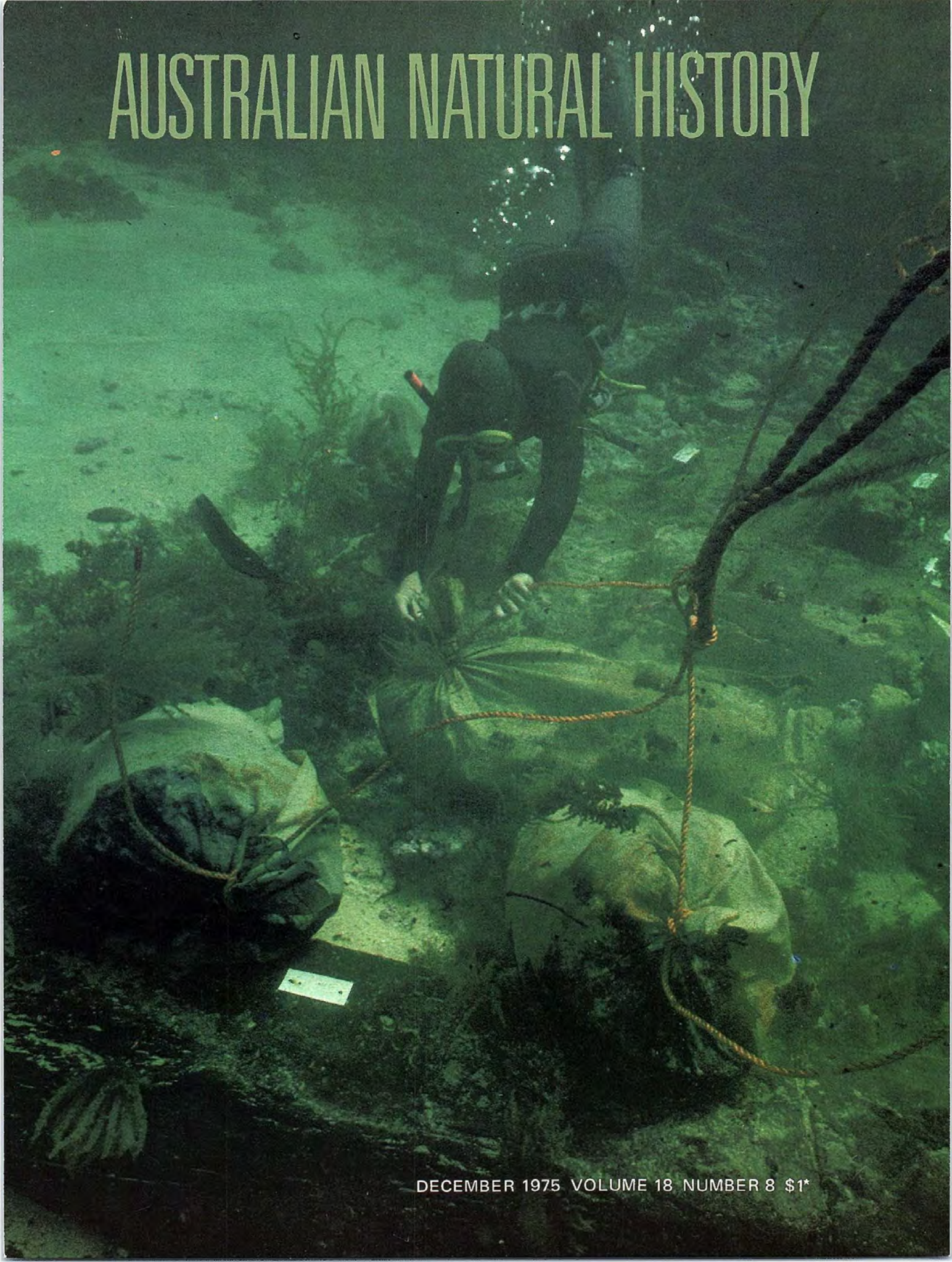
AUSTRALIAN NATURAL HISTORY



DECEMBER 1975 VOLUME 18 NUMBER 8 $1*

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COVER: A diver from the Western Australian Museum's Department of Maritime Archaeology attaches a rope to bags containing relics from the Dutch East Indiaman *Batavia,* wrecked off the coast of Western Australia in 1629. (Photo: Jeremy Green)

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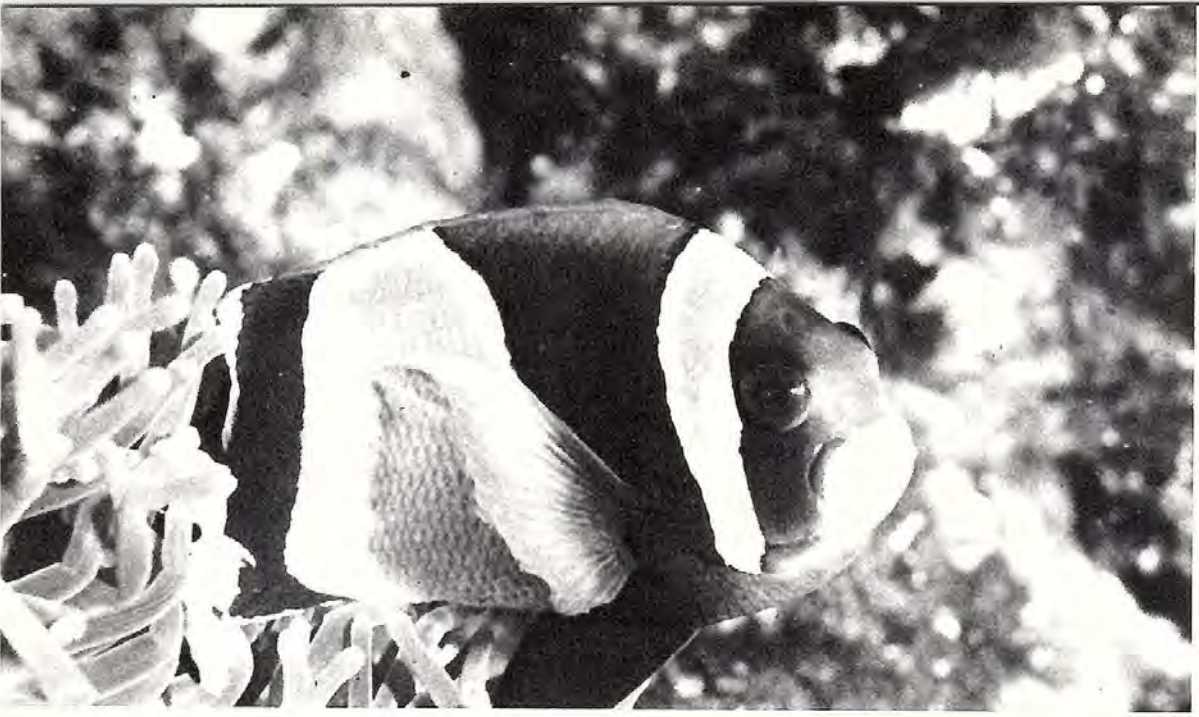


G.R. ALLEN

The Wide-banded Anemonefish *(Amphiprion latezonatus)* has an extremely limited geographic range which includes Lord Howe Island and northern NSW.

The British naturalist, Collingwood, was the first person to record the unusual relationship between bright-coloured fishes and giant sea anemones. That was back in 1881. Since that time, both laymen and scientists have marveled at this unique partnership. Most fishes avoid the anemone's tentacles, and for good reason. Equipped with specialised cells called nematocysts, they are capable of paralysing careless intruders. Anemonefishes, however, actually nestle among the deadly tentacles and rely on them for protection from their enemies.

These fishes belong to a large family of tropical reef species, Pomacentridae. The twenty-six species which comprise the anemonefish genus, *Amphiprion,* are confined to the Indo-Pacific region. Eleven species inhabit Australian coral reefs. Some, such as the Pink Anemonefish *(A. perideraion),* are relatively drab; others exhibit striking colour patterns, for example, the two species of Clown Anemonefish *(A. ocellaris,* and *A. percula).* Several species are able to alter their colour according to the type of anemone with which they are associated. The Orange-finned Anemonefish *(A. chrysopterus),* a rare inhabitant of northern Queensland, is predominantly orange and black with white bars when it lives with the Giant Anemone *(Stoichactis giganteum),* but when residing with the White Anemone *(Radianthus malu),* it is frequently brownish with white bars. Similarly, Clark's Anemonefish *(A. clarkii)* is primarily black when found with the Giant Anemone and largely orange when associated with several other host species. The fishes can actually be induced to change colours if experimentally switched from one anemone to another. The change generally requires one or two weeks.

There are at least a dozen anemone species which serve as hosts. They vary in size from the diminutive Douglas Anemone *(Physobrachia douglasi),* which has an oral disc diameter of only a few centimetres, to the gargantuan Giant Anemone, sometimes measuring more than one metre across. The anemones are sometimes encountered without fishes, but the latter are never found without their invertebrate host. The occasional reports of fishes without an anemone are no doubt the result of the cryptic habits of several of the host species. They may attach in cracks and crevices or among dense coral growth, where they easily escape notice. Such is the case with the Douglas Anemone which is the haven for the Black Anemonefish *(A. melanopus).*

Typically, the fishes feed on minute planktonic animals a short distance above their lair. Copepods, a type of minute crustacean, are a preferred food item of many of the species. Periodically the fishes retreat to their anemone where they 'scamper' over the oral disc and literally 'bathe' among the tentacles. If threatened by a diver or large predatory fish, they make a headlong dash for the sanctuary offered by their host, completely burying themselves among the tentacles . . . only to reappear headfirst, seconds later, as if checking to see if the coast is clear.

The Pink Anemonefish is usually associated with Ritter's Anemone *(Radianthus ritteri).* Generally there is an adult pair and three or four smaller fish with each host. A 'pecking order' exists in which the smaller individuals are constantly harassed by the larger ones. Investigations conducted at Eniwetok Atoll in the central Pacific revealed that the dominant adults actually exert an inhibiting effect on the growth of the

GERALD R. ALLEN, Curator of Fishes at the Western Australian Museum, is particularly interested in the biology and behaviour of tropical reef fishes.

ANEMONEFISH AND THEIR AMAZING PARTNERSHIP

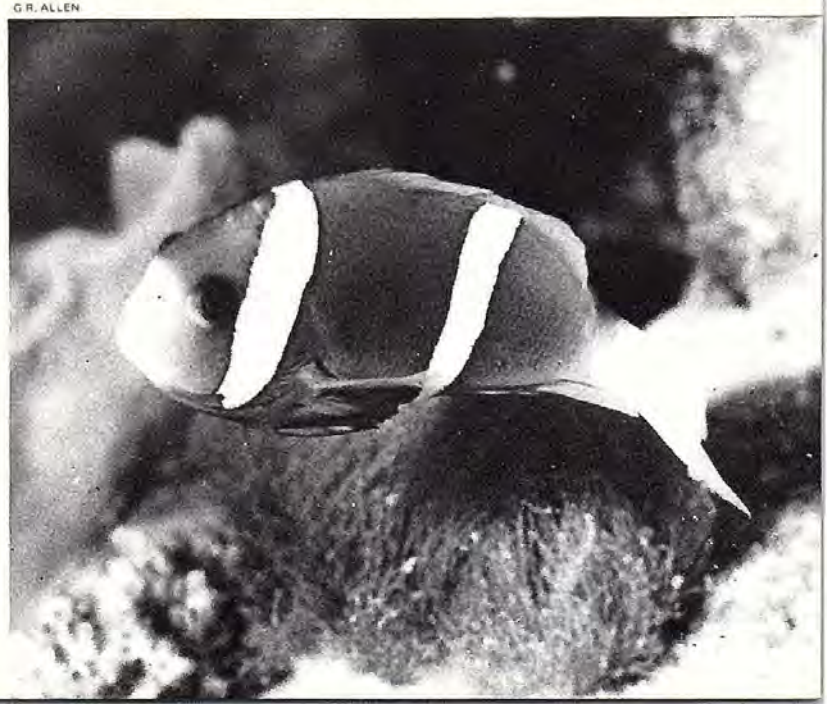
BY GERALD R. ALLEN

smaller fish. Very little growth was recorded for the smaller fish at several anemones during a six-month period. At the end of this period the adults were removed and the remaining fish subsequently showed a distinct acceleration in development. One individual nearly doubled in size over the next few months. Apparently, the adults suppress the feeding activities of the smaller individuals, forcing them to forage in areas of limited food supply.

It is easy for a diver to spend hours observing and photographing this fascinating relationship. The fishes obtain the obvious benefit of protection from the partnership. In addition, some species actually obtain food from their host in the form of regurgitated waste material. The benefits derived by the anemones are less obvious. The territorial residents provide protection from the numerous coelenterate-feeding species such as butterflyfishes. Also, the fishes help keep the oral disc free of debris and sometimes feed upon small parasites which attack their host.

In spite of the popularity of anemonefishes as aquarium pets, few people are aware of their interesting life history. Most spawn throughout the year at approximately monthly intervals. Several days prior to spawning, the pair selects a nest site on the rocky bottom adjacent to the anemone. The male, occasionally assisted by his mate, vigorously bites at the nest site, gradually clearing away the plant growth and other debris from an area about eight centimetres in diameter. At the same time, the courtship activities of the pair become noticeably increased. There is a good deal of chasing and the fish frequently confront one another with a series of nuptial postures. The most popular of these consists of erecting the fins while quivering the body. On the day of spawning, the courtship activities become even more intense until finally the whitish egg-laying tube of the female becomes visible. A short time later, she enters the nest area and begins depositing eggs, followed by the male who quickly fertilises them. The spawning process usually lasts from one to three hours and generally 300 to 700 pinkish-orange eggs are deposited. The eggs are capsule-shaped, about two millimetres long and three-quarters of a millimetre wide. Each is attached to the bottom by an adhesive bundle of tiny, hair-like filaments. The incubation period lasts one week. During this time the male busily takes care of the nest and actively fans the eggs with his pectoral fins or tail fin. This behaviour serves to keep the eggs free of debris and disease-producing organisms. He also labours over the nest with his mouth, removing eggs which are dead or diseased. He is aided only infrequently by the female, who now spends most of her time feeding. The eggs hatch during the night on the seventh day of incubation. The liberated larvae struggle towards the surface of the water and are subsequently swept out to

G.R. ALLEN



The Barrier Reef Anemonefish *(Amphiprion akindynos)* was recently described by the author from the Capricorn Group, Queensland. It also occurs at New Caledonia.

G R ALLEN

The lovely Golden-finned Anemonefish *(Amphiprion chrysopterus)* dwells mainly around islands of the western tropical Pacific. A single specimen has been found off Australia near Lizard Island on the northern Great Barrier Reef.

sea by the local currents.

The larvae are planktonic for at least two to three weeks. They are approximately four millimetres long at hatching and double their size in two weeks. They are transparent and slightly yellowish with a silvery abdomen. The characteristic anemonefish colour pattern is assumed when they are ready to settle to the bottom and begin their life-long partnership with an anemone. Survival is insured if a suitable, unoccupied host can be found. If the newly-settled postlarvae attempt to settle into an anemone which is already 'saturated' with fish occupants, they may be repelled by the fiercely territorial residents and will eventually succumb to predators if another home cannot be located.

Upon contact with an anemone, the young fish is confronted with the problem of acclimation. That is, it must gradually become immune to the deadly tentacles. The fish makes only brief contacts at first, but usually after twenty-four hours it can safely remain along the tentacles. Researchers have set forth an array of theories in attempts to explain the process which enables the fishes to live safely with their dangerous host. There are basically two schools of thought regarding the mechanism which is responsible. Some scientists feel that the active part in the acclimation process is played by the anemone. In other words, the anemone gradually becomes habituated to the fishes' presence, and after a period of time, no longer fires its nematocysts. Others have showed conclusively that during acclimation a chemical change takes place in the mucus coat of the fish, which renders immunity by actually lowering the threshhold of nematocyst discharge.

The bulbous tentacles of the Douglas Anemone *(Physobrachia douglasi)* provides refuge for this juvenile Black Anemonefish *(Amphiprion melanopus)*. Young fish seldom wander more than a few centimetres from their protective host.

G R. ALLEN

Juveniles grow at rates which vary from about two to seven millimetres per month and it requires one and a half to two years to reach sexual maturity. The larger species attain a length of nearly fifteen centimetres. At Eniwetok Atoll, the fishes form pairs and live at the same anemone throughout their lifetime. There is very little information on their longevity, but anemonefishes have thrived in the Noumea Aquarium at New Caledonia for more than ten years.

FURTHER READING

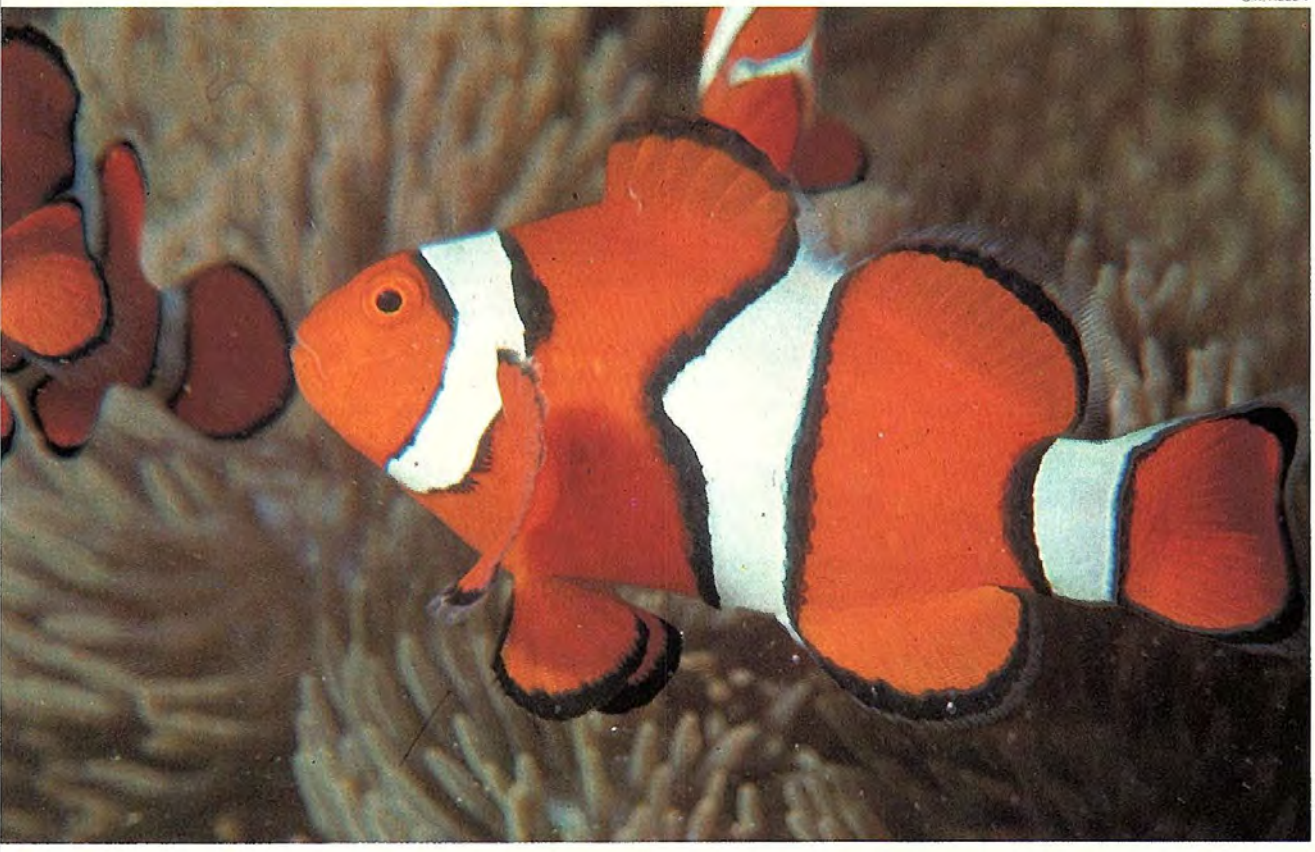
Allen, G.R. *The Anemonefishes, Their Classifications and Biology;* 2nd edition; T.F.H. Publications, Inc., New Jersey, 1975.

Allen, G.R. *Damselfishes of the South Seas;* T.F.H. Publications, Inc., New Jersey, 1975.

The Pink Anemonefish *(Amphirion perideraion)* is generally encountered in groups consisting of an adult pair and several smaller individuals. They usually associate with Ritter's Anemone *(Radianthus ritteri)*.

G.R. ALLEN

G.R. ALLEN



The Clown Anemonefish *(Amphiprion percula)* is well-known to aquarists. It is occasionally encountered on the northern Great Barrier Reef. A very similar species *(A. ocellaris)* occurs along the coast of north-western Australia and the Northern Territory.

SLIT DRUMS AND THE HUNGGW OF EASTERN AOBA

BY FRANCIS CAMERON

Aoba, which the local people call 'Omba', lies between the two arms of the Y-shaped chain of islands which collectively make up the Anglo-French condominium of the New Hebrides. It is a medium-sized island, some 15km wide and a little less than 40km long. The interior is well forested and rises to a maximum height of 1496 metres. Some of the peaks were once active volcanoes. Now they are quiet, their craters filled by lakes. The harbour of Lolowai, on the northeastern-most tip, also has volcanic origins but today the sea ebbs and flows through a gap in the old crater wall while around the bay is grouped the Melanesian Mission with its hospital, schools, manual training centre and, since January 1974, the seat of the first Anglican Bishop of the New Hebrides.

F. CAMERON

These men in the village of Lolovenue are performing a dance as part of the ceremonies announcing that a Hunggwe pig-killing will take place in the near future.

Contact with white people has affected the lives of New Hebrideans in many ways, but in some areas, and eastern Aoba is one of them, the traditional customs are still maintained along with such recent innovations as copra growing co-operatives and cassette tape recorders.

Outstanding among the Aoban customs is the Hunggwe, a graded society whose members advance to higher ranks by promoting public ceremonies where feasting and dancing is preceded by the ritual slaying of specified numbers of selected pigs. Men who rise to the higher grades earn a great deal of respect and can exert influence in their communities, but the road to such a position is long and arduous. The taking of each step may require ceremonies spread out over a number of years and involve intense personal effort in the production of the vast quantities of pigs, fowls, yams, taro and kava needed to make impressive feasts. Not only this; each act of the Hunggwe also requires considerable organisational skill. The proper ceremonial announcements must be made. Supporters must be encouraged to attend subsidiary feasts which will place them under an obligation to return the hospitality in tangible form at a later date. Especially will they be encouraged to present themselves at the vital ceremonies, for lack of public recognition on such an occasion would nullify its effect.

Then the right sponsors must be found. A boy making his entrance to the Hunggwe has no difficulty about this if his father is already of sufficient rank in the society. If he is not, then a young man will first need to demonstrate the necessary qualities of diligence and organising ability to justify his enrolment. He does this by such means as working extra hard in his garden, growing enough food and raising enough pigs to be able to give small feasts to his neighbours, so exercising the code of reciprocity which regulates many of the activities in his community. When he has begun to be recognised as an individual of the right quality, then he may find a Hunggwe of the appropriate rank who will act as a sponsor.

Here another cycle of reciprocity begins because

FRANCIS CAMERON is chairman of the Department of Musicology at the Conservatorium of Music in Sydney. At the end of 1971 he and Peter Crowe were joint leaders of an ethnomusicological team sent to Lolowai on the island of Aoba by the Musicological Society of Australia.

F. CAMERON

Charles Mera demonstrates his part in a slit drum orchestra for the benefit of the visiting enthnomusicologists.

the soonsor is obliged to supply a certain proportion of the special pigs for the grade-taking ritual. The candidate himself may supply some of the rest, but he also calls in pigs which are due to him from previous reciprocal transactions. In his turn he places himself under an obligation to repay pigs to his sponsor, and this repayment will be with interest. (In western Aoba, so anthropologist Michael Allen reports, the rate of interest is 100%).

Considerable negotiating skill is apparent among those who most successfully exercise the rules of reciprocity. At one level, the willing acceptance of another's goods or services may involve no more than a simple obligation to make a suitable repayment at a convenient time. At another level, the system can be used to personal advantage by imposing obligations on others in the expectation of suitable return at the right moment.

When a man feels certain that he will be able to produce a stipulated number of ceremonial pigs, when he feels confident that his store of food will make an impressive feast, when his sponsors have agreed to act for him and his supporters can be relied upon to be there in such abundance that the occasion will be a truly public one, then the Hunggwe candidate may make active preparations for the actual ritual. This takes place on a dancing ground where the selected pigs can be tethered to cycas palms, where there is ample room for the ritual dances, and where there is a group of slit drums which can be sounded in traditional style during a great part of the action. If, at an earlier stage, the candidate did not already have his own dancing ground and group of slit drums, he would have taken steps to prepare such a ground and acquire a set of drums or would have made arrangements to use someone else's.

There are usually three, four or five slit drums in an east Aoban set. New ones are still made in the villages and are played in the same orchestras with older ones, some of which are reputed to have been in use for at least a century. In its simplest and smallest form, a slit drum is made of a single internode of bamboo with

F. CAMERON

On the day of a Hunggwe ceremony, the slit drums are brought out from the *gamali* or men's club house and placed in position under a specially erected awning on one side of the *sara* or dancing ground. The large drum on the left was made recently by a man in the village. The other, which has a looped handle at one end, is reputed to be more than a hundred years old. Both are fine drums capable of sounding at many different pitches.

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A Hunggwe grade-taking ceremony in progress at Lovuimatamboe, east Aoba. Fred, who is thirteen years old, kills ten pigs to attain the rank of Fortaga. He is wearing the mats and plant leaves required by this particular ritual.

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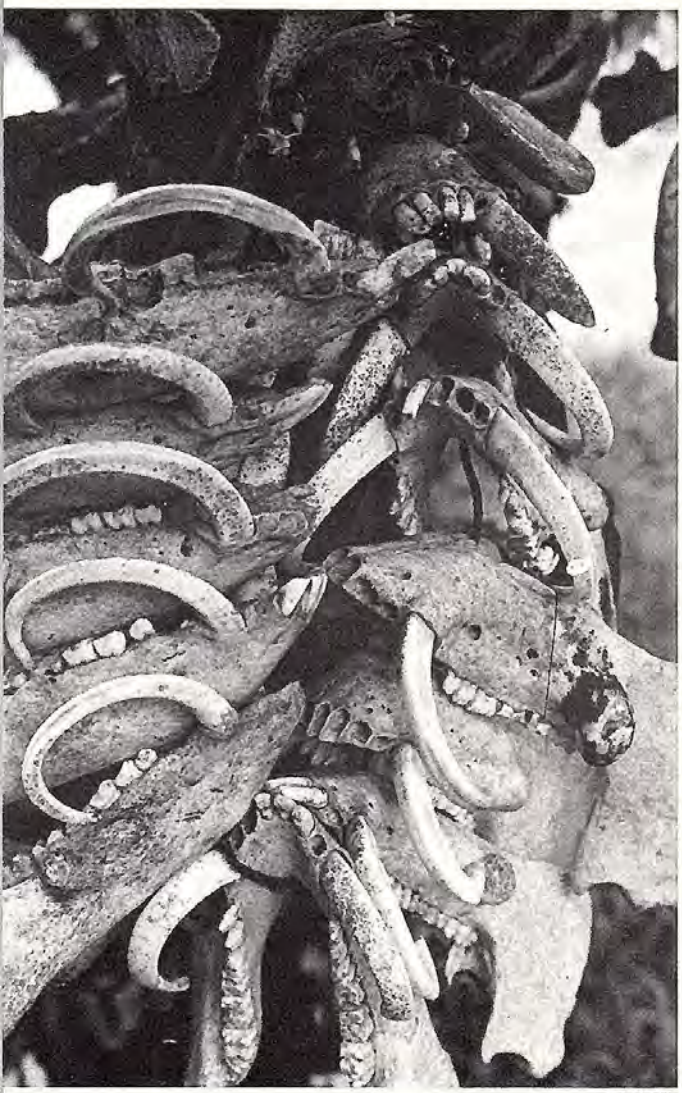
When the pigs have been ceremonially killed they are carried off to be cut up and cooked for the evening's feasting.



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Tusked pigs are an essential and very valuable part of the Hunggwe. This collection is displayed on a tree at the edge of the dancing ground. Sometimes a jawbone like this is shattered as part of a ceremony.

a lengthwise slit cut into it. Such an instrument is held in one hand while the player manipulates the beater with the other. A Hunggwe slit drum, on the other hand, is made by hollowing out a section of tree trunk. The exterior is trimmed so that many of the original contours remain, while the unwanted material from the inside is all removed through the slit so as to leave playing lips of varying thickness. This makes it possible to produce sounds of different pitch from one drum and as all the drums in the orchestra are of different sizes, the players are able to make good use of the resultant wide range of pitches. The smaller drums each have their own player. The largest drum often has more than one.

Drum sticks are freshly cut for each occasion. At least one of the men playing the largest drum uses the butt end of a palm leaf rib in one hand, while all the other sticks are selected from nearby bushes. The palm leaf rib makes a sound which is quite distinct from the more incisive raps of wooden beaters on the wooden lips of the drums so that the overall effect is that of subtle contrasts of timbre and pitch, colouring and intricate interplay of rhythms.

The patterns played by the drummers sound very complex to a European-trained ear. My colleague Peter Crowe wondered if he could learn enough of the technique to be able to sustain a part in a ritual orchestra, but he was told that this was impossible. It was necessary to begin at a very early age. A young boy must sit next to a close relative and imitate his rhythmic actions until he has completely absorbed them. This may take months, or even years. There are no known short cuts.

When Peter Crowe and I were in eastern Aoba during the later part of 1971 and the early part of 1972, we made a number of tape recordings of slit drum orchestras. Recently I have been listening to these again and have begun to transcribe some sections into western notation. The process is not an easy one, though some patterns reveal their surface structure sooner than others. By slowing down the tapes to half speed and making maximum use of the advantages of stereophonic listening, it is sometimes possible to isolate sufficient of the individual sounds to appreciate the skill and finesse of the Aoban performers.

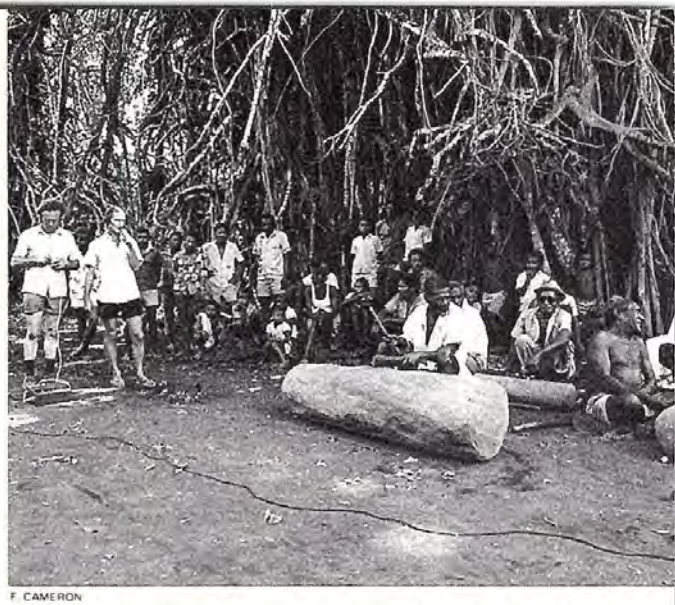
One of the preliminary dances of the Hunggwe begins by conveying a two-part effect and I have transcribed this by using notes with stems going up to represent the rhythms of our left-hand channel and notes with stems going down for the right-hand channel.

In this section the drums produce six musical pulses a second and I have chosen to represent each pulse by a quaver, that is, an eighth note so that when notes are grouped together by a common horizontal beam, the first note of each group is to be understood as

While Fred is killing his pigs, the women of Lovuimatamboe inspect the mats which are being exchanged. These mats are woven by the women in the villages and represent wealth to their owners. Mats and pigs are, in fact, a form of currency and may pay for services rendered as well as being items for reciprocal exchanges.

F. CAMERON

Under a banyan tree at Longana a slit drum orchestra is assembled for a recording session.



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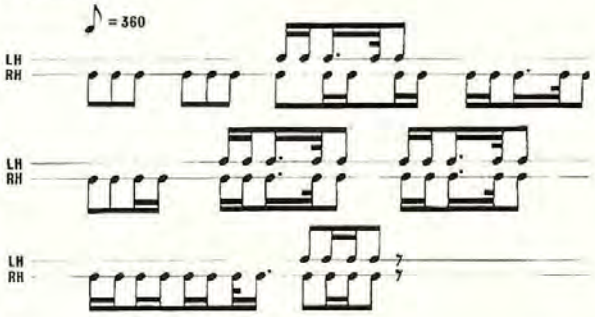
corresponding to the 'strong beat' of the European tradition or the 'rhythmic ictus' of Solesmes plainchant interpretation.



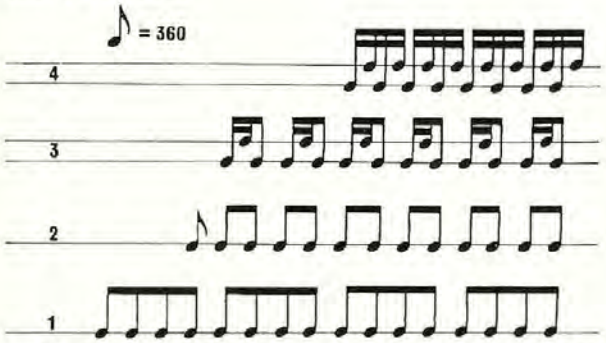
Inside a *gamali*, food for the evening's feast is cooked by heated stones in special fireplaces. Men normally use the fireplace reserved for the grade they have reached.

F. CAMERON

A view of a small part of Longana village showing a house built in traditional style near to others built of imported materials. The trees are coconut palms which are harvested for their copra and sold by a local co-operative.

This first passage is followed by a longer one where it is possible to distinguish four rhythmic strands beginning as shown below and continuing for 23 seconds with an insistent re-iteration of the final four pulse unit.

(1) stands for the rhythm of the lowest pitched sound, possibly that of the palm leaf rib beater on the largest drum. (2) is a moderately low pitched sound. (3) represents a single drum making two fairly high-pitched sounds a major third apart. (4) is the highest-sounding drum which produces a different pitch from each of its sticks.



On the day of a Hunggwe celebration, the drums have a very important role. They are taken to the dancing ground and set out in position under a specially-erected awning.

The day's events may well begin with ritual dances for which the orchestra will provide an accompaniment. There is singing, too, with some of these dances. Often a soloist begins a melody in free-sounding rhythm. Then the drums join in, setting the pulse for the remaining singer-dancers. The item continues in responsorial style with the chorus of men responding to each solo from their cantor.

There are special rhythms which signal the arrival of each ceremonial pig on the dancing ground, more patterns while the candidate dances round the tethered

F. CAMERON

pigs and special rhythmic signals to mark the slaying of each animal. The signal patterns can be extended as necessary to cover the entire duration of each specific ritual action. The leader of the orchestra watches each event carefully, picking up his cues to change or introduce rhythmic patterns at the appropriate moment.

The central part of the ritual varies in length according to the grade being taken: the higher the rank, the greater the number of pigs to be killed and, in the case of the higher ranks, there is a very real test of a candidate's stamina since he must kill all the pigs himself. Traditionally, a special club was used. Today a steel axe may take its place, but even so the ritual killing of a hundred pigs makes great demands on a candidate seeking great distinction.

At the end of the day prayers are said in the Anglican villages, then fires are lit and food cooked for the evening's feast. The ceremonial pigs are cut up and baked in earth ovens while the successful candidate joins the kava ceremony.

Each coconut-shell cup of kava is freshly prepared by grinding the roots of *Piper methysticum,* a species of pepper, and adding water until the right consistency is reached. The men taking part prepare each cup of liquid individually. When it is ready, they offer it politely to another of the participants who takes it down in one draught. In his turn the recepient prepares a shell for someone else, though not necessarily his donor. This action seems to suggest that, at this point in the evening, a sense of community prevails in place of the attention given to one particular individual throughout the day, though this is brought about in a very subtle way. Members of this community prepare bowls of kava which others drink without signs of reciprocal contracts between pairs of individuals. Everyone mutually contributes to the ceremonial. Everyone mutually benefits. Kava is not alcoholic, though it does induce a pleasant relaxed feeling of quiet companionship as the dusk quickly gathers. Later that night, when the feasting is done, there will be general singing and dancing until dawn.

F. CAMERON

It is just before dusk on the day of Fred's Hunggwe. The pigs have been killed. Food for the feast is cooking and the men prepare kava for each other. Here the liquid is being squeezed from the ground-up roots.

The actual events of the Hunggwe grade-taking ceremonies are fascinating in themselves and the detailed study of Hunggwe music is proving to be equally fascinating. There is even a possibility that the complex drum rhythms used for musical purposes are linked with other rhythms used for signalling. Future research into this link may well lead to a deeper understanding of the nature of music itself.

F. CAMERON

When we were recording Hunggwe music at Longana, a great number of women and children came along to watch. These are just a few of them.

A SEVENTEENTH CENT

BY JEREMY GREEN AND COLIN PEARSON

PART 1: EXCAVATING THE WRECK OF

At the Museum in Western Australia, we are building a time machine. When it is completed, it will take us back to the morning of June 3rd, 1629 when the Dutch East Indiaman *Batavia,* was wrecked in the Houtman Abrolhos. This group of islands lies about 50 km off the Western Australian coast, and is named for the Netherlander, Fredrick de Houtman, who discovered them in 1619, and from the Portugese word *Abrolhos* or 'beware!'.

The *Batavia* is an archaeological time capsule. When the ship sank, it froze a particular moment in time in a sort of suspended animation. For three years now, the Western Australian Museum's Maritime Archaeology Department has been slowly and systematically excavating the wreck, which has yielded material beyond our wildest dreams. In spite of the terrible seas that pound the wrecksite, year in and year out, we have found the navigation instruments of the ship, the apothocaries' jars, the whole of the stern shot locker and, most important of all, about a third of one side of the ship—solid oak timbers, as hard as the day they were cut, which have endured the sea for three and a half centuries to enable us to rebuild at least part of the ship and to reconstruct the strange and terrible events that surround her.

Our story is not one of buried treasure, gold, skeletons and sharks that occupy the commercial minds of treasure hunters and underwater looters. Undoubtedly, some shipwrecks have been discovered in recent years with fabulous treasure, especially those in the Spanish Main. But frequently, the gold fever that brings a gleam to the businessmen's eyes, leads to historically priceless wreck sites being ripped to pieces for gold and silver, and often to violence as the greedy men fall out.

Against this sordid background, the marine archaeologist works, often in competition with the looters. Fortunately, this is not the case in all places. Here in Western Australia we are lucky. On the *Batavia,* we have an underwater nine-to-five job in six metres of water for six months of the year where, in the green silence, we are only disturbed by the fish, which are so tame on the wrecksite that they can be fed by hand.

Photo: GREG MILLEN/AUSTRALIAN MUSEUM

Perhaps the *Batavia* is one of the world's most unusual maritime archaeological sites. It is associated with one of the most infamous mutinies on record. In 1628, the *Batavia,* under the command of Francisco Pelsaert, set sail from Texel at the mouth of the Zuider Zee. She was bound for Batavia, the headquarters of the Dutch East India Company in the East Indies. The ship was richly laden with coin and cargo, bound for the company's coffers in the Indies.

Although Pelsaert was the commander of the ship, the skipper or captain was Adrian Jacobsz and it seems that the two men did not get on. By the time the ship arrived at the Cape of Good Hope (at the time, a watering place but not settled), the ship was bordering on mutiny.

Whilst Pelsaert was off buying cattle from the Hottentots, Jacobsz went on a drunken rampage with his lady consort and the sinister undermerchant Jeronimus Cornelisz.

On Pelsaert's return he found that Jacobsz had caused uproar amongst the other ships of the fleet with his outrageous behaviour. One can easily visualise Jacobsz, the worldly skipper, being reprimanded by Pelsaert the intellectual commander. Jacobsz stumped off muttering dark threats of mutiny, of breaking away from the fleet and capturing the ship for piracy. A group of plotters formed.

As the ship departed from the Cape it did break away from the rest of the fleet during a storm, by luck or by Jacobsz's design we do not know.

Pelsaert, possibly anticipating a confrontation, retired to his cabin, ill. The plotters committed an outrage on Lucretia Jansz, an important woman passenger going to the Indies to join her husband. Lucretia was stripped and smeared with filth and excrement.

It should be noted here that earlier, Lucretia had caught the eye of Jacobsz but his advances had been firmly rejected. Chagrined, he took up with Lucretia's chambermaid, Zwaante Hendrix—as the cook's wife records, a loose woman (Pelsaert records that at one point Cornelisz surprised Jacobsz and Zwaante in the act of carnal knowledge in the stern privy!).

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Thus with mutiny imminent, while the plotters were waiting for Pelsaert to punish the people responsible for the outrage on Lucretia so that they could subtly recruit popular support to take over, the *Batavia* sailed on — straight onto the Houtman Abrolhos.

On June 3rd, 1629 at 4 o'clock in the morning, Pelsaert records, he was lying ill in bed, when he heard the rudder strike the bottom and was then violently thrown from his bed as the ship struck a reef.

When he came out of his cabin, he found the ship firmly lodged on a reef. Pelsaert and Jacobsz immediately set about trying to save the ship. Orders were given to jettison the cannon and to lay a kedge anchor astern. It was hoped that the ship had struck at low tide and that it would be possible to warp off as the tide rose.

Unfortunately for Pelsaert and the *Batavia* (but fortunately for us, centuries later) the ship had struck at high tide. As the sun rose to reveal their awful predicament, the Indian Ocean swells were building up ominously. As the ship bucked and crashed, trapped on the reef, it became impossible to stand upright on the deck.

One can imagine the panic and terror of women and children and soldiers unused to ship-board life at the best of times. Predictably, some of the crew, soldiers and their chosen women started drinking with abandon. Any attempts to save provisions or water or even to save the ship were hampered by mobs of drunks.

When the ship broke open and flooded at 10 am, only six hours after she struck, all attempts to save her were abandoned. Pelsaert was able to rescue all but 70 of the complement of over 300.

The survivors were put onto two nearby, waterless, low-lying islets. Pelsaert was unable to save the others from the ship because the sea had built up to such an extent that the boat could not come alongside and they were unable or unwilling to swim for it.

The majority of the people from the ship having been rescued, the next critical problem was that there was not enough fresh water for those marooned on the islands. It is here that Pelsaert made an extraordinary decision: to go and search for water, with *all* the officers and senior men. Jacobsz even took Zwaante along. The undermerchant Jeronimus Cornelisz was still on board the *Batavia.*

Pelsaert claims he was forced to sail with the senior officers. (Was this true?) In effect, he abandoned the survivors without a leader. No water was found on the neighbouring islands. (It should be noted that the survivors abandoned by Pelsaert did, in fact, later discover water on these islands.) So Pelsaert and the officers sailed in the ship's boat and skiff (they even took both boats) to the mainland. They gradually headed further north without finding any water; fortunately there was a lot of rain during this period.

It was eventually decided that the search was hopeless and that they should head directly for Batavia to get help.

On arrival, Pelsaert informed the Governor-General of the loss of the ship and the near mutiny. Coen, the Governor-General at the time, was a noted puritan and a ruthless judge. He promptly had the High Boatswain executed for his part in the Lucretia Jansz affair. Jacobsz, the skipper, was imprisoned. Pelsaert was given terse instructions and sent off in command of the yacht *Sardam.* He was ordered to proceed immediately to rescue the survivors and recover the money on board the wrecked ship.

After considerable delays, Pelsaert eventually arrived back at the Abrolhos. On his arrival he was met unexpectedly by a corporal, Weibbie Hayes, in a small home-made boat. Hayes recounted a grim story of mutiny and a massacre that had been perpetrated in the commander's absence, and reported that his men who had remained loyal were holding the ring-leader, Jeronimus Cornelisz, prisoner. He quickly warned Pelsaert that the mutineers would be arriving at any moment.

In fact, as the *Sardam* arrived, a battle was taking place between the loyalists and the mutineers. Both sides had rowed off to intercept the ship: Hayes to warn Pelsaert, the mutineers to capture the ship. With Hayes' warning, when the heavily-armed mutineers arrived, they were looking down a cannon loaded with grape shot.

The *Batavia* aground on Morning Reef. Two small boats are transporting some of the passengers to the two islands. (From the 1647 edition of *Ongeluckige Voyagie dan't Schip Batavia* by Francisco Pelsaert in the Mitchell Library.)

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The murders on Beacon Island, once known as 'Batavia's Graveyard'. (From *Ongeluckige Voyagie dan't Schip Batavia* in the Mitchell Library.)

Pelsaert tried the mutineers and the questioning (often under torture) gradually revealed the full enormity of the crime. Men, women and children had been brutally hacked to pieces and the better-looking of the women had been forced to be consorts or concubines of the leaders.

Inevitably, Lucretia Jansz, who one feels must have been a beautiful and strong-willed woman, was selected by Cornelisz. For several weeks she refused to have intercourse with Cornelisz and it was not until another mutineer brutally told her to co-operate or suffer the fate of the others, that she bedded with Cornelisz. Other women were available for common service.

The hangings on Seals Island. (From *Ongeluckige Voyagie dan't Schip Batavia* in the Mitchell Library.)

The mutineers at one point bet on whether it was possible to decapitate a person with one blow of the sword. Children were drowned; pregnant women were butchered.

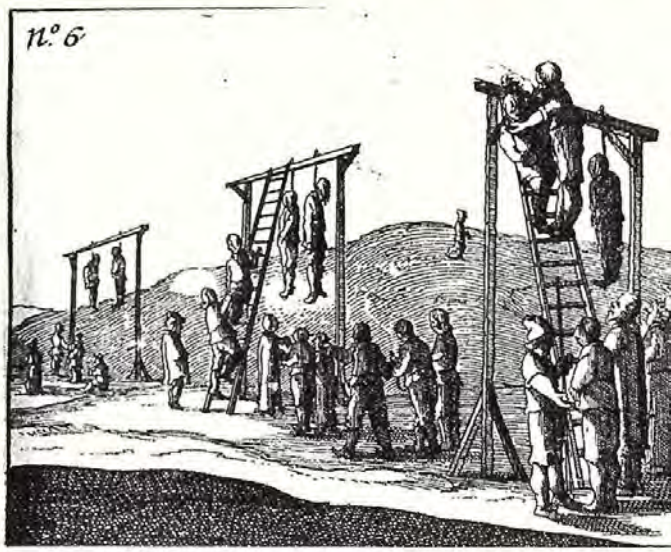
The motives of Cornelisz and the mutineers are obscure, as it appears that they were never really short of food or water. Cornelisz's name has been linked with the anabaptist movement and, in a recent historical documentary film, an analogy between the actions of Charles Manson and those of Cornelisz has been suggested. We know, however, so little of the 17th century with its everyday acceptance of unspeakable brutalities.

One of the two structures thought to have been built by the loyalists, on West Wallabi Island.

Cornelisz refused to confess to being the leader of the mutineers, even under torture (an accepted judicial process then). At the gallows, he claimed he was going to get justice in heaven as he had not found it on Earth. His last cry was "Revenge!".

Thus died Jeronimus Cornelisz. One wonders: Was he innocent? Was Pelsaert making him a scapegoat? Was he another Urbain Grandier being tortured for a confession to absolve others (as described by Huxley in *The Devils of Loudon)?* We may never know, but this all took place off the coast of Western Australia in 1629, two hundred years before the first European settlement. The 'forts' or shelters that we examined and concluded were Wiebbie Hayes' work, still exist in the Houtman Abrolhos, the first known European buildings or structures in Australia.

Pelsaert was able to recover 10 out of the 12 chests of coin in the wreck together with some of the cargo and two cannon. He sailed for Batavia after hanging the



leaders of the mutineers and marooning two boys on the mainland. The remainder of the mutineers were either keelhauled or dropped from the mast and then given 200 lashes. Unfortunately, when they arrived at Batavia, the Governor-General decided to hang them anyway. Out of the total ship's complement only

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about 30 people survived the mutiny and punishments. Pelsaert died in the Indies a few years later.

In 1950, Henrietta Drake Brockman and Drock published *The Voyage to Disaster, The Life and Times of Francisco Pelsaert.* This included an English translation of the journal of Francisco Pelsaert and, interestingly, indicated that the wrecksite of the *Batavia* was more likely to be in the Wallabi Group than in the Southern Group as Lord Stokes, Royal Navy, had suggested in 1830. Thus interest focused on the Wallabi Group as the site of the *Batavia.* Local writer Hugh Edwards and some other divers visited the group and searched with no success.

In 1963, Dave Johnson, a local cray fisherman from Beacon Island, knowing the local interest in the wrecks, contacted Max Cramer, a local skin diver in Geraldton, to inform him that he had seen a large anchor on Morning Reef in the Wallabi Group, which could be from the *Batavia.*

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The trial and torture of some of the mutineers at Batavia, now Jakarta. (From *Ongeluckige Voyagie dan't Schip Batavia* in the Mitchell Library.)

When Max Cramer went out to the Islands, he was the first person to dive on the wrecksite. However, to specify who found the *Batavia* is far from simple as so many people are linked together in the actual discovery.

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A skull found on Beacon Island. Note the sword slash on the back of the skull.

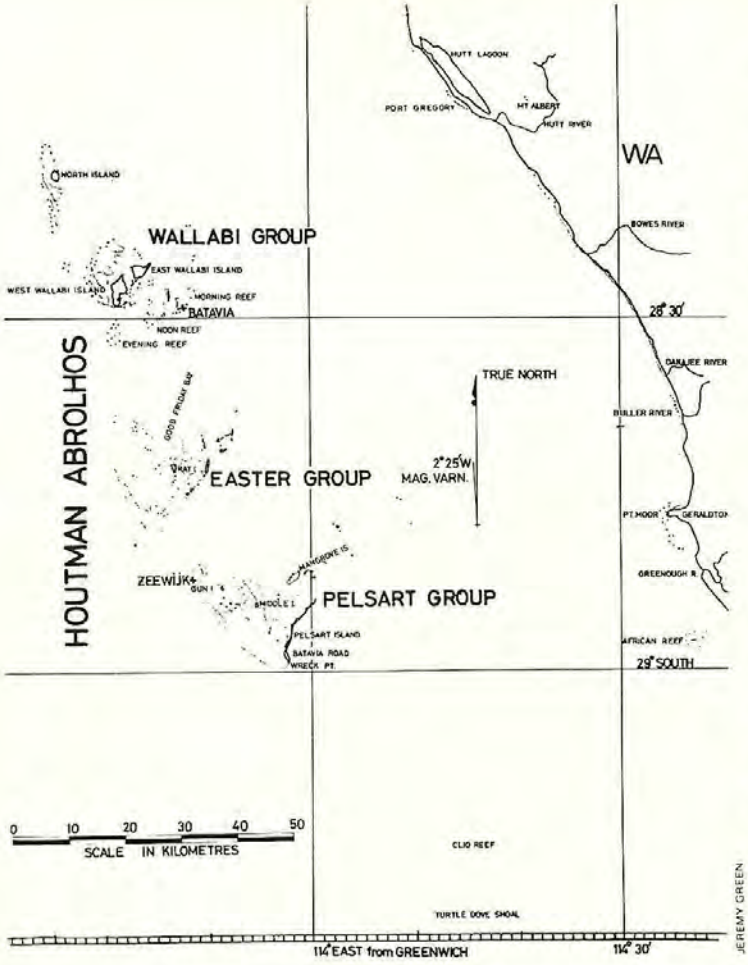
Following the discovery, an interservice expedition was mounted, comprising Royal Australian Navy, Australian Regular Army and civilian divers. This first expedition recovered most of the bronze cannon and a large variety of artefacts. The details of the first expedition are described in Edwards' *Islands of Angry Ghosts.*

In 1964, the Western Australian Government introduced the Museum Act (Maritime Archaeology) which was designed to protect all wrecks on the Western Australian coast prior to 1900. It was not until 1972, that the WA Museum's Department of Maritime Archaeology was able to start excavation work on the *Batavia.*

Prior to this, a base camp was built on Beacon Island to house a staff of six, with workshop, generator, freezer and radio communication. Perhaps one of the most important developments on the island was the construction of a jetty so that medium-sized vessels (25-metre) could tie up at the island.

A new steel workboat, *Henrietta,* was built to the Department's specifications. This was to be our main working platform and transportation system whilst working on the *Batavia.* It is 13 m long with twin diesel engines for manoeuverability and reliability

Thus in January 1973, we were ready to start the first full-scale excavation of the *Batavia.*



Beacon Island was the site of the *Batavia* massacres and then aptly named 'Batavia's Graveyard'. Today the island is inhabited by four fishermen and their families and the Museum's Maritime Archaeology Department. The fishermen are part of the crayfishing industry of the Abrolhos. From August to March each year the Abrolhos Islands are closed to crayfishing and during this period they are completely uninhabited. The usual *Batavia* (excavation season lasts from Christmas until April or May. Thus, for half of our season, we live on an uninhabited island and for the other half we have the bustle of fishermen, their families, boats and children.

There are many misconceptions about wreck excavation. The exercise does not, for a start, consist of indolently swimming over an area picking up goodies. Rather, it is a careful, demanding and often monotonous operation, For instance, in three years' excavation, we recovered about 50 tonnes of artefacts and this required us to physically move about 200 tonnes of coral by hand from the wrecksite.

This major task of shifting such a mass of overburden was further complicated by the huge swells, generated thousands of kilometres out in the Indian Ocean. They converged onto Morning Reef to break into a raging surf that sometimes crashed right over the divers working on the shallow site, sometimes racking beyond to cascade in a brilliant burst of foam and lacy mist halo over the top of the reef.

In safe conditions, the gentler swell was like a pulse for the divers on the seabed. One could feel the water pressure building up as a wave passed overhead. If it was a heavy swell, the divers could be driven perhaps three or four metres up the reef.

Paradoxically, there is no real danger to the divers in such a situation because their air supply is firmly attached to the workboat. It is the boat which is the cause of constant anxiety. Diving must be terminated on the *Batavia* wrecksite when the waves start breaking around the workboat. Up to a seven-metre swell, we found, was tolerable. But one day in the 1975 season, a freak wave broke completely over the workboat, shattering the heavy glass windows and injuring two of the crew.

For security in these circumstances, we used a mooring chain heavy enough to hold a destroyer.

A hookah diving system was used to supply com-

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Using a chain saw, a diver cuts through one of the heavy timber beams from the *Batavia*.

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pressed air from the boat to the divers below. Aqualung units would have severely limited diving time but the hookah unit enabled divers to stay as long as eight hours underwater without surfacing.

The well-equipped underwater archaeologist on the *Batavia* site carries a bag (for holding artefacts), a Nikonos underwater camera, a geologist's pick and a gimpy-small sledgehammer.

When we started the *Batavia* excavation in 1973, we concentrated on the problem of an area of massive sandstone blocks, puzzlingly shaped. Ultimately, the blocks proved to be a complete portico facade of a building—down to the very last block—presumably intended as a prefabricated structure designed for the Indies. We decided to raise them, firstly to find out their significance, and secondly because we hoped that underneath would be some remains of the ship's timbers.

With pick and hammer, each block was chipped from the coral encrustation so that rope strops could be tied around the blocks. The workboat was manoeuvred into position precariously over the top of the site while the blocks were winched on board. Urgency was the keynote of this job, carried out while the workboat was without the safety of its mooring. With a good load of building blocks, the boat would return to the Beacon Island jetty for unloading. The blocks totalled 124, an all-up weight of 27 tonnes.

Initially it took us about forty-five minutes to unload one building block, using boat rollers. But at the finish, we raised and unloaded sixty blocks in one day (an average of about five minutes per block).

The 'Beacon Island Express', a four-wheeled trolley made up in the island workshop by one of the divers, Geoff Kimpton, carried everything that was brought ashore, from stores to artefacts. We had expected to find the hull of the ship buried under the building blocks, but there was not a sign of it. We dug holes with airlifts and moved coral by hand but there was no timber to be seen.

Artefacts are raised from the wrecksite to be taken on board the workboat and transported to Beacon Island for preliminary conservation treatment.

At this point a severe storm blew up and all diving was off for about a week. There was plenty to do while we were confined to the island—catching up on maintenance, paper work, cataloguing and drawing items recovered from the site.

Back at the site, a shock awaited us. During our absence the storm had scoured the seabed. The whole scene had changed, and there, in an unexpected corner, was revealed the timber structure of part of the ship. Ribs and planking, unmistakeable, trapped under an iron cannon. (Eventually we were to discover that this first glimpse was only a portion of a huge section of the *Batavia's* solid timber hull; one-third of the port side of the vessel, including half of the stern. Uncovering the timber was to take most of the time and effort of three years).

Our first task was to carefully remove the sand and coral that covered the timbers and, as each section was uncovered, it had to be tagged and photographed to enable us to make a plan of the structure.

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Using a hammer and pick, a diver chips at a mass of coral and rock, possibly to expose some hidden artefact from the wreck.

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A concreted mass of cannon balls is broken up using hammers and picks.

Now a problem arose. In their three-and-a-half centuries under water, the iron fastenings of the ship's timbers had corroded away so that as we uncovered the ribs they began moving with the surge. It was obvious we could not safely expose the whole of the structure at once, because a storm would be likely to carry everything before it over the reef. We could afford only to expose short sections of the hull at one time and raise the loose ribs. This procedure exposed the planking, those long timbers which run horizontally along the side of a wooden ship.

Another problem: the planks, 10 to 15 metres long, were too long and too heavy to bring aboard our workboat, *Henrietta*. We had no alternative but to cut the planks into workable lengths.

Still another problem: the planking proved to be unbelieveably hard. A hand saw would bite only one centimetre deep and ten centimetres long in a full hour of hard work. We were getting nowhere in timber that was about 15 cm thick and 6 m across.

The answer emerged from a council ashore—an air-powered chain saw. This had to be air-freighted 500 kilometres from Perth to Beacon Island, for immediate use, powered from an air compressor on the workboat.

A cannon is released from the reef bed to be raised aboard the work boat *Henrietta*.

Ashore, a chain saw may throw up a little sawdust. It is easy to use, but must be treated with respect for its lethal, chained teeth. Underwater, with the surge of the *Batavia* site, it was a terrifying experience.

As soon as the chain bit into the timbers, a great black cloud spread out and covered the operator and surrounding area. But it worked. We were able to cut the planks into lengths of three to four metres and raise them to the workboat for transport to the island.

To avoid the inevitable damage that results to water-logged timbers when they dry out—even for 15 minutes in the case of this timber—we kept it wet even on the short journey to the island. Then it was unloaded into saltwater storage tanks ashore, to await the next stage. Unless such timber is kept wet, it soon cracks and is irreparably damaged.

On Beacon Island, bad weather days were put to use in taking the timber sections out of the holding tanks, photographing and drawing them and then placing them in sealed, waterfilled polythene sheeting. Like so many bodies, they were put aside to await transport to the Fremantle Maritime Museum's Conservation Laboratory.

During the 1975 season, we were working on a large coin concentration that we dubbed 'Fort Knox'. This is not considered by the diving team to be terribly exciting work because each coin has to be cleaned, catalogued, and registered. It means hours of painstaking work with acid and electrolytic baths, fibreglass brushes etc. cleaning the coins. The acid gets into one's cuts, the electrolytic bath gives minor electric shocks and the fibreglass bristles stick in the hands. All in all, coins are not too popular.

'Fort Knox' was proving very diffcult to work on underwater, so we isolated a huge lump of it, raised it intact and brought it ashore on Beacon Island to work on at our leisure.

The first task was to break it up into convenient lumps. To do this we used sledgehammers; it was the only way.

As we were breaking up the lump and the coins were dropping out something glinted from the edge of the hard, black iron concretion — an astrolabe. The coins were forgotten and the sledge hammers were discarded. For the next couple of hours we gently extracted this rare old navigational instrument from the concretion, complete and undamaged.

Concretion like this is a serious problem on a wreck-site. Not only is it very hard, sometimes striking

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sparks on steel on dry land, but it often contains fragile hidden artefacts. The problem is to break the concretion without damaging the artefacts.

During one particular phase of the excavation, we came across an enormous concretion of cannon balls weighing about five tonnes, too heavy to lift. Initially we tried to break it up using the standard pick and hammer but, even with the utmost care, some damage was done to the cannon balls.

Included in the concretion matrix were delicate cast iron objects which disintegrated no matter how careful we were in extracting them. This led us to experiment with small explosive charges to break up the concretion without damaging the objects.

It was a carefully controlled experiment, using charges so small that it was almost impossible to detonate them underwater (about 10 grams). We found this was an excellent way of dealing with the concretion.

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The hard body shattered, leaving the softer objects intact.

I have seen sites both in Europe and in Western Australia which had been devastated by looters using explosives in crude quantities related to their destructive use. But this was a completely unique use of the explosive force in measured quantities, which conserved material.

A visiting camera crew filming part of the excavation were disappointed. There was no plume of water when the small charge went off. "Nothing newsworthy here", was their verdict, so that story was never told.

Like the timber, the cannon balls and other iron objects require field conservation, pending the full scale treatment provided by the Conservation Laboratory. (These essential processes are dealt with in the next article.)

The WA Museum's Department of Maritime Archaeology, with the associated Conservation Laboratory facilities, are unique in Australia. In terms of activity, the Maritime Archaeology department is

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undoubtedly one of the world's largest.

Using compressed air, timbers from the *Batavia* are prised from the ocean floor.

The programme not only consists of work on the *Batavia* wrecksite; a parallel excavation programme is proceeding on the later, colonial wrecks which, in fact, have much more relevance to the history of European settlement of the Australian continent. Perhaps the Dutch shipwrecks on our coast belong to international history.

The *Batavia* wreck, without Pelsaert's journals and related documentary evidence, would not be a valid part of the 17th Century time machine. And the documents by themselves are lifeless.

One of the stern timbers from the *Batavia* is hauled aboard the workboat

Eventually, the *Batavia* timbers will be reconstructed and displayed, together with the reassembled building facade, cannons, coins, astrolabe, and trinkets. And with the documentary material, Commander Pelsaert, Lucretia Jansz, Jeronimus Cornelisz, Weibbie Hayes and the others — villains or heroes, but real people — will come to life again as a source of information, entertainment, even wisdom.

This is our time machine. There will never be another 17th Century. There will never be another *Batavia*.

One seasons load of timber, carefully wrapped in polythene, about to be sent by barge to the Department of Maritime Archaeology at the Fremantle Maritime Museum.

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PART 2: CONSERVING THE WRECK AN

Under the sea lie the remains of many ships—wrecked by coral reefs and storms or sunk in battle. A ship may remain in one piece, such as the famous *Wasa* which sank on her maiden voyage in Stockholm harbour in 1628, while others are scattered by waves and no longer exist. Many wrecks, however, contain heavy objects such as cannon, anchors and the large wooden pieces from the hull. These, along with many other smaller relics, especially ones of metal, glass, stone and ceramic, will survive the ravages of time. Even the remains of leather and lace have been found.

After the ship has been wrecked, it slowly settles on the sea bed. While the super-structures are disintegrating they provide protection to what lies underneath, and with the covering of sand, mud or coral growth, the remains of the wreck soon become encapsulated. The rate of deterioration of the material slows down under this concretion and, depending on the type of object and its composition, deterioration can cease altogether. There the objects lie in a stable environment until disturbed by the marine archaeologist or, all too often, by the amateur skin-diver or treasure seeker. The stable environment is suddenly changed and in all cases this causes an increase in the rate of deterioration of the underlying object, often with disastrous results. The excavated objects are invariably brought to the surface for examination and then left lying about. Iron objects especially, if treated in this manner, will rapidly commence to corrode, so rapidly in fact that cannon balls have been known to explode and hemp wadding recovered from the barrel of a cannon to commence to smoulder. Solid-looking iron cannon have lost all their surface markings and anchors have continued to flake badly. Bronze objects which normally do not corrode rapidly under the sea may suffer from what is termed 'bronze disease' when exposed to the atmosphere. This slowly causes the complete disintegration of the object, resulting in a pile of green powder. Ceramics, which again appear to be well preserved, if allowed to dry out without desalination will commence to deteriorate due to the salts from seawater crystallising out, causing the glazes and sometimes the body of the ceramic to flake and disintegrate. Wood, bone and leather, all of which become waterlogged, will crack and warp if allowed to dry out uncontrolled.

It can be seen, therefore, that an essential part of any marine archaeological expedition is the facilities and expertise of a Conservation and Restoration Laboratory to clean and stabilise the excavated objects. It is, in fact, no exaggeration to say that excavation without conservation is a form of vandalism.

The Western Australian Museum's Conservation Laboratory, which was established in 1969, now has a staff of 15. The Laboratory is responsible for the conservation of all the collections held by the Museum, but due to the nature of the material, it specialises in the treatment of objects recovered from the sea. Other work currently being carried out includes the treatment of historical/colonial objects, ethnographic material, Aboriginal rock art and vintage automobiles.

Conservation must commence the instant an object is removed from its stable environment on the sea bed. It must not be allowed to dry out and, until full conservation procedures can be implemented, it must be stored in a stable environment. Due to the isolation of a wreck site, all excavated objects may have to be stored locally for up to several months prior to transportation to the Conservation Laboratory. It is, therefore, essential that a full-time conservator is attached to the expedition to carry out on-site conservation procedures.

The objects that arrive at the Laboratory cover a wide range of materials including wood, metals, ceramics, bone, ivory, glass, stone, leather and textiles. The staff required to handle this material includes physical chemists, a metallurgist, biochemist, and craftsmen to do restoration work.

Conservation is defined by us as the cleaning and stabilisation of an object against further deterioration, whereas restoration is the repair of broken objects and also the replacement of missing pieces when this is necessary. Although all objects recovered from a wreck require conservation treatment, only a relatively few are fully restored, in particular broken ceramics and objects required for display purposes. Replica work is also carried out for display purposes and also to obtain the impression of an iron object, for example, which has completely corroded, leaving behind just the shape of the original object in a piece of coral.

For the past three years, the Department of Maritime Archaeology has been carrying out extensive excavations of the Dutch East Indiaman wreck, *Batavia* which was lost in the Houtman Abrolhus off the coast of Western Australia in 1629. (See the proceeding article.) Some of the conservation and restoration techniques used in the Conservation Laboratory to treat the material from the *Batavia* will be discussed here in more detail. It must be emphasised that it is not only the type and size of the object which causes conservation problems but also the quantity. To date the excavated material includes several iron cannon and

anchors, 27 tonnes of sandstone building blocks, approximately one-third of the wooden hull of the *Batavia,* over 800 pieces of shot, 4,000 silver coins and several thousands of other individual items.

The basic aims of conservation are to retain as much of the original object as possible but without in any way altering its shape, structure or properties and by using techniques which are completely reversible.

With iron recovered from the sea, it is essential to extract all salt contamination and water and then to apply a protective surface coating to prevent further corrosion. A coral-encrusted, wrought iron anchor was recovered from the *Batavia* which, until the conservation procedures could be commenced, was stored in a aqueous solution of 2% sodium hydroxide to prevent further deterioration of the iron. After the mechanical removal of all encrustations, the salt contamination was removed by electrolysis. The anchor was made the cathode or negative terminal of a large electrolytic cell and mild steel sheets on the positive side of the cell were used as anodes. A current was applied to the cell, which contained 2% sodium hydroxide solution as the electrolyte, and this extracted the salt from the metal into the electrolyte. The process, which took three months, was continued until all the salt had been removed, this being determined by analysis of the electrolyte. At the same time the salt was being removed, the process also reduced corrosion products on the metal surface. The anchor was next washed in distilled water to remove the final traces of salt and the sodium hydroxide electrolyte. The wash solution contained 2000 ppm of sodium nitrite as inhibitor to prevent further corrosion during washing. The wash water was removed from the surface of the anchor by a dewatering fluid which allowed rapid drying of the anchor without the formation of fresh rust. Finally, the anchor was coated with a clear anti-corrosion undercoat and a clear matt acrylic lacquer topcoat to give it a natural appearance.

The *Batavia* was carrying 260,000 guilders in the form of silver coins and pieces of silverware for trading in the East Indies, and some of this material has been recovered.

To date, 4000 silver coins have been excavated, many of which are concreted together. These are chemically cleaned, followed by electrolytic reduction (using a technique similar to that used for the anchor) to convert the corrosion products on the coin back to the original silver. Followed by careful fibreglass brushing, a clean bright silver coin results and, although many cannot be identified, some are in excellent condition.

PAT BAKER

A salt-glazed stoneware Bellarmine jug and silver coins after conservation and cleaning.

The pieces of silverware, when excavated, appeared to be battered bits of rather fragile black metals; however, after cleaning and electrolytic reduction, bright metal appeared. Due to the often fragile nature of the metal, the objects required heat treatment before being carefully hammered back into shape by a silversmith. These included a water decanter, a bed post and a plate, the latter still bearing the date and maker's

COLIN PEARSON

A handful of coins prior to cleaning.

marks which enabled verification of the source of the silver. Following treatment, all silver objects were coated with a special clear acrylic lacquer to prevent tarnishing.

Among the more remarkable objects recovered from the *Batavia* was the remains of a stack of leather-lined front and rear iron breast-plates. Although the leather had survived reasonably well, the iron had completely corroded; however, an impression of the plates was retained in the surrounding coral. This is a case where retention and examination of all pieces of concretion is so important. Although no original metal remained, the concretion was used as a mould to enable a replica of the breast plate to be made.

A tentative reconstruction of the building blocks from the *Batavia*.

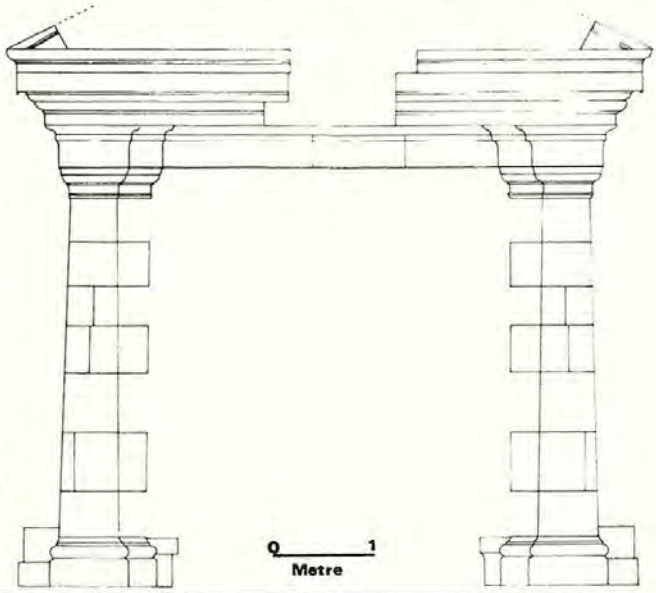
The pieces of leather were carefully extracted from the concretion, and dirt particles were mechanically removed by gentle brushing under water. The leather was next treated with potassium permanganate solution to oxidise absorbed organic materials, and the resultant violet-brown colouration was removed by reduction with sodium bisulphite solution. Further treatment with dilute acid solutions removed iron stains and calcareous deposits, and the resulting carbon dioxide gas mechanically removed final traces of dirt.

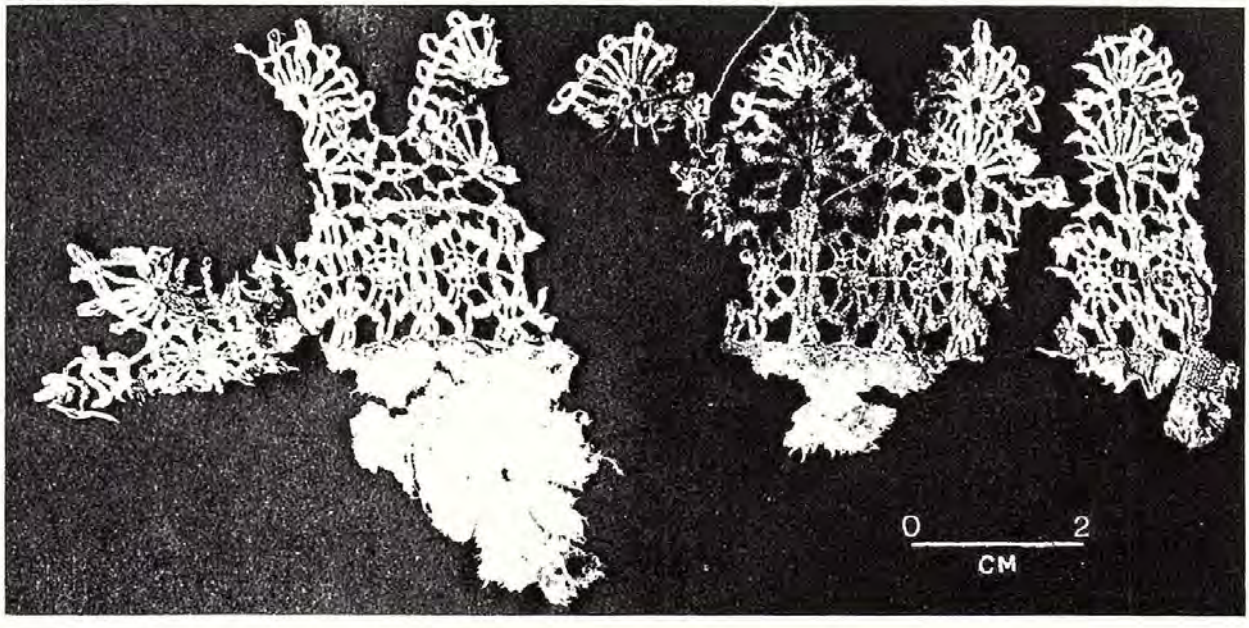
Fragments of lace following conservation and restoration.

COLIN PEARSON

An alkali wash was then used to neutralise the acid. The leather was next soaked in neatsfoot oil to keep the internal moisture content at a level sufficient to retain suppleness.

The impression of the original iron breast plates was very well preserved in the surrounding concretion. In fact, the rivets holding the leather linings to the plates were coated with gold leaf and this still remained on the concretion. In fact, the rivets holding the leather linings to the plates were coated with gold leaf and this still remained on the concretion. Using the concretion as a mould, a polyester/fibreglass replica of an original iron breast plate was made using silicone rubber as the intermediate mould. The resin was impregnated with tin metal powder which imparted a steel-grey metallic finish to the replica which could also be polished in a similar fashion to metal after the resin had cured. The 'gilding' on the rivets was obtained by





the use of a gold-coloured wax. Some pieces of armour were apparently for high-ranking officers as the remains of some breast plates were much more ornate than others.

Amongst the more delicate items collected from the *Batavia* was a conglomerate which contained what was believed to be the effects of the ship's barber. These were contained in two brass barber's bowls joined edge to edge. Amongst a number of small artifacts – including majolica ware drug jars, a tortoise shell comb and a leather shoe—was a tuft of seaweed like material which, upon closer examination, proved to be a piece of lace. This was heavily contaminated with dirt and other corrosion products and was freed by careful mechanical excavation.

The lace was cleaned under a microscope by carefully removing all particulate matter with a fine probe. The black staining was removed by soaking the lace in a dilute oxalic acid solution which was neutralised and the lace was then washed in distilled water. It was finally pinned out to dry before being supported on a fine polyethylene gauze backing. The lace is probably a piece of Italian bobbin lace commonly used to enrich the edges, collars and cuffs of garments. For display purposes it has been sealed between two sheets of special perspex containing an ultra-violet filter to prevent radiation damage.

The survival of the lace indicates how sometimes delicate objects survive on a wreck site whereas others such as iron breast plates have completely disappeared. It is virtually impossible to predict how well an object will survive on the sea bed.

One of the difficult types of objects to clean and restore are low-fired earthenware ceramics. A majolica ware drug jar, when recovered, was in a number of pieces, coated with coral and badly stained. These were very fragile and, if mishandled, would revert back to clay.

The first stage of the cleaning process was to remove all seawater contamination; otherwise salts crystallising out would tend to disrupt the glazes for which majolica ware is famous. This was done by careful washing, slowly reducing the salt concentration in the wash solution to ensure that no osmotic pressures would be created which again could cause a disruptive influence. The next stage was removal of concretion. It was impossible to use acids for this purpose as they would tend to dissolve the body of the ceramic. The concretions were therefore removed by mechanical means using dental tools. Staining was removed with hydrogen peroxide and the ceramic given a final wash to remove all residual chemicals.

Earthenware ceramics are very susceptible to flaking glazes and, with the drug jar, this was very evident. Before repairing broken pieces, the glazes were consolidated by careful impregnation with polyvinyl acetate dissolved in acetone and ethyl acetate. The jar was finally repaired using a polyvinyl acetate adhesive

COLIN PEARSON

The fibreglass replica of an ornate piece of armour.

which is readily reversible and also retains slight flexibility. It is important not to use adhesives such as epoxy resins as these are very difficult to remove and, if mechanically much stronger and more rigid than the ceramic, can themselves cause damage. Epoxy resins should only be used when the piece of ceramic is well-fired, has to take a load, or to repair the sprung crack in a plate, for example. Missing areas are not always filled as the missing pieces might be found on a later expedition. However, those that are replaced are made quite obvious, using a suitably coloured polyfilla compound.

This article has briefly described some of the processes and facilities available for treating marine archaeological material which cannot always be carried out by the amateur. Therefore expert advice should be sought if objects are to be raised—before raising—not afterwards when the damage has already been done.

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COLIN PEARSON

Majolica-ware drug jars following conservation and restoration.

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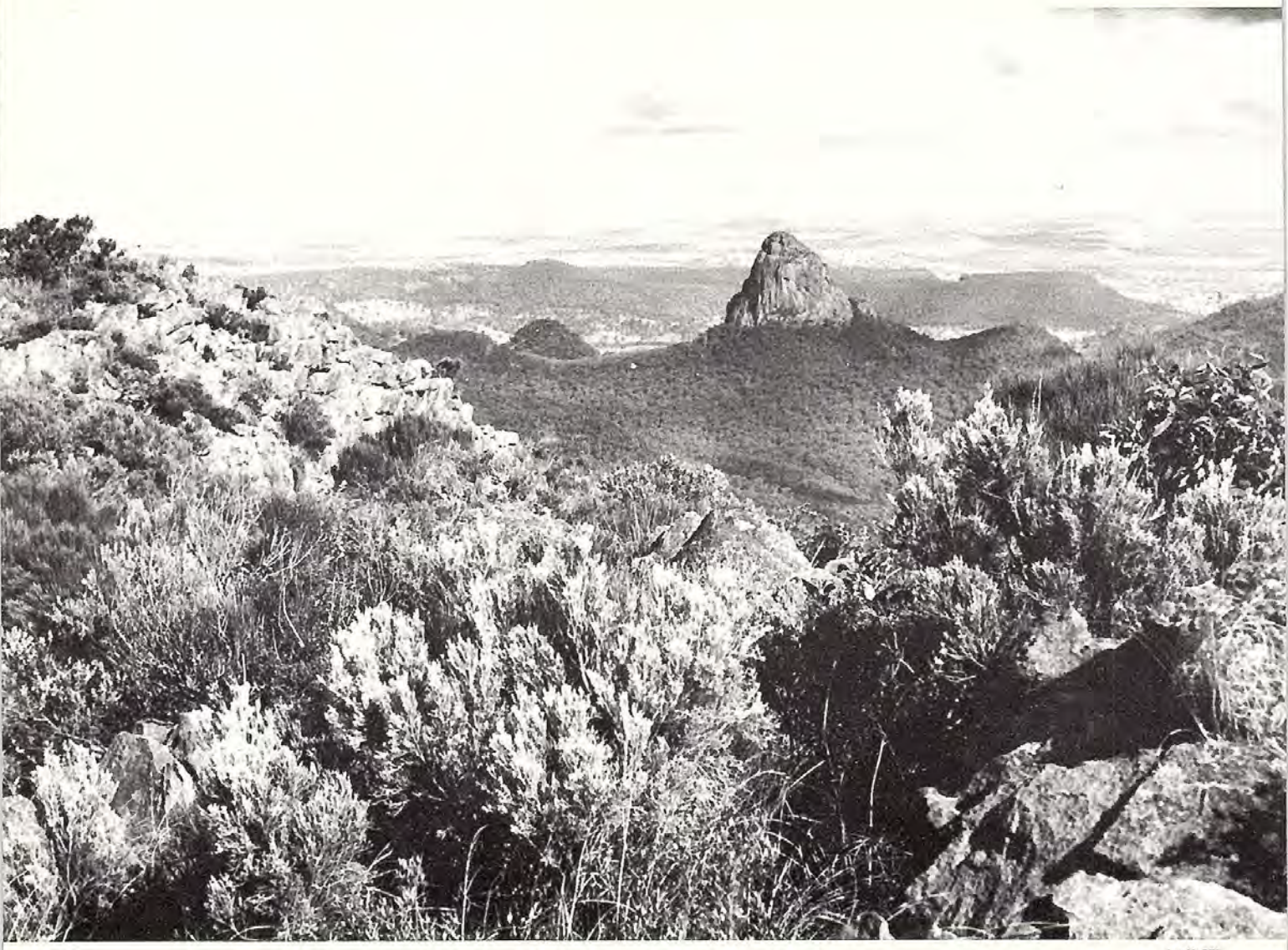

ALLAN FOX

The Warrumbungles —a vast pile of volcanic debris and mountain stubs rising above the plains. Tonduron Spire can be seen in the background.

Frequently one is asked, "What gave you your interest in nature conservation?" Obviously there is no single, clearcut answer, for an interest in nature conservation involves a host of interacting intellectual and personality factors. In contemplating the material for this article I have become aware that the impact of Oxley's "most stupendous range of mountains, [Warrumbungle Mountains] lifting their blue heads above the horizon" upon my interest in nature conservation has been profound.

Looking back, there appear to have been three periods of perceptual growth. The first was childhood when the field of view was just a few kilometres, when an intense interest was stirred by the continuous and exciting discovery of new sights, sounds, tastes, odours, textures and forms, of plants and animals, and of a few 'shocking' animal interactions. The second period was one of broadening horizons in a largely physical context—of walking and climbing, of physical exhaustion, of lying against warm rock, of campfire smoke and bright stars. The third, rising from these earlier experiences, was a strong yearning to under-

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WARRUMBUNGLE MOUNTAINS

A PERSONAL EXPERIENCE

BY ALLAN M. FOX

stand the why and how of the mountains, of their organic cover; and with this intellectual involvement came a strong urge to preserve the integrity of the interacting natural processes within which the Warrumbungle systems evolved. And now, I suspect a fourth period of attitude to the mountains is emerging—that of an 'old friend', which will require quiet association—to be one with the living systems.

My exposure to the Warrumbungle Mountains has produced developing perceptions culminating in a relationship which, to me, is a 'recreating' of my spirit and which leaves me with a strong desire to maintain the quality of the resource. Some highlights from these periods of perceptual evolution will serve to describe the mountains while at the same time perhaps posing some interesting problems for the Warrumbungle National Park manager and interpreter.

My earliest impressions were focussed about Timor Rock, a spine of trachyte which had been intruded into the Jurassic sandstones that underly the mountains and into the great pile of volcanic debris above, and that has since been almost completely removed by erosion and transported down Shawn's Creek to the Castlereagh Valley. Residual sandstone sugarloaf hills, some capped with columnar basalt lay scattered in a disorderly fashion while the Castlereagh River broke into the local area from its headwaters near Siding Spring Mountain by way of a gash in the hills known somewhat romantically as The Canyon. The southern horizon was set by the Tableland, a peninsula of horizontal sandstones and, as the locals would say, "dry as a dingo's donga".

On the flats and slopes of the stream valleys, squeezed in by the steeper slopes of the residuals, land had been taken up for mixed wheat and sheep production. Little of the land was productive, being derived from the infertile and 'droughty' sandstones. One of these farms was our 'mecca', its well-trimmed deep-green orange and mandarin trees, looking so out of place set among the tussled grey-green of white box and white gums. Above loomed Timor Rock, so high that, to the five-year-old, its rounded crest seemed to reach for the clouds with only the wedge-tailed eagles threading the space between on glistening wings. In those pre-war days the high tops were the only safe place for the eagle—it was the rare bird indeed that reached the black phase of old age! Today, legally protected throughout New South Wales, the eagle numbers appear to be increasing.

The well-worked warm white sand and clay of the orchard was better than any beach to play in and doubly attractive near the sweet mandarins. Numerous birds were also attracted to the dense green shelter, particularly when kestrels and falcons were hunting. This was galah country and in the heat of mid-day they would perch in the tops of the white gums with fluffed-up pink and grey feathers, just the odd one bickering. Our first warning, as we poured warm sand over our legs, that the predators were on the wing was when the treetops exploded into a screeching mass of galahs, tumbling and wheeling as they hurtled into the protection of orange trees nearby. More often than not, smaller honeyeaters, pardalottes, zebra finches or silver-eyes would be driven into the open to be picked off by the falcon.

On rewalking the 'long walks' of those early visits I have been surprised at the short length of them, but how full of interest they all were. The more interesting the track, the longer it seemed to be.

So far as I can remember we met no one who wished to eradicate the grey kangaroo or wallaroo, though the fences had to be constantly repaired as the 'roos broke them down to move onto the flats for their evening and daybreak feed, a routine which long pre-dated settlement. Consequently we always carried a rifle and had a shot at any 'roo that came into range. It wasn't until we had maimed an old pet 'roo in error, which we had released into the bush after it became too large to maintain at home, that we came face to face with the barbarity of loose amateur shooting.

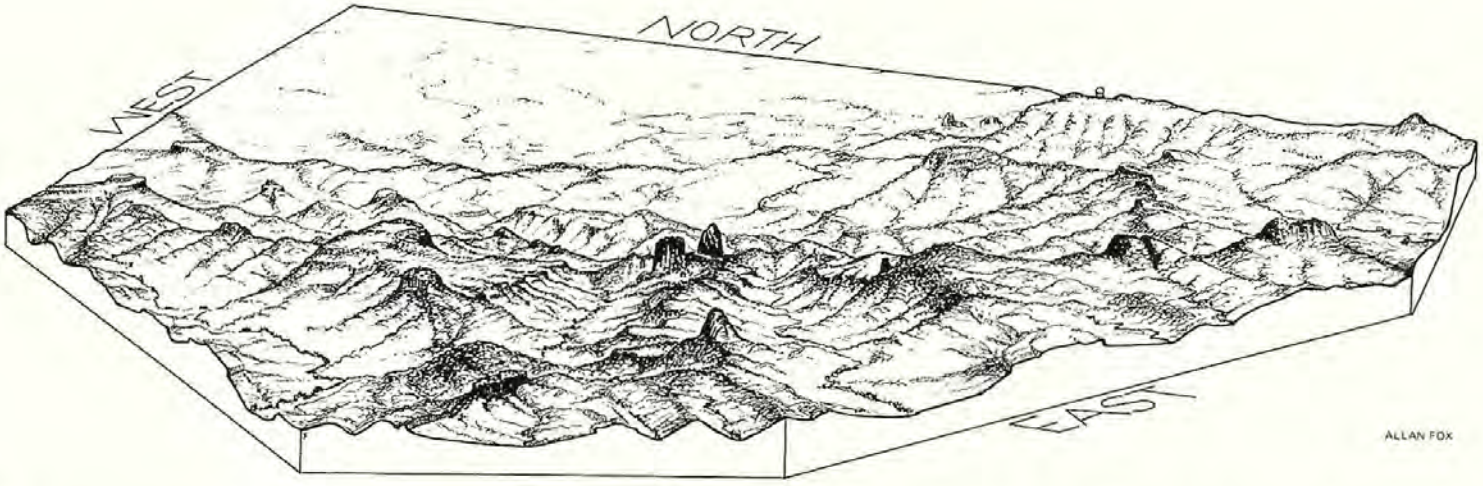
Our walks after that became excursions into discovering the secrets of plant and animals, made more fascinating by the observational games we played along the track. My father would lag behind and hide a coin; fifty or so metres along, he would pronounce that the scribbles on the white gum were in fact a message left by the Aborigines, which he would proceed to decipher using the objects of the track as landmarks. In this was we learned to recognise the rocks, gums, cycads, boronias, and a variety of animal tracks and faeces. Once the process of observation had been awakened, our awareness of the mountains and their life systems had become open-ended. The same process spelt early doom for the game when we had a long look at the scribbles with a hand lens and discovered that they were in fact insect tunnels —but it was good fun and we kept our secret from Dad.

Evenings by the log fire in the homestead were no less wonderful, when Bill Conn would recount his

conversations with geologist Dr. Osborne who also made the farm his base. In the flames we imagined fiery volcanic pits and boiling caldrons of lava. Ours was a very dramatic and simplified picture indeed, which was not to be corrected for many years. And when we had tired of volcanoes there was the story of Ben Hall's loot, which had been buried in a cave high on the wall of The Canyon beside a gaunt and deformed cyprus pine. There was talk too of the once-high populations of koalas and of thousands of 'pademelons' driven to extinction by the organised drives. What times those must have been, when a farmer with as many neighbours as he could muster, would gather in the hills for a weekend 'drive'! The best horsemen would form a loose line across a valley and then with 'whoops' and yells they would career down the valley, hunting all of the 'roos before them. At the far end, as the mobs of 'roos broke into the spires, the bluffs and Terra Terra (Mt. Exmouth).

My first view of the spires "lifting their blue heads above the horizon" came some twelve years after I had first heard of them, while on a Caloola Club bicycle trip from Yass to Maitland. The Caloola Club, a forerunner of the National Parks Association, and its founder, Allen Strom, were instrumental in broadening the horizons of and inspiring hundreds of teachers to a deeper insight into their land, its processes, and its management. The Club provided a social environment for the common enjoyment and critical analysis of the landscape and its use by man while Strom provided inspiration, knowledge, and leadership and actively fermented critical analysis. Facts became pivots for discussion, not sacred ikons.

In the year between skirting the mountains and walking into them (1949) the Caloola Club extended the view of its members from coast to plains and from



The Warrumbungle Mountains with their cool gullies, high tops and the hot, dry western slopes provide a variety of habitats for plants and animals of the humid coast and of the semi-arid interior as well.

open they would be met by a hail of bullets from the rest of the farmers. Then, stories over, we were off to bed to be lulled by the tired metallic grind of the windmill on the dry bore in the next paddock.

Long before sunrise, while the frost was still forming, we would round up the little black mare, 'Maydell', and with two of us aboard, bareback, and a dozen clanking rabbit traps we would steam off down the track to the Castlereagh, kangaroos thumping away as we approached. How brilliant were the stars, before the east began to glow along the horizon! Each time I hear Coonabarabran listed as the coldest place in the state in spring news items, my mind slips back to the crisp air, the lustrous nights and the grass with its crunchy, sparkling rime of frost.

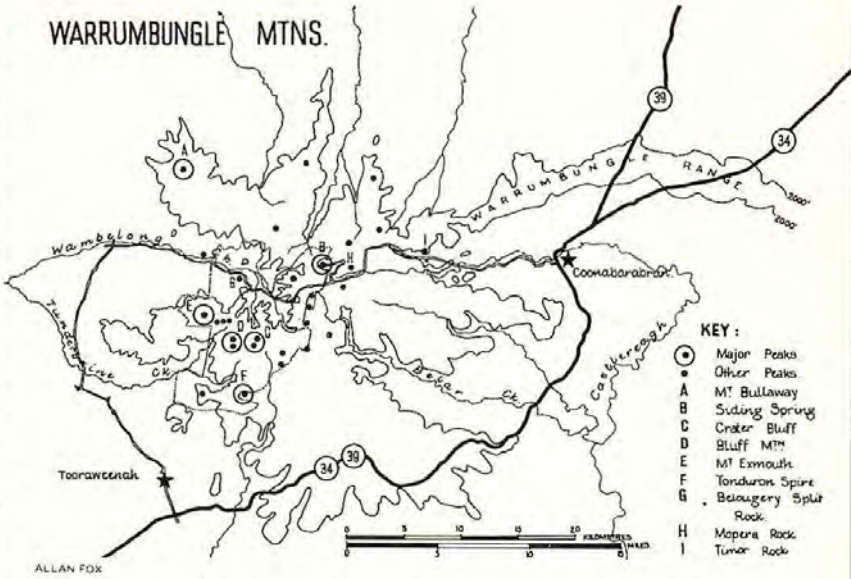
The early days in the Warrumbungles were these things and much more—they were full of legend, of colour, of the smell of woodsmoke, of rich textures and soft-eyed joeys, of beetles, of singing winds, of frost and heat, and sometimes of fearful episodes. But always beyond the western horizon lay the mystery of the big mountains, the sub-tropics to the alps. The broad mosaic of vegetation was discerned and relationships between landscape features and underlying geology began to gel. Works of Beadle, Costin, Anderson, Cayley and Troughton shared the space in our rucksacks. Regional differences in vegetation and wildlife became more apparent.

Our approach to the mountains in 1949 was by air to Toorahweenagh followed by a walk into Tundebrine Creek via the trachytic columns of the Mt. Naman dome. Camp that first night in May was typical and beside a dry creek, pebbles were stained white with calcium carbonate and the frost-whitened grass was almost as pale. Light from the smokeless redgum flames flickered against dark river oaks as we contemplated the morrow.

We broke camp as the sum lit a fiery halo around the smooth contours of Tonduron Spire which stood beyond the pine-covered ridge to the east. Soon the creek was barred by dykes and the hills pressed tightly in. River oaks gave way to the bright green and gnarled canopy of the rough-barked apples while legions of scribbly gums, mugga ironbark and cyprus pines strode

up the slopes. Flashes of crimson rosellas and the shaggy backs of disappearing wallaroos were lost among the trees and sclerophyll shrubs of the woodland floor. Crater Bluff, the great squarish and rifted trachytic plug, stood in the way of the creek which forked about its base. Deep in a rift of its red-brown southern face, shining green fig leaves marked damper niches. Above, the cold southwest wind roared about the crags with three eagles hanging on the turbulent air.

The final climb to the Grand High Tops was up a steep field of loose trachyte blocks. Nothing can adequately describe the first time one reaches these tops from the south to look into the amphitheatre-like Wombelong Valley. Here was the sheer exuberance of sitting on the edge of the world with the wind whipping at one's face. Belougery Spire, the Breadknife, Bluff Mountain, Mount Exmouth, Bullaway and Siding Spring line the rim with rugged slopes dropping into chasms which open into the broad Wombelong Valley. As we lounged there, in the lap of the gods, just below the edge, the questions came crowding in—why the great variation in rock resistance, the soft tuffs and breccias, the hard trachytes and fine-grained basic lavas? Was this the stump of one great volcano of the Hawaiian type? Was the hollow of Wombelong Creek the remains of a caldera? Had the centre of the old volcano collapsed after the many cubic kilometres of lava had been ejected? Where had all of the rock gone which had been removed by erosion and transport? Where from and how did the figs, the cycads, the snow grass arrive on the mountains set like an island in the plains? And the rock wallabies, where were their links with other populations? Why did the kurrajongs favour what appeared to be the most unstable areas of all, the block streams? Why was there so little evidence of fire in such a dry area? So the questions came, followed by



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discussions, with the group's total experience flowing into a common pool of knowledge. This was not the fabric of interpretation, this demanded personal involvement with challenging thoughts, a truly educational process.

Answers to many of these questions are still unclear though this early trip and the many since, added to the growing pool of research information, much stimulated by the Club activities, have helped to build a coherent dynamic picture of the living mountains, their geology, geomorphology and biogeography.

Defined by the lines of vertical 'Pilliga' sandstone cliffs and the white trunks of scribbly gums the mountain mass is underlaid by an old erosion surface of Upper Jurassic sediments which form major intake beds for the Great Australian Artesian Basin. During the Tertiary Period (mid-Miocene) while the Australian continental plate was drifting northward away from

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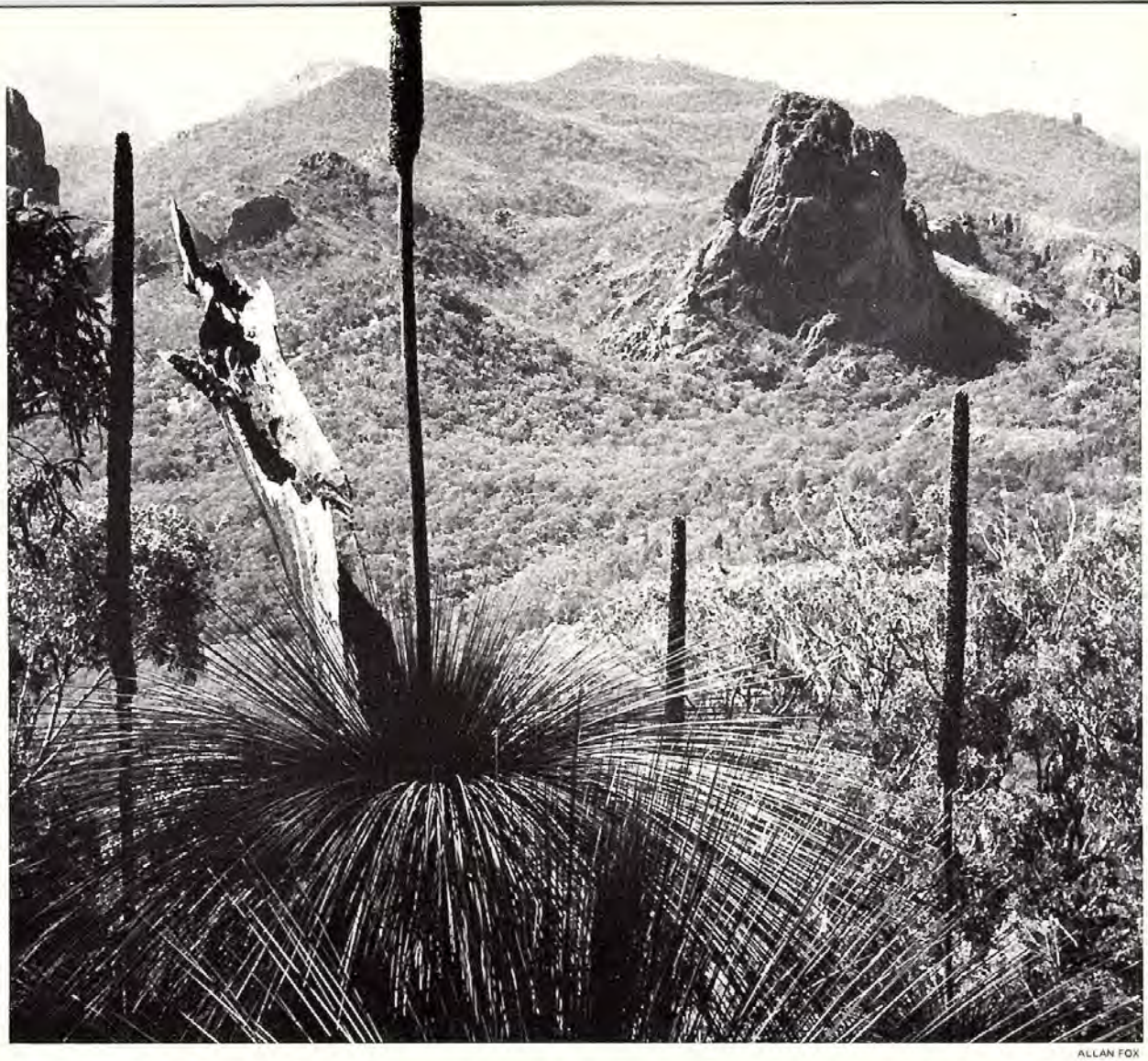
Out over the ranges to the south of Timor lie the domes of spires of the old volcanoes. Left to right, The Breadknife, Belougery Spire, Crater Bluff and Bluff Mountain in the distance.



The spikey leaves of grasstrees explode in rays along the trail to Crater Bluff.

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the broken Gondwanaland, volcanic activity and irregular uplifting spasmodically occurred in the region for some four to six million years, terminating about thirteen million years ago.

Unlike Mount Fuji or Vesuvius, the Warrumbungle volcano had no central vent, a fact which is borne out by the varying composition of the blue, white and green trachytes, rocks of the plugs or spires. An interpretation of the geology suggests three phases of development of the volcanic pile—first, the establishment of fissures from which flowed great volumes of olivine basalt, basalt (blue metal) and hawaiite to submerge the previous landsurfaces, deeply in valleys and as a thin veneer over hills and residuals. It is evident from diatomaceous earth deposits and fossil fish that lava flows dammed valleys and perhaps the lake water levels were even maintained by warm springs. Erosion, transportation and deposition, however, are endless processes and valley formation proceeded to cut back the new surfaces.

The second phase of development appears to have ushered in violent activity with scattered areas of pyroclastic material (volcanic bombs, breccia, tuff) being interbedded with flow material. At least four periods of violent volcanic activity can be identified, between each of which periods of quiescence occurred with the materials being weathered and resorted by erosion agencies. Thickness of these materials today vary from a few metres to one hundred and thirty metres. Finally, into this great heap of volcanic debris were injected and intruded the viscous trachytic bodies which cooled relatively slowly. This dense, resistant rock has become exposed as the weather of the last twelve million years or so has removed the softer ash, breccia and tuff. Thus we stand on the Grand High Tops of resistant trachyte blocks and look along the Breadknife; the cast of a fossil rift (dyke) beside us is the toothlike Belougery Spire rising five hundred metres above Spirey Creek; behind Crater Bluff and to the west Dagda Gap stands the massive dome plug of Bluff Mountain.

That evening, after slipping and sliding at a bounding gait down the block stream behind Belougery Spire we camped by Hurley's Spring. Here was a different world of figs and ferns with the permanent spring running out of the sandstones at the base of the Spire,

the black fang spearing above us, backed by brilliant stars. Talk continued long into the night, of the biogeographic problems posed by figs and cycads and of the absolute need and the processes required to set this area aside for all people to discover, not only the mountains but to discover themselves as well—shades of Yellowstone! Government action following Myles Dunphy's foresighted recommendations was taking too long . . .

According to Oxley's (1818) descriptions, the mountains were covered by a woodland with heath on the exposed and drier aspects. Since then, the clearing of the valleys for wheat and sheep farming has added a grassland community—not very remarkable in itself; what is, however, remarkable is the mixing of the species within these communities.

Using all of the knowledge now available to us we can piece some of the story together. It seems clear that erosion over the past thirteen million years has removed much of the bulk and height from the mountains—after all, the spires were once fully enclosed within the volcanic pile, much of which now constitutes the deep soils of the Castlereagh plain to the northwest. The mountains today lie like an island in a subdued landscape. How did the rich flora and fauna originate?

Imagine the arid interior of Australia as a great pulsing area which expands towards the coast from time to time and at others, contracts due to causes which also produce major fluctuations in world climate.

With the onset of the arid period, plants and animals requiring more humid, cooler conditions are better adapted to positions on higher and cooler aspects. Successful in competition, they move into the new community. Similarly, lower down, the arid species of the interior colonise the increased areas of the drier, hotter aspect. Some species, unable to cope, will be eliminated if they cannot adapt or if their seed cannot germinate in more suitable habitats. With a return to more humid conditions, the seed of species from the table-lands and from across the low divide at the head of the Hunter Valley, find their way by wind, water or animal agency onto new and suitable sites and plants from high in the mountains colonise lower levels. So, over the long term, a continual movement and sifting out of species has occurred and because of its very diverse set of environmental niches, the Warrumbungles have provided a refuge for both arid and humid-adapted species. Comparison of the plants of the Mt. Arthur Reserve (Wellington), Currembenya Nature Reserve (Parkes), the Lees Pinch area and the Cootambal Range suggests that such a hypothesis is valid. To the visitor, the mountains show off their flora best in late winter and spring when some twenty-two species of wattle flower amid the massed purple of the Hovea and the false sarsparilla.

A week later we were back at the Teachers' College writing our reports and checking out references while Allen Strom was penning strongly-worded representations from the Caloola Club to the Under-Secretary for Lands suggesting that something might be done to ensure the future security of the area for the nation. This interest finally presented him with the opportunity to become a Trustee of the new National Park on 30th November 1955, and to give the Trust the benefit of his wisdom and experience with Australian ecosystems.

Many more trips followed, refining our impressions, building up the information pool, and repaying us with the deep satisfaction of knowing nature.

But changes were coming which were significantly accelerated by the Club's efforts, by the later National

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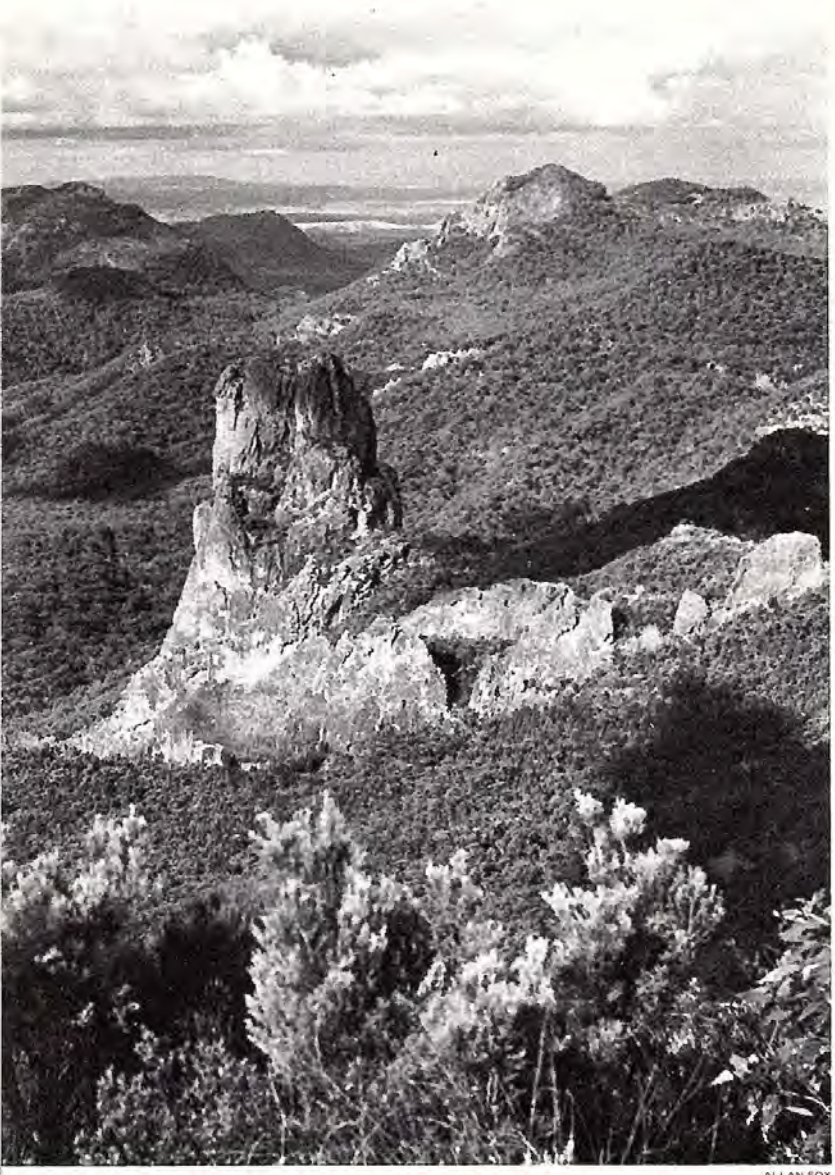
Right: The Breadknife towers to one hundred metres where even cypresses find scant roothold among the lichens. On the left, The Breadknife can be seen in the distance, surrounded by cool shaded gullies which provide a haven from the summer heat for Koalas, Wallaroos and Grey Kangaroos.



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Belougery Spire from Bluff Mountain.

Parks Association, and by the development work of the Trust and publicity and which threaten to overwhelm the Park. In 1952. eleven people visited the area during Easter; by 1966 more than two thousand camped and walked the tracks while forty climbers queued for four hours at the base of Belougery Spire and fifty climbers shared the cliffs of Bluff Mountain with the eagles. The annual figures for the period 1968-73, while they indicate greater mobility, affluence and interest in National Parks, give rise to the fear that unless strictly managed, the only animals that we will see or hear in the mountains will be humans.

Judge Cornelius Hedges in Yellowstone (1870) made this universal plea, for National Parks: "It is impossible that any individual should think that he could own any of this country for his own in fee. This great wilderness does not belong to us . . . Let us make a public park of it, and set it aside . . . never to be changed, but kept sacred always, just as it is now, so that [people] always may know how splendid this early [land] was, how beautiful, how wonderful."

Charged with such a philosophy, how does one balance accelerating use with the maintenance of the integrity of natural systems? Clearly, locking up

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the system and excluding people is not facing the task of letting people know how splendid, how beautiful, how wonderful this land is or, for that matter, giving them the opportunity to find their affinity with nature.

Fortunately New South Wales has a dual system of protected natural areas. Nature Reserves, where the maintenance of pristine communities may be paramount, can largely carry the pressure of scientific re-

Year	1968/9	1969/70	1970/1	1971/2	1972/3	1973/4
No. of visitors	26,327	34,048	39,624	48,486	56,638	58,031
% increase over previous year		29.3	16.4	22.4	16.8	2.4

search from the National Parks for both the benefit of the researcher and of the Park, so some diminution of the integrity of the natural systems in the Parks by their primary 're-creation' role may be acceptable as visitation climbs. Ultimately, usage limits must be set by the management. If not, the natural process itself will certainly take a hand by downgrading the quality of the resource. The National Parks and Wildlife Service's management planning process accepts this responsibility.

Resource management is a conscious process, involving judgement, preference and commitment and tends

to emphasise rationality over emotionalism, ethics over economics, and ecology over engineering. The process should be dominated neither by the market place nor the quasi-political forum, but by a combination of social, cultural, economic and institutional processes.

Having said that, I would make a plea that in managing the National Parks, space be allowed within the Park to satisfy the phases in the development of the kinds of ethics which stem from Aldo Leopold's *Sand County Almanac* and which I believe have arisen in me by way of the activities described in this article. Such ethics involve a sense of responsibility and regard for the interests of other users and society, and towards the fundamental processes of the biophysical environment.

Let us have specially selected, stimulating, small-scale space for testing child senses and capacities, and for his discovery of himself . . .

Let us have sensitive teachers tuned to the needs of the child, or if missed as a child, to the underpriveleged adult . . .

Let us have large-scale space without any trails whatsoever where the mind and the body can wander at will and where the body can feel its elemental environment . . .

Let us have free space enough to light a campfire and to smell woodsmoke in communion with companions . . .

Let us have some danger, some excitement . . .

Let us have access to the wisdom of the hills, plains and seashores . . .

And finally, as our bodies tire, let us have the tranquil site where we can dream of our past association with nature.

The responsibility in managing such a resource to be used and yet kept sacred is quite a new and daunting task for which we, as yet, have little skill.

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Dykes of the Breadknife radiating from Crater Bluff. Belougery Spire and the Breadknife are on the right and left in the foreground and Crater Bluff can be seen in the background.

The grasstrees of Mount Exmouth, moulded by frost and snow in winter and furnace-like winds in summer.

ALLAN FOX

THE

The black eyespots and head of the unhatched lobster and the unused yolk are quite visible through the transparent wall of the egg.

CSIRO/FISHERIES AND OCEANOGRAPHY

This puerulus larvae is in the last larval stage. It returns and settles on the inshore reef at the end of its larval life.

CSIRO/FISHERIES AND OCEANOGRAPHY

The habitat most favoured by the Western Rock Lobster—the sandy floor of a typical reef.

WORLD OF THE ROCK LOBSTER

BY BRUCE PHILLIPS

Australia is the world's largest producer and exporter of rock lobsters, the Western Rock Lobster accounting for approximately sixty percent of the total Australian catch. In addition to domestic consumption, nearly 5.5 million kilograms of lobster is exported annually, the current value being more than $32 million.

There are nine Australian species of rock lobster, all belonging to the family Palinuridae. Those of the genus *Jasus* are confined to the cooler waters of South Australia, Victoria, New South Wales and Tasmania, and six tropical species of the genus *Panulirus* are found across the northern areas of Australia. The most important group, however, is the subtropical population of *Panulirus longipes* on the western coast of Australia, the Western Rock Lobster. This species has also been known as *Panulirus cygnus* and *Panulirus longipes cygnus*.

Because of the importance of the Western Rock Lobster to Australia, CSIRO has been investigating the biology of this species for a number of years, particularly the ecology, physiology and behavioural patterns of the larval and juvenile stages, so that we might have a better understanding of fluctuations in the size of the mature population.

Adults of *Panulirus Longipes* can weigh 4.5kg, although most are caught at about 0.5kg. The largest rock lobsters in Australia are from the eastern species *Jasus verreauxii*, some of which exceed 7.7kg.

Rock lobsters live on the ocean floor, usually preferring rocky bottoms as this offers a plentiful supply of food as well as protection from enemies. As rock lobsters have no claws, they rely on defence for survival. Unlike most clawed lobsters they are gregarious, and group together under crevices presenting would-be predators, such as fish, sharks and rays, with a mass of waving, spiny antennae. They are nocturnal and remain hidden in rocky crevices or weed beds during the day, coming out of their shelter at night to walk about the ocean floor seeking food and returning to shelter before dawn. Their diet consists of molluscs, crustaceans, echinoderms, small fish and other small animals, plus some plant material. They are commonly found in the role of scavengers. Most feed shortly after sunset although some animals are found feeding at any time during the night and, when very hungry, even in daylight as food is often in short supply on crowded reefs.

The life cycle of the rock lobster is very complex. A female rock lobster is mature at six or seven years of age. Mating takes place during the winter or early spring with the male depositing the sperm packets, the 'tar spot', on the underside of the female behind the last pair of legs. Although almost equal numbers of males and females are present, we do not know whether one male serves more than one female (though this has been recorded in our laboratory aquaria).

The eggs are laid (about 300,000 per female) in the spring and early summer. Some females spawn twice in one season. The eggs pass through a pair of openings at the base of the third pair of legs. At the same time, the action of the last pair of legs scraping the 'tar spot' releases the sperm which then fertilise the eggs as they pass back and stick to the fine hairs on the swimmerettes on the underside of each tail segment. The eggs are then carried on the 'berried' female's abdomen for three to nine weeks, (depending on temperature) until the larvae hatch. The newly hatched larvae, called phyllosoma, concentrate at the surface of the water and are carried up to 1000km out into the Indian Ocean by surface wind drifts and currents.

The larvae remain in the phyllosoma stages for nine to eleven months, moulting as they increase in size. At least nine phyllosoma stages are recognisable although the number of moults is considerably higher than this. The first phyllosoma stage is less than 2mm in length and, because they are almost transparent, are only just visible to the human eye; by the last phyllosoma stage, they are about 35mm long. The last phyllosoma stage moults into another almost trans-

BRUCE PHILLIPS, a Senior Research Scientist with the CSIRO Division of Fisheries and Oceanography (W A) is at present engaged in ecological studies of the late larval and early juvenile stages of the Western Rock Lobster.

CSIRO/FISHERIES AND OCEANOGRAPHY

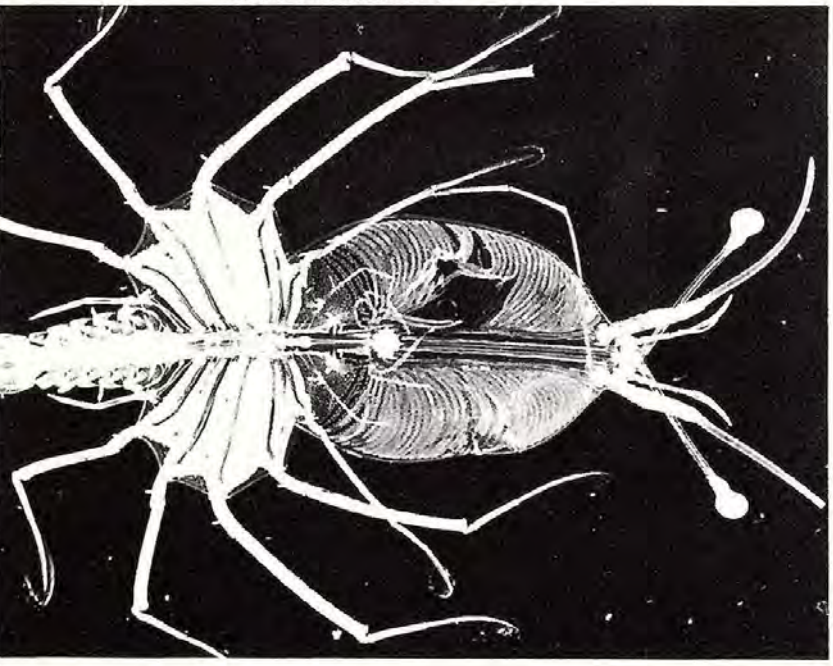
These very young juveniles of *P. longipes* are approximately one year old.

parent stage, the puerulus. This is the first stage which in any way resembles the adult animal.

Less is known about the return of the larvae to the coast than of the offshore movement, but the surviving puerulus larvae return to the coast and settle in the shallow (1 to 20m) inshore limestone reef areas. The settling puerulus larvae moults into a small pigmented lobster about 3cm long, not identical with, but very similar to, the adult. These juvenile lobsters remain in the shallow coastal reefs for three to six years. Research on juveniles on the shallow coastal reef areas has shown that these individuals have small home ranges, not exceeding 15 metres in radius. If the juveniles are removed from this home range to another locality, they apparently become disoriented and have been recaptured up to 8.3km away within nine weeks. At about five to six years of age the juveniles migrate from the shallow reef areas onto the continental shelf into depths of 30 to 150m. It is in these depths that mating takes place, and the life cycle is complete.

This larvae is in stage nine of the phyllosoma stage, the final larval stage before the larvae moult into the puerulus stage. In nature this specimen would appear almost transparent.

CSIRO/FISHERIES AND OCEANOGRAPHY



A significant process throughout the whole life-cycle is moulting. Growth in Crustacea is a stepped process, the length and weight of the animal increasing abruptly at each of a succession of moults. In some stages of the life cycle, moulting also involves a dramatic metamorphosis, e.g. in the moult from the flattened phyllosoma larva to the shrimp-shaped puerulus stage.

Moulting of juvenile rock lobsters has been observed in the laboratories and, because of its importance, is the focus of considerable investigation. The process of moulting takes several days although the actual shedding of the shell, which usually takes place at night, may take only a few minutes. For several days before moulting; some of the lime in the hard exoskeleton is dissolved by the animal which then feels more flexible when handled. Before moulting, while the muscles and internal organs in the animal shrink slightly. At the onset of moulting, the animal's body takes up sea water, creating an internal hydrostatic pressure which pushes out the new soft shell underlying the old shell. The old exoskeleton then splits across the back at the junction of the cephalothorax and abdomen, and along the gill chamber. The animal in its new soft shell gradually emerges through this opening using short flips of the abdomen. The last part to be freed from the old shell is the tail. If a leg is caught in the old shell during the critical minutes of moulting, it is deliberately shed and left in the old shell so that the animal is not trapped. Legs or antennae lost either during or between moulting can be regenerated at subsequent moults. The internal hydrostatic pressure within the new shell keeps it expanded while the shell hardens, and in this way the animal increases in size as a result of the moult. During the hardening period, the lobster is defencless and must hide to avoid predation or cannibalism. It abstains from feeding for the three to four days of this period, but as soon as the new shell has hardened, the rock lobster feeds hungrily. Even youngsters only two years of age will eat up to 9g of flesh (abalone meat) per night just after moulting. A rock lobster must eat approximately 360g of flesh to gain approximately 100g of body weight.

During summer, the young juveniles may moult as frequently as every fortnight, but moulting cycles lengthen as water temperatures decline toward winter. Frequency of moulting also decreases with age, so that adults only moult once or twice each year. Really old animals (which we believe may be more than fifteen years old) may not moult every year.

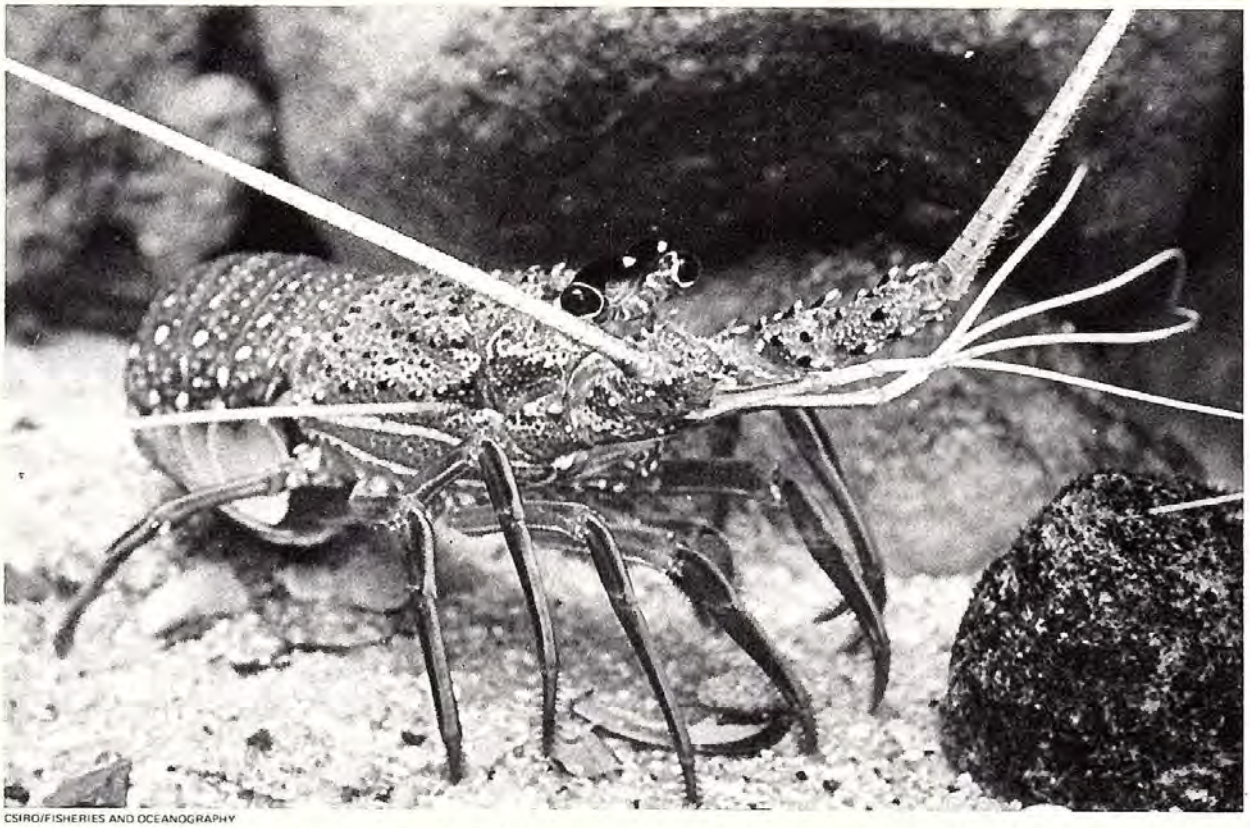
Frequency of moulting is affected by other factors as well as temperature, food supply, and age. For ex-

ample, individuals held in isolation moult less often, despite having plenty of food and shelter; this gregarious animal likes company and is inclined to mope when alone!

In our quantitative studies, we have found that the return of the settling larvae to the coastal reefs varies in numbers from year to year and also between locations along the coast. The results so far indicate that there are high levels of larvae settling near the centre of the rock lobster population, i.e. near Dongara and Geraldton, but towards the edges, such as around Fremantle, there has not been a large settlement since 1964/65. This may be the result of a long-term cycle of variation in the water circulation pattern but the reasons for it are sitll being investigated. The possibility exists that it may be linked with the ecological changes in the coastal waters of the area, perhaps because of changes in land use near the coast with the rapid development of large industrial and urban centres.

Current research programmes in CSIRO are aimed at understanding the effects of water circulation and the behaviour of the larvae when they return to the coast at the end of the planktonic phase, and at determining the factors affecting their successful settlement. Juvenile studies are being expanded to determine the availability of food in the coastal reefs and the effects of juvenile densities, shelter and predator levels, as well as other environmental factors, which limit their recruitment to the adult stocks.

A high rate of mortality occurs in some areas amongst young juveniles when there is particularly heavy settlement of larvae on reefs already heavily stocked with older juveniles because of the more severe competition for food and shelter. The possibility of using some of this excess for other purposes without affecting the level of subsequent recruitment to the fishery is being investigated. A recent review of the prospects for rearing rock lobsters has shown that there is no technical barrier to mass rearing; indeed, under optimal environmental conditions, two-year-old lobsters can be reared to commercial size in an aquarium in less than half the time it would have taken in the wild state. There are, however, economic and legal barriers to be overcome before commerical pond farming of the rock lobsters would be practical. Other possibilities, including the relocation of the excess juveniles to areas where low levels of settlement of larvae have occurred, or the placing of artificial shelters to open up new feeding areas in the sea-grass beds, are also being investigated.



CSIRO/FISHERIES AND OCEANOGRAPHY

This juvenile lobster has assumed a typically defensive pose with antennae spread out and erect.

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REPTILES AND AMPHIBIANS OF AUSTRALIA

REVIEWED BY PETER RAWLINSON

REPTILES AND AMPHIBIANS OF AUSTRALIA by H.G. Cogger, *A.H. & A.W. Reed, Sydney, 1975; 584 pages, 786 plates incl. 192 in colour, $23.95*

There has always been a demand for a comprehensive volume on the Australian herpetofauna yet none was available before publication of *Reptiles and Amphibians of Australia.* This situation arose because such a book required an author who was familiar with all reptile and amphibian groups, the herpetological literature, and who also had extensive practical experience in field and museum work. Harold Cogger has proved to be such a person and the book is a personal tribute to him.

The author states in the Preface that the primary aim of the book is to provide the means to identify the majority of reptiles and frogs found in continental Australia and Tasmania. A total of 664 species are described, 448 of which are figured in colour or black and white photographs (many for the first time). All valid described species found in Australia (including the marine turtles and sea snakes) are covered, but subspecies are merely listed.

To make a species identification, the author suggests several approaches (pp. 18 & 19) depending on ones expertise. His advice is sound and involves using all the data sources provided — keys, descriptions, photographs, line illustrations and distribution maps. It is difficult to evaluate the keys and descriptions of genera and species provided as aids to identification in the hands of non-specialists, but it appears that some of the keys for amphibians may at least prove baffling as they combine morphological, biological and distributional features. However, all keys are truly dichotomous which overcomes many problems as the contrasting features are obvious. The photographs are excellent and will prove to be very valuable in identification, but it must be remembered that 216 species and 13 genera, including some rare and unique groups, are not figured. Virtually all photographs are captioned with the locality of the specimen as well as its identity and there are few mistakes—the only ones located by the reviewer were: pl. 588 labelled as *Leiolopisma pretiosa* is actually *L. metallica;* pl. 589 labelled as *Leiolopisma trilineata* is an unidentifiable species of *Leiolopisma;* and pl. 628 labelled as *Sphenomorphus tympanum* is actually *S. koscuiskoi.* The distribution maps will not prove to be such a good aid, partly because of our incomplete knowledge of distribution patterns and partly because of the small scale of most of the maps, while species known only from a restricted area or a single locality (e.g. *Philoria frosti, Rheobatrachus silus, Ophidiocephalus taeniatus* and *Pseudemoia palfreymani)* are shown on maps of Australia. The wrong map accompanies the description of *Egernia slateri* while the maps for *Mixophyes balbus* and *M. fasciolatus* have been transposed. Some of the maps are also inaccurate, for example *Notaden bennettii,* is erroneously shown as extending into Victoria while some Victorian species *(Neobatrachus centralis* and *Uperolia rugosa)* are shown to be absent. As the author admits, one serious omission from the book is an account of immature stages—the eggs and larvae (tadpoles) of frogs and the eggs and egg nests of oviparous reptiles.

The book has been set out in a clear manner and proofreading has been very thorough, few errors showing up in a quick examination. The most serious criticism of the book centres around the treatment of the higher taxa, especially genera. As this is the first book on Australian reptiles and amphibians, it will be widely used by non-specialists as a text and this reviewer believes that a conservative approach to nomenclature should have been used. Although the author states that he has "... anticipated a few name changes which will be made, and explained ..." in his proposed *Primary Checklist of Australian Reptiles and Amphibians,* a number of the changes introduced may not be accepted by specialists and, as the book will be used by many as a text, confusion over names must result. Examples are the replacement of well-known species names (e.g. *Amphibolurus inermis* by *A. nuchalis)* or of new generic combinations (e.g. the rejection of Blake's 1973 concept of the myobatrachine genus *Ranidella,* the absorption of Australian *Anotis* into *Hemiergis,* the continued recognition of the skink genus *Trachydosaurus* and confusing name combinations in the snake family *Elapidae.*

In summary, this is an exceptional and very worthwhile book. Some of the main grounds for criticism will disappear when the author's *Primary Checklist of Australian Reptiles and Amphibians* is published and when this takes place, Harold Cogger will have two of the most significant publications on Australian herpetology to his credit. The author deserves the congratulations of all interested in the Australian fauna for his efforts.—*Peter Rawlinson, Zoology Department, LaTrobe University.*

Shown opposite is a reproduction of the back of the dust jacket for *Reptiles and Amphibians of Australia.*

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