captured in the neighbouring nearshore environment. Such data is not yet available for a specific mangrove area and the total associated fisheries. At a somewhat higher level of sophistication the relationship between the net primary production of the mangrove forest — that is the material produced by a mangrove forest after some of the products have been used to sustain the growth and maintenance of the forest — and fisheries production could be used to predict fisheries production as a function of time on the basis that material from the mangrove forest will vary with the seasons.

The same model could be used to predict the economic loss through a fall in amount of fish caught if a mangrove forest is totally cleared to make room for an allegedly more profitable purpose.

In some areas the lack of fresh water is critical to the process of economic development. Engineers tend to view fresh water running into the oceans as wasted and they therefore divert the fresh water into dams or reservoirs. The consequent damage to local mangrove forests and the relationship that this may have to a fall in fish productivity must be weighed against the economic advantages perceived by the engineers.

It must be understood that at this time the economic significance of the mangrove forests is very poorly documented. Much work is urgently required to make the appropriate data available before the mangroves are destroyed for want of a better alternative.

UNESCO has expressed its concern about the uncontrolled destruction of mangroves in our part of the world. It has called for a joint scientific, sociological and economic study of the problems. Australia, as a well developed country scientifically, has an important role to play through scientific leadership and education to enable such a joint venture to be a success. The implications for the long term economic future of the region are enormous and the Australian Government should not hesitate to support the proposals of UNESCO by providing significant resources in terms of scientific manpower and research funding.

PHYTOPHTHORA IN QUEENSLAND MANGROVES

K.G. PEGG AND L.I. FORESBERG

Queensland Department of Primary Industries,
Meiers Road,
INDOOROOPILLY

During the past three years many white mangrove trees (*Avicennia marina* [Forsk.] Vierh.) have died in the Gladstone area of central coastal Queensland. A few dead trees were first observed in 1978 in the vicinity of the Gladstone power house by Dr Peter Saenger, a biological consultant with the Queensland Electricity Generating Board. The number of deaths increased considerably in 1979 and at present approximately 70 per cent of white mangrove trees growing near the mouths of the Calliope River and Auckland Creek have died (Figure 1). Twelve species of mangrove occur in the Gladstone area (Saenger and Robson, 1977), but only *Avicennia marina* is affected.

The first visible symptom in the aerial parts of affected trees is a wilting of the leaves. These leaves then become yellow and gradually fall so that trees are almost completely defoliated. The lateral absorbing rootlets which are borne at the base of the pneumotophores become black and decayed. A trunk rot is also occasionally present. This originates at ground level and may extend two metres up the trunk. Trunk lesions are a deep purple colour, and when this discoloured tissue is cut it has a sweet, sickly odour.

At the request of the Queensland Fisheries Service, a study was initiated by the Plant Pathology Branch of the Queensland Department of Primary Industries to determine whether a plant pathogen was responsible for the death of these trees. Isolations were made from decayed absorbing rootlets and from trunk lesions. A fungus belonging to the genus *Phytophthora* was consistently recovered.

The genus *Phytophthora* has come into prominence in Australia in recent years following the discovery that the disease known as "jarrah dieback" in Western Australia is caused by *Phytophthora cinnamomi* Rands. This fungus also caused severe damage to some eucalyptus forests in Victoria. Diseases such as avocado root rot, pineapple root and heart rot, collar rot of citrus, root and stem rot of soybeans, blight of potato and black rot of cocoa pods are also caused by species of *Phytophthora*. The name *Phytophthora* (Greek: *phyton*, a plant; *phtheiro*, destruction) literally means "plant killer".

In any plant pathological investigation the isolation of a fungus from an ailing plant cannot alone be accepted as evidence that the fungus has caused the disorder. To be ascribed a causal role the fungus must first be grown in pure culture and then be used to inoculate the same-plant species in which the disorder appears, and it must produce the same disease symptoms. Therefore, small pieces of mycelium of the fungus isolated from white mangrove roots and grown in pure culture were placed in slits in the stems of two-month old white mangrove seedlings raised in a glasshouse. Within two weeks the fungus grew upwards and downwards in the stem to produce lesions up to 40 mm in length (Figure 2). This experiment demonstrated that the fungus is a wound pathogen of white mangrove stems. However, in nature *Phytophthora* species infect plant roots by means of motile zoospores and, less commonly, by direct invasion by fungal hyphae. Therefore, two-month old seedlings raised in the glasshouse were inoculated with concentrated zoospore suspensions of the fungus. These seedlings developed a slight necrosis of the root tips but otherwise remained quite healthy. If plant roots were severely damaged prior to inoculation, considerable decay of root tissue resulted. From these experiments it was concluded that the *Phytophthora* species isolated from declining mangroves is not an aggressive pathogen of healthy white mangrove trees and could not be considered the primary cause of mangrove deaths in the Gladstone area.

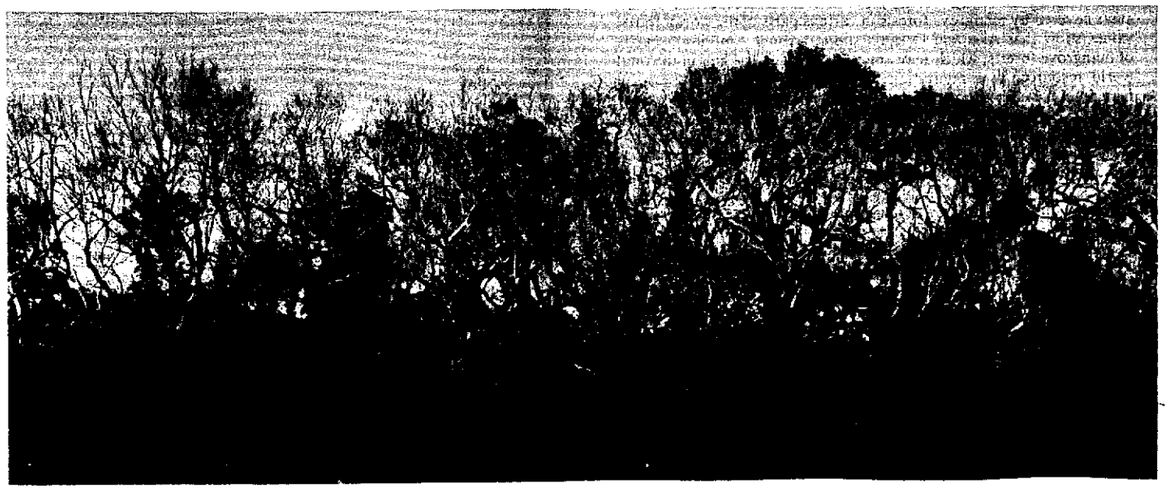

Figure 1. Declining white mangrove trees along the Calliope River, Gladstone.

Further investigations have indicated that the *Phytophthora* species is prevalent in mangrove communities in southern coastal Queensland. It was readily isolated from the stems of *Avicennia* seedlings where the bark had been damaged by crabs. It was also recovered from decayed absorbing rootlets and discoloured trunk tissue of *Avicennia* trees and seedlings growing in waterlogged sites in Moreton Bay in south-east Queensland. In addition the fungus was isolated from fallen *Avicennia* leaves in Moreton Bay and from the necrotic roots of drifting *Avicennia* seedlings which had failed to establish. Natural populations of the *Phytophthora* species also readily invaded the stems of *Avicennia* seedlings which were artificially wounded to simulate crab damage in several Moreton Bay mangrove communities. During these investigations the fungus could not be recovered from roots or trunks of healthy *Avicennia* trees and seedlings growing in areas where the fungus was found to be present in damaged or decaying mangrove tissues.

All terrestrial species of the genus *Phytophthora* are regarded as aggressive plant pathogens. Some also possess considerable saprophytic ability (Ribeiro, 1978). Only five species have been described from the marine environment. They are *P. vesicula* Anastasiou & Churchland, *P. bahamensis* Fell & Master, *P. epistomium* Fell & Master, *P. mycoparasitica* Fell & Master, and *P. spinosa* Fell & Master. They are considered by Fell & Master (1979) to be important organisms in the decomposition of mangrove leaf litter, where they apparently help to convert a nutrient poor litter into a protein rich food for fish and crustaceans. Parasitism could be a distinct disadvantage for a *Phytophthora* species in a wetland environment where soil moisture levels would nearly always be favourable for host invasion. Unless it was a recent invader of the mangrove community, an aggressive *Phytophthora* species would have eliminated a susceptible host long ago.

A *Phytophthora* species has been isolated previously from roots of declining *Avicennia* trees in New Zealand (Maxwell, 1971). Maxwell also found that his isolates were not aggressive pathogens, and did not consider them to be the major cause of mangrove death in the area he studied.

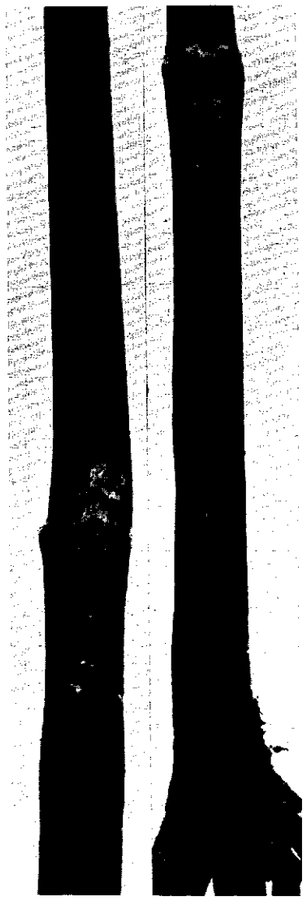

Figure 2. Effect of wound inoculation of *Avicennia* seedlings with *Phytophthora* sp.
Left, noninoculated control. Right, lesion development on inoculated plant.

During the investigations in Queensland mangrove communities a number of *Phytophthora* species have been recovered. Four of these (including the isolate from *Avicennia* roots) produce sporangia with exit vesicles (Figure 3a). None of these four isolates are considered by Dr. D.J. Stamps of the Commonwealth Mycological Institute, Kew, England, to be *P. vesicula*, which has similar sporangial characteristics. Another *Phytophthora* species regularly recovered from fallen *Avicennia* leaves has a method of zoospore release different from that previously described for any species in the genus. Sporangia of this fungus are non-papillate, and have a wide flat apex (Figure 3b). Prior to zoospore release a lateral slit occurs and an apical 'lid' curls back (Figure 3c).

In the Gladstone area there has been considerable earth filling of streams to create bund walls and causeways and to reclaim mangrove swamps for industrial development. Initially, it was thought that the *Phytophthora* isolated from roots and trunks of declining trees was a terrestrial fungus which had been introduced into the estuarine environment with earth filling. However, attempts to recover this fungus, and other *Phytophthora* species isolated in these studies from terrestrial habitats were unsuccessful. All mangroves isolates recovered are considered to be marine members of the genus.

Figure 3. Sporangia of *Phytophthora* spp. from *Avicennia*
(a) showing exit vesicle (x300)
(b & c) showing operculate sporangia before (x300) and after (x250) zoospore release.

It appears that the *Phytophthora* species encountered in this investigation are efficient saprophytes with only limited parasitic ability. The species most commonly isolated from *Avicennia* roots and trunks is considered to be a secondary invader and not a primary pathogen. It seems that some stress factor, such as waterlogging or wounding, has to be imposed on the host plant before it is susceptible to invasion by the fungus. At Gladstone the tremendous disturbance to the mangrove ecosystem by one or more of the industrial operations in the area may have provided the stress factor which has predisposed the plants to invasion. This factor has not been identified.

The deaths at Gladstone demonstrate that a community, which normally has a high level of resistance to a fungal pathogen, can be devastated in times of environmental stress.

References

Fell, J.W. and Master, I.M. (1979) — *Phytophthora* spp.: Their association and roles in mangrove detrital systems. Proceedings International Marine Mycology Conference, Moorehead City, United States of America (Abstract).

Maxwell, G.S. (1971) — *Phytophthora* in mangrove communities at Piako, New Zealand, M.Sc. (Botany) Thesis, University of Auckland. 144 pp.

Ribeiro, O.K. (1978) — A source book of the genus *Phytophthora*. J. Cramer, Vaduz. 417 pp.

Saenger, P. and Robson, J. (1977) — Structural analysis of mangrove communities of the central Queensland coastline. Marine Research in Indonesia. 18: 101-118.