of Ulithi lagoon and should be offloaded under controlled conditions within the "window of opportunity" as specified. A number of options have been detailed in the body of this report.

A release of the vessels' cargo whether by chronic low level discharge over a long time period, or by catastrophic failure during a storm or typhoon, could have severe impacts on the lagoons coral reefs, the foreshore environment and subsistence fishing, food supply and health of the Ulithi population. As well as one of the most significant remaining sea turtle breeding regions in the western pacific.

Section 2. Summary of Foreshore Impacts on Ulithi Islands & Recommendations

From the surveys carried out on a limited number of islands in the atoll it is apparent that no major foreshore oiling remains in Ulithi lagoon. Some oil had impacted the turtle island of Pau.

The western beaches Falalop facing the lagoon was probably the most contaminated with oil during our surveys. This oil tar balls and mats were concentrated in the upper tidal zone region near the concrete boat ramp and the boat harbour.

The natural removal/cleaning processes due to wind, wave and sediment abrasion action during the storms to have passed through the region over the past few months has helped the self cleaning of most of the previously oiled foreshores.

A major gap in the knowledge of the fate of the heavy residues of oil removed by the natural foreshore cleaning processes. Where is the "sink" for all the remaining persistent oil residues in Ulithi lagoon?

It is recommended that surveys be carried out in Ulithi lagoon to determine if any oiled sediments exist in any significant quantities in the intertidal and near shore areas of the previously oiled foreshores.

No signs of any abnormal crustacean or mollusc mortality were apparent above normally expected on tropical foreshores.

No dead turtles examined showed any sign of oil contamination and the deaths may be attributed to natural causes.

The bird population appeared to be diverse, healthy and very active with no signs of oil contamination, oil intoxication or behavioural changes

No apparent or significant damage was observed on wildlife by the oil spill on any island surveyed during this assessment.

Section 3. Impacts on Fisheries from the Oil Spill

In my assessment I believe the ban placed on fishing within Ulithi lagoon by the Yap Authorities during the height of the recent oil spill was a prudent and sound measure to protect the health of it's citizens.

Since the immediate spill source has been contained and sufficient time has passed for most fish species to depurate (detoxify) from the effects of oil components I believe the ban can now be lifted.

I recommend the reopening of the fisheries within Ulithi Lagoon immediately.

Any long term monitoring of seafood for hydrocarbons should focus on the "indicator" or "sentinel" species mentioned in the report which are more sensitive to background levels of oil in the environment.

Section 4. Spill Protection Priorities and Environmental Resources

To assist in the management of any future oil spills in Yap waters I recommend a National Marine Spill Contingency Plan be completed as soon as possible based upon the Pacific Regional template provided with this report. This plan development should be carried out as a matter of urgency, especially if no removal of oil cargo from the USS Mississinewa is carried out in the near future.

It is impossible to protect an entire coastline and every resource during a major oil spill event, therefore priorities have to be made between protection and sacrifice based upon the environmental significance of the resource.

If possible coral reefs should receive a high protection priority since they are easily damaged if oiled, may take several decades to recover if killed and extremely difficult to clean.

The highest risk coral reefs identified are those that are:

1. Intertidal reefs and reef flats, where direct contact with the oil is likely.
2. Sheltered, shallow water settings, where high concentrations of oil are likely to persist.
3. Where leaching from adjacent area creates a chronic source of oil exposure.
4. Where coral reef communities are already stressed by pollution, sedimentation, thermal quality problems, etc.

In the case of Ulithi lagoon turtle and bird Islands to the East satisfy all the internationally recognised criteria for an area to receive the highest category of protection and preservation by governments, highlighting the need to ensure protection from any further oil spills.

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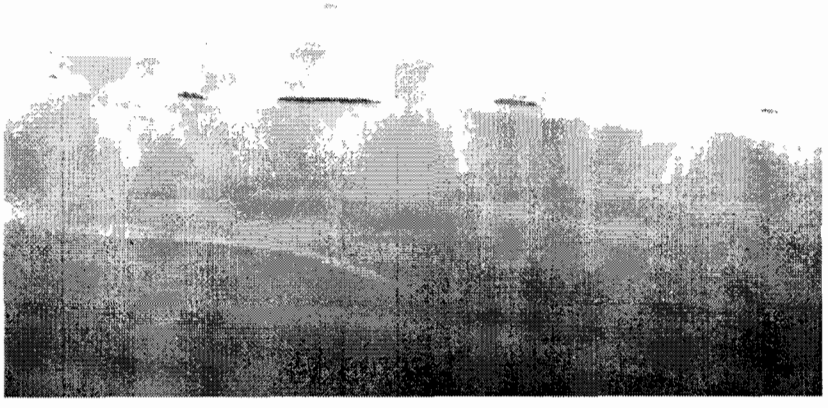
Introduction & Request for Assistance

On August 29, 2001 an urgent request was received by the South Pacific Regional Environment Programme (SPREP) from the Secretary of the Department of Foreign Affairs of the Federated States of Micronesia (FSM). This request followed a plea from the Governor of Yap State Mr. Vincent Figir to his excellency Mr. Leo Falcam the president of FSM for assistance from SPREP and other regional organisations for an environmental emergency in Yap State.

A State of Emergency had been declared in Yap State FSM following a significant oil spill from a sunken WWII US warship/oil tanker in Ulithi Lagoon as well as a compete ban on fishing within the lagoon area had been imposed by the Environment Protection Agency and Marine Resources Department of Yap State. The request for assistance to SPREP was to provide an independent study on the wreck and environmental impacts of the recent oil spill from the WWII USS Mississinewa in Ulithi Lagoon in Yap State.

The Director of SPREP responded to the FSM government on August 30, 2001 and informed the President that the Marine Pollution Adviser, Mr Trevor Gilbert of the SPREP Pacific Ocean Pollution Prevention Programme (PACPOL), would be dispatched immediately to Yap State. His initial brief would be to provide an independent assessment of the situation and provide any advice on appropriate response options.



Oil Spill from USS Missinewa – Ulithi Lagoon, Yap State (Yap EPA photo)

Provision of Support by SPREP Under PACPLAN

This technical and scientific support was provided under the *Protocol Concerning Co-operation in Combating Pollution Emergencies in the South Pacific Region* (SPREP Pollution Protocol). The Protocol provides a formal framework for co-operation between Pacific Island Countries and Territories when responding to marine spills.

A regional contingency plan also exists called the *Pacific Islands Regional Marine Spill Contingency Plan* (PACPLAN). PACPLAN was adopted by consensus at an intergovernmental meeting of the South Pacific Regional Environment Programme (SPREP) and contracting parties to the SPREP Convention at the 11th SPREP Meeting held at Guam in October 2000.

Under Section 2.1 of PACPLAN SPREP has agreed to:

- Provide/co-ordinate scientific and environmental advice to island member governments in the event of a spill.

This report summarises the findings of the Strategic Environmental Assessment (SEA) carried out by the PACPOL Marine Pollution Adviser (MPA) and makes a number of recommendations to the Yap State and FSM Governments.

Objectives of Strategic Environmental Assessment

In discussions with Yap State Disaster coordinator and various other agencies of Yap State the following objectives were determined by the Marine Pollution Adviser (MPA) to guide field assessment activities at the spill site.

- To confirm if all oil leaks from the sunken USS Mississinewa refueling oil tanker has ceased.
- To determine the resources at risk in the area of the spill and any ecological damage.
- Document the oiling and physio-ecological character of the shorelines of Ulithi lagoon.
- To assess extent of remaining oil on shorelines with particular focus on the environmentally sensitive islands known as the "turtle islands", to the south east of the lagoon.
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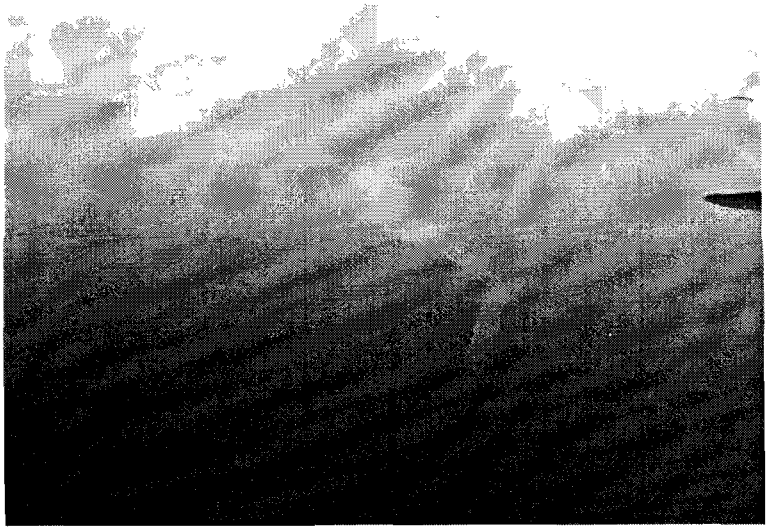
(Yap EPA photo)



Section 1.

Assessment of Wreck, Response Options and Recommendations for Action

On September 8, 2001 two SCUBA dives were carried out by myself and Faustino Yalomai (dive master) of Ulithi dive shop and underwater video footage of the wreck obtained. Mr Faustino Yalomai had dived the wreck many times and was involved in the original discovery of the wreck early this year. He is probably the most knowledgeable diver on the wreck and was able to show the location of previous oil discharges. No oil was observed leaking or seeping from any location on the vessel during our dives.

No oil or rainbow sheen was apparent on the water surface above the wreck. Some screen grabs taken from the underwater video tapes are provided in this report. *(please disregard the incorrect time stamp as Mr Yalomai had not reset the cameras timer prior to the dive, the timing of the dives were midday on September 8, 2001.)*

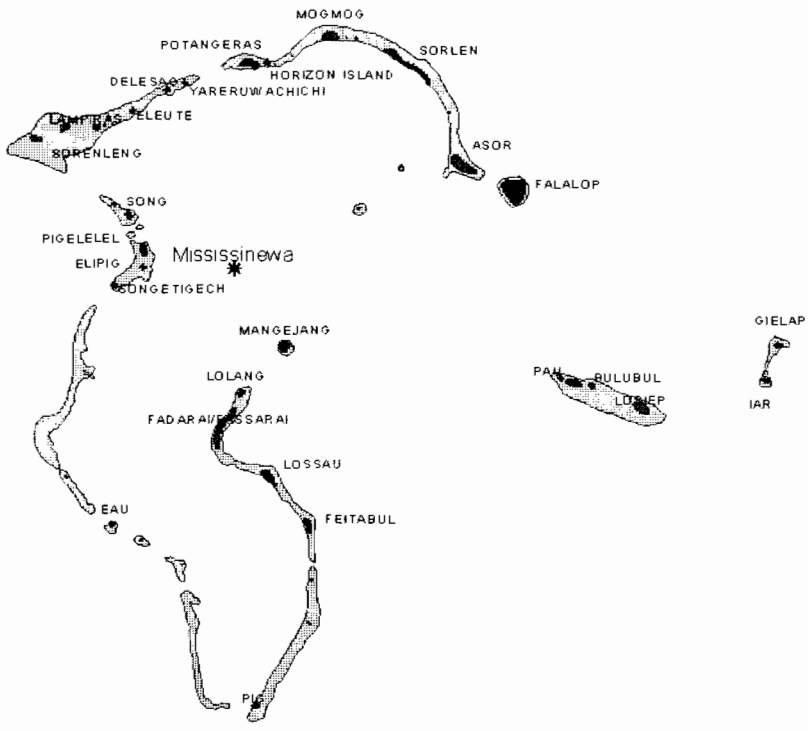
Condition of USS Mississinewa Wreck

The vessels damaged bow is on its port side with the remainder of the vessel hull facing vertically up with some wreckage and debris from the forward sections of the ship located between the two. There has been two geographic location of the wreck reported in the information provided.

E 139, 39', 37.3" (Long. 139.6604)
N 9, 58', 43.6" (Lat. 9.9788)

The position provided by the Yap Dept of Transport has been used for the GIS mapping on Ulithi nautical charts (figure 1& 2) ie.

E 139, 39.911' (Long. 139.6652)
N 9, 58.898' (Lat. 9.9816)



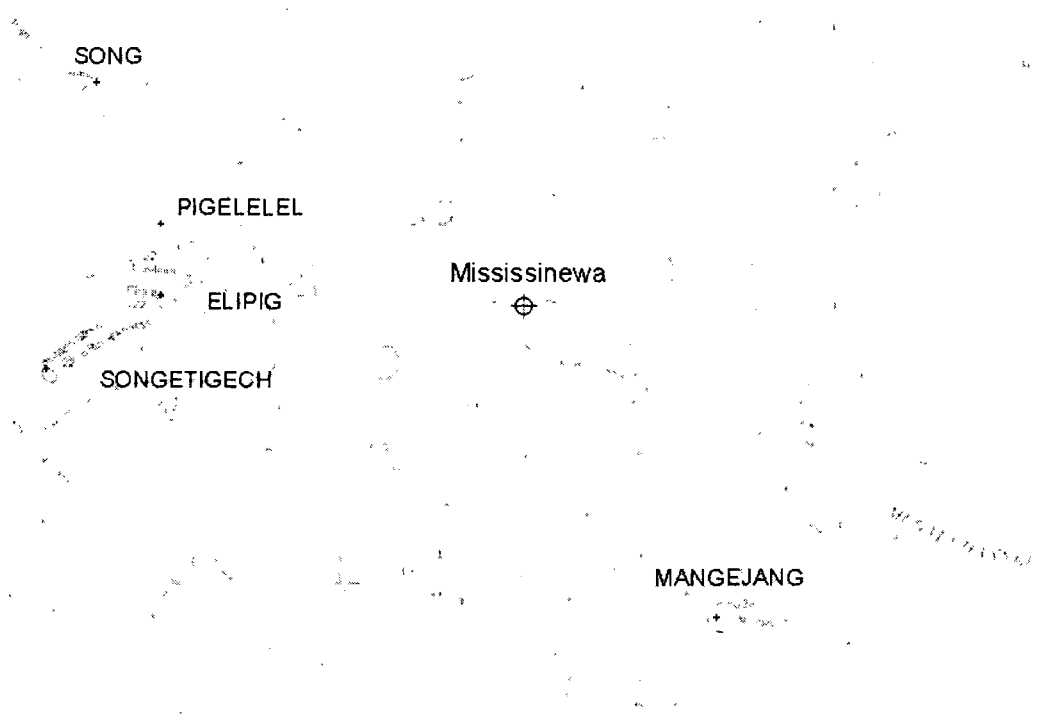


Fig.1 & 2 - Ulithi Lagoon Islands, Position of Atoll Reefs and Location of the Sunken Vessel USS Mississinewa on Ulithi Lagoon nautical chart.

The vessel position is in relatively deep water (about 40 meters- 120 ft) and approximately 2.5 nautical miles (nm) in a NW direction from Mangejang Island and 2 nm from the Mugai Channel.

Only an external visual inspection of the wreck was carried during the two dives. The external appearance of the hull is good with no major superstructure problem areas noticed during the dives. No internal assessment was carried out due to safety considerations working on limited SCUBA air and at below 35m on the wreck.

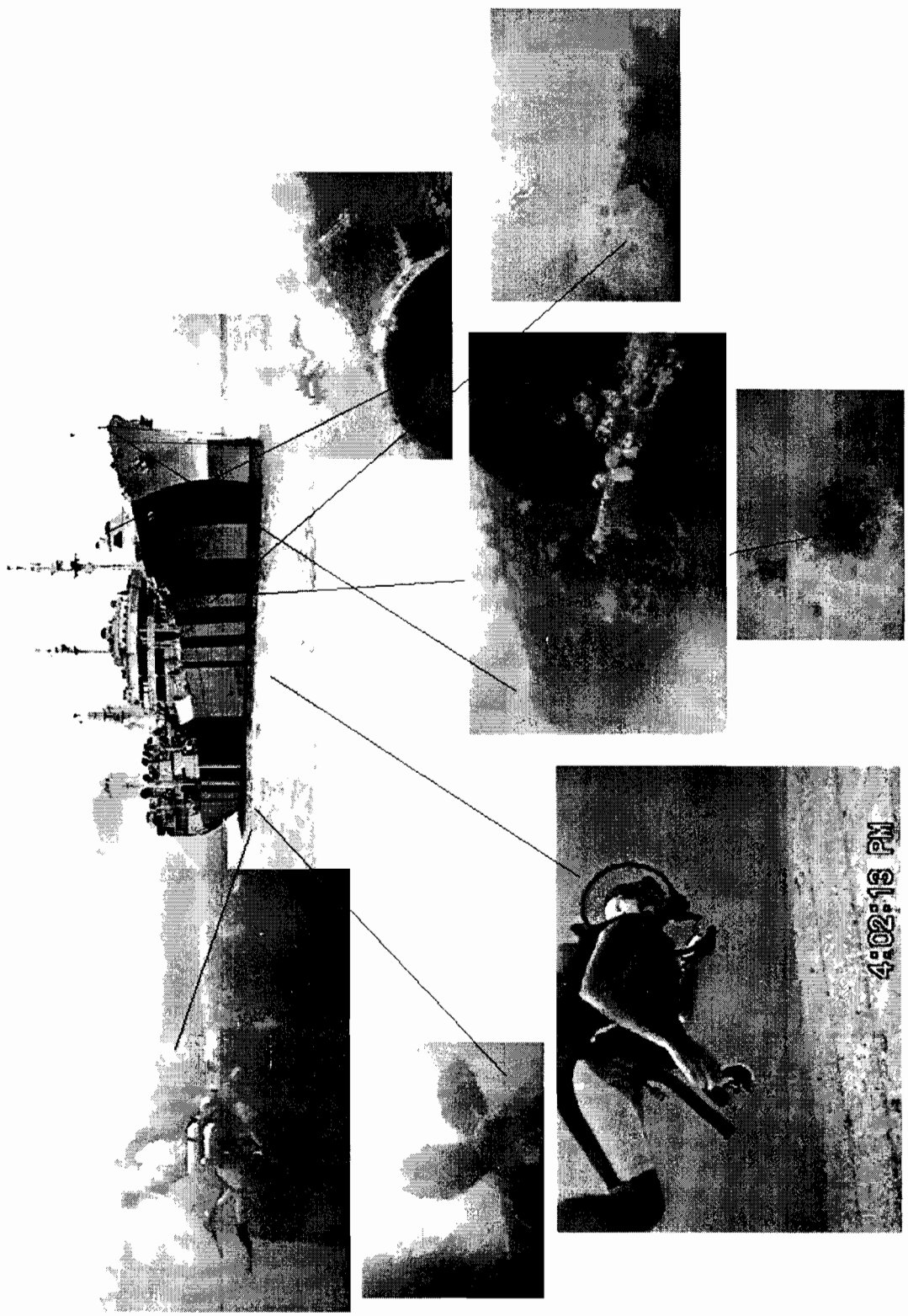
For a visual interpretation of the wreck please see attached montage of underwater photos with arrows indicating approximate locations to the original vessel. (figure 3)

The US Navy, salvage team experts and dive contractor reports were not available at the time of this report, nor provided to the Yap government during my assessment. From verbal accounts given to Yap officials from the Navy salvage contract divers it appears that metal thickness measurements on the vessels hull structure showed varying thickness and remarkably good for the age of the wreck.

It should be remembered that the hull is usually the most robust structure of the vessel and coated externally with antifouling/anticorrosion paints. Also that metal thickness measurements are only an indication of general metal wasting and does not account for random pit corrosion the most common source of oil seepage from wrecked vessels of this age. Pit corrosion often occurs at metal fractures, damage points, inconsistencies and impurities within the plate steel and other steel components, a common problem with mass produced vessels of this era especially exposed to 55 years of seawater at elevated temperatures of the tropics, accelerating the metal loss.

Figure 3.

Montage of underwater screen grabs from underwater video of USS Mississinewa Inspection Dives indicating reference points to historical photo of the vessel.



Oil leakage from wrecked ships also often occur at pipe-work and at mechanical connections, valves and joints, usually in internal parts of tanks and the vessel. Fasteners over time lose their ability to hold flanges (e.g. nuts and threads waste away), rubber seals fail and the ingress of seawater to metal components and seals causes rust and metal wastage. Iron oxide (rust) occupies more physical volume than iron/steel itself causing expansion and the forcing apart of the already weakened fasteners, hence oil leakage and seepage.

Currently the oil leak has ceased due to the temporary repairs undertaken by the US Navy contractors and dive teams. But there is major doubt and uncertainty in my mind as to the structural integrity of the vessel in the long term. I believe it is not a case of "if" the next oil leaks occurs from the USS Mississinewa but "when".

It must be recognised that the wreck is:

- at least over 55 years old,
- been continuously exposed to corrosive seawater at high oxygen levels and at high water temperatures accelerating steel corrosion,
- weakened by the initial explosions that sank the vessel and the fires on board prior to it sinking,
- served in combat with associated wear & tear prior to sinking
- has settled over time into bottom sediments and will continue to do so placing different structural stresses and strains on the vessel over time,
- suffered the impacts of typhoons and storms over many decades,
- suffered slow degradation of the structure due to general metal loss from rust,
- already shown that the loss of strength of fasteners throughout the vessel superstructure and pipe-work causing further internal leaks of oil,
- already demonstrated a number of leaks by historical accounts over many decades.

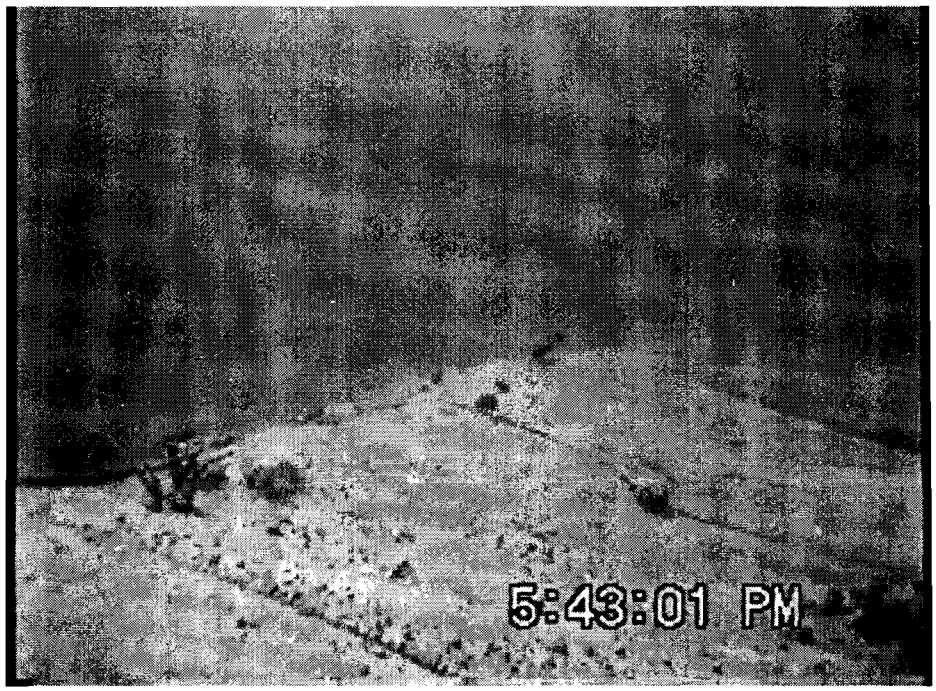


Figure 4. Deformed hull near section destroyed during sinking of USS Mississinewa

Figure 5. Deformed plate metal forward section USS Mississinewa

The possible release of oil from the wreck by the interference of the vessel and its oil tanks by unregulated recreational divers and souvenir hunters is a possibility. Yap government should consider that it allows only regulated dives on the wreck until it has been made safe and pollution free.

It must also be remembered that the vessel is a war tomb of the US and Japanese military for over 50 or more personnel and should be treated with the respect and reverence it deserves.

Scenarios for Possible Release of Further Oil from the Wreck

It is not a case of "if" the oil from the vessel USS Mississinewa will leak into the waters of Ulithi Lagoon but "when" and how much? From estimates provided by US Navy dive teams up to 9.6 million gallons of heavy fuel oil could still be on board the wreck. Two categories of scenarios could eventuate for the release of oil from the wreck one during a major storm event resulting in a catastrophic failure of one or more cargo tanks or slow gradual loss of oil over time.

Storm Event

The most likely scenarios for a major release of oil from the wreck of the USS Mississinewa is by a structural failure of one or more fuel oil cargo tanks caused by excessive stresses on the superstructure during tropical storms or typhoons.

Such a release could be anywhere from 1 to 9.6 million gallons released in to the lagoon from one or more of the vessels tanks ruptured. It could also be many days or weeks before ships could be on the scene and any response could be mounted in the remote atoll of Ulithi.

During one of these severe weather events resulting in high seas, storm driven currents/surges and winds of varying directions and velocity it would not be possible to seal leaks on the wreck, contain, nor recover released oil. Oil spilled during such events would spread quickly and contaminate much of the lagoon and its natural resources. There would not be any possibility of protecting sensitive foreshores during storm events even if spill response equipment and trained personnel were available in the region.

Figure 6. Stern section of USS Mississinewa - showing propeller, drive shaft and rudder system intact.

Storm surges, high wave action, strong winds and variable direction would result in much of the oil impacting on shorelines of the lagoon and distributed widely causing extensive environmental damage. The residual oil would also be driven high onto the upper tidal zones of the foreshores as well as the possibility of being driven by high wave action into the fringing coral reefs causing major impacts on the reef ecology and associated fisheries.

Slow Degradation of Vessel and Seepage of Oil

Another possible scenario for release of oil is a slow gradual degradation of the wreck resulting in chronic low level seeps of fuel oil, of varying quantities and over long time scales into the lagoon.

This low level chronic oil pollution of the lagoon is also unacceptable on both environmental and response planning grounds. On-going fouling of lagoon beaches from oil seeping from the wreck would result in many coastlines around the lagoon being impacted due to the changing seasonal winds & tides. This would result in on-

going ecological and wildlife damage as well as a need for continuous surveillance of the wreck, spill monitoring and on-going foreshore cleanup operations.

Response Options

The first line of any maritime pollution response where possible is to contain and recover the oil at the source before it impacts the environment.

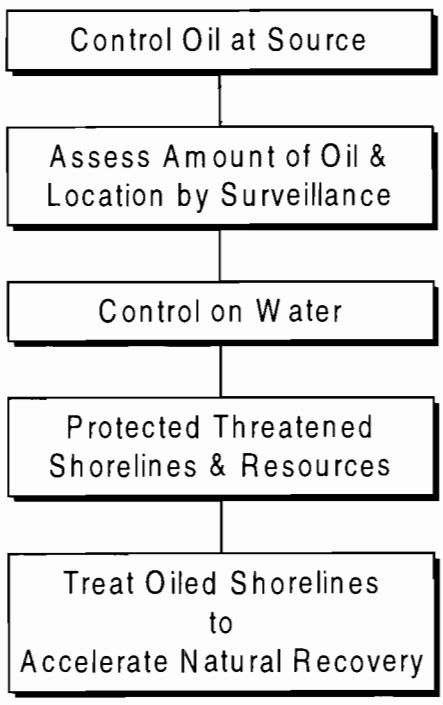
In almost all spill cases it is:

- easier
- more efficient
- less damaging
- generates much less waste and
- cheaper,

to remove oil from the source or from the water surface than it is to have to clean shorelines.

The priorities in spill response can be summarised in the following chart.

Priorities in Spill Response



Window of Opportunity for Remedial Action & Salvage of Oil

The release of the oil from the vessel over the past two months as well as the historical accounts of intermittent oil spills over the past few decades should be taken as a timely warning. A warning of the potential problems and impacts associated with a major release of the remaining oil from the wreck.

The only sensible option is to "hot tap" the remaining oil cargo tanks and pump out the oil under controlled conditions with appropriate contingency arrangements in the event of a failure in the oil salvage attempt.

There are a number of options for salvage of oil cargo including "hot tap" of tanks and pump out to a vessel of the surface, as well as "canopy containment" underwater and multiple release points created by divers. Conceptual designs can be provided by MPA for any of these cargo salvage options if required.

Severe weather events like tropical storms and typhoons are a major factor in the potential release of oil from the wreck. Any remedial or offloading actions of oil cargo from the vessel should avoid the peak storm/typhoon season.

There is a clear "window of opportunity" to offload the oil on the wreck under controlled conditions that can avoid severe weather periods and also the peak breeding season for turtles should also be avoided if possible.

Military Vessels and Marine Pollution Regulations

Although most world wide marine pollution conventions like MARPOL, other treaties and agreements as well as regional laws only have limited application to military activities and warships, governments reserve the right to apply internal codes of practice and standards on their own armed forces and military equipment.

Countries like Australia, the United States and other major military powers in the Pacific have codes of conduct and environmental impact management plans that exist for military operations, war games, vessels at sea and construction of facilities. The major military powers pride themselves on their high environmental standards and in leading by example e.g. "if government can't do it with its resources, then how do you expect industry to do the right thing"

Most developed countries acknowledge that they have a moral and ethical obligation to minimise the impact of their military operations and facilities, particularly during peace time and after combat action has ceased. For example the clean up of unexploded ammunition and on-going pollution from previous combat activities has been undertaken by US forces through out the Pacific both on land and at sea. E.g. Hawaii with removal of WWII wrecks causing potential pollution in fisheries areas, Palau with Navy Seals removing ammunition and potential oil pollution in tourist and recreational areas.

Compensation Claims During Oil Spills & Salvage of Vessels Cargo.

There is a global maritime insurance and oil pollution compensation regime for the oil tanker trade but often theses Conventions only applies to all seagoing vessels except warships or other vessels owned or operated by a State and used on Government non-commercial service.

General criteria.

The following general criteria apply to all claims under existing commercial marine oil pollution and insurance regimes:

- any expense/loss must actually have been incurred:

- any expense must relate to measures which are deemed reasonable and justifiable
- a claimant's expense/loss or damage is admissible only if and to the extent that it can be considered as caused by contamination
- there must be a link of causation between the expense/loss or damage covered by the claim and the contamination caused by the spill
- a claimant is entitled to compensation only if he has suffered a quantifiable economic loss
- a claimant has to prove the amount of his loss or damage by producing appropriate documents or other evidence.

Salvage operations may in some cases include an element of preventive measures. Such operations can be considered under existing marine pollution conventions as a *preventive measure* only if the primary purpose is to prevent *pollution damage.* If the operations have another purpose, such as salving hull and cargo, the costs incurred are not admissible under the existing marine pollution Conventions. If the activities are undertaken for the purpose of both preventing pollution and salving the ship and cargo, but it is not possible to establish with any certainty the primary purpose of the operations, the costs are apportioned between pollution prevention and other activities. The assessment of compensation for activities which are considered to be *preventive measures* is not made on the basis of the criteria applied for assessing salvage awards; the compensation is limited to costs, including a reasonable element of profit.

For this incident as the vessel is a US war ship and the cargo the property of the US government sunk at a time of war and by a foreign nation (namely the Japanese Navy). The exact status of the vessel currently as to whether it was officially decommissioned is unknown at this time. This may need to be clarified with the US Navy and/or government channels.

Scale of Potential Future Spill Incident

Assuming a continuous steady oil release over the whole time period for this recent spill, somewhere between 18,000 (approx. 68,000 litres) to 24,000 gallons (approx 91,000 litres) of oil was released into the lagoon over the past two months.

From estimates provided by the US Navy dive team approximately 9,600,000 gallons (36,000,000 litres) remains on board cargo tanks within the wreck of the USS Mississinewa. Therefore only between 0.2% and 0.25% of the oil cargo was released in the recent oil spill.

The magnitude of the worse possible case scenario is between 400 and 500 times the amount of oil already spilt.

Recommendations for Minimisation of Further Oil Spills From the Wreck

The prime consideration in my recommendations is the conservation of the marine environment of the lagoon and its associated natural resources, which are essential for the maintenance of the health and standard of living for the population of the atoll.

There is major doubt and uncertainty in my mind as to the structural integrity of the vessel in the long term. I believe it is not a case of "if" the next oil leaks occurs from the USS Mississinewa but "when".

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From a spill responders standpoint the most efficient and cost effective response option is to "control at source" any potential marine pollutant.

The magnitude of the risk, the likelihood of extensive environmental damage, and common sense dictates that the most responsible option would be to tap the fuel oil tanks of the vessel and drain any remaining oil under controlled conditions from the deteriorating wreck.

The wrecks extensive oil cargo poses an unacceptable and ever present risk to the marine environment of Ulithi lagoon and should be offloaded under controlled conditions within the "window of opportunity" as specified. A number of options have been detailed in the body of this report.

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Section 2. Spill Conditions and Environmental Assessment of Foreshores

Geography of Ulithi Atoll Islands

Ulithi Atoll is approximately 100 miles northeast of the main Island of Yap and contains the highest population of the outer islands (around 750). Ulithi lagoon is the 4th largest in the world and encompasses 209 sq. miles of sea area and is made up of over 49 islands. The total land mass is only around 1.79 sq. miles.

The atoll islands mostly have fringing reefs and extensive atoll reefs join many of the Islands in a continuous band. The interior of the lagoon varies in depth from 40 meters to only a few meters. A number of navigable channels allow large vessels to enter and anchor in the lagoon.

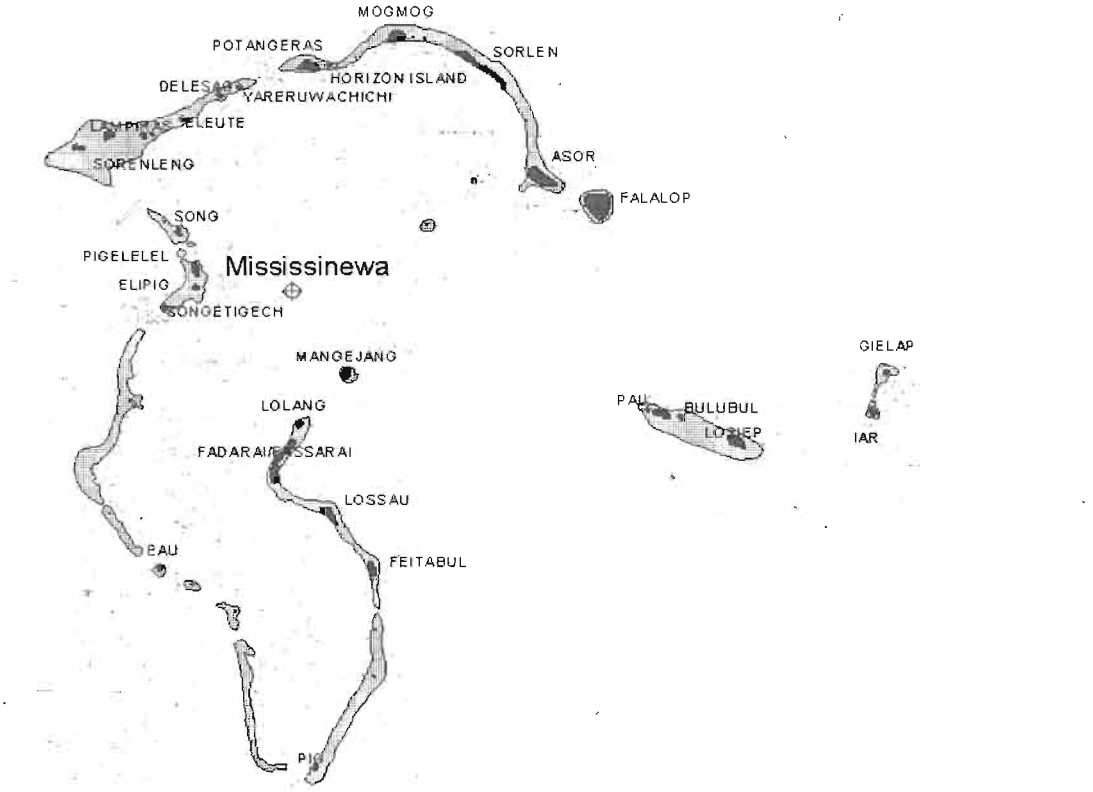

Figure 7. Reefs, channels and major Islands of the Ulithi Lagoon on ArcView GIS

Ulithi played a significant role in WWII for both the Japanese and then the United States military. It was a major sea plane base, weather and communications center for the Japanese then in September 1944 the Americans took over and constructed many buildings and other facilities on the islands and the airstrip on Falalop.

Ulithi atoll was a major anchorage, supply and regional base for the final six months of the war as troops massed for the final assault and possible invasion of Japan (Okinawa)

Many tens of thousands of military personnel used the various islands and it is reported that close to 700 ships were at one time anchored in the lagoon.

Sinking of the USS Mississinewa in Ulithi Lagoon

The USS Mississinewa was essentially an oil/fuel tanker (auxiliary oiler) supplying a range of aviation fuel and heavy marine fuel oil for the regional US fleet. In November, 20 1944 a manned Japanese torpedo hit the vessel and sank it in 40 meters of water near Mangejang and Lolang Islands along with around 50 personnel.

It was not until April this year that a private dive team found the exact position of the wreck within the lagoon.

It has been reported in the web site http:/www.ussmississinewa.com that both aviation gasoline and a full load of full oil went down with the vessel but it is not known how much survived the attack, subsequent fires and leaks.

Period of Spill and Quantity of Oil Released

It has been reported by the local population of Ulithi that the oil spill commenced early in July after a tropical storm and the final containment of the leak was reported by the divers in late August 2001. The result time period would have around 60 days approximately.

The spill was not reported to the Yap authorities until early August one month after the first oil was sighted in the lagoon.

In a flow test carried out on the oil leak from the USS Mississinewa by MRMD personnel estimated between 300-400 gallons leaking per day.

Assuming a continuous steady release over the whole time period, somewhere between 18,000 (approx. 68,000 litres) to 24,000 gallons (approx 91,000 litres) of oil was released into the lagoon during that period.

From estimates provided by the US Navy dive team approximately 9,600,000 gallons (36,000,000 litres) remains on board tanks within the wreck of the USS Mississinewa. Therefore only between 0.2% and 0.25% of the oil cargo was released in the recent oil spill.

Assimilation of Oil into the Environment

Most oils will eventually be assimilated by the marine environment. However the rate at which this occurs depends on the chemical and physical properties of the oil, the amount spilled, the prevailing climatic and sea conditions, whether the oil remains at sea or is washed on shore and the type of shore it is washed onto.

In figure 8 the dark oil is in the center of the slick, sheen is seen dispersing even under calm sea conditions.

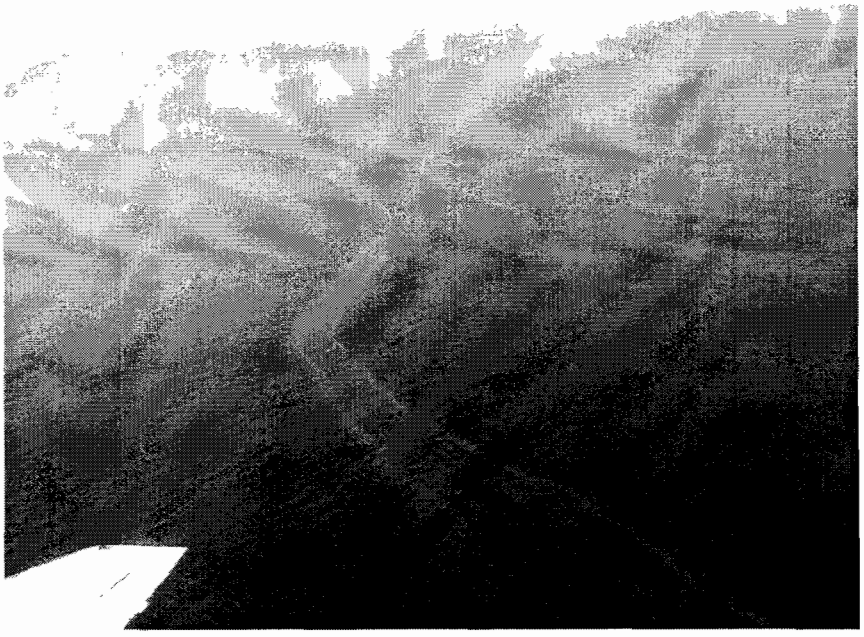

Figure 8. Oil spill plume from USS Mississinewa- Yap EPA photo
(Oil rainbow sheen dispersing from darker oil band under calm sea conditions)

Type of Oil Spilled

In considering the fate of spilled oil at sea and the likely impacts a distinction has to be made between persistent and non-persistent oils. In this case the fuel oil is a blend of non-persistent as well as persistent oils. It appears to be a blend of bunker oil (#6) and marine diesel (#2)

Figure 9. Photograph of oil sample taken by divers at wreck.

Tests requested by MPA and performed at the local science lab in a local Yap school yielded the following evaporation results.

Under still and windy conditions simulated in the lab the oil has evaporated between 10-20% of its weight over a 2 day period. This demonstrates that the oil will leave considerable residues even after 2 days of weathering at sea. The oil is obviously a heavy fuel oil with only between 10-20% of lighter oil blended.

Some of the oil will naturally disperse and dissipate as the slick spreads, some components will dissolve into the water other amounts onto sediments which can settle into inter-tidal zones.

The heavier persistent components can form emulsions in rough seas or end up as tar balls and pats on shorelines or travel long distances at sea.

Figure 10. Photograph of tar pats on beach on Falalop Island.

Environmental Factors that Affect Oil Fate

To assist the understanding of the weathering and fate of oil in the marine environment please refer to the appendix (1)

Environmental factors which affect the fate and removal of oil are:

- Area of slick exposed, which changes rapidly
- Wind speed and water surface roughness
- Air temperature and exposure to sunlight (solar radiation)

- Formation of emulsions, which dramatically slows evaporation

The high water and ambient temperatures of the lagoon as well as high winds accelerate the evaporation rate of the oil spilled. The ambient average temperature of the region is 81F (27C) with less than 10 degree variance between night and day.

Under the spill conditions in Ulithi Lagoon, the released fuel oil after weathering would behave in a manner similar to conventional #6 fuel oils. By observations from the leaking tanker it has a slightly lower density than full-strength seawater at tropical temperatures. Many heavy fuel oils are likely to float and remain liquid during the early stages of a spill. The light fractions will be lost by evaporation, and the floating oil will initially form contiguous slicks. Eventually the slicks will break up into widely scattered fields of pancakes and tarballs, which can persist over large distances and concentrate in convergence zones. Because of the higher viscosities of these oils, the tar balls may more persistent than expected for conventional crude oils.

Wind Conditions Ulithi Atoll

Wind speed and direction data requested from the Yap Meteorological office was provided for the months of July and August. This data was taken at the Ulithi airport monitoring station at Falalop and provided manually at 6 hourly intervals.

In summary the high winds speeds of early July (2nd July) were in a SW to SSW direction exceeding 35 knots (wind monitoring ceased recording at that time –actual wind speeds could have much greater than that recorded). Wind data sets resumed early on the 3rd July and had reduced to light winds SW to SSW. For the remainder of July winds were variable and mostly light from SW-SSW and then W to WNW to NW. Later in month winds were also recorded coming from the E to ENE to NE also. No consistent pattern was established for wind direction during July.

For August light winds of variable direction were recorded until the mid month storms where winds speeds varied from 14 to 27 knots lasting around 6 days. The direction of the wind was from initially from the WNW then W then WSW then SW then SSW. Variable strength winds persisted for the remainder of July generally from the SW and W directions.

It can be seen from the wind recorded that winds over the months of July and August were of varying strengths from light to strong and that wind direction varied considerably. Resulting in no one predicted path for any leaking/spreading oil but distribution in many directions within the lagoon and at different speeds.

Ecology of Ulithi Atoll and Lagoon

The atoll of Ulithi have extensive coral reefs both fringing the islands and connecting the islands which act as barrier reefs to the lagoon. Both extensive emergent and submerged reefs exist in the region.

Figure 11. Photograph of atoll reefs – aerial photo Ulithi Lagoon.

Significant subsidence fishing occurs both within the lagoon on the reefs surrounding the islands as well as outside the lagoon. Many species are utilised by locals (see section 3 Impact on fisheries)

Sandy shores of the lagoon form a large part of the coastline. They are ecologically important as a habitat for a variety of organisms, including crabs, birds and nesting turtles.

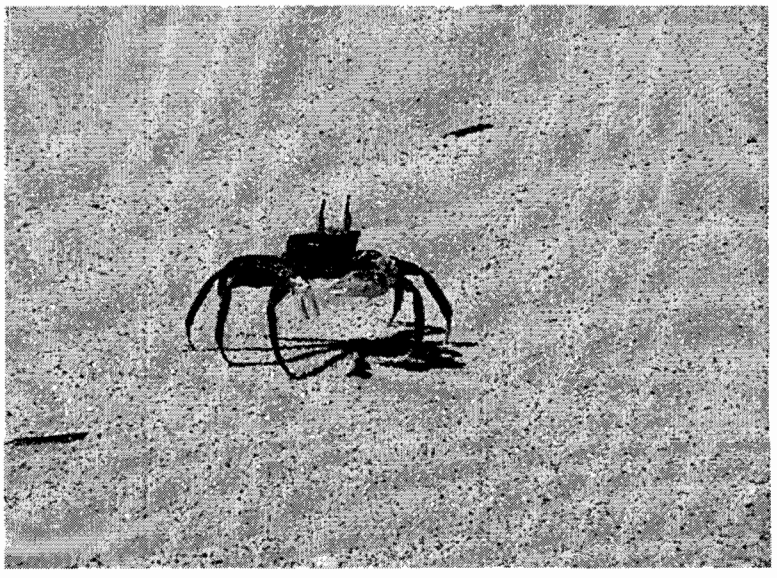

Figure 12. Photo crabs Mangejang Island.

There are many protected and endangered wildlife that utilise the islands of the lagoon as well as to the west of the lagoon known as turtle and crab islands. Pau, Bulubul, Losiep, Gielap and Iar are known turtle nesting/hatching islands with significant populations of green turtles possibly over one thousand using the islands to breed and forage.

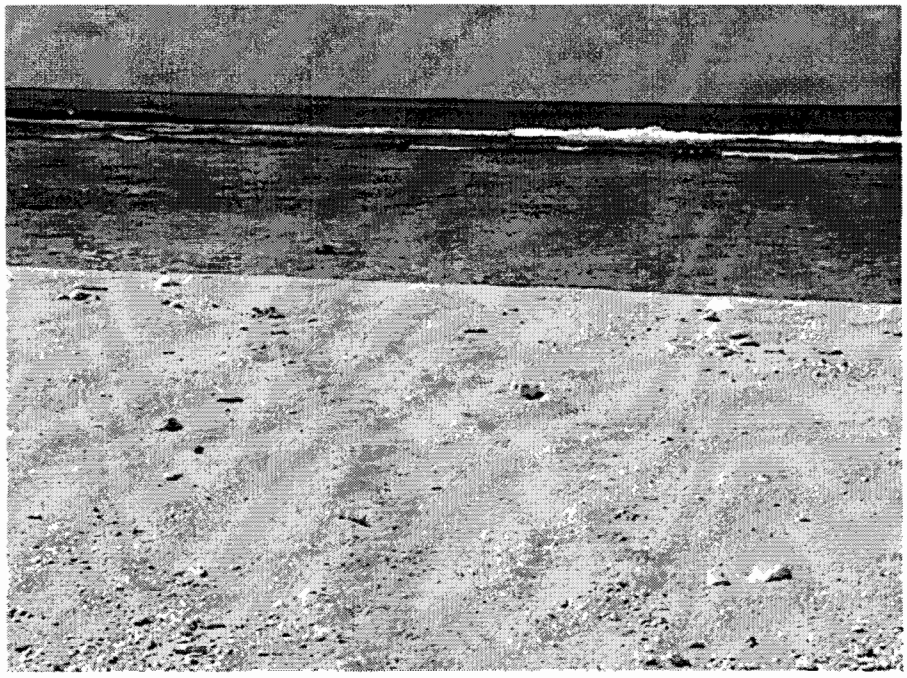

Figure 13. Fresh turtle tracks nesting - Gielap Island.

For details on the turtle types, population, feeding and nesting habits and please refer to Appendix (2)

Some foreshores are essentially flat form limestone rock others contain coral rubble and rocks that are moved and transported by the storms that impact the lagoon.

Figure 14. Coral rubble foreshore with tar ball – Pau Island Ulithi Lagoon

Methodology used for Strategic Environmental Assessment

The volume of oil lost is not necessarily the most important factor in determining the seriousness of an oil spill incident. The location of the incident, how the oil behaves and weathers, the prevailing sea and weather conditions as well as the sensitivities of the environmental resources it impacts are often the important considerations.

The main questions that pose the greatest scientific problem in addressing the environmental impacts during oil spill events are:

What environmental damage has occurred?
How long will it take for the environment to recover?

The seven main steps used in the strategic environmental assessment were:

1. Cross check existing information & reports
2. Identify major types of habitats/ecosystems
3. Assess intertidal biota
   - character/health
   - state of indicator species on shores
   - mortality
4. Assess health of nearshore, shallow and subtidal areas
5. Observe and assess wildlife
   - species
   - abundance
   - any oiled
6. Assess any ecological constraints on cleanup operations
7. Provide photo documentation

Biological and other impacts of oil spills

The range of oil impacts during and after an oil spill can range from:

- Physical and chemical alteration of natural habitats e.g. resulting from oil absorption into/onto sediments
- Physical smothering effects of fauna and flora
- Lethal and sub-lethal toxic effects on fish, fauna and flora
- Short and longer term changes in biological communities resulting from oil effects on key organisms (e.g. food chain interruptions)
- Tainting of edible species, notably fish and shell fish
- Loss of use of amenity areas such as sandy beaches
- Loss of market for fisheries and tourism
- Fouling of boats, fishing gear, boat ramps, jetties etc.
- Temporary interruption of any marine based industries.

Practical Criteria used to Assess Foreshore Contamination During a Spill

A modified assessment procedure commonly referred to by oil spill practitioners as SCAT was used. Time and resources did not allow a full scale SCAT assessment of all the shorelines of the lagoon as well as conduct an impact assessment on the ecology of the area.

It is unrealistic to expect to remove every last trace of oil from the water and shoreline after a major oil spill. Not only would it be expensive and time consuming but sometimes inappropriate, or over zealous, clean up operations can do more damage to a habitat than the oil itself. Therefore a practical and pragmatic approach was used to determine if the various shorelines assess were "clean" during this assessment. The ad hoc criteria used was:

- Is the remaining oil a potential source of harm to the environmentally sensitive resources of the lagoon?
- Is the remaining oil affecting or disrupting the economic resources or subsidence living in the area?
- Does the remaining oil interfere with the aesthetic appeal and amenity use of the shorelines of the lagoon?
- Do the benefits of cleaning the remainder of the oil from the shorelines outweigh the environmental and economic costs?

Given the high sensitivity of the human senses to oil hydrocarbons, if sight and smell can not detect any remaining oil it is therefore not present in sufficient quantities to cause concern to the foreshores and wildlife in the region.

1. *Sandy beaches were considered as "clean" with no visible oil, oily feel or smell of oil at the surface or at depth in the sand.*

2. *Water surface is considered "clean" when no visible oil slick, sheen that could adhere to the feathers of sea birds or contaminate boats, nets and fishing gear.*

3. *Shorelines that are major habitats for seabirds, turtles, crustaceans, molluscs and other intertidal life are considered "clean" when the oil residues do not impact that wildlife directly, inhibit the use if that habitat or slow the ecological recovery after a spill.*

4. *Rocky shores and manmade structures with low public use or recreational use was considered "clean" where no gross oil contamination was visible or can leach oil into near shore waters.*

Exposed areas are usually "weathered" by the action of the waves and suspended sand self-cleaning or "polishing" of the remaining oil from the rocks helps remove residual oil staining.

To assess when a habitat has "recovered" after an oil spill the guiding principle should be *"has the biological communities, both plants and animals, characteristic of that habitat present in sufficient numbers and diversity and are functioning as normal"* e.g. feeding, breeding & behaviour.

Summary of Movement of Oil Impact and Locations

It appears that during the recent storm events, normal tidal fluxes and ocean currents as well as the usual light and variable winds the continued oil spill over the past 2 months has moved oil through out the lagoon as well as impacting Fais Island 50nm SE from the spill.

Summarising the reports provided by US Coast Guard, the Yap EPA and MRMD surveys along with this SEA report the following impact zones can be represented.

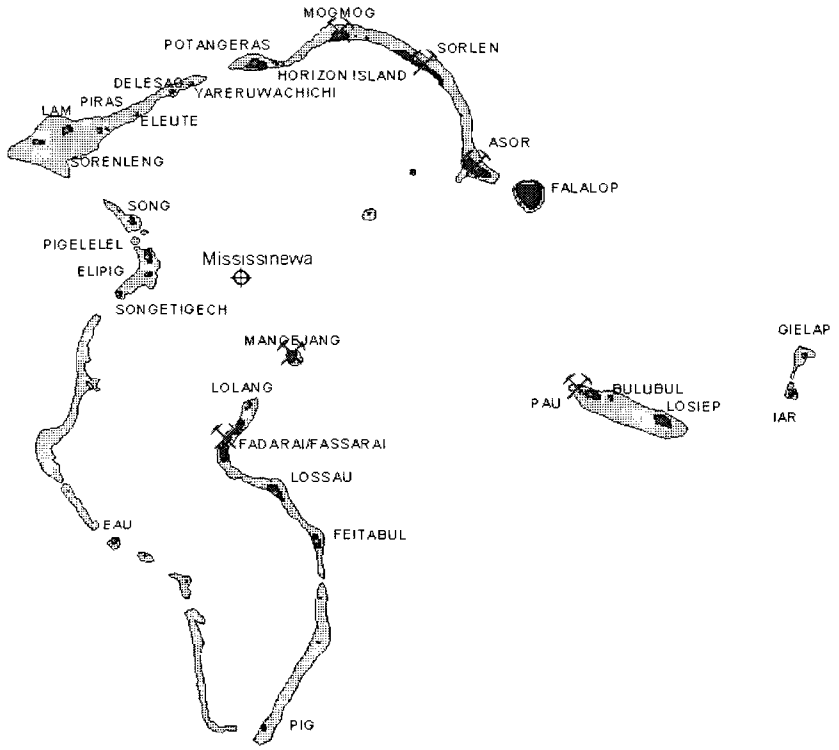

Figure 15. GIS screen grab summarising field surveys of Ulithi Lagoon showing positive sightings of oil by survey teams.

Assessment of Oil Deposited on Fais Island

Fais Island is a single limestone Island 50nm from Ulithi with a significant elevation of 60 ft compared to the other Islands in the region. It is just over 1 sq. mile of land with partial fringing reefs, some sandy beaches, cliffs and some sea caves. The population of around 250 people is centered on the western shore mostly in one village

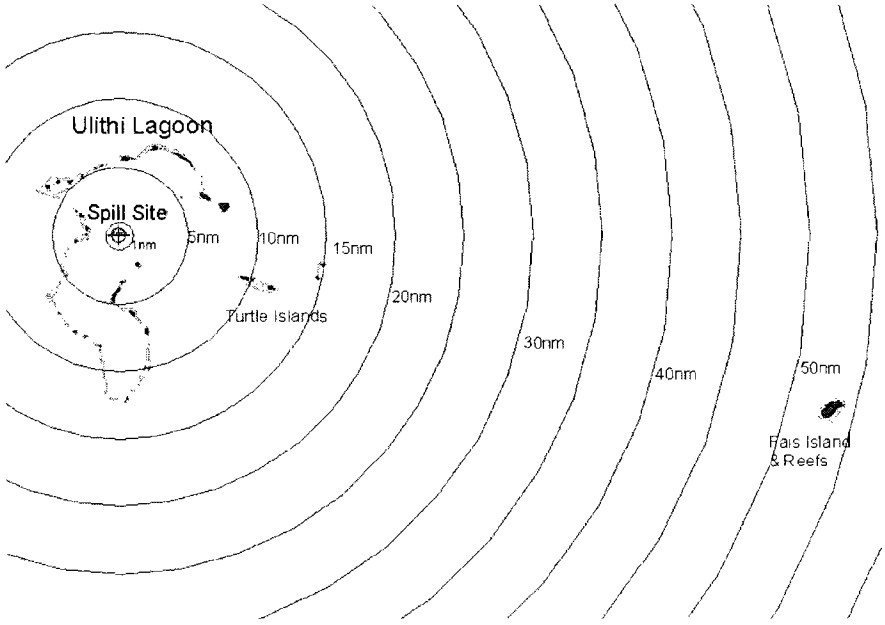

Figure 16. Distance measurements from spill site the significant locations in region.

Reports had been received that oil had washed up on beaches of Fais Island 50nm from Ulithi lagoon in recent days. On September 7, 2001 an assessment was carried out in conjunction with Yap EPA on the two major beach areas of Fais Island, the region known as the Japanese Harbour (an previous phosphate loading port on the northern side of the Island) and the main beach near the village locally called Fatadol. No oil was observed on the Japanese Harbour foreshore but a small amount of tar balls on the upper-tidal area of the rocky platform foreshore was found.

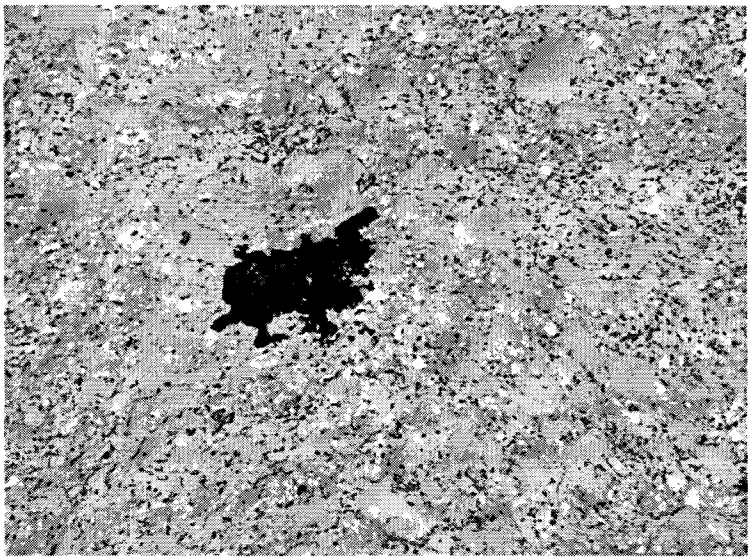

Figure 17. Photo tar pat western shore Fais Island

The oil residues on Fais Island had the same visual appearance, odour, texture, colour and character as that found on other beaches around the spill site.

Without chemical fingerprinting of the oil we cannot be 100% sure that the source of the oil was from the USS Mississinewa, but it highly likely that it is the same oil considering the similar nature of the oil residues, the wind, currents and proximity to the spill site.

On the flight to/from Fais minor oil sheen was observed on the waters near the island.

Assessment of Oil Deposited on Ulithi Atoll Islands

During the two days for the dives upon the wreck and field assessment of the islands in Ulithi only a few major islands could be surveyed. The main focus was to assess the sensitive islands known as the "turtle & crab islands" to the south east of the lagoon.

Surveys were conducted on the following islands by MPA and Yap EPA representative Peter Fattamag.

- Fais (see previous)
- Gielap
- Iar
- Pau
- Falalop
- Asor
- and Mangejang islands.

During the field surveys of 8 and 9th of September, oil was found on the Islands of Ulithi Atoll Islands of Falalop and Pau. Previously on the 7th of September at Fais Island also.

Small trenches were dug in the sand on all islands surveyed to determine if oil had been buried in sediments. No sign of any oil was found in all trenches due on the surveyed islands.

It was noted in the surveys that turtles are still nesting/laying on the islands of Pau, Gielap and Iar as well as tracks of baby turtles hatching were apparent over most beaches. One dead baby green turtle was found that had died of exposure and no signs of oil were apparent.

Figure 18. Dead baby turtle –Gielap Island

A large adult Green Turtle was found dead on the Eastern shore of Iar. It had been dead some time (3-4 weeks) but no oil was apparent near or on the turtle. The turtle was on its back and apparently had died of natural causes.

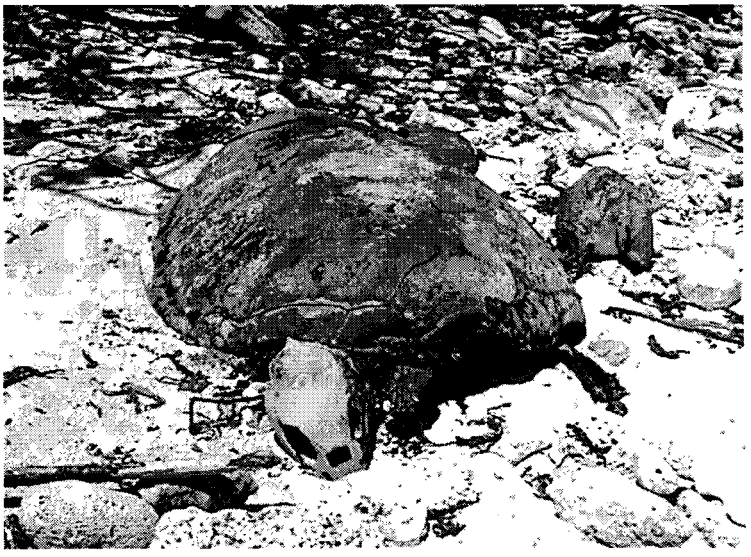

Figure 19. Photo of dead adult green turtle – Iap Island

Significant bird populations were apparent on both Iar and Gielap. Many nests were occupied and no signs of dead or oiled birds on the islands. The bird population appeared to be diverse, healthy and very active with no signs of oil contamination, oil intoxication or behavioural changes.

Figure 20. Photo – Red footed Booby – Iar Island

The hermit crab population was extensive with crabs of all sizes on the beaches and in upper tidal ranges. No signs of any abnormal crustacean or mollusc mortality was apparent above normally expected on tropical foreshores.

A report had been received of a dead turtle washed up on the southern beach of Asor and reported by locals to have died from the oil spill.

On examination of the turtle, a juvenile Hawksbill, there was no apparent evidence to indicate that it had died from the oil spill. The head and some flippers had been eaten off by local dogs and it had been dead for a few days. No oil was on the shell or remaining body parts. It cannot be ruled out that oil had been ingested or inhaled by the turtle causing mortality.

No oil was apparent on the southern beaches of Asor during our inspection of the dead turtle.

The turtle island of Pau had a small quantity of tar balls on the southern beaches in the upper tidal area. It was also observed that recent turtle tracks showed that nesting/laying was still occurring on those beaches. No oil was buried or seen on the water in the area of the turtle islands during our surveys.

The western beaches Falalop facing the lagoon was probably the most contaminated with oil during our surveys. This oil tar balls and mats were concentrated in the region near the concrete boat ramp and the boat harbour (small boat anchorage formed by US Navy in WWII for landing craft access to Falalop)

The oil was mostly weathered but in the strong sun some oil pats were melting and slowing flowing down the rock face. Samples were taken of the residual oil for the Yap EPA purposes and security tags sealing the samples prior to transportation to the analytical laboratory.

Figure 21. Photo of oil melting in sun on shore of Falalop Island

Less than a few percent of oil coverage was noted in the surveys and very patchy in distribution across the platform rocks. No obvious environmental damage was apparent from the residual oil. The main problem is aesthetics of foreshore and concern raised by locals of the "pollution" whilst walking the beaches.

Natural Foreshore Cleaning Processes

In spill response cleanup operations it is now recognised that nature plays a significant role in cleaning and restoring oiled foreshores after a spill event. Mostly by the action of waves and physical abrasion and removal of oil from foreshores by entrained sediments.

Waves are important at an oil spill site in that they can work against spill response containment and recovery operation and can assist in oil removal from the sea and foreshore cleaning. Waves have the advantages and disadvantages in that they:

1) May inhibit cleanup activities by creating rough seas.
2) Disrupt or inhibit booming activities.
3) Mix oil into the water column.
4) Erode the beach.
5) Cleanse beach sediments of oil.

Many of the foreshores previously contaminated by oil have now been surveyed and found clean. The natural cleaning processes of waves and sediment have removed much of the oil from the foreshores of the lagoon but the question remains....

Where has that residual oil gone and where are the oiled sediments now?

Possibility of Contaminated Sediments in Near Shore Regions

Oil which remains at or near the surface and which is exposed to heavy wave action does not persist for long but subsurface or oiled sediments may in some cases persist for several years.

When heavy persistent oil residues are transported into shallow water, it is more likely to be temporarily mixed into the water column by wave turbulence because it is relatively heavy. (figure A below)

Where the bottom is sandy, the sand is also suspended in the water column by the waves, and some sand is mixed with the oil. The specific gravity of quartz is 2.65 and calcium carbonate is 2.71, so it only takes about 2-3 percent sand by weight mixed into oil with a specific gravity of 1.00 to make it heavier than seawater. The oil/sand mixture is deposited in relatively sheltered areas where it can form extensive, thick layers of oil on the bottom (figure A & B).

The intertidal zone could also be fringing coral reefs where the deposited oil could cause more extensive damage than sandy beaches indicated in the diagrams.

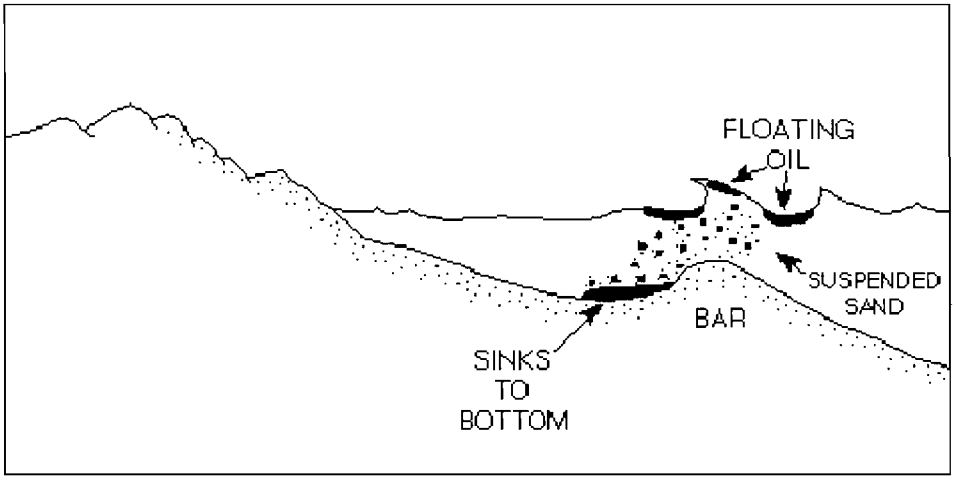

Figure A – Suspension of heavy oil in surf zone and sedimentation process of heavy persistent oil with sand that causes majority of oil to settle in intertidal zone.

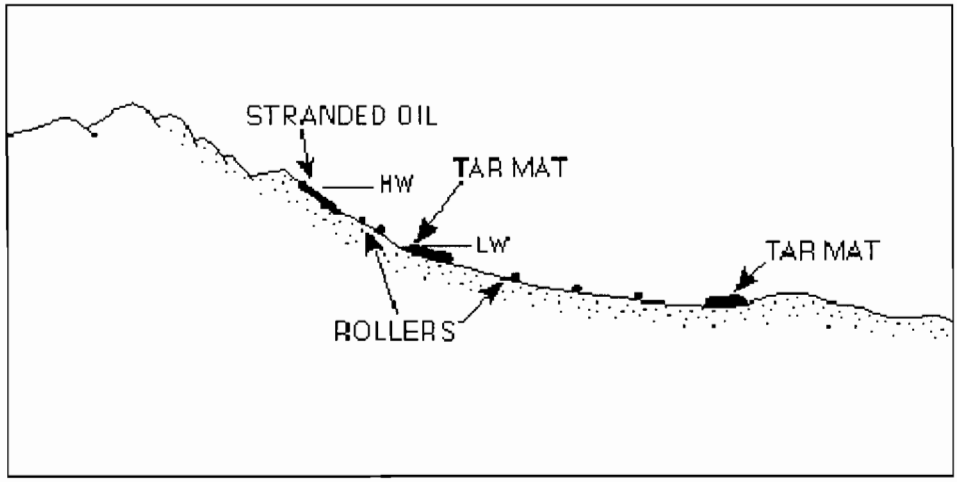

Figure B - Sedimentation process of heavy persistent oil with sand that results in a mixture of stranded oil above the high water line and also settlement within the intertidal zone.

When heavy contamination of sediments by oil occurs it is likely to have an adverse effect on local populations of bottom dwelling species (benthic life) or intertidal life.

No surveys were carried out in the near shore tidal zones to determine if any oiled sediments had been deposited by sedimentation.

This is a major gap in the knowledge of the fate of the heavy residues of oil removed by the natural foreshore cleaning processes. Where is the "sink" for all the remaining persistent oil residues in Ulithi lagoon?

It is recommended that surveys be carried out in Ulithi lagoon to determine if any oiled sediments exist in any significant quantities in the intertidal and near shore areas of the previously oiled foreshores.

Summary of Foreshore Impacts on Ulithi Islands & Recommendations

From the surveys carried out on a limited number of islands in the atoll it is apparent that no major foreshore oiling remains in Ulithi lagoon. Some oil had impacted the turtle island of Pau.

The western beaches Falalop facing the lagoon was probably the most contaminated with oil during our surveys. This oil tar balls and mats were concentrated in the upper tidal zone region near the concrete boat ramp and the boat harbour.

The natural removal/cleaning processes due to wind, wave and sediment abrasion action during the storms to have passed through the region over the past few months has helped the self cleaning of most of the previously oiled foreshores.

A major gap in the knowledge of the fate of the heavy residues of oil removed by the natural foreshore cleaning processes. Where is the "sink" for all the remaining persistent oil residues in Ulithi lagoon?

It is recommended that surveys be carried out in Ulithi lagoon to determine if any oiled sediments exist in any significant quantities in the intertidal and near shore areas of the previously oiled foreshores.

The hermit crab population was extensive with crabs of all sizes on the beaches and in upper tidal ranges. No signs of any abnormal crustacean or mollusc mortality were apparent above normally expected on tropical foreshores.

No dead turtles examined showed any sign of oil contamination and the deaths may be attributed to natural causes.

The bird population appeared to be diverse, healthy and very active with no signs of oil contamination, oil intoxication or behavioural changes

No apparent or significant damage was observed on wildlife by the oil spill on any island surveyed during this assessment.

.....

Section 3.

Impacts on Fisheries from the Oil Spill

The population of Ulithi lagoon have a high reliance on subsidence fishing in the lagoon and utilise many different species for consumption in the household or villages.

The population of Ulithi are located primarily on four islands (see figure 22)

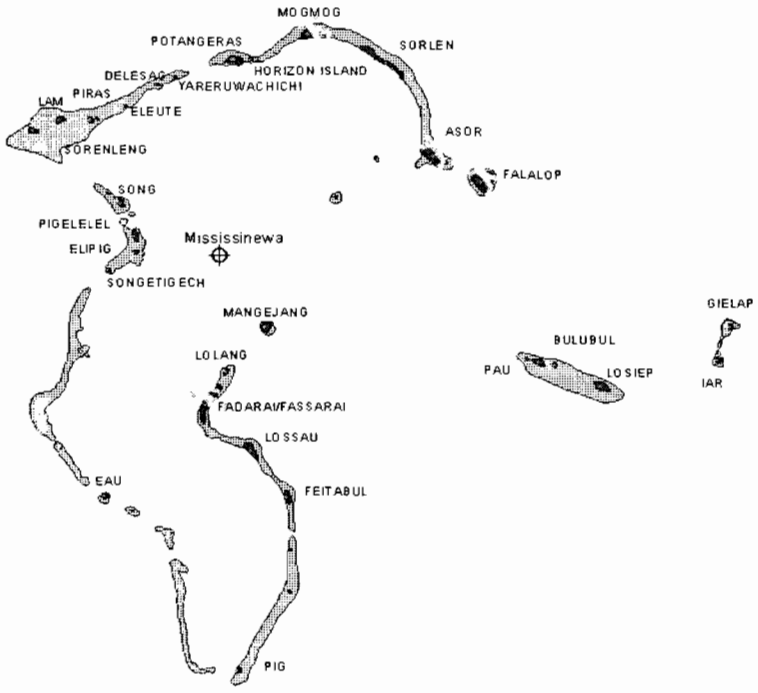

Figure 22. Location of population on Ulithi Atoll islands.

There are more than 2000 species of fish that live in the rich coral reefs of the Indo – Western Pacific. The coral reefs around Ulithi would be classified as highly diverse and productive fisheries. (figure 23).

Biologically Important Fish Species

The fisheries that are biologically important for this report fall into three main biological groups:

- fin fish
- crustaceans
- and molluscs

Finfish can be further divided into bony-fish which are the majority and cartilaginous fishes e.g. sharks & rays.

Crustaceans are animals with a hard but flexible jointed shell or exoskeleton which is periodically shed or moulted to allow the animal to grow e.g. lobsters, crayfish, crabs, prawns/shrimps etc.

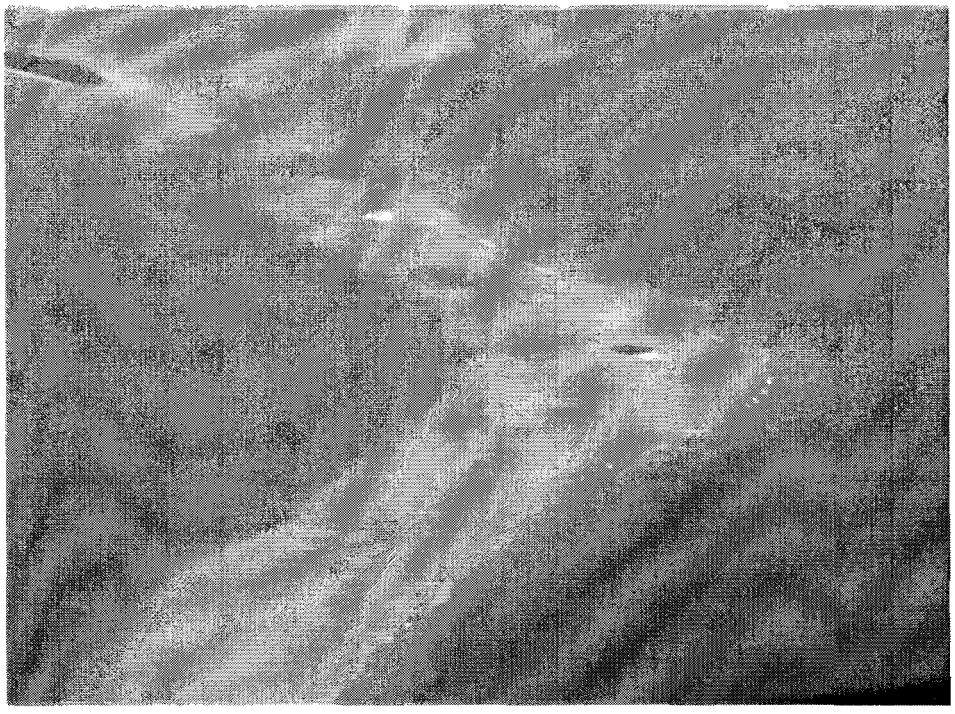

Figure 23. Atoll Coral reefs of Ulithi.

Molluscs are commonly referred to as "shellfish" because the animal lives inside a hard, inflexible shell. Usually a two hinged shells e.g. oysters, mussels, clams. Squid, cuttlefish and octopus are also molluscs but do not have outer shells.

Oil spills can impact upon fisheries in three main ways:

- lethal and/or sublethal effects on fisheries
- tainting or interference with fishing activities
- indirect effects through impacts on the food chain (ecosystem disturbances)

The habitat as well as feeding/swimming behaviour of fish is a very important aspect of the exposure route for different species.

- Pelagic fish spend their lives swimming in open water.
- Benthic species live and feed on the sea bed.
- Demersal fish live near the seabed mostly feeding on bottom-living animals.

Some fish migrate over long distances others live primarily in restricted habitats. Even highly mobile fish may have territories for breeding/spawning. Many fish are territorial and could be significantly affected by localised spills yet other species in open waters remain unaffected.

Coral reefs can be considered restricted habitats and many reef species maintain a territorial behaviour and feeding pattern.

The eggs and young stages of most fish are more vulnerable to oil pollution than adults.

<u>Molluscs</u>

Mussels (*Mytilus edulis*) have been observed to survive heavy oiling without apparent acute effects in Alaska. They are frequently used as indicators of bioaccumulation for various contaminants, partly because the species occurs widely, and is therefore a convenient test organism.

Clams, in contrast, often show long-lasting impacts from oil contamination, partly because they usually inhabit fine sediments in low-energy environments where oil is likely to be slow to weather and therefore remain for long periods of time.

Soft-shelled clams were thought to be particularly sensitive to the adverse effects of oiling since their physiology makes them unable to completely close their shells. This means that the clam's mantle and gill surfaces are always exposed to sediments and interstitial water, and thus, to any contaminants in those media.

The herbivorous (algae grazing) species of molluscs have been known to be highly sensitive to oil spills that impact shorelines. When these species are affected the resulting algae bloom (green slime) on intertidal rocks and rock pools can last many months before recolonisation from outside the affected area can occur.

Some evidence of algae blooms on rocks was noticed on the western shores of Falalop but this could be a result of natural causes or removal of shellfish by the local population.

Crustaceans

Subtidal and water column crustaceans are less likely to come into contact with oil although amphipods do seem to be particularly sensitive to oil hydrocarbons. Copepods appear to be one group of crustaceans that are less sensitive to oil.

In lobsters and crabs many activities are guided by their highly-developed sense of smell. Exposure to oil disrupts these senses and has been shown to affect searching, feeding and grooming behaviour in lobsters and mating behaviour in crabs.

Barnacles, like other crustacea, are acutely sensitive to oil and often experience high mortality rates when impacted by oil on shorelines.

In surveys conducted I did not see any evidence of contamination amongst the coconut crabs on the turtle/crab islands and ad hoc sensory tests of smell and taste proved negative.

Figure 24. Hermit crab – Gielap Island

Seafood Contamination

The extent to which an organism may be contaminated results from the combination of several factors, including the product to which seafood resources are exposed, the route of exposure, the metabolic detoxification systems present in organisms of interest, and the tissues eaten by the human consumer.

The degree to which a given oil constituent (chemical) of interest is soluble in water not only determines how and how much an organism might be exposed, but also is a major factor in how the compound behaves in a biological system.

The different components of oil will have different impacts on fisheries. The light components of oil have:
- high water solubility
- high evaporation rates
- high acute toxicity and
- not usually persistent

Therefore the lighter components of oil although the most toxic tend to be short lived in the marine environment and the effects usually show up very early in a spill incident.

The medium components of oil are:
- lower water solubility
- reduced evaporation rates
- higher in aromatics that are persistent and taint seafood
- moderately bioaccummulative.

The heavy components of oil are known to contain more persistent organics and aromatics that are known to be carcinogenic.

It is still largely unknown what components of oil impart a bad odour and taste on seafood but it is likely to be the light and middle fractions of oil which are the most potent.

Route of exposure

There are three principal ways in which hydrocarbons may interact with an organism to become contaminated:

1. Ingestion of food contaminated with product.
2. Absorption of dissolved hydrocarbons through respiration, i.e., through gill tissues.
3. Absorption of dissolved hydrocarbons from the water through the skin.

The route of exposure can be influenced by a number of related and unrelated parameters, including feeding strategy, fat content of the organism, the solubility of the product(s), physical characteristics of the water mass, reproductive state of the organism, etc.

A related factor that is also important is the length of exposure. Obviously, this will affect not only potential tissue contamination of the organism, but also whether the animal experiences any direct acute or chronic toxicity.

Toxicity of Oil

Toxicity is defined as, "The inherent potential or capacity of a material to cause adverse effects in a living organism" (Rand and Petrocelli 1985). Concentration, duration of exposure, and sensitivity of the receptor organism will all determine the toxic effect.

Toxicity - Acute effects

Acute toxicity refers to immediate impacts that result in death of the organism. One acute effect of oil on shoreline organisms is the physical process of smothering (NAS 1985). Intertidal invertebrates and some plants may be especially sensitive to smothering. Acute effects can also result from the toxic components of the oil. Acute toxicity will be dependent on the toxic properties of the oil (a combination of the oil type and weathering), and the concentration and dose that the organism receives

Toxicity -Chronic Effects

Some toxicity effects of oil pollution may not be evident immediately, or may not cause the death of the organism. These are called chronic, or sublethal effects, and they can impact an organisms' physiology, behavior, or reproductive capability.

Chronic effects may ultimately impact the survival rates of species affected and are harder to detect than acute effects and may require more intensive studies conducted over a longer period of time.

Many chronic effects result from stress responses in the physiology of an organism, such as increased metabolism, increased consumption of oxygen, and reduced respiration rate. These can be short term responses, but over extended periods of time, may cause other impacts to the organism. A common chronic response is reduced growth rates, for example in benthic organisms that live in chronically oiled sediments. Effects on reproduction from chronic exposure to oil in sediments has been documented for benthic fish species.

Changes in behavior have also been noted for several species of fish and invertebrates when exposed to oil.

One mechanism of impact of a sublethal effect is the disturbance of an organism's chemosensory ability affecting feeding, breeding and orientation within its habitat.

Bioaccumulation and Biomagnification of Oil Hydrocarbons in Seafood

Bioaccumulation can be defined as the uptake of a contaminant by an organism from water directly or through consumption of contaminated food. Organisms that live in a contaminated environment, for example, mussels in oiled sediments, may appear to be healthy but still contain elevated levels of petroleum compounds in their tissue. Some components of oil can be bioaccumulated by marine organisms, particularly the group of longer lasting compounds known as polycyclic aromatic hydrocarbons (PAH).

Biomagnification is defined simply as the magnification of concentrations of a contaminant over two or more trophic levels. One concern with bioaccumulation is that contaminated organisms (such as mussels) may be eaten by higher trophic level

organisms. If biomagnification was occurring, the higher level predator could concentrate contaminants to a level which would cause toxic effects. In the case of organisms that are harvested by humans, concerns about bioaccumulation may cause restrictions on collecting shellfish or other items consumed by humans.

Metabolic detoxification systems

To varying degrees, all organisms are capable of metabolizing foreign compounds in order to render them more easily excretable (depuration). The presence or absence of enzyme systems capable of processing specific materials in large part determines the ease with which hydrocarbons are processed and passed from an organism.

Some invertebrates such as bivalves do not carry the biochemical machinery necessary to metabolize petroleum hydrocarbons. As a consequence, aromatic hydrocarbons are not readily excreted and instead tend to accumulate in body tissues. It is for this reason that bivalves such as mussels, clams, and oysters are often used as "sentinel" organisms to assess environmental exposure to contaminants.

Though all animals can take up hydrocarbons from water column directly and from food, the processes of uptake vary by species group.

Macroinvertebrates can take up hydrocarbons, and the majority also metabolize them readily, with the exception of the molluscs. Within invertebrates, detritus feeding bivalves usually accumulate more hydrocarbons than suspension feeders. Depuration rates vary, but can range from a few days too much longer. Levels of hydrocarbons in fish are usually higher in liver and neural tissue than in muscle tissue. Their efficiency of uptake from food may be low. Fish have the enzyme systems capable of processing aromatic hydrocarbons relatively efficiently.

Contaminated sediments can provide a continual source of hydrocarbons to benthic fish once an on-water spill has dispersed.

Tainting

Although causes for tainting are not necessarily limited to exposure to hydrocarbons—spoilage, for example, can cause a familiar "off" smell or taste—in the context of this discussion, the term will refer to that arising from petroleum hydrocarbons.

Fin-fish, crustaceans and shellfish exposed to spilled oil may become tainted and unfit for consumption or sale by impacting unpleasant odours and flavours.

It should be noted that by definition, tainting comprises those examples of seafood contamination that are identifiable through normal human sensory systems such as taste or smell. Tainting, therefore, is determined by *organoleptic* analysis--which is a complicated way of saying the detection of oil through taste or smell.

The time scale for the loss of taint once the source of pollution has been removed ranges from hours to days and sometimes weeks depending upon the severity of the incident degree and length of exposure. Other factors include the feeding habits of the fish caught and water temperature.

Species with high body fat (lipid content) are more easily tainted and retain that taint for longer than lean-muscle species. Taint is usually lost through the normal processes of metabolism known as "depuration"

Ban on Fishing in Ulithi Lagoon

The Yap State officials had at the time of the assessment placed a complete ban on fishing for both commercial and subsistence fishing on Ulithi Lagoon.

The "due diligence" approach for the closure of the fisheries on the part of Yap government was a prudent and responsible measure. Most international seafood safety laws have the requirement that seafood consumed by its population is not injurious to health, unfit or so contaminated that it would be unreasonable to expect it to be eaten.

It is normal international practice to close fisheries or place exclusion zones in the location of an oil spill until the source has been secured and checks can be carried out on the safety and marketability of seafood from the incident scene. This precautionary measure not only protects the health of consumers but the reputation of the fisheries.

The population of Ulithi rely very heavily on subsidence fishing in the lagoon and with the ban on fishing within the lagoon and the bad weather, and high seas, has meant great hardship and not being able to supplement their usual catch from outside the area. It also places an extra risk of human safety fishing in the rougher waters outside the lagoon.

Figure 25. Idle fishing boats – Falalop Island

Reports were received by the Yap State authorities of sickness after consuming fish in the area and these reports should always be taken seriously. This has been contributed by the Marine Resources Department and other reports as possibly linked to ciguatera poisoning.

In my observations on site on fish species, variability and quantity and own sensory tests I believe the major risk from the July/August oil spills has now passed and the fisheries can now be reopened.

All reports of any sickness due to consuming seafood should be examined and a reassessment of the position on fisheries management and safety be reviewed.

Any long term monitoring of seafood for hydrocarbons should focus on the "indicator" or "sentinel" species mentioned previously which are more sensitive to background levels of oil in the environment.

Observations & Recommendation

In my assessment I believe the ban placed on fishing within Ulithi lagoon during the height of the recent oil spill was a prudent and sound measure to protect the health of it's citizens.

Since the immediate spill source has been contained and sufficient time has passed for most fish species to depurate (detoxify) from the effects of oil components I believe the ban can now be lifted.

I recommend the reopening of the fisheries within Ulithi Lagoon immediately.

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Section 4.

Spill Protection Priorities and Environmental Resources

It is impossible to protect an entire coastline and every resource during an oil spill event, therefore priorities have to be made between protection and sacrifice based upon the environmental significance of the resource.

These natural resources, their environmental significance and protection status is usually mapped out in a countries National Marine Spill Contingency Plan. Currently there are no detailed resource maps nor spill contingency plans for the Ulithi lagoon and Fais Island area.

Protection and response priorities

Sensitive wildlife and other resources that are to be considered for protection and cleanup decisions have been identified as including:

- endangered or threatened species protected by international treaties, Federal and state governments;
- nesting, spawning, breeding, and nursery areas for mammals, birds, fish, and shellfish;
- fish and wildlife concentration area where these animals feed, rest, or migrate;
- sensitive marine habitats, including
  - coral reefs
  - sea grass beds
  - shellfish beds
  - tidal flats
  - marshes
  - mangroves
  - shallow subtidal areas
  - low energy bays and harbors
  - rocky intertidal areas
- commercial areas which are shallow enough to allow impacts from oil spills eg recreational and industrial areas.

(note there are no known mangrove foreshores identified in the Ulithi lagoon)

Objectives of Shoreline Protection

The main objectives of shoreline protection are:

- Prevent oil from making contact with a shoreline, a resource or a sensitive area in the shore zone
- Minimise the effect of oil that makes contact with a shoreline or sensitive area
- Avoid causing more damage than the oil alone
- Use available resources in a safe and effective manner, and
- Minimise the generation and handling of waste materials.

Coral Reefs and Oil Spills

Coral reefs are the richest and most diverse all of the ecosystems in the sea and very sensitive to marine pollution. With 70% of the world's coral reefs these ecosystems need to be protected and conserved.

Coral reefs should receive a high protection priority since they are easily damaged if oiled, may take several decades to recover if killed and extremely difficult to clean.

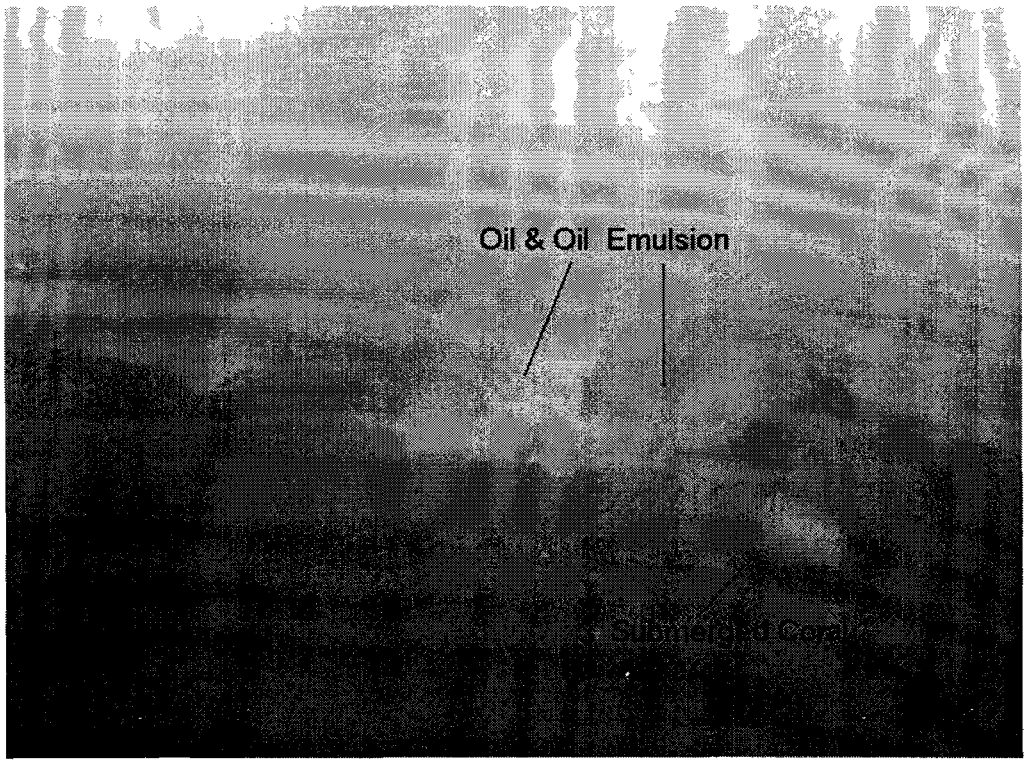

Figure 26. Oil spill from USS Mississinewa near coral reefs in Ulithi Lagoon (Yap EPA photo)

Coral reefs are mostly subtidal in nature, although the shallowest portions of some reefs can be exposed during very low tides.

The three major categories of reefs are:

- Fringing reefs - long, narrow bands of coral reefs parallel to and near the shoreline. When near coastal development, they are susceptible to stress from sedimentation and chronic pollution. (eg Figure 27.)
- Barrier reefs - similar to fringing reefs except they are further offshore and much broader (e.g., barrier reefs)
- Atoll reefs - reefs formed by buildup of coral on the rim of a subsiding volcano. They are circular or portions of a circle, forming a sheltered lagoon.

All of the reefs are completely submerged during high tide, and only a few reefs are routinely exposed during normal low tides. More commonly, reefs are exposed only during extreme low tides a few times a year.

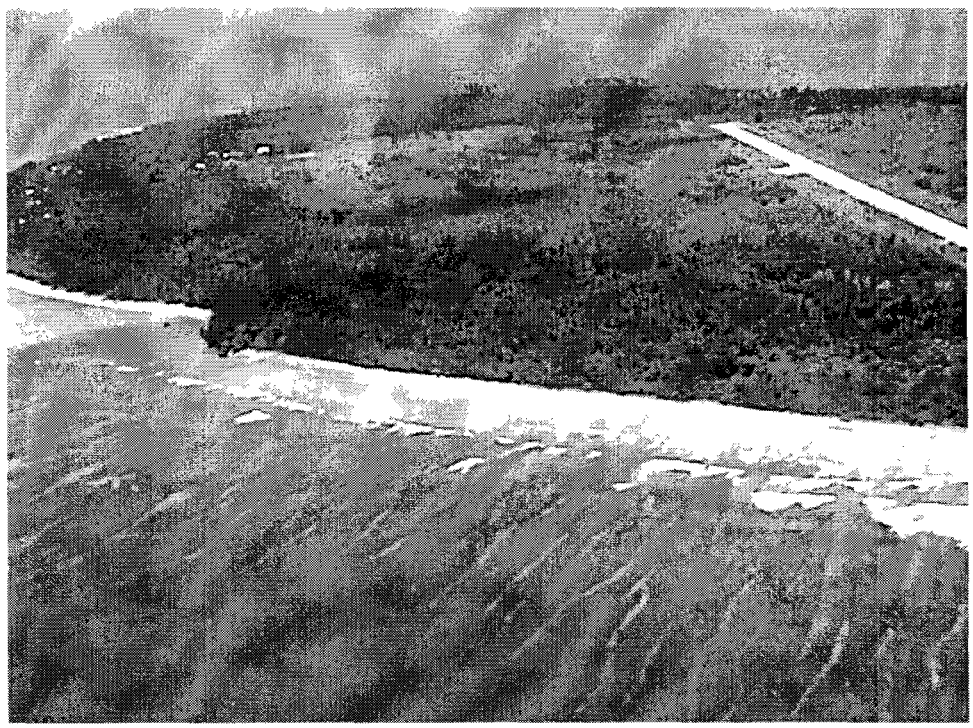

Figure 27. Fringing coral reefs Fais Island.

The potential for impacts from oil spills on reefs can be divided into three main categories, as summarized below:

Low risk Coral Reefs

- Reefs located at greater than five meters water depth at low tide; dilution should reduce oil concentrations in the water column to below acute toxicity levels.
- High-energy setting could mix fresh oil into the water column, but exposure is more likely to be short (hours to one day).
- Studies have shown healthy reefs rapidly recover from sublethal effects
- Where the reef is exposed to heavy surf, deposition of oil is unlikely.

Medium risk Coral Reefs

- Reefs located in water depths of 1-5 meters below low water, where high concentrations of dissolved and particulate oil are possible, especially when the oil slick is fresh.
- When the oil is fresh, toxic concentrations may cause acute impacts; more likely sublethal impacts may occur (NAS, 1985):
  - Increased algal growth
  - Slower growth rates
  - Lower fecundity (lower number of ovaria per polyp, fewer larvae per coral head, and lower settlement rate of planulae)
  - Localized tissue rupture
  - Premature expulsion of larvae
  - Excessive mucous production

- Degree of impact from a spill on a coral reef will be determined by:
  - The oil type
  - How much oil is likely to be mixed into the water column
  - How much weathering of the oil has occurred.

High risk Coral Reefs

- Intertidal reefs and reef flats, where direct contact with the oil is likely.
- Sheltered, shallow water settings, where high concentrations of oil are likely to persist.
- Where leaching from adjacent area creates a chronic source of oil exposure.
- Where coral reef communities are already stressed by pollution, sedimentation, thermal quality problems, etc.

Summary of Coral Reef Potential Damage by Oil Spills

Submerged reefs may be exposed to oil droplets in the water column, especially if the oil is either physically dispersed through high wave energy. Deep corals are more likely to come into contact with sedimentary oil adsorbed onto particles. If slicks float over submerged reefs without significant dispersal of oil into the water column, adverse effects are likely to be less and recovery more rapid.

Marine Birds

Marine birds can be divided into six broad categories based upon their behaviour and sensitivities to oil spills.

These categories include:

- Seabirds
  - Surface-feeding pelagic seabirds—albatrosses, petrels and shearwaters
  - Diving pelagic seabirds
  - Diving coastal seabirds—pelicans, cormorants, frigate birds, gannets, and boobies
  - Surface-feeding coastal seabirds
- Gulls and terns
- Raptors
- Shorebirds
- Wading birds—herons, egrets, ibises, cranes
- Waterfowl

In Figure 28 populations of birds Iar Island Ulithi lagoon.

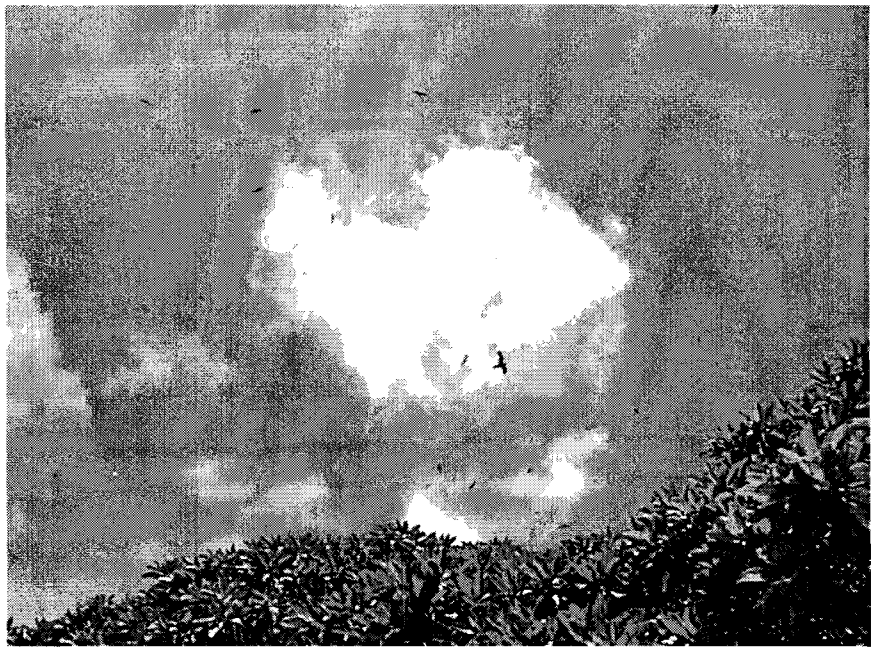

Figure 28. Birds – Iar Island

Effects of Oil on Birds

Bird species experience a variety of documented effects when exposed to spilled oil. These effects include:

- Fouling of plumage
- Ingestion of oil
- Effects on reproduction (egg damage)
- Physical disturbance.

Marine Mammals

Marine mammals have a number of behavioural, anatomical, and physiological adaptations that enable them to spend most or all of their lives in the ocean. As a group, they have evolved to be able to utilize nearly every marine environment along the open waters of the world.

Dolphins & whales have been seen in and close to Ulithi lagoon.

Primary emphasis is on defining the interaction and effects of oil on marine mammals, which occurs primarily in three ways:

- direct surface fouling;
- direct and indirect ingestion with the affects of bioaccumulation; and
- inhalation of the toxic vapors released from the petroleum hydrocarbons as they evaporate.

Protection Status for Turtle/Bird Islands

In an oil spill many different natural resources can be at risk. For an area like Ulithi Lagoon the turtle and bird Islands to the East of the lagoon are most important to protect form any further oil impacts.

It is internationally recognised that for an area to receive the highest category of protection and preservation the following criteria must be met…

1. Large numbers of species/individuals are concentrated in a relatively small area, such as bays or Islands during migration, breeding and overwintering.

2. They come ashore for nesting, birthing, resting, or molting.

3. Early life stages are present in somewhat restricted areas, such as nursery areas for anadromous fish, turtle nesting beaches, and bird rookeries.

4. Areas important to specific life stages or migration patterns, such as foraging, breeding or overwintering sites, are impacted by oil.

5. The species present are international and/or locally threatened or endangered.

6. A significant percentage of the population is likely to be exposed to oil.

In the case of Ulithi lagoon turtle and bird Islands to the East all these criteria are met, highlighting the need to ensure protection from any further oil spills.

Recommendations

To assist in the management of any future oil spills in Yap waters I recommend a National Marine Spill Contingency Plan be completed as soon as possible based upon the Pacific Regional template provided with this report. This plan development should be carried out as a matter of urgency, especially if no removal of oil cargo from the USS Mississinewa is carried out in the near future.

If possible coral reefs should receive a high protection priority in any spill response since they are easily damaged if oiled, may take several decades to recover if killed and extremely difficult to clean.

The highest risk coral reefs identified are those that are:

1. Intertidal reefs and reef flats, where direct contact with the oil is likely.
2. Sheltered, shallow water settings, where high concentrations of oil are likely to persist.
3. Where leaching from adjacent area creates a chronic source of oil exposure.
4. Where coral reef communities are already stressed by pollution, sedimentation, thermal quality problems, etc.

In the case of Ulithi lagoon turtle and bird Islands to the East satisfy all the internationally recognised criteria for an area to receive the highest category of protection and preservation by governments, highlighting the need to ensure protection from any further oil spills.

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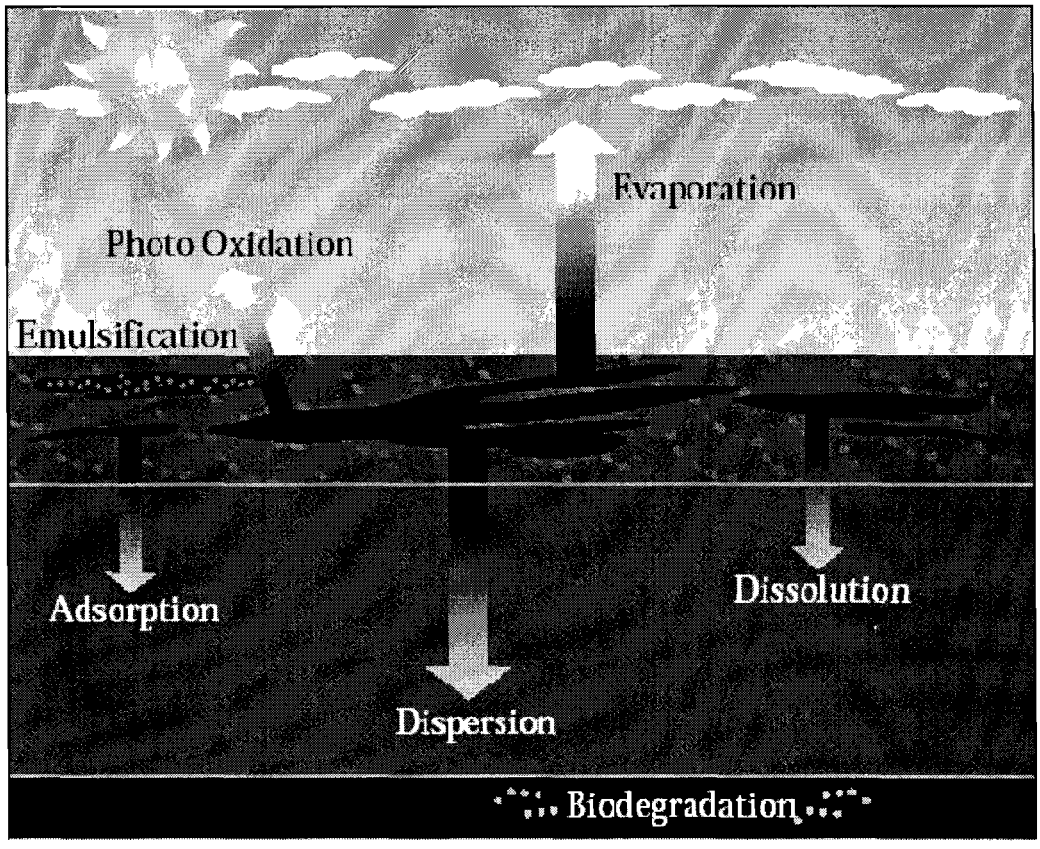
Appendix 1.

Weathering and Behaviour of Oil at Sea

There are many different processes affect the amount remaining, the chemistry and physical properties of oil at sea as it weathers due to the prevailing environmental factors.

The weathering of oil can be represented graphically in the figure below.



(ref. NOAA graphic)

These processes are summarised below.

Adsorption
The process by which one substance is attracted to and adheres to the surface of another substance without actually penetrating its internal structure

Biodegradation
The degradation of substances resulting from their use as food energy sources by certain micro-organisms including bacteria, fungi, and yeasts

Dispersion
The distribution of spilled oil into the upper layers of the water column by natural wave action or application of chemical dispersants.

Dissolution
The act or process of dissolving one substance in another

Emulsification
The process whereby one liquid is dispersed into another liquid in the form of small droplets

Evaporation

The process whereby any substance is converted from a liquid state to become part of the surrounding atmosphere in the form of a vapor

Photo Oxidation

Sunlight-promoted chemical reaction of oxygen in the air and oil

Evaporation of Oil

Evaporation is the single most important weathering process in the first several days of an oil spill. For light, refined products such as gasoline, evaporation will remove 100 percent of the spill within a very short time. For heavy refined products such as No. 6 fuel oil or Bunker C, evaporation will only remove 5-10 percent of the spill.

Environmental factors which affect the rate of evaporation are:

- Area of slick exposed, which changes rapidly
- Wind speed and water surface roughness
- Air temperature and exposure to sunlight (solar radiation)
- Formation of emulsions, which dramatically slows evaporation

Windy, sunny days, high water temperatures and currents rapidly spread the slick over large areas and speeds evaporation. Evaporation can even remove dissolved hydrocarbons from the water column.

Dissolution of oil into the sea

Dissolution of petroleum hydrocarbons into the water column poses risks to aquatic organisms because of the acute toxicity of the compounds that have significant water solubility.

The monoaromatics have the highest solubilities, by a factor of 50, than similar weight alkanes. Benzene has the highest solubility, at 1,750 mg/L, with toluene at 515 mg/L, and xylene less than 100 mg/L.

Emulsification of Oil

Formation of emulsions affects the behavior of an oil spill in many ways. First, weathering rates are much slower. The oil is more viscous and sticky. The volume of "oil" is increased by a factor of 2-3, because the emulsion is up to 70 percent water.

Most oil spill recovery equipment works very poorly on mousse. Tendency to emulsify and emulsion stability is very closely related to the asphaltene content.

General Spill Types and Behaviors

Based on all the properties of spilled oil, there are four types of oil for which a general assessment of the behavior and fate can be made:

Type 1—Very Light Oils (Jet Fuels, Gasoline)

- Highly volatile (should all evaporate within 1-2 days).
- High concentrations of toxic (soluble) compounds.
- Result: Localized, severe impacts to water column and intertidal resources.

- Duration of impact is a function of the resource recovery rate.
- No dispersion necessary.
- No cleanup necessary.

Type 2—Light Oils (Diesel, No. 2 Fuel Oil, Light Crudes)

- Moderately volatile; will leave residue (up to one-third of spill amount) after a few days.
- Moderate concentrations of toxic (soluble) compounds, especially distilled products.
- Will "oil" intertidal resources with long-term contamination potential.
- Has potential for subtidal impacts (dissolution, mixing, sorption onto suspended sediments).
- No dispersion necessary.
- Cleanup can be very effective.

Type 3—Medium Oils (Most Crude Oils)

- About one-third will evaporate within 24 hours.
- Maximum water-soluble fraction 10-100 ppm.
- Oil contamination of intertidal areas can be severe and long-term.
- Oil impacts to waterfowl and fur-bearing mammals can be severe.
- Chemical dispersion is an option within 1-2 days.
- Cleanup most effective if conducted quickly.

Type 4—Heavy Oils (Heavy Crude Oils, No. 6 Fuel Oil, Bunker C)

- Heavy oils with little or no evaporation or dissolution.
- Water-soluble fraction is less than 10 ppm.
- Heavy contamination of intertidal areas likely.
- Severe impacts to waterfowl and fur-bearing mammals (coating and ingestion).
- Long-term contamination of sediments possible.
- Weathers very slowly.
- Chemical dispersion seldom effective.
- Shoreline cleanup difficult under all conditions.

Under the spill conditions in Ulithi Lagoon, the fuel oil would behave in a manner similar to conventional #6 (type 4) heavy fuel oils. By observations from the leaking tanker it has a slightly lower density than full-strength seawater at tropical temperatures.

Many heavy fuel oils are likely to float and remain liquid during the early stages of a spill. The light fractions will be lost by evaporation, and the floating oil will initially form contiguous slicks. Eventually the slicks will break up into widely scattered fields of pancakes and tarballs, which can persist over large distances and concentrate in convergence zones.

Because of the higher viscosities of these oils, the tar balls may more persistent than expected for conventional crude oils.

<u>Generalised Physical Behaviour of Heavy Fuel Oil.</u>

- No. 6 fuel oil is a heavy oil produced by blending heavy residual oils with a light oil (often No. 2 fuel oil) to meet specifications for viscosity and pour point.

- When spilled on water, No. 6 fuel spreads into thick slicks which can contain large amounts of oil. Oil recovery by skimmers and vacuum pumps can be very effective, particularly early in the spill.

- Very little of this viscous oil is likely to mix into the water column. It can form thick streamers or, under strong wind conditions, break into patches and tarballs.

- It is a persistent oil; only 5-10% is expected to evaporate within the first hours of a spill. Thus, spilled oil can be carried long distances by winds and currents. Previous bunker oil spills have contaminated shorelines over 200 miles from the spill site.

- The specific gravity of a particular No. 6 fuel oil can vary widely, from 0.95 to greater than 1.03. Thus, spilled oil can float, suspend in the water column, sink, or do all of these simultaneously, if the oil is poorly mixed. Floating slicks may become non-floating when they spread into areas of freshwater influence.

- Floating oil could potentially sink once it strands on the shoreline, picks up sediment, and then is eroded by wave action.

- No. 6 fuel oil can be very viscous and sticky, meaning that stranded oil tends to remain on the surface rather than penetrate sediments. Light accumulations usually form a "bath-tub ring" at the high-tide line; heavy accumulations can pool on the surface.

- Shoreline cleanup can be very effective, particularly soon after the spill before the oil weathers, becoming stickier and even more viscous. Removal is needed because degradation rates for heavy oils are very slow, taking months to years.

- Adverse effects of floating No. 6 fuel oil are related primarily to coating of wildlife dwelling on the water surface, smothering of intertidal organisms, and long-term sediment contamination. No. 6 fuel oil is not expected to be as acutely toxic to water column organisms as lighter oils, such as No. 2 fuel oil.

- Direct mortality rates can be high for seabirds, waterfowl, and fur-bearing marine mammals, especially where populations are concentrated in small areas, such as during bird migrations or marine mammal haulouts.

- Direct mortality rates are generally less for shorebirds because they rarely enter the water. Shorebirds, which feed in intertidal habitats where oil strands and persists, are at higher risk of sublethal effects from either contaminated or reduced population of prey.

Even at high wind speeds, usually over 70% of a Fuel Oil No. 6 will persist as floating or beached oil for a week or longer.

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Appendix 2

Sea Turtles of the Pacific

After hatching from beach nesting sites, young turtles are subject to dehydration and predators, such as sharks, during the time they attempt to swim offshore. The hatchlings remain in offshore currents, drifting and feeding in the epipelagic layer of the ocean. They generally return to inshore feeding grounds as immature adults when they are about 20cm (Straight Carapace Length–SCL). When they attain sexual maturity, which may be up to 30 years for some species, they return to the open ocean, once again embarking on long migration routes to breeding and nesting sites. Interactions with tuna fisheries are therefore thought to occur during the period when young turtles are in the open ocean, drifting with or without debris and prior to association with inshore feeding grounds, as non-breeding adults and also when sexually-mature adults are migrating to breeding/nesting sites. Certain species of marine turtles are more prevalent in oceanic waters than others. They rely on their visual senses in their search for food and need to surface at regular intervals to breathe. They also exhibit some preference for distinct thermal regimes.

Green Turtles

The green turtle (*Chelonia mydas*) is a circumglobal and highly migratory species, nesting and feeding in tropical/subtropical regions. Their range can be defined by a general preference for water temperature above 20°C.

This species is known to live in pelagic habitats as post hatchlings/juveniles, feeding at or near the ocean surface. The non-breeding range of this species can lead a pelagic existence many miles from shore. The breeding range primarily live in bays and protected shores and are rarely found in the open ocean. Most migration from rookeries to feeding grounds is via the coastal environs with females migrating to breed only once every two years or more.

The green turtle is a primarily herbivorous species and typically feeds during the day in shallow-water seagrass beds. Nesting season occurs throughout the year in the region, with peaks in summer months where water temperature is typically over 25°C. The range of age at first maturity has been estimated to range from between 6 and 13+ years, depending on the author. Some studies also show that these animals commence reproducing when in captivity less than 10 years. The green turtle is currently listed as "endangered" under the 2000 IUCN–World Conservation Union red list of threatened species and "threatened" under the U.S. Endangered Species Act (ESA).

Hawksbill Turtle

The hawksbill turtle (*Eretmochelys imbricata*) lives in littoral waters of mainland and island shelves and is more common where reef formations are present. It is the most tropical of all sea turtles and nesting is confined between 25°N and 35°S.

Juveniles exhibit some degree of residential or non-migratory behaviour. Adults are capable of undertaking both short and long-distance migrations.

Nesting season occurs mostly toward the end of spring and throughout summer. Age at first maturity is not entirely clear; the female is estimated to reach maturity at sizes between 68 and 80 cm and at body weights from 40 to 56 kg depending on the locality. The hawksbill turtle is a benthic feeder and its diet consists principally of corals, tunicates, algae and sponges.

The hawksbill turtle is currently listed as "critically endangered" under IUCN red list of threatened species and "endangered" under the ESA. Throughout the Pacific, this species is rapidly approaching extinction primarily due to harvesting for its meat, eggs and shell, as well as destruction and disruption of its nesting habitat.

Leatherback turtle

The leatherback turtle (*Dermochelys coriacea*) is the most widely distributed of all sea turtles and can be found in the Pacific Ocean from the Gulf of Alaska to Tasmania and New Zealand. It is a highly pelagic species that approaches coastal waters only during the nesting season. They are the largest of the marine turtles and may span 270 cm (SCL) length as an adult.

It is assumed that this species is carnivorous throughout its life cycle. The adults feed mainly on jellyfish, tunicates and other soft-bodied invertebrates that are abundant in the epipelagic layer, although observations have also found that the animal frequently descends into deeper waters. Rare nocturnal feeding within the deep scattered layer has been observed, with some speculation that leatherbacks may locate pyrosomas (salps) due to their bioluminenscence. Maximum depths for dives have been reported to beyond 500 metres, but the majority of dives in one experiment with transmitters were less than 150 metres.

Migratory routes and nesting populations in the region are not fully known; major nesting sites listed include Indonesia and the Solomon Islands, with scattered sites in Australia, Fiji and PNG. This species appears to grow faster than any other marine turtle and is believed to reach sexual maturity after a minimum of 9 years, at a size of about 125 cm (SCL). The leatherback turtle is currently listed as "critically endangered" under IUCN red list of threatened species and "endangered" under the ESA. Primary threats to this species are coastal and high seas fishing and, to a lesser extent, the disruption and destruction of nesting sites.

Loggerhead turtle

The loggerhead turtle (*Caretta caretta*) is widely distributed in temperate and subtropical waters throughout most of the world, and is known to undertake long migrations using warm currents. There is some tendency to follow temperature fronts, for example, satellite telemetry studies in Hawaii showed individuals following the 17°C and 20°C isotherms.

Nesting has been observed from Japanese waters in the north to New Caledonia in the south, with major sites in Australia. Summer surface temperature for nesting must be over 20°C.

Both juvenile and sub-adults forage in open ocean pelagic habitats. As adults, this carnivorous species feeds in coastal bays and estuaries, as well as in the shallow waters along continental shelves. The diet of this species shows some preference to benthic fauna such as shellfish, crabs, shrimps and small fish. Age at first maturity has not been clearly determined and data from studies of individuals in captivity suggest this to be between 6 and 20 years. The loggerhead turtle is currently listed as "endangered" under IUCN red list of threatened species and "threatened" under the ESA. Primary threats to this species are the disruption and destruction of nesting sites and commercial fishing.

Olive Ridley turtle

The olive ridley turtle (*Lepidochelys olivacea*) is a pantropical species, living principally in the northern hemisphere, but limited to waters at or above the 20°C isotherm. It is considered the most abundant of the world's sea turtles.

The geographic extent of this species is not as well documented in the region as in other ocean areas, although it is known elsewhere to rarely frequent oceanic islands with major nesting colonies found primarily in the continental coastal waters.

Adults are mostly neritic, travelling or resting in surface waters, but turtles diving and feeding to a depth of 200m have been reported. The olive ridley is an omnivorous turtle, feeding on crustaceans, mollusks and tunicates.

In general, the nesting season is in the summer and autumn months. Large nesting aggregations with massive arrivals of thousands of females on the beach have been reported. Age at maturity is considered to be 6–8 years, with studies suggesting an average size of 62 cm (SCL). The olive ridley turtle is currently listed as "endangered" under IUCN red list of threatened species and "threatened" under the ESA, although most concern relates to the over-harvesting of the Mexican nesting population.

***(Ref. A review of turtle by-catch in the western and central Pacific Ocean tuna fisheries** (2001) A report prepared for the South Pacific Regional Environment Programme (SPREP) by the Oceanic Fisheries Programme, Secretariat of the Pacific Community, Noumea, New Caledonia)*

Appendix 3.

Prediction of Oil Behaviour on Shorelines and Assessment Procedures

Prediction of the behavior of oil on intertidal habitats is based on an understanding of the coastal environment, not just the substrate type and grain size.

The sensitivity of a particular intertidal habitat is an integration of the:

1) Shoreline type (substrate, grain size, tidal elevation, origin),
2) Exposure to wave and tidal energy,
3) Analysis of the natural persistence of the oil on the shoreline,
4) Biological productivity and sensitivity, and
5) Ease of cleanup without causing more harm.

From the perspective of oil behavior on beaches, there are three basic factors:

1) The depth of oil penetration into the sediments
2) The potential for burial of oiled layers by clean sediments
3) The ability of the sediment to support equipment

In more sheltered settings, oil will persist longer, but burial is less likely because of the low wave energy. Therefore, asphalt pavements may form in such areas if they are heavily oiled.

The behavior and short-term impacts of oil on fine-grained sand beaches can be summarized as follows:

On fine grain exposed sandy beaches:

- During small spills, oil will concentrate in a band along the high-tide line
- Under heavy accumulations, oil can cover the entire intertidal areas, although the oil will be lifted off the lower part of the beach with the rising tide
- Maximum penetration of oil into fine-grained sand will be less than 10 cm
- Burial of oiled layers by clean sand within the first few weeks after the spill will be limited usually to less than 30 cm along the upper beach face
- Deeper burial is possible if the oil is deposited at the beginning of an accretionary period
- Much of the oil will be removed during the next storm
- Biological impacts include temporary declines in infaunal populations, which can also affect feeding shorebirds
- The usually hard, compact sediments will support pedestrian and vehicular traffic

On fine grain sheltered sandy beaches:

- More of the beach face can be covered because it is narrow
- Even less oil penetration occurs because the sediments are finer and can contain small amounts of silt and clay
- There is little to no likelihood of burial, except by wind-blown sand
- Depending on the degree of exposure to any waves, oil persistence can increase to months or years
- A moderately rich biological community can be supported

- Asphalt pavements can form under heavy accumulations; pavements will change nature and stability of the substrate and thus its biological utilization

Coarse-grained sand beaches pose much greater oil persistence and cleanup problems than fine-grained sand beaches because of the deeper penetration and rapid burial. The stage of the beach cycle at the time of oil deposition will greatly affect the total potential depth of burial. If the oil strands just after a major storm, when the beach is at its erosional maximum, rapid deposition of clean sand can bury the oil until the next storm or perhaps the next storm season

Because of the mobility of coarse-grained sand beaches, they do not generally support a rich biological community. Some animals may be found in association with beach wrack, mostly amphipods and insects. Burrowing animals can be seasonally low to moderate in densities, but with low diversity and consisting of bivalves, crustaceans, and polychaetes. These beaches can be important resting and feeding habitat for shorebirds and coastal diving birds.

The behavior and short-term impacts of oil on coarse-grained sand beaches can be summarized as follows:

On coarse grain exposed sandy beaches:

- During small spills, oil will concentrate in a band along the high-tide line
- Under heavy accumulations, oil can cover the entire intertidal zone, although the oil will be lifted off the lower part of the beach with the rising tide
- Large amounts of oil can accumulate in the berm runnel where it is unable to drain off the beach at low tide
- Penetration of oil into coarse-grained sand can reach 25 cm
- Burial of oiled layers by clean sand within the first few weeks after the spill can be rapid, and up to 60 cm or more
- Burial over 1 m is possible if the oil is deposited at the beginning of an accretionary period
- Persistence of deeply buried oil could be long, depending upon the season of year and beach cycle
- Biological impacts include temporary declines in infaunal populations, which can also affect feeding shorebirds
- The sediment can be very soft, making vehicular access difficult

On coarse grain sheltered sandy beaches:

- More of the beach face can be covered because it is narrow
- Oil penetration will be less where the sediments are finer and more poorly sorted
- Depending on the degree of exposure to any waves, oil persistence can increase to months to years
- Burial by clean sand is still significant but less than exposed beaches
- Asphalt pavements can form under heavy accumulations; pavements will change nature and stability of the substrate and thus its biological utilization

Oil Behavior on Gravel & Coral Beaches.

A number of special features of gravel and coral rubble beaches enhance oil accumulation and preservation during an oil spill. The major ones are:

1. *They have high porosity and permeability that allow deep penetration from the surface.*
2. *They have a high potential for oil burial by accretional features*
3. *The formation of asphalt pavements in sheltered areas is likely where accumulations are heavy*

Gravel and coral rubble tends to be highly mobilized during peak and waning periods of storm and typhoon activity. The finer gravel classes, such as granules, pebbles, and small cobbles, are readily moved by normal wave activity. The gravel may be moved onto the beach, in the form of berms or swash bars. Large blocks are only "reworked" during major storm events.

The behavior and short-term impacts of oil on mixed sand and gravel beaches can be summarized as follows:

On exposed gravel or coral rubble beaches:

- During small spills, oil will be deposited along and above the high-tide swash
- Large spills will spread across the entire intertidal area
- Oil penetration into the beach sediments may be up to 50 cm
- Burial of oil may be deep at and above the high-tide berm, where oil tends to persist
- Oil can be stranded on low-tide terraces composed of coral pieces or gravel, particularly if the oil is weathered or emulsified

On sheltered gravel and coral rubble beaches:

- Pavements are likely to form wherever heavy accumulations of oil can fill the voids between the sediments
- Once formed, these pavements are very stable and can persist for many years
- Any oil stranded above the high-tide line will be highly persistent.

Recommended Procedure for Oiled Foreshores

A systematic approach is required when assessing oiled foreshores. The procedure should have the following objectives:

1. Identify oiled & unoiled areas
2. Describe location, character and amount of floating & stranded oil
3. Evaluate operational & logistic factors
4. Establish shoreline treatment priorities
5. Propose treatment or cleanup methods

Copies of proformas for the uniform and systematic assessment of oiled foreshores have been provided to the Yap EPA to assist in any subsequent oil spill event.

NOAA has produced a guideline for the cleanup of foreshores which is summarised below.

Shoreline CleanUp End Points (NOAA guidelines)

OIL EXPOSURE PATHWAYS	OIL EFFECTS	CLEANUP ENDPOINT	CONSIDERATIONS
I. Remobilization Potential (Sheening)	• Recoiling of sensitive areas • Ongoing exposure to water surface users (e.g., birds, mammals, people) Effects from: - direct contact - transfer to early life stages - ingestion from preening	• No longer generates sheens that will affect sensitive areas or wildlife	**Degree of Exposure:** • High exposure speeds removal, breaks up sheens • Sheltered area will sheen longer, episodically **Use:** • High use—higher cleanliness • Low use—more tolerant to natural removal of residues • Seasonal variations in presence of users • Sensitivity of resources to chronic exposure
II. Oil Coat / Cover / Stain **Ecological Concerns**			
• Potential for sheening	• Same as for sheening	• Same as for sheening	• Same as for sheening
• Sticks to organisms using surface	• Oiling of fur / feathers / feet • Habitat / food loss because of avoidance	• Oil removal / weathering so it is no longer sticky	• Timing: Oil will eventually weather, become non-sticky
• Coat / smother biota / vegetation	• Acute / sublethal toxicity	• Oil removal to allow recovery / recolonization without further disturbance	• Aggressive techniques have potential for causing greater ecological impacts than oil alone, delaying rather than speeding recovery
Human Health/Aesthetic Concerns			
• Rub off on people / property	• Human health risk	• No longer rubs off with casual contact	• Don't do more harm than good
• Visual contamination	• Mostly aesthetic / economic	• Depends on substrate / use	• High use—higher cleanliness • Low use—more tolerant to natural removal
Cultural Concerns	• Aesthetic • Damage to artifact fabric	• Oil removal without causing further damage	• Very little past experience with most types of substrates and / or artifacts
III. Contaminated Sediments **Ecological Concerns**			
• Potential to release oil / sheens	• Same as for sheening	• Same as for sheening	• Same as for sheening
• Direct contact by infauna / epifauna • Uptake in food web by other organisms	• Acute and chronic toxicity; sublethal effects	• Oil removal to allow recovery / recolonization without further disturbance	• Oil is usually more persistent in sheltered, sensitive areas where cleanup tends to be more disruptive
Human Use Concerns			
• Dermal exposure	• Shoreline closure	• No longer rubs off	**Use:** • High use—higher cleanliness • Low use—more tolerant to natural removal of residues **Sediment Removal:** • Potential for erosion • Replacement sources • Disposal options
• Visual / aesthetic	• Shoreline closure	• Oil removal to a stain	
• Seafood safety via food web uptake	• Seafood advisories	• Pass organoleptic testing	• Background sources of oil contamination

Yap State Disaster Coordination and Management
Office of the Governor
Colonia, Yap, Western Caroline Islands 96943

Press Release
September 12, 2001

Mr. Trevor Gilbert, Marine Environmental Advisor to Australian Government for oil spill in Australian waters, who is on attachment with the South Pacific Regional Environmental Program has completed his survey and assessment of the oil spill in Ulithi and its impact on the environment of Ulithi and Fais Island and briefed Governor Figir and State Disaster Coordinating officials on his findings and recommendation.

Mr. Gilbert, in introducing himself, said that his main job is a Marine Environmental Advisor to the Australian Government on oil spills in Australian waters, saying that "every day there is a minor oil spill and every year there is at least one major oil spill in Australian waters, which has the 5th largest ship movement in the world."

He informed the Governor that on Fais Island he went and observed the shorelines of both sides of the island, the northern side where the Japanese once mined phosphate and found no oil specimen there but on village side of the island, he observed small tar balls on the rocks. He said that he also observe and notice oils sheen on the water around this part of the island. He said that these evidences of oil on Fais have the same characteristics of the oil that leaked out from the USS Mississinewa in Ulithi Atoll.

Mr. Gilbert and his party flew next to Falalop Ulithi where they stayed for two days diving the wreck and observing the shorelines of many of the islands in the atoll. He dove the wreck and found it to be in verily good condition, saying that "the navy divers and engineers had done a very good job is sealing the leaks and in pumping the residual oil from the hull but we can only say that it is only safe for the moment for no one can tell what may happen when a major storm or typhoon hit the area." He said, " that his observation of the extensive damage on Falalop's shore line from the last typhoon, convinced him that one such storm hitting the area in the future could move the ship enough to cause another oils spill and perhaps a major oil leak going."

His observation is that there has been some damage to the environment but much of the oil spill has simply weathered or been absorbed into the environment and the large size of the atoll is sufficient to absorb and minimize the impact. He went to the two turtle islands and found no evidence of the oil spill and that turtles continue to breed normally. There was no evidence of any dead birds that can be contributed to the oil spill. A small leather back turtle was reported dead on one island and Mr. Gilbert went and saw the turtle but there was no evidence that the turtle died from being smothered by the oil.

Mr. Gilbert made his recommendation to Governor Figir that the Environmental Health Declaration, banning fishing in Ulithi be lifted as there is currently minimal danger to health in consuming the fishing caught in the lagoon at this time and the heavy dependency by the people on fish in their daily diet requires an early lifting of the ban.

In relation to the wreck itself, it continues to pose a major threat and real danger of a major oil pollution hazard because if its size and location. The removal of this oil and thus the danger of a major catastrophe must be undertaken. He pointed out that there are tested technologies for safe and secure recovery of the oil today and the US Navy should be approached to have this threat remove from Ulithi Atoll. He said, "it is clear that we have passed the stage of 'if it will happen' to the stage of 'when it will happen.' It is just a matter of time."

Mr. Gilbert said, he will remain in Yap for several more days during which he will complete his report and submit it to the FSM and Yap State Government. Mr. Gilbert informed the Governor that a meeting of member-countries of SPREP is taking place in Apia, Western Samoa and the oil spill in Ulithi is likely to be one topic of discussion.

In thanking Mr. Gilbert for what he has done, Governor Figir said, " I have stated it from the very outset that the removal of all the oil is not an option whether to take or not and the reason is very clear, if that amount of oil comes out all at once it will spell dooms day not just for Ulithi but for all of our islands. If that happens and the wind and current are from the east, which will starting October, when the typhoon season commences, Yap will be impacted to a point where we will have to move to somewhere, because if we move to any of our smaller islands, it will sink. I believe that when that catastrophe happens it will impact all of the islands in this part of Micronesia, from Palau to Yap, Guam, Saipan and all of our small islands in between. So I hope that others may appreciate our anxiety as we awake each morning, knowing that millions of gallons of oil wait their time to come to our shores and threaten our very existence."

Governor Figir thank Mr. Gilbert for what he has undertaken to assist and asked that he convey these sentiments to SPREP for this very important assistance.[]

Yap State Disaster Coordination and Management
Office of the Governor
Colonia, Yap, Western Caroline Islands 96943

Press Release
September 10, 2001

Mr. Jim Ruth, US Navy towing and salvage engineer, debriefed Yap State Government officials Friday afternoon after arriving from Ulithi. "The leaks in the oil tanks were successfully sealed by our divers and so at least, the immediate emergency [of oil leak into the lagoon] is over." Said, Mr. Ruth. However, thousands of gallons of oil remain in the tanks on the sunken ship and the fear of the eminent disaster of a major oil spill in the future by the people of Ulithi Atoll and the leaders of Yap State continues.

Mr. Jim Ruth, US Navy towing and salvage engineer from the Office of the Director of Ocean Engineering Supervisory of Slavage and Diving, USN in a debriefing with Lt. Governor Yatilman and other state officials, assured the state that since they have successfully sealed all of the leaks on the sunken ship, "that the immediate emergency may now be over." He said that "as to what the next step will be, he cannot speculate until his report is issued." Mr. Ruth said, "his report will basically state what they saw, what they have undertaken and what the condition of the ship is."

Mr. Ruth said that when they got to the site they found a second leak, which they have incased in concrete and is now sealed. He said that "there may from time to time evidence of oil on the surface of the water and that is expected because of small amount of residual oil that may still be trapped in the hull of the ship and was not possible to pump out".

As to the amount of oil left in the tanks, he said that for planning purposes it is wiser to assume that the tanks are full and there are five tanks that are intact on the ship—tanks 5,6,7,8 and 9.

Information received earlier from Ulithi was corroborated that Euw island on the eastern side of the atoll was hardest hit by the oil spill, which did reach most of the other islands in the atoll.

Mr. Ruth said that the sound readings on the steel plates on the bottom of the ship which is now the top side of the over turned hull indicate that the thickness of the hull plate is between 7/8 to ¾ inch thick. A sample of the steel plate was taken for analysis.

He said that he is cognizant of what Governor Figir has said from the outset with regard to the urgent need for immediate and effective removal of all the oil from the sunken ship in order to prevent the certain and expected catastrophe when the tanks burst open one day. Mr. Ruth agreed that one day the steel plate will go in the event of a typhoon or due to corrosion, but as to when that will happen, no one can tell right now but its happening one day, no one can dispute or deny.

The removal of the oil from the ship is not something that is new, according to Mr. Ruth. Technologies do exist for doing such a task in what is called, "hot-tap" but the hard part is the remoteness of the location. If the job is undertaken it should not take more than 30 days, he said.

Lt. Governor Yatilman thanked Mr. Ruth at the end of his debriefing for the job they have successfully undertaken to at least stop the oil from further leak into the Ulithi Lagoon and restated the position expressed by Governor Figir on the immediate recovery and removal of all the oil from the sunken ship as soon as possible. Lt. Governor asked, "if that concern " may be reflected in the report when it is issued and Mr. Ruth, said that it will as part of what was expressed by Yap State on this emergency.

Mr. Ruth thank the Lt. Governor and through him the Governor and the State leaders for the support and assistance provide them to undertake their work including making the Micro Spirit available for their use while working on the wreck to seal the tank and remove the residual oil.

A dinner reception was held Saturday evening in honor of Mr. Ruth and his diving team during which the Lt. Governor thank Mr. Ruth and his team for the work they had undertaken successfully in sealing the oil tanks on the vessel. The evening, the Lt. Governor state was for Mr. Ruth and members of his team and state officials to share fellowship in an informal setting, "after all, most solutions to problems and concerns come from basic human understanding and aspirations." A question was raised whether the oil leak could have been caused by divers, who dove the wreck since it was discovered in April this year. Mr. Ruth, said, "When I first arrive on Yap, I thought of that very possibility but after I dove the wreck, I became convinced that that leak cannot possibly be caused by divers, diving the wreck."

The State Disaster Coordinating and Coordinating Team recognized and thank the Master and crew of the field trip ship, Micro Spirit in a reception on board the ship Sunday for the hardship they undertook in stormy weather to assistance the efforts by the State to contain the oil spill in Ulithi, where the ship was stationed as a platform from which the our divers and the navy divers did their work.

The Environmental engineer from the South Pacific Environmental Program, Mr. Tervor Gilbert, accompanied by Peter Fatamag from the State EPA office and John Lingmar from the Governor's Office left by plane after meeting with state officials in Yap Friday morning to observe the oil spill impact on Fais Island and Ulithi Atoll. He and Peter Fatamaag will remain in Ulithi to conduct an assessment of the oil spill in Ulithi Atoll and return today [Monday, September 10] to Yap. []