described as the most important new instrument for solar observations to be built in the United States for a decade and its resolving power of 0.2 s of arc matches that of the most powerful telescopes in existence.

Sacramento Peak Observatory is at appropriately-named Sunspot, New Mexico, ten miles south-east of Alamogordo, 9,200 feet above sea level, and specializes in solar work. In particular, the observatory is concerned with the influence of solar activity on air force communications, and several years ago the air force initiated a research programme of solar forecasting. Radio blackouts caused by the absorption in polar regions of high energy protons from the Sun are

Solar telescope at Sacramento Peak Observatory (objective mirrors on top of the telescope have not yet been positioned in this photograph).

especially serious, but military activities can be affected in other ways. Solid state electronics on satellites can be damaged and satellite orbits can be altered by changes in air resistance induced by high energy particles. From March 1 next year the air force will have a system which, it is hoped, will predict solar bursts and the effect on the atmosphere. The basis of the system is a network of ground-based and satellite observatories feeding information into a complex of computers at Offutt Air Force Base, Omaha. No unambiguous claims are made about how good the forecasts are going to be, but some hints are dropped in an article on the system by the commander of AFCRL (D. J. Flinders, *Air University Review*, in the press). Long term prediction of flares seems to be almost impossible, and the best that can be done at present is to say that under certain solar conditions no flares are likely to occur for between three and five days. Prediction of the likely effect once a flare is seen is easier but still fraught with problems—not all flares influence the atmosphere. The travel time of radiation from the flare is important here and can be several days. AFCRL radio astronomers can help, and there is a certain spectral pattern in the centimetre range which means that there is an 80 per cent chance of high energy protons arriving within hours.

The new telescope and its \$1 million worth of instrumentation will be used for research into solar forecasting. One aim is to search for signs on the Sun which can be used to predict the occurrence of bursts. The telescope is 365 feet long, of which 227 feet is underground, and great care has been taken to remove instabilities in the image. Air currents within the telescope are eliminated by evacuating all of the light path to 250 torr, and by water-cooling the concrete walls of the tower, and light enters the system above most of the ground turbulence. The 321 feet long, 250 ton, evacuated tube which contains the optics is suspended like a pendulum and rotates on a mercury bearing to follow the Sun. Light enters the telescope through a 32 inch quartz window and is deflected to a 64 inch mirror near the foot of the tube which brings the image to a focus near ground level. The instruments at ground level include two large evacuated spectrographs which rotate with the shaft.

FISHERIES

Farming the Sea

from our Special Correspondent

FARMING marine fish has progressed from fiction to fact at Hunterston nuclear power station in Ayrshire, and at Ardtoe, on a remote loch in Argyllshire. In less than five years, the White Fish Authority has convincingly shown that it is possible artificially to hatch and rear large numbers of flatfish (Dover sole at Hunterston and plaice at Ardtoe) to a market size of about eight ounces weight in half the time it takes in the open sea.

This effort has been achieved with very limited funds (currently less than 10 per cent of the authority's annual research and development budget of just over £400,000) and in face of very little knowledge about the biology of marine fish and engineering aspects of running a marine fish farm in British conditions. The authority's experiments so far have been carried out with only a handful of professional staff, the majority of whom are engineers, stock breeders or agriculturists and not fishery biologists. Indeed, in practice, farming sole and plaice at high densities seems to have more similarities with intensive chicken and pig farming than with biological research and this may explain the project's success.

At present, the White Fish Authority is concentrating on intensive methods of cultivation in shore tanks, and in cages and net enclosures in the sea. It is finding that the fish can be most successfully reared in high densities—up to five or more fish per square foot of bottom—but as yet little is known about disease and sustained growth in these conditions.

The technique used at both Hunterston and Ardtoe is essentially a development of that pioneered at the Ministry of Agriculture's fisheries laboratories. At Hunterston, fish are grown in shore tanks fed with warm seawater discharged from the power station. After the eggs have hatched, the larvae are fed first with nauplii of the brine shrimp (*Artemia*); when they start to metamorphose, the fish are weaned by way of a cultivated red worm (*Lumbriculus*) on to a specially prepared solid food. The food, which is made largely from fish wastes, is given in larger pieces as the fish grow. At Ardtoe, the farm is in a small inlet of a loch cut off from the sea by a dam wall with sluice gates

so that the temperature and salinity of the water inside can be to some extent controlled. There, three main types of husbandry are being studied: netting enclosures on the sea bed, floating tanks and netting cages of various sizes, and submerged cages anchored to the sea bottom. The fish are grown first in onshore tanks or in small floating nursery cages, and are then transferred, once past a certain size, to one of the other types of tank or cage for "fattening".

The White Fish Authority has been successful and some would say lucky. There is still much to be done, particularly on the question of the most economical food for all species and sizes of fish. The experiment can be extended to other species of marine fish and the authority has already made a start by including turbot, lemon sole and brill in its programme for bony fish; it has also been operating for some time a pilot oyster hatchery at Conway in North Wales. Once the genetics of marine fish are better known, selective breeding

Experimental floating cages of various types at the White Fish Authority's fish cultivation unit at Ardtoe.

could be used to improve the stock. There are then exciting possibilities ahead. It may be that the most practical method of the future will be to rear fish to a certain size in warm water effluent at coastal power stations, and then to transfer young fish of various species to sea farms in sheltered regions of the coast such as in Scottish lochs. The authority is already collaborating with the Highlands and Islands Development Board to build cages for use in open lochs which could be suitable for crofting-type industries in the Western Highlands.

The authority has shown that farming the sea is possible; it must now persuade industry and the Government that it could be an attractive alternative to hunting the sea for certain species, particularly those on the decline or costly to catch, but it will be up to others to develop farms into commercial ventures. Meanwhile, the project needs more money and more

scientific data. The Natural Environment Research Council, the Ministry of Agriculture, the Ministry of Technology's Torry Research Station and some universities are already involved in a small way, but the White Fish Authority needs more coordinated support if the full promise of its fish farming venture is to be realized.

UNIVERSITIES

How the Cake is Cut at Stirling

THE annual battle for staff and funds between university departments is often won by those who shout the loudest, not by those who are most deserving. A notable departure from this laissez-faire situation is the procedure used at Stirling University whereby the allocation of staff between departments is decided by a formula. Devised by the vice-chancellor, Dr T. L. Cottrell, the formula is a sophisticated calculation of the expected workload in each class. Given the total number of staff that the university can afford, staff are allocated among subjects so as to give each the same workload. Members of staff at Stirling seem well pleased with the visible fairness of the formula. Although it may not be a perfect description of reality, what matters is that its assumptions are plausible and applied uniformly.

The basic formula, for the workload in a class, is

$$X = mL + N \left(Ww + w_t + w_e + \frac{1}{14}x \right) + Ft_p \left(\left[\frac{N}{4n} \right] + 1 \right) + Ft_g \left(\left[\frac{N}{n} \right] + 1 \right) + sS \left(\left[\frac{N}{r} \right] + 1 \right) + Q \left(\left[\frac{N}{p} \right] + 1 \right) + q_0 \frac{Q}{4} + q_1 \left(\left[\frac{N}{p} \right] \right) \frac{Q}{4}.$$

The symbols have the following meanings: X —workload in h/week; m —time to give and prepare a lecture; L —number of lectures; N —students in class; W —weekly essay frequency; w —time to correct an essay; w_t —time to correct a translation per week; w_e —time to correct lab book; x —time to correct an exam script; F —weekly tutorial frequency; t_p —time to prepare a tutorial; n —number of students in a tutorial group; $[]$ —integral part of; t_g —time to give a tutorial; s —time to prepare and give a language lab class; S —weekly frequency of language lab class; r —number of students in a language lab; Q —hours of lab work per student per week; p —number of students in a laboratory group; q_0 —time to prepare experiments for a 4 h lab period; q_1 —time to replicate experiments as class grows.

The formula was first put into practice last year and produced results not greatly different from what would have been expected, though doubtless at lesser emotional cost than can be incurred by the usual horse-trading. Stirling took its first students only in 1967 and the formula will certainly stand it in good stead as the student population grows to the 3,000 planned for the mid-1970s. A similar, though less sophisticated, formula is operated at Loughborough University. The example is one to be followed.