

phenomena have been observed, and some have been related with measurements at ground stations. It will be interesting to correlate these results with those from the various particle experiments but there are still some problems. Confusion over the number density and temperature of the plasma, however, may well be resolved by a determination of the energy spectrum of the various particles, but it needs further investigation of the contribution of the observed photoelectron cloud from the satellite itself and of the effects of spacecraft changing. These problems may be solved later in the year when Geos goes into eclipse.

Some experimenters have been unable so far to completely understand their results through the lack of reliable attitude data necessary to sort out spin modulation effects. But it should be only a matter of time before the relevant analysis programs are fully working.

The experiments measuring high energy particles are least affected by these problems. Preliminary results from a sophisticated mass spectrometer for measuring ion composition, indicate the presence of the doubly charged ions  ${}^4\text{He}^{++}$  and  ${}^{16}\text{O}^{++}$  deep in

the magnetosphere. The new orbit of Geos is almost a bonus in this case because ion compositions can be measured as a function of distance from the earth. Another unexpected bonus of the new orbit is the fact that Geos now spends considerable time near the geostationary satellite ATS-6. Earlier attempts to persuade NASA to drift ATS-6 past the planned geostationary position of Geos were unsuccessful but now the possibility of correlated measurements with similar instruments on the two satellites has become a reality.

The progress that has been made in such a short time after the disappointment of the failed launch is impressive and prospects for the future look bright. But most of the Geos programme in which coordinated measurements were planned with ground-based campaigns has had to be abandoned. Indeed the rocket campaigns from northern Sweden have been persistently plagued with bad luck. The rockets are supposed to pass through the transient auroral arcs and correlate their measurements with satellites poised at magnetically conjugate points above the equator. On the first launch ATS-6 was in position but the rocket exploded.

Geos should have been in position for the second rocket but delays had pushed back the Geos launch date and it was still on the ground. ATS-6 had meanwhile moved on. These difficulties are increased by the refusal of Norway to allow the rockets to overfly their territory and the consequently restricted rocket range makes it very difficult to hit the aurora. There are two rockets planned for 1978 and the rocket team hope their luck will change and that the second Geos spacecraft will have been launched into geostationary orbit.

Geos 2 has already been refurbished and will be of flight standard by the end of the year. It can either be launched into geostationary orbit by NASA early in 1978 using another Delta launcher, or it could wait until late 1979 to be sent up on ESA's own launcher Ariane. An early reflight on a Delta is what the experimenters want—from the way they have evaluated their data in such a short time they have in a sense earned it—and from some view points this appears the most likely option, but the extra cost to ESA will be about \$14 million and it is unclear where this will come from. ESA is expected to decide early in October. □

## USA

# Opening a biological pathway

*The signing of the Panama Canal Treaty last week has implications for the ecology of the Atlantic and Pacific Oceans. Colin Norman reports*

AMID the diplomatic fanfare and loud political protest which greeted the signing last week of the Panama Canal Treaty, muted rumblings of a scientific controversy were also faintly audible. The controversy centres on a little-noticed article in the Treaty committing the United States and Panama to conduct a joint study of the feasibility of building a sea-level canal within a few miles of the existing waterway.

The idea of carving out a direct, sea-level link between the Pacific and Atlantic Oceans has been investigated many times in the past, but political, economic and technical problems have so far kept it from becoming a reality. In fact, in spite of the renewed official interest in the idea, it is still considered unlikely that the channel will ever be dug. Nevertheless, the possibility is worrying some marine scientists, who fear that a sea-level canal would damage the ecology of the surrounding oceans.

The worry stems from the fact that

the tropical Pacific and Atlantic Oceans have been separated for perhaps five million years, since North and South America were joined by the isthmus or Panama. Consequently, marine life has evolved independently in the two oceans for long enough to ensure that few species are common to both. Blasting a sea-level link across Panama would open a biological pathway which may result in the migration of plants and animals into a new environment, a process which some marine scientists believe could have considerable impact on the oceans' ecology.

Very little migration takes place through the present canal because a freshwater lake in the middle of the waterway provides a barrier to most marine life, and the large number of locks along the canal means that there is little flow of water through the system. A sea-level canal would, however, be an entirely different prospect. Tidal ebb and flow through the canal, coupled with the fact that the average sea level on the Pacific side is slightly higher than that on the Atlantic side, could result in the transport of plants, animals, larvae and other organisms through the channel.

Among the more dramatic consequences that have been predicted as

a result of breaching the land barrier are the possibility that the yellow-bellied sea snake, a poisonous reptile which now lives only in the Pacific water, could become established in the Caribbean, and that the crown-of-thorns starfish might similarly invade the tropical Atlantic coral reefs. Other potential worries are that fish travelling through the canal might carry pathogens or viruses which are not known to native species. The central problem in such interchange is that the introduction of flora or fauna into a new environment might upset the ecological balance because there may be no natural predators and native species may not have evolved an effective defence mechanism against the newcomers.

Such possibilities are, of course, highly speculative, and some marine biologists contend that it is very unlikely that major environmental damage would result from opening a sea level channel. Nevertheless, there are several sobering examples of previous experience with the introduction of animals and plants into a new environment. For example, the building of a canal to bypass the Niagara Falls, providing a channel joining the Great Lakes to the Atlantic, has resulted in invasion of the lakes by a predatory fish-like creature called the sea lamprey. The lamprey has spread throughout the Great Lakes,

and decimated native species. Similarly, the introduction of the European rabbit into Australia and New Zealand was followed by a population explosion which caused serious damage to vegetation and topsoil.

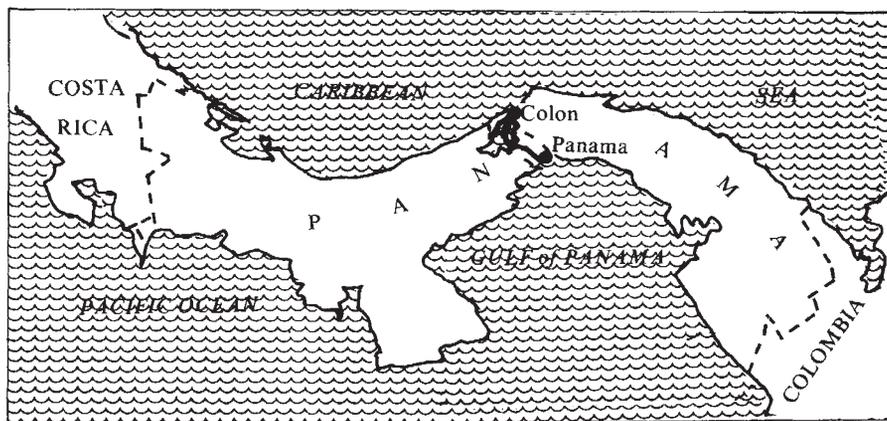
Such concerns were given wide publicity in the late 1960s, when the sea-level canal last came under serious study. A Presidential Commission, established in 1964, conducted a major feasibility study of such a canal, examining potential routes, engineering problems and the possibility of using nuclear explosives to blast out a channel. In 1970, the Commission recommended that the project should go ahead, along a route about 10 miles west of the present canal. Excavation should be by conventional means, the Commission said, and it calculated that the effort would cost about \$2,900 million in 1970 dollars.

Because of the high price tag, and in view of political problems in re-negotiating the existing Panama Canal Treaty, the Commission's recommendations were never implemented, and the whole idea swiftly dropped out of the limelight. It is, in fact, something of a surprise that the idea has been resurrected in the new canal treaty.

As part of the Commission's study, the National Academy of Sciences and the Battelle Memorial Institute were asked to conduct independent analyses of the likely ecological impact of opening a sea-level link between the Pacific and the Atlantic. The Academy's report, which was published as an appendix to the Official Commission Report, must rank as one of the most forthright statements of concern ever to emerge from that august institution. Calling the sea level canal "a gigantic natural experiment" which will have "unforeseeable" consequences, the Academy called for a massive study of the tropical Pacific and Atlantic ecosystems before the project is allowed to go ahead. "Available information is altogether insufficient to allow reliable predictions of particular events resulting from the excavation of a sea-level canal in Panama", the Academy said.

The Battelle report was, however, more sanguine about the impact, noting that although there is scant knowledge of the ecology of the region, there is "no firm evidence to support the prediction of massive migrations from one ocean to another, followed by the extinction of thousands of species". The Commission itself was even less impressed with the warnings of disaster. It devoted a mere four pages of its report to a discussion of environmental concerns and concluded that the hazards, whatever they may be, would be "acceptable".

The argument for building a sea-level



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Camera Press

#### *Miraflores locks, preventing flow between Atlantic and Pacific*

waterway is simply that the present canal is already heavily travelled and it is likely to reach its capacity in the 1990s. Moreover, its locks are too small to take the large freighters and super-tankers which are now appearing on the oceans. Such limits were, in fact, realised, back in the 1930s, when work was begun on the construction of a series of larger locks alongside the present canal, but construction was stopped during the war and it was never resumed. (The new Panama Canal Treaty in fact calls for a study of the feasibility of completing the construction of the old locks as an alternative to building a new sea-level canal.)

More recently, a new argument has appeared: a sea-level canal will be needed to transport Alaskan oil and gas to the east coast of the United States. According to this argument, which has been advanced most prominently by Senator Mike Gravel of Alaska, the cost of building a new canal (about \$5,900 million at today's prices, Gravel reckons), should be measured against the cost of building a new pipeline system to transport Alaskan oil and gas from the oil-rich west coast to markets in the east. Once all the advantages are counted up, Gravel reckons that the canal will seem like a bargain. He has stated that he will seek congressional approval for the 1970 report to be up-

dated.

In anticipation of such renewed interest, Dr Frank Press, President Carter's Science Adviser last month asked the National Academy of Sciences to take a fresh look at its earlier report to the Commission to see whether recent scientific data are available to help predict more precisely the likely environmental consequences. Last week, the Academy Committee held two days of hearings and it is hoping to produce a report for Press by early October. Judging from last week's meeting, the Committee is likely to conclude that although a good deal of work has been done, knowledge of the Panamanian ecology is still too sparse to predict with certainty the impact of breaching the land barrier between the tropical Pacific and Atlantic oceans.

Asked last week when the joint US-Panama study envisaged in the treaty is expected to get under way, a State Department spokesman said that no details have yet been worked out. The first priority will be to steer the treaty itself through conservative shoals in the Senate. In view of the immense political problems involved in re-negotiating the treaty, the prospects for negotiating a new treaty to build a sea-level canal in Panama must, at this point, be considered remote. □