

NEWSLETTER No. 2

It is gratifying to reflect that the Society has been in existence for less than a year and that we already have two newsletters and a conference to our credit. It would however be very dangerous to feel smug at this early stage and we should withhold our congratulations for another two or three years until we are sure that the original enthusiasm has generated a self sustaining body with a continual inflow of new members.

The next year or so will be the critical ones for the growth and expansion of the Society. They also seem likely to be critical ones for the future of freshwater research. More workers and considerably greater funds are urgently needed to fill in the many gaps in our basic knowledge of freshwater environments before civilisation with its multiplicity of polluting and destructive agencies overtakes them irreparably. It is to be hoped that liberal and enlightened attitudes will prevail.

The future form of the newsletters seems to be taking shape, with the first issue of the year, appearing about April or May, and containing the major accounts of research work in progress, which we hope will give some indication of the findings and not be confined to a mere list of topics. The second issue appearing in November will be primarily to give an account of the conference. At the general meeting in Auckland it was suggested that abstracts of student theses be included as so often non-university workers remain unaware of potentially useful information, particularly if it remains unpublished. We are also attempting to compile lists of all freshwater theses presented in the past, but this is incomplete as yet. The editor naturally hopes that a wide variety of other contributions for both issues will be sent in.

Two members of the Society were fortunate enough to attend the International Congress of Limnology in Israel and we include their necessarily brief but tantalising accounts of the highlights of their tours in this issue. It is perhaps not an impossible wish to hope that some day the Congress may be held in New Zealand, or even in Australia.

A LIMNOLOGIST OVERSEAS

V.M. Stout

In the second week of August I left for a month overseas, principally to attend the XVII International Congress of Limnology in Jerusalem and the subsequent excursions to places of interest in the rest of Israel. It was with a good deal of regret that I missed our own first limnological conference, but I did so in the assurance that the conference here was in good hands and that I might myself perhaps best serve our society by promoting it and New Zealand limnology generally overseas.

On the way to Israel I spent two days at Monash University where Dr Bill Williams and Dr Ian Bayly (previously of Auckland) have an active group of limnology students. Much of their work is on the saline lakes northwest of Melbourne which have already been the subject of several papers by Williams and Bayly. The lakes are 150 miles from Monash and a field station is planned for the area, to be built close to the large, shallow Lake Coulangamite. The lakes are situated in volcanic rock, several of them in calderas. Ph.D. students are working on a general survey of several lakes; a laboratory study of tolerances, etc, of the copepods from the lakes; and calorific values of the zooplankton from one lake. Ian Bayly had already left for the congress in Israel. Here he gave a paper on the

calanoid copepods of 17 of the saline lakes, all of which have a high carbonate and bicarbonate content and a pH greater than 9.0. Calanoid copepods are present in 11 of the lakes, Calamoecia in ten and Boeckella triarticulata in the other.

The congress in Israel was attended by about 300 people and held at the Hebrew University in Jerusalem. The campus site is a new one, situated on one of the barren Jerusalem hills and an impressive display of modern buildings and carefully tended rose gardens. Nearly all the sessions were held in one building conveniently provided not only with two large and several smaller lecture rooms, but also with a foyer containing comfortable chairs and a very welcome cafeteria supplying quantities of soft drinks, essential in the hot Israeli weather.

There were symposia on the first three mornings while in the afternoons and later in the week four sessions of papers were run concurrently. The symposia covered salt and brackish waters, tropical and subtropical lakes, and the fishpond as a limnological model. The last of these symposia included an excellent paper by Hall and Cooper (U.S.A.) describing their work on a series of experimental ponds held at three different nutrient levels and two predator densities. Initially the predators were all invertebrates, but recently fish have been introduced. The effects of these different regimes on the chemistry, phytoplankton, rooted vegetation, zooplankton and benthic fauna has been measured, much of the data still requiring computer analysis.

A plenary session was held one afternoon with Fontaine speaking on endocrine control of reproduction in teleosts and Rodhe on "Limnology, social welfare and Lake Kinnereth". The paper by Rodhe was generally considered probably one of the outstanding papers of the congress. It

reviewed some of the effects of man on lakes and rivers and made a general plea for limnologists to exert their influence to try to decrease the amount of contamination of the inland waters of the world. This concern with accelerated eutrophication and pollution was very much discussed throughout the congress.

The shorter papers were grouped into various sections such as general limnology, chemical limnology, general algology, water organisms, physical limnology and bottom sediments, benthic fauna, fish ecology and physiology, limnological surveys and productivity and saprobity. I can mention only a few of the more interesting papers. Brinkhurst described some experimental work on the food of aquatic oligochaetes using plated bacteria and sterilising the guts of the worms with antibiotics. Hynes (also now in Canada) gave a paper on protein production by fallen leaves and its relationship to dissolved nutrient salt content. Laboratory work on elm, alder and oak showed that elm produced the most and oak the least but in all cases there was some addition of N and P to the water. Lake Tahoe, in California, once one of the clearest of lakes has been markedly affected by holiday settlements on its shores and comparisons of 1962 and 1968 values for the lake were given by Goldman. Thus the C14 productivity has increased from 102 to 167 mgC/m/day, the nitrate increased by a factor of three and the ammoniacal nitrogen by a factor of ten. Work using ultrasonic transmitters attached to fish to follow their migrations was described by Hasler. This technique is now being used to follow salmon movements in Puget Sound. An IBP programme in progress was described by Efford (Vancouver). His team is working on Marion Lake a small, shallow lake with a large amount of flushing. Much of the production is detritus-based, with bacteria on the detritus forming the food of the amphipod Hyaletella, which is itself eaten by fish and salamanders. Frey

(Indiana) has just spent a year in the Philippines and described the lava-dammed Lake Lanao, situated at a latitude of 8° . With a depth of about 114 m the lake shows stratification in the summer with a thermocline at $27 - 25^{\circ}\text{C}$. There is a pronounced algal bloom, mostly nanoplankton, which increases the oxygen content of the upper waters. A situation found in L. Maggiore and thought to be common for the large lakes of the European alps was described by Madame Tonolli. In this extremely deep lake complete mixing of the water takes place only once in every five to seven years, when the atmospheric temperatures fall especially low. This results in a volume of very cold water at the bottom of the lake, this water remaining stagnant until the next exceptionally cold winter. The effect on the copepod populations present in this deep water was discussed by Madame Tonolli. Lake George, in Uganda, was the subject of several papers by members of the team studying the lake as part of Britain's IBP programme. Lying on the equator, this is a shallow lake with a temperature range of 25° to 35°C . and pH about 9.0. The shoreline consists of papyrus swamps which have a distinct zooplankton. In the open water the dominant zooplankton are copepods and all developmental stages are present at all seasons.

A meeting of IBP participants was held during the congress and the programs of the participating countries outlined. Most ambitious is undoubtedly that of the U.S.A. who have combined with the terrestrial section (PT) in an attempt at as complete an analysis as possible of different ecosystems. These have been divided into deciduous, conifer, grassland, tundra and deserts, and grassland is the only one which has so far started work. The aim is to make an intensive measurement of environmental factors and attempt to predict the effects of timber mills, etc. on the ecosystem.

One of the highlights of the congress was the Baldi Memorial lecture given one evening by Jannasch on "Recent concepts in aquatic microbiology". This was an excellent review of previous work plus an account in some detail of his own work with aquatic bacteria.

Rodhe's paper probably brought together the main thoughts of many participants at the congress - concern at interference with the lakes and rivers of the world and the need for a concerted effort at the international level to minimise this interference.

It is anticipated that the next congress will be held in Russia in 1971.

After the meetings in Jerusalem, a number of participants took part in the excursions aimed at showing as much as possible of the rest of Israel. Included were visits to several sets of fish ponds, where mainly Tilapia and carp are produced, with artificial feeding and with a very high rate of growth. The Fish Diseases laboratory at Nir-David was also visited, this being the centre of good deal of work on blue-green algae and their toxic effects. Visits were also made to the Dead Sea and to Lake Kinnereth (the Sea of Galilee) where a new laboratory is being built for work on this Israel's only freshwater lake. From the lake an immense pumping scheme takes water up over the surrounding hills and distributes it throughout Israel, principally for use in irrigation.

After the conference I spent several days in England, discussing New Zealand's IBP effort and visiting the River Laboratory in Dorset, especially to see their work on fish production. On the way home I visited Michigan State University, one of the largest in the U.S. and with very active Zoology and Botany departments together with an Institute for Water Resources

including both fisheries and pollution sections.

In general I found a good deal of interest in New Zealand work and in our newly formed society.

The papers given at the congress will be published in the Proceedings of the International Society for Theoretical and Applied Limnology. This society holds a congress every three years and also publishes occasional 'communications' covering symposia and reviews of methods. The subscription is £1-8-6 (sterling) a year for which one receives also the two or three volumes of the proceedings of each congress. I should be glad to supply further information about the international society to anyone interested.

TWO MONTHS OVERSEAS

G.R. Fish

The amount of freshwater research done in this country over the past few years has steadily increased. As a result, it has become increasingly more important to have up-to-date knowledge of recent developments in this field overseas in order to avoid duplication and wasteful application of local effort. The N.Z. Marine Department therefore decided to send me to attend the 17th Limnological Congress and subsequently, with some financial support from the Rotorua City Council, on a brief tour of water research establishments in Europe and the United States.

At the congress a great deal of extremely valuable information was made available to the delegates but possibly the most interesting paper from my point of view was that given by Professor W. Rodhe on the programme of Lake Kinnereth (previously called Lake Galilee). Professor

Rodhe, who incidently was elected President of the Association at the conclusion of the Congress, has been associated with the investigations into the limnology of this lake for many years. Many data are now available on the water circulation and hydrology of Lake Kinnereth and so the current emphasis of research is shifting more towards measuring the magnitude of its biological production. The biology is now being worked out both by direct plankton and fauna sampling and by frequent measurement of rates of photosynthesis. The post-congressional tour, whilst providing an opportunity to see a great deal of Israeli history and the past and present utilization of its limited and therefore most valuable water resources, also included a visit to Lake Kinnereth. This enabled delegates not only to inspect the new limnological laboratory sited on the lake shores near Tiberius but also to see for themselves the extent and quality of the lake waters. Diversion of many of its saline inflows and springs has been successfully accomplished in recent years. Records of water conductivity extending over a long period of time were available for inspection and discussion. These were most informative for they showed that the quality of the lake water for drinking and irrigation purposes has now been greatly improved compared to its condition in the past in spite of the very large increase in urban and agricultural development of the catchment.

At the conclusion of the congressional tour, I spent a few weeks visiting water research establishments in Sweden, United Kingdom and in the United States to discover current trends mainly in salmonid rearing and freshwater reclamation.

It was surprising to discover the increasing importance of stations devoted to trout and salmon rearing. In many cases, these new stations are

supported directly or indirectly by funds from commercial firms, often those concerned with the production of hydro-electricity. The general opinion seems to be that as the essential design and operation of hydroelectric stations has had a very adverse effect on local salmonid fisheries, it is proper that these concerns should support the efforts made to restore the fisheries as far as possible. This cooperation between industry and government has resulted in considerable improvement in the salmon and trout fisheries in rivers in Sweden, Canada and America. In some cases of serious depletion of the fishery the opportunity is being taken to change the stocks by selection of brood animals for particular traits, usually larger size or greater fecundity. However, Professor Donaldson of Seattle University, who is a leading authority in this field, found that the timing of the original run of salmon in the river there was particularly inconvenient. It started before the fall university term opened and it was difficult to obtain student workers to document the early stages. By careful selection, he has now been able to establish a good salmon population of a late running variety that returns from the sea a few days after the academic term starts thus greatly facilitating research work on the species. In a slightly different context, a bold step is being taken in Sweden who are replacing one freshwater species by a completely different one. The freshwater crayfish is an esteemed food delicacy there and one that is popularly associated with a national feast day. The local species had suffered a devastating mortality a few years ago owing to its susceptibility to an exotic fungal disease. Several possible courses of action were considered but it was decided to acclimatise a much larger Californian species that was resistant to the fungal infection. Some years of careful study of the animal in the Swedish environment followed and this year, large-scale distribution of the species throughout the country has begun.

Considerable work is being done in all countries to combat the increased rate of eutrophication and pollution of natural waters that occurs when their catchments are settled and developed by man. Current surveys to detect sources of pollution on the River Ouse in U.K. are nearing completion. Analyses of the river and its inflows by the staff of the Water Pollution Laboratory in Stevenage have shown that most of the fertilizing material comes from sewage rather than from industrial concerns or sewage. The increment of this material to the river is greater than its loss by outfall and the present work by the Civil Engineering Department at Newcastle University in estimating the respiration rate of the bottom sediments in different parts of the river shows how the difference can be accounted for.

Probably the most interesting survey noted on the tour was that being made by members of the Limnological Institute, Uppsala on the several hundred miles of waterway that constitutes Lake Malaren. Several towns are situated on the lakes or its inflows including the capital of Sweden, Stockholm. The surveying team has been able to identify major sources of pollution and to monitor the effects of any improvements made. Much encouragement has therefore been given to local authorities to incorporate a nutrient-stripping stage in their sewage plants with the result that although eutrophication is noticeable in some areas, on the whole the lake waters are clearer and better oxygenated than would be expected from such a well-developed and heavily populated catchment.

A concluding highlight of my tour was afforded by a study of the behaviour of marine mammals at Sea World in San Diego, U.S.A. In the beautifully clean and enormous aquaria at this establishment, I was completely captivated by the antics of the resident killer-whales, seals, dolphins and

and penguins. In spite of the flippant dialogue of the commentator, I was still impressed by the sight of a team of three dolphins who, on command, somehow managed to "stand" on the water surface with only their tails submerged and move in unison across the lagoon.

N.Z.L.S. CONFERENCE

The Society's first meeting was held at Auckland University on August 18-19, following immediately after an Ecological Society meeting. In spite of the travelling involved some 20 non-Auckland members attended, together with at least as many local people, so that a satisfying crowd were present to hear the speakers.

On the first day 12 members went off on an all-day excursion into the Lower Waikato basin, about 60 miles south of Auckland. A brief stop was made at the discharge point of water used for cooling the Meremere steam power station on the banks of the Waikato. The rather rare red alga, Batrachospermum, has been found growing on the outlet there. The party then went on to cross the river at Rangiriri and visited Lake Whangape, before re-crossing to reach Lake Waikare. Fortunately it was warm enough for a picnic lunch at the foot of the lake, and then after a look around the shore, we went on round the lake to the outlet gates of the flood control scheme before returning to Auckland.

The Waikato River is one of the major rivers of the North Island, draining much of the Volcanic Plateau via Lake Taupo. It has had several major changes of course in the lower reaches but now passes through the low-lying swamps of the lower Waikato Basin to discharge on the west coast at Port Waikato. The large amount of material carried down by the river has

led to a high rate of aggradation (20-30' since the Taupo Ash Shower of 130 AD) and hence to the formation of a number of lakes where tributary streams have become dammed. Lakes Waikare (8461 acres) and Whangape (2914 acres) are the largest of these - there are others at Huntly and in the middle Waikato basin. The lakes are all shallow (2-3m deep) grading imperceptible into the surrounding flood plains with their swamps and peat bogs (though these are now much modified by improved drainage and flood control schemes).

Lake Whangape has extensive weed beds and supports large populations of birds. Lake Waikare is open, and functions as a flood relief for the river, excess water being channelled into it and discharged back again later. The fauna of the lakes is of interest, being a mixture of freshwater and brackish species. Mysid shrimps (Tenagomysis chiltoni, an estuarine species) occur in both lakes, and the brackish water crab, Halicarcinus lacustris, has been recorded from L. Waikare, though not recently although this is perhaps due to lack of collecting effort rather than to extinction. The mysid is also found in L. Wahi at Huntly. These are relicts of incursions of the sea into the Waikato Basin, which even now is only 30-40'a.s.l. Miss Mason pointed out on the excursion that Kirk in 1874 had commented on a marine element in the flora of the lakes also. The zooplankton of the lakes is numerically rich but lacks diversity, although in L. Whangape many pond species are found as well as typically lake species. A major peculiarity is the co-occurrence of two calanoid copepod genera, Calamoecia lucasi and Boeckella delicata being found in both lakes and in L. Wahi. This co-occurrence is almost unique in Australasia but appears to be typical of the Waikato system. Since the excursion both genera have been found in the hydro lakes of the upper Waikato as well. Fish in L. Waikare include smelt, gobies, carp, long-finned eels, galaxiads, mudfish and catfish.

On the second day a selection of papers were given, of which abstracts are printed below. It is perhaps worth mentioning that of the 13 papers arranged, only 4 were offered initially, the remainder being extracted by request. One paper had unavoidably to be withdrawn at the last minute. For the benefit of those who were not present we might also add that the length of the papers varied from 15-30 minutes so that the programme was not quite as concentrated as one might think. Displays of aquatic plants were on view in the Botany Department and of equipment and photomicrographs of zooplankton in the Zoology Department. In the evening a short general meeting was held.

N.Z.L.S. GENERAL MEETING

A general meeting was held in the Botany Seminar Room, University of Auckland, on Monday the 19 August, 1968 at 8 p.m. Dr D. Scott chaired the meeting of 20 members.

Apologies for absence were received from: Dr V.M. Stout, Dr G.R. Fish, Mr R. Hicks, Mr G. Duncan Waugh, and Dr M Winterbourne.

It was decided to conduct the meeting informally and the following business was discussed.

1. The Constitution. Copies of a draft constitution were given to members. The proposed constitution is based on that of the Australian Society for Limnology. A number of changes were suggested by members, and were mainly concerned with the procedures of election of officers, resignation of members, suspension of members, term of office, and affiliation with other societies.

It was agreed that the Committee take these suggestions and incorporate them in the constitution, which can then be circulated to all members who will have the opportunity to vote on the constitution.

Once the constitution is accepted by members, a formal election of officers should be held.

2. The Newsletter. Dr M.A. Chapman outlined proposals for the next newsletter which would include a report on the conference, information on University theses, book reviews, comments on equipment. The overseas distribution of the Newsletter was discussed, and it was pointed out that this will help N.Z. limnologists to contact overseas workers.

3. Next Meeting. It was agreed that meetings should be held alternately in the North and South Islands. The time and place of the meeting was left to the Committee to decide. There was a comment on the predominance of Auckland speakers, but it was agreed that a local bias was to be expected, and in fact is probably desirable. It was suggested that the field trip follow the meeting in future and that a social evening be held.

4. General. There was no general business.

The meeting adjourned for supper and informal discussion.

A.M.R. Burnett

CONFERENCE PAPERS

We print here abstracts of the papers given at the Auckland conference.

Piscator as Limnologist

K.R.S. Morris. (Rotorua)

Limnology parallels marine biology as one of the most challenging of sciences; we are working in three dimensions, the objects and areas we study are often invisible, always difficult, even hazardous of access. Fortitude and ingenuity are tools of our trade, as well as the broadest possible concepts of ecology, which must include factors such as wave action and water circulation, which the terrestrial ecologist can ignore. We are field naturalists par excellence.

The old amateur naturalists, poking about in ponds and headgerows, were ecologists. Darwin, surveying on a global scale, made ecology a respectable as well as a fruitful science. Exact classification was needed, however, so that the biologists moved into the laboratory, and comparative morphology and physiology became the only respectable studies for half a century. Now we're back in the field again, and respectable, because we're essential, in the growing demands on applied biology. But we're still a bit hidebound by the aura of morphology.

In the old naturalist days almost a dozen British species of trout were described and recognised. Then the great morphologist, C. Tate Regan, in the South Kensington Natural History Museum, decided to tidy them up, and brought them under a single species, Salmo trutta. He oversimplified, because he tried to classify on anatomical differences, from museum specimens only. He was not a fisherman. No alert angler who has fished for sea trout would ever confuse it with the brown trout, he distinguishes the two both by

appearance and behaviour. Fishing on a pitch black night, he knows at once if he has hooked a sea trout or a brown trout, by the way they fight. I have known this all my life, and have never accepted Tate Regan's classification. It is stimulating to find this controversy being cleared up here in New Zealand by Dr. Scott, who has come through the final ecdysis by shedding the straightjacket of anatomy and accepting behavioural characteristics as valid criteria for defining a species. The amateur naturalist, unfettered by dogma, has always done this.

Again, a definite rhythm in the trout's daily feeding activity has been recognised as long as anglers have angled, the proverbial dawn and dusk rises for example. Yet the first and only exact biologist study of this, of which I am aware, is that of J.D. Smith, made on Lake Windermere in 1962. Personal observations, extending over many years trout fishing in Britain, have shown a daily rhythm, in which brief activity periods, of 20 to 60 minutes, alternate with longer rests, of 2 - 3 hours. A strikingly similar rhythm is being observed with rainbow and brown trout in New Zealand, 25% of their time is spent actively feeding, 75% in resting.

This rhythm is influenced by so many factors, either intrinsic to the trout, such as sex, age and hunger, or extrinsic, i.e. conditions of the weather etc., that accurate prediction of the activity periods is a matter of considerable difficulty. A way round, empirical but practical, came to me years ago in night-fishing for sea trout in Cornwall. On nights of marked activity among visible and audible creatures, water rats, water hens and water fowl, above all when the predatory brown owls were calling freely, the predatory sea-trout would feed voraciously and my bag would be full. On quiet nights I might as well pack up and go home, the trout wouldn't move, were tantalisingly shy. This is the principle of "indicators", animals of widely separate families responding in a similar way to the complex of

stimuli comprising "weather". Encouraging parallels are being found in New Zealand, angler friends quoting bell-bird song and cries of Pukekoe as indications of a good day's trouting. The most enterprising watched a bowl of goldfish in his front parlour. Practical fisherman's tips maybe, but the concept suggests fruitful lines for research in animal behaviour.

Two general conclusions emerge:

1. A reservoir of potentially valuable observers exists in our anglers, which could be tapped, with precautions such as cross checks etc. for collating mass data over wide areas. This has been done to great effect in Allen's "Diary Scheme". The British Nature Conservancy make full use of Amateur Naturalist Societies, School Nature Clubs and individual naturalists of repute, for ecological and survey purposes.
2. Exact identification of species is vital in ecological work, but a rigidity in our methods of classification makes us overstress the importance of morphological characters at the expense of the less easily defined ones of behaviour and physiology. This is natural; as Professor Leach put it, it is easier to understand the workings of a watch than of a jellyfish. Yet when anatomical differentiation is impossible, as with the viruses, behavioural differences are accepted for classification. A Pathologist diagnoses the amoeba of amoebic dysentery by the speed with which it traverses his microscope field. The fact that our studies in animal behaviour are not yet sufficiently advanced to enable the precise calibration and measurement of their quantities, is no reason for discarding these characters as invalid for the recognition of species. The mind of the amateur naturalist is not clogged with scientific dogma. Behaviour, to him, is a valid and valuable character, even if he cannot express it in the metric system.

Diurnal Changes in Temperature and Plankton Distribution in Lake Rotoiti,
North Island

M.A. Chapman. (Zoology Department, Auckland University)

A series of temperature measurements were made at 1-3 hour intervals at a station on L. Rotoiti over a 24 hour period starting at midday on Feb. 14, 1968. Series of zooplankton samples were also taken in divided vertical hauls with a Nansen closing net.

The temperature data showed that a distinct internal seiche was operating, of which the period was calculated to be 21.9 hours (Green, Norrie & Chapman, 1968). Such a phenomenon is not unexpected in a long narrow lake like Rotoiti.

The plankton results were of interest in that (a) a clearcut picture of diurnal migration into the surface layers was found for the calanoid copepod Calamoecia lucasi and the cladoceran Bosmina meridionalis, beginning 2-3 hours before sunset and completed 3-4 hours after sunset. Populations of Ceriodaphnia dubia and Macrocyclus albidus were too small, and particularly in the case of the latter were at too deep a level in the lake, for the sampling to provide much information about changes in their vertical distribution; (b) the total numbers of animals caught in the samples showed a marked decline after 11 pm when the thermocline was oscillating upwards, but were again increasing during the downward oscillation on the following morning. It was postulated that animals coming into the surface layers during the evening as they migrated were being carried away from the sampling area by epilimnetic currents associated with the seiche. By the time the current direction reversed the majority of the animals would have migrated deeper again and hence the population at the sampling station was not fully

replaced. A comparison of the populations at a second station at the eastern end of the lake at the beginning and end of the sampling period showed that the numbers at this station had increased somewhat, particularly in the thermocline, as would be expected if animals originally present further up the lake were being swept down by nocturnal currents.

Preliminary Observations on the Plankton Biology of a
Waitakere Reservoir

J.D. Green. (Zoology Department, University of Auckland)

Since October 1967, a study has been carried out of the plankton biology of the Auxilliary Nihotupu Reservoir, a small water storage dam in the Waitakere Ranges west of Auckland.

Water shortages over the summer period caused the reservoir to be emptied on the 10th of March, and it was not refilled until the 1st of April. During this period the reservoir was completely dry except for a small stream which meandered through the basin. Thus for a period of three weeks the planktonic community ceased to exist.

Overseas workers have demonstrated the existence of resting stages in the life-cycles of many planktonic species. Of particular interest are the quiescent and diapausing stages of Calanoid and Cyclopoid copepods. Such resting stages have not previously been specifically recorded in New Zealand species, although suggestions that they exist have been put forward. It was hoped that when the reservoir was refilled more precise information on possible resting stages in the plankton species could be obtained, in conjunction with a study of the regeneration of the main species.

Before emptying, the zooplankton community comprised the two dominant

cladocerans Bosmina meridionalis and Ceriodaphnia dubia, the two copepods Mesocyclops leuckarti and Boeckella propinqua and two rotifers. Of these, all reappeared in the plankton after refilling except for Bosmina and the two rotifers. These latter were replaced by the colonial form Conochiloides sp. which was present in very large numbers. By the 11th of August, the plankton had regenerated to approximately 30% of its previous level.

The Calanoid copepod Boeckella initially reappeared in the plankton in a sample taken only a few days after the reservoir was refilled, as did all of the main Entomostraca. The life stages present in vertical net hauls were Nauplii, stage 1 and stage III copepodites. Thus it may be tentatively suggested that Boeckella survived the dry period as resting eggs and possibly as quiescing stage III copepodites. The first females appeared during late April and early May, and a large phytoplankton increase also occurred over this period. These animals produced enormous clutches of eggs (69 to 125) giving rise to large numbers of the early life stages, which could be subsequently followed through to the adult stages. This initial increase was followed by a lag period during late June to early July when the population was small, although increases in the early stages were again occurring in early August. An analysis of the metasomal lengths of the adult animals suggested that there were three generations of Boeckella during the period from refilling up till early August. An initial generation of large animals producing large clutch sizes was followed by a second smaller generation, while towards the end of the period considered, a third generation of intermediate size had appeared.

Mesocyclops reappeared mainly as stage V copepods, together with nauplii and some of the earlier copepodite stages. Thus it may be suggested that

Mesocyclops survived the dry period as diapausing stage V copepodites and possibly as resting eggs. The life cycle followed a very similar pattern to that of Boeckella already described.

Ceriodaphnia also appeared early and consistently maintained a population level approximately 10 times that of the copepod species. The life cycle was followed by analysing the changes in length of the animals. The initial population consisted of very small animals, and it would seem that they probably hatched from ehippial eggs deposited by the earlier community. These reached maturity by mid-May, and were followed by at least two and possibly three other generations.

(This work forms part of an M.Sc. thesis)

The Limnology of Lake Ohakuri

F. Hill. (Botany Department, University of Auckland)

The present study of the limnology of Lake Ohakuri was begun in 1966 after prolific growth of the rootless aquatic water plant Ceratophyllum demersum began interfering with the operations of some of the power installations on the upper Waikato. Ceratophyllum itself is the dominant macrophytic weed in Lakes Ohakuri and Atiamuri and is becoming established along the more northerly parts of the river also. The successful growth which this weed makes in its new habitat led to the need to study and characterise its environment.

Lake Ohakuri is the largest on the Waikato River. It is 5 square miles in extent and some 35 miles long. At the dam face it is approximately 100' deep although this depth is not maintained, and much of the lake is less than 50' deep. The lake itself occupies for most of its length the old

river course and is, in consequence, narrow (100-500 yds). Only in the most northerly reaches does the lake broaden out and attain its maximum width of $\frac{3}{4}$ mile.

Inflows originate chiefly from Taupo and are artificially regulated. Assuming an average depth of seventy feet, a calculation can be made, using outflow - inflow data from the power stations, to determine the throughflow of water. In winter periods, the average flows are such that they equal in volume the total volume of the lake every 6 - 7 days. In summer this period is lengthened, because of less demand for power, to 13 - 14 days. As a consequence of this rapid through flow of water, oxygen levels at all depths in the lake remain high (greater than 60% saturation) and supersaturation of the water is common. Lake water temperatures over the year are in the approximate range 9 - 23°C, and no thermocline develops in the open lake.

Light penetration varies greatly in different areas of the lake. During summer months the southern end of the lake (Aratiatia) gives Secchi disc readings of 15 - 18 metres, while the upper Wirinaki tributary gives 1 - 2 metres. The lake adjacent to the Ohakuri Dam face has a reading of from 5 - 7 metres. This great difference in the degree of light penetration is due chiefly to plankton densities as the difference in light penetration decreases during the winter when plankton populations decline. There is no doubt however, that, in the northern parts of the lake colloids and suspended particles also play some role in decreasing light penetration. The dominant phytoplankter is Melosira granulata var. angustissima and bloom and local concentrations of numerous other species also occurred e.g. Anabaena, Microcystis, Volvox and Pediastrum.

Water samples were collected from 8 stations on Lake Ohakuri, north of the Orakei-korako thermal area, and from each of the hydro-electric power stations on the Waikato, as well as from the Taupo Gates and Meremere power station. Soluble phosphates (s-phosphate) were determined by using the ammonium molybdate - stannous chloride method. Total phosphate (t-phosphate) was determined by oxidation of the water residues by perchloric acid and later colorimetric determination of s-phosphate produced (Mackereth, 1963). Results of analyses show that the source waters of the Waikato have the lowest levels of soluble and total phosphorus (average $43 \mu\text{g PO}_4$; $60 \mu\text{g P}$ litre respectively). Water flowing from Taupo however quickly becomes enriched with s-phosphates and a rise also occurs in the level of other phosphorus compounds. At Lake Ohakuri s-phosphate levels of water flowing through the station averaged $93 \mu\text{g/l}$ s-phosphate, $550 \mu\text{g/l}$ t-phosphorus. As the water flows north from Ohakuri there is little further change in the level of s-phosphate. Instead it is the t-phosphate levels which change. These show a steady increase and reflect a situation which indicates that phosphates are also being liberally supplied to the more northerly Waikato water.

Maraetai - $73 \mu\text{g/l}$ s-phosphate; $800 \mu\text{g/l}$ - t-phosphorus

Karapiro - $63 \mu\text{g/l}$ s-phosphate; $1100 \mu\text{g/l}$ - t-phosphorus

Certainly from the high level of phosphorus compounds in the Waikato chain it is not likely that availability of the ion ever affects or limits production by the biota.

Levels of nitrate in the Waikato show a similar trend to that found for t-phosphate. That is, nitrates increase in concentration along the Waikato from south to north. As the waters of the Waikato tend to be well aerated this accumulation of nitrates is to be expected. Ammonia apparently arises in the normal fashion from sediments, bacterial action, etc. and in the few

analyses made appears to be present in concentrations approximately the same as those for nitrate (trace - 500 $\mu\text{g/l}$. NH_3) nitrate shows a distinct seasonal fluctuation in quantity.

Typical levels in Ohakuri lake are:

Winter - Early Spring - approximately 1 mg/l NO_3

Summer - low levels around 50 $\mu\text{g/l}$ NO_3

Often summer levels fall below the limit of detection of the analytical method used (50 $\mu\text{g/l}$ NO_3) and it is possible that these low levels represent a period when the availability of nitrogen could be limiting to the growth of certain organisms. Ammonia at the same period however is still present and could no doubt serve as an alternative nitrogen source. Ammonia concentrations do not appear to undergo seasonal fluctuations although the limited number of analyses carried out may have obscured some short term fluctuations.

This short report presents some results obtained during limnological research carried out at Lake Ohakuri over the past two years, and now being written up for a Ph.D. thesis.

The Limnology of Lake Pupuke

M.A. Barker (Hamilton)

Lake Pupuke, situated on the North Shore of Auckland, is a relatively small circular body of water with a maximum width of 1,020m. and a maximum depth of 55m. The lake was studied over the period November 1966 - November 1967 with observations being made twice monthly on the plankton and the physico-chemical factors. Seasonal sampling for zooplankton was carried out using a pump and hose, while a Nansen closing net was used for diurnal

sampling.

Surface temperature ranged between 24.2°C and 12.0°C and temperature at 40m. were between 14.5°C and 11.3°C . A thermocline was forming between early November and early January and was strongly developed, at about 17m. between then and late April. From this time until late June it was breaking down and the lake was homothermous between mid-July and mid-September.

Light transmission, as measured with a photometer, was high from mid-August to mid-December (53 - 76% per m.) but was very low from then until mid-February (23 - 49% per m.). After high values in March (75% per m.), transmission was relatively constant over the winter months (53 - 64% per m.). Light transmission was very largely governed by phytoplankton concentration. Changes in Secchi depth very closely followed those for light transmission. Values ranged from 1.0m. to 5.2m. with a seasonal mean of 2.2m.

Oxygen concentrations down to 30m. were highest at all depths from mid-November to early January (112 - 134% saturation). A strongly developed oxygen stratification was evident from early January to late April, when epilimnion values varied between 55 - 100% saturation, but hypolimnetic oxygen sank to a minimum of 24% saturation. Oxygen values gradually increased at all depths during winter.

Surface pH's varied between 9.50 and 7.85 and those at 30m. between 8.60 and 7.85. From early January to late April a strongly developed stratification of pH was evident, but from mid-July to mid-August values were nearly uniform. Alkalinity (mainly as bicarbonate) varied from 76.0 to 80.3 ppm CaCO_3 , with a slight summer stratification. Carbonate ion was present from early October to mid-June, but only trace amounts of free carbon dioxide were ever found.

Nitrate concentrations varied between 0.05 and 0.31 ppm, with an obvious summer depletion. Nitrate values, with one exception, were always insignificant. Ammoniacal nitrogen built up to a maximum of 0.95 ppm in the hypolimnion, but was lower over the rest of the year, while albuminoid ammonia (0.16 - 1.03 ppm N) generally varied with the quantity of living matter present.

The total ionic concentration (3.30 meq./l) was high, and was of this order: Na Mg Ca K and HCO_3 Cl SO_4 . Dissolved salts in Pupuke are believed to be derived from the precipitation of airborne particles, dissolved in rain or as sea spray.

Such features as the low rate of water renewal of Pupuke, and low Secchi transparency, the nature and abundance of the phytoplankton, and the high total ionic concentration suggest that Pupuke may be definitely described as a eutrophic lake. It is suggested that eutrophication may have occurred relatively recently.

(This paper is based on an M.Sc. thesis at Auckland in 1967).

The Zooplankton of Lake Waikare

W. Donovan (Zoology Department, University of Auckland)

Lake Waikare is a large, shallow, turbid lake situated in the Waikato lowlands area in close proximity to the Waikato River. It is one of a group of lakes of the Waikato lowland area which appear to have very similar fauna and chemical composition.

Temperature was measured with a 0 - 110°C mercury thermometer and a thermistor resistance thermometer. Oxygen samples were obtained using a

Hales Water Sampler and the amount present determined by a modification of the Winkler method. pH was measured on a pH meter and a photometer was used to measure light penetration. Plankton samples were obtained using a plankton pump.

Stratification was not exhibited by the lake water, the oxygen concentration of which was low throughout the sampling period (75%-90% saturation). Temperature varied from 19.6°C-9.3°C and the pH was from 6.7 to 7.7.

Variation in the species of Entomostraca present in Lake Waikare was found to be small. Distinction was made between adults and various copepodite stages. A seasonal fluctuation in numbers of the zooplankton was recorded with total reduction occurring in early June until early August when a slight increase occurred. It is possible that one generation of Calamoecia lucasi may have occurred from late March to mid-May. One pulse only was recorded for Mesocyclops leuckarti. At no time during the sampling period did Boeckella delicata form a significant part of the plankton. Nauplii, of which no distinction was made between cyclopoid and calanoid nauplii, were in greatest numbers in late March. The mysid Tenagomysis chiltoni was also found to be present. There was apparently no breeding during the winter months. Rotifers were present only during late March.

A 24 hour study was made in mid-May. A decrease in temperature over the period was recorded from 13.9°C to 10.3°C. with the air temperature displaying a range of 16.5°C to 5.2°C. Oxygen concentrations were similar for surface and bottom waters varying from 6.9mg/l to 9.9mg/l. Illumination of bottom waters decreased as the overhead conditions clouded and turbidity

increased. A nocturnal pattern of migration was suggested for Calamoecia and a modified twilight migration pattern for Mesocyclops with variations of these two patterns displayed by the respective copepodite stages.

(This work was done as a IIIB project in 1968).

Food and Feeding Behaviour of Smelt from Lake Waikare

C.S. Hatton (Zoology Department, University of Auckland)

Smelt (Retropinna sp.) from Lake Waikare were studied both in the field and in the laboratory. They were caught principally by towing a trawl net from a dinghy, and in order to keep them alive for experimental work it was found to be essential to avoid exposure to air, 'excitement', and above all handling.

Laboratory experiments showed that there was little if any feeding in total darkness, in contrast to their behaviour in light. Other experiments using mixtures of Daphnia and copepods, and of amphipods and copepods, (all of which were readily taken as food when supplied separately), suggested that the fish selected the larger food items, whilst trials with mixtures of normal pale coloured copepods and ones stained vitally with neutral red showed that the fish tended to select the more readily visible red animals. Thus it appears that vision plays an important part in food selection. No response to suspensions of ground up plankton was noted.

Field work over the March-July period suggested that there was a definite change both in the distribution of the fish in the lake and in their diet. Fish of about 58mm in length or less were found to be widely distributed throughout the pelagic zone where they fed almost exclusively

on zooplankton. The larger fish found from August onwards were caught in the littoral zone where almost all of them had been feeding on insects (mainly adult Chironomidae). Mysids, although abundant in the lake, were found only once in the gut contents.

During the 4 months of observations the fish grew from an average length of 49mm to a maximum of 74mm, the maximum growth rate being 0.91mm per week. A considerable size variation in adult females was found. Spawning occurred in the lake despite the absence of clean sand or pebbles.

(This work was done as a IIB project in 1968)

Some studies on Oniscigaster wakefieldi (Ephemeroptera)

J.A. McLean (Gisborne)

Detailed studies of external morphology have shown the synonymy of O. intermedius Phillips 1930, and O. wakefieldi McLachlan 1873. There are clear morphological distinctions between O. wakefieldi and O. distans.

Because O. wakefieldi had been found previously only as isolated specimens and because of its highly local distribution, a more efficient collecting net was devised. In design, the net had a cork line and lead line. Instead of suspending the terylene netting directly between the two lines, it was sewn into the shape of a pyramid on a rectangular base. On the truncated vertex, a collecting bag was attached. All larvae caught were measured (in mms) and returned to the population in the pool. The percentage frequency of each mm size group in any one month was plotted as a kite diagram. In this manner, by monthly sampling, a detailed picture

of the life cycle of O. wakefieldi in the Waitakere Stream was built up.

Greatest number of young larvae (3 - 10 mm) were found in February and March and populations showed a constant rate of growth through to October (2.5 mm per month). The first emergences were recorded in mid-October and continued till late January. By measuring a sample of 56 final exuvia collected from boulders in the stream bed during the emergence period, it was shown that the emergent females averaged 24-25 mm in length while the emerging males averaged 20-21 mm. This 4 mm 'average difference' in the size of male and female larvae showed up in populations as early as June. O. wakefieldi has a univoltine life cycle.

(This work formed part of an M.Sc. thesis at Auckland in 1967).

Flight Activity of Mayflies

P.H. Norrie (Zoology Department, Auckland University)

The M.Sc. thesis research on which this report is based was carried out in the Cascades area of the Waitakere Ranges. The main sampling apparatus was a Robinson light trap, modified so that the catch fell directly into a bottle of alcohol thus eliminating handling of the insects in the field. The trap was operated from the stream bed.

Light trapping as a sampling technique has the disadvantage that the catch size and its composition is to a very great extent dependant on the behavioural response of each species to the trap. Sex and physiological state may also be important. It must therefore be kept in mind when interpreting results that the light trap catch is probably a biased sample of the flying population.

Deleatidium spp. constituted the largest fraction (66%) of the catches, followed in order by Zephlebia cruentata, Coloburiscus humeralis, Zephlebia sp., Zephlebia scita, Ichthybotus hudsoni, Rallidens mcfarlanei, Nesameletus ornatus, Zephlebia nodularis, and Ameletopsis perscitus. Subimagoes were taken in greater numbers than imagoes, the former making up some 85% of the catches.

Diurnally a very clear light trap catch pattern was found. This took the form of a peak in numbers shortly after sunset followed by an exponential fall off in numbers till morning. No dawn peak was found. This pattern is not necessarily equivalent to the pattern of flight activity but it can be used to show that a two hour light trap sample at dusk will collect all of the species and 80% of the specimens that would be taken in a full nights collecting.

A fortnightly programme of two hour samples was maintained through the year to determine seasonal patterns. With the exception of Ichthybotus hudsoni (late November to mid January), it was found that all species had flight seasons in excess of eight months. July was the only month during which no mayflies were captured.

There appears to be a correlation between air temperature and the number of animals flying. Flight ceased below an air temperature of 10°C.

Work is still continuing and it is hoped that a suction trap will allow the diel flight pattern to be clarified and also estimates of population size to be made.

Age and Growth of New Zealand Salmon

M. Flain (Fisheries Laboratory, Christchurch)

The Rakaia river approximately 50 miles south of Christchurch is one of the major salmon spawning rivers in the South Island.

The Glenariffe stream is a tributary of this river, and is used extensively by Quinnat Salmon for spawning. Preliminary surveys carried out by Marine Department personnel (January 1965) resulted in this site being chosen for a one way adult trap, for the following reasons.

1. It is not subject to frequent violent flooding.
2. It is reasonably accessible.
3. It is a good spawning area.

The trap was constructed by February 1965 in time for the 1965 spawning run. This successful pilot scheme resulted in further plans for a more elaborate two way adult and fry trap. The site was surveyed in July 1965 and the present trap was installed by February 1966. Subsequently modifications and improvements have been made. The trap provides the means to obtain data and samples for age determinations and growth rates. For the 1965 run scale readings were tried, but were found to be subject to bad erosion, and a change was made to otoliths. These were found to be entirely satisfactory.

The method employed is as follows. The fish are measured, tagged, recorded and then passed through to spawn. Subsequently the otoliths are removed from the tagged, recovered carcass, stored and cleared in a 3% solution of tri-sodium orthophosphate ($\text{Na}_3\text{PO}_4 \cdot 12\text{H}_2\text{O}$). Storage in air

results in opaque unreadable otoliths. The otoliths are then stained in water soluble Fluoresceine (saturated solution) for at least two days. Overstaining does not affect the ease of reading. Once stained they are read by transmitted blue light which enhances the rings.

So far no absolute proof of the validity of the method has been obtained, although fin clipping of smolts on subsequent recapture at the trap should provide this information. Independent workers (Finlay, Parrott and Washington University) give comparable results. Also the length frequency data agrees very well with the otolith recordings.

A synchronous sampling of the anglers catch of quinnat was carried out in 1967 and 1968.

Results

In the 1967 and 1968 runs a very small proportion of 2 year old females was found. No records of this happening in North America have been sighted.

It is evident from the several years material now available that growth rate varies only slightly from year to year, but that the proportions of year groups in each spawning run varies considerably. This accounts for the variation of mean size of fish for a particular run or in angler terminology for the "good" and "bad" runs.

Very few five year old fish were found, and none were older than this. In North America and Alaska fish up to eight years old at maturity occur.

There was a bias towards older fish in the anglers "creel" at the mouth (1967), suggesting a higher rate of cropping of older fish by the anglers. Large fluctuations in the sex ratios occur.

Finlay (1928)	Males 39.8%	Females 60.2%
Glenariffe (1967)	Males 58.3%	Females 41.7%

The Freshwater Interstitial Habitat

Maureen H. Barclay (Zoology Department, University of Auckland)

It is now known that the sand of marine and freshwater beaches is not the 'desert' it was once thought - the interstitial water of these habitats supports a varied and often dense fauna. The study of this fauna has resulted in some important systematic discoveries e.g. the syncarid and mystacocarid crustaceans.

Freshwater lake beaches can be divided into three main zones:

1. Hydropsammon - the permanently submerged sand along the shore below the water's edge.
2. Hygropsammon - adjacent to the water's edge and saturated by capillarity and wave action (about 1 meter wide).
3. Eupsammon - the beach beyond the hygropsammon which is only partially saturated.

Most sand is composed of angular or rounded quartz crystals which cannot be compressed to diminish the water filled interstices. Silting up of these interstices is an important factor in limiting numbers in the Auckland district.

Sampling is difficult. Water for chemical analysis is usually drawn out using a pipette with a suction bulb. For the animals two main methods are practised. The first is one which uses a probe to draw up the water, leaving the sand behind. Drawbacks include animals escaping

the sample by strong attachment to sand grains, nor is there any reference to the volume of sand drained and no guarantee that the water comes solely from the depth sampled. The second possibility is the core sample. The sand collected can be cut into suitable lengths to indicate the depth preference of the various animals. However sorting the animals is often a lengthy and tedious business.

Temperatures near the water's edge are determined largely by the lake water temperature. Surface temperatures of the sand between 50-250 cms from the edge are homogeneous because of the influence of capillarity water and its evaporation. At greater distances the sand is often dry and temperatures may rise to high values on hot days.

It is essentially a lightless habitat. Light does not penetrate more than 10-15 mm below the surface.

There is a rapid decline in dissolved oxygen from the shoreline outwards whereas free carbon dioxide is commonly much higher than in the adjacent lake water. Consequently pH is usually 0.2 - 0.6 of a pH unit more acid in the water of the sand. Most striking is the great concentration of dissolved organic and inorganic materials. This has led to the habitat being labelled extremely eutrophic.

Plant material is usually dense in the top cm: mostly diatoms with several green and blue-green algae. Desmids, dinoflagellates and bacteria are also present. Of the fauna most of the invertebrate groups have interstitial representatives. In Lake Tarawera, at Rotorua, Protozoa, Turbellaria, Rotifera, Nematoda, Oligochaeta (Chaetogaster), Crustacea (such as the ostracods Gomphocythere and Darwinula sphaena, and the bryozoan Phyllognathus) and Insecta (Chironomidae and

Collembola) are found.

The animals are usually small and elongate. Several have developed hooks or claws to enable them to cling to the sand particles. For food they are dependent upon microscopic organic detritus as a basic source but unicellular green algae and bacteria are also important. Food material is abundant and hardly ever a limiting factor.

Variations in population density have been shown to occur in a single beach or from one beach to another even on the same lake. Explanations for this are fragmentary. Among the possibilities are chemical composition, grain size, wave action, sand saturation and localised food material. Horizontal distribution (shown by rotifers, tardigrades and copepods) is thought to relate to the degree of wetness of the sand. The harpacticoid Phyllognathopus on Lake Tarawera is concentrated just above the water's edge. There is active migration of the fauna during the year as the lake level rises or falls. Vertically active organisms are seldom found below 8 cms. Generally more than 95% of the population is restricted to the top 6 cms with the 3-4 cm level usually being the optimum. This level provides the most animal numbers in core samples taken on Lake Tarawera.

Because of the uniformity of the habitat and dependence on the lake itself it would appear that the psammon is indeed an integral part of the lake system, equal to the plankton, benthos, littoral etc.

Haemoglobin in Simocephalus

L.E. Edwards (Zoology Department, University of Auckland)

Simocephalus vetulus from Western Springs pond were kept for 2-3 weeks in 250 ml flasks in water of low oxygen content (less than 5.0 mg/l). Nitrogen was bubbled into the water to lower the oxygen content, which was determined by Winkler titration of 5 ml subsamples.

It was found that, like many other Cladocera, Simocephalus gained haemoglobin in response to low oxygen concentrations. The amount synthesised was inversely proportional to the oxygen content and directly proportional to the length of time that the animals had been kept in the water. The rate of synthesis was approximately constant, being two-to threefold in ten days. The amounts were measured in arbitrary units based on colour comparisons with a diluted blood sample, a method used by Fox and co-workers.

The synthesis of haemoglobin was reversible, the pigment being lost when the animals were placed in highly aerated water. The rate of loss was similar to that of synthesis. Survival experiments showed that the possession of haemoglobin increased the length of life of the animals in poorly aerated water.

(This work was done as a IIIB project in 1968).

AUSTRALIAN SOCIETY FOR LIMNOLOGY

It is very pleasing to note that at the A.G.M. of this Society in May Dr V.H. Jolly was elected President. She is a temporarily expatriate New Zealander known here for her pioneer work on our lakes (she expects to return to N.Z. next year when she retires from the Sydney Water Board), and was one of the prime movers in the formation of the A.S.L. The new secretary is Mr J.S. Lake, School of Biological Sciences, Sydney University.

I was lucky enough to be able to attend the A.S.L. meeting in May, held in Renmark, a town on the Murray River in South Australia. It was a weekend gathering of 40 or so freshwater workers from most parts of Australia, with a day of papers followed by the A.G.M. and annual dinner, and then an excursion day to the site of the proposed Chowilla Dam. This very large dam, of 5 miles or so in length, would hold back the waters of the Murray River for irrigation etc. Two interesting papers on the scheme were given at the conference. The first, by the Chief Engineer of the project, was a most fascinating and illuminating example of the problems which arise in designing a dam - problems of applied physical limnology, such as the size and strength of the waves to be expected on the lake (and therefore how strong the dam wall should be), or the possible increase in salinity to be expected (a matter of concern to the orchardists) etc. The second paper, although not directly limnological, was equally interesting in dealing with the archaeological survey of the area to be flooded which is being carried out by the Melbourne Museum. Many aboriginal burial sites and other evidences of occupation have been found, and during the excursion we inspected a gum tree with scarred trunk where bark had been cut off for a canoe. The remaining papers dealt with more conventional limnological topics, and abstracts will be published in the Bulletin of the A.S.L. An enjoyable feature of the excursion was the barbecue lunch on the banks of the Murray River, complete with ice chilled beer and vast amounts of steak.

Australia, in spite of, or rather, because of the aridity of so much of its area, is a particularly fascinating place for freshwater research, and in hearing of the work of A.S.L. members I could not help being impressed by the variety of topics being tackled: the problems of osmo-regulation in inland saline waters, speciation of isolated river faunas, problems of survival and

regulation of growth in fluctuating environments, colonisation and changes in artificial lakes, and many others.

M.A. Chapman

RESEARCH NOTES

S.C.U.B.A. Diving

Malcolm Flain (Fisheries Management Div., Marine Department, Christchurch)

One facet of an investigation of Lake Coleridge involved sampling the littoral fauna to determine distribution by depth and on a seasonal basis. Conventional grab sampling was tried, but due to drifting of the surface boat, and the steepness of the littoral zone the grab frequently did not operate, and the samples were inconsistent.

Modified 1sq. foot Wisconsin closing nets were constructed, and the samples were taken by divers. Operations could be continued under adverse weather conditions, and so regular sampling was assured. The method involved 1 surface attendant and two divers, who sampled at predetermined depths and points. One diver passed over each net and collected the sample obtained, leaving the other diver free to manoeuvre. The nets with the samples in were brought to the surface, where the silt was washed away. The sample was then transferred into an Agee jar and preserved with formalin for later analysis.

While collecting the quantitative samples the divers were able to make a general assessment of the area sampled. The method was found to be efficient and quick. Departmental regulations limited the diving to sixty feet. but dependent on the experience of the divers it would be possible to

sample up to 200 feet.

Another application has been a quantitative assessment of the adult bully population density in the lake. It was found that at night adult bullies were readily visible on the surface of the weed and made no attempt to swim off. Rectangular string transects 50 x 2 metres were laid out and were subdivided down the middle by a further length of string. Two divers with lights counted the fish very readily. From this information, numbers can be derived for the whole lake.

Recently an experimental liberation of fin clipped rainbow trout was carried out. The fate and behaviour of the fish were observed by divers, and a follow up dive was carried out to assess the distribution of these fish ten days after liberation. Again by diving at night with lights it was easy to count the yearling rainbow trout and to determine whether they were fin clipped or not. It was evident from the count that the fish had remained in the area of liberation.

Zoology Department, Canterbury University

D.J. Staples has begun a Ph.D. thesis on the production biology of the Upland bully, Philypnodon breviceps (Stokell), in Lake Grasmere, Canterbury. The aim of this study is to estimate the net production of a population of bullies and to correlate this with their energy intake as food. Sampling is done with an electric fishing machine and with trap nets, and the numbers and mean weights of each age group taken at monthly intervals. A multiple capture-recapture technique is being employed. During the breeding season fecundity estimates and embryonic survival will be determined. Stomach analyses are being used to ascertain the types and proportions of food

consumed throughout the year and these will be supplemented by energy intake laboratory studies. The results should determine the annual production, the seasonal distribution of production and the energy intake for this lake population of bullies.

B.Sc. Honours III projects:

B.M. Ayers: "The repopulation of four temporary ponds after drying out in summer".

A study of the general features of the ponds was made, all being small farm ponds subject to different periods of desiccation over the summer. Mud collected from the ponds when they were dry was wet experimentally under various conditions in the laboratory and the hatches obtained compared with the animals actually appearing in the ponds when they re-filled with water.

A.G. Clark: "The effect of flooding on the invertebrate fauna of a section of the Lower Selwyn River".

A portion of this shingle river was surveyed and the effect of a major flood (caused by the storm of Easter, 1968) on the invertebrates present was ascertained. Several surveys at intervals after the flood showed the gradual recovery of the fauna. The physical effect of the flooding was marked and the invertebrate fauna greatly reduced. Animals such as chironomid and hydroptilid larvae were completely eliminated while the nymphs of the mayfly Deleatidium seemed best adapted to survive.

J. Crumpton: "Feeding of the bully Philypnodon breviceps in L. Pearson".

A brief survey was made of the invertebrate fauna of part of Lake Pearson in which bullies are common in order to estimate the potential food available. Stomach analyses were made from bullies collected in the area. A series of

experiments was then carried out on food preferences of the bully in the laboratory.

J.A. Nield: "Laboratory growth of Daphnia carinata".

Cultures of D. carinata were grown in the laboratory at 20°C. and the growth rates of females and males measured. The intervals between moults, the number of immature instars and the number of eggs produced were also noted.

Zoology Department, Otago University

Mrs N.M. Grimmond is working on aspects of the ecology of Hyridella menziesi in a tidal freshwater lake.

Dr Caroline Burns has been appointed to the staff and expects to arrive next year. She has been working on trophic ecology of zooplankton.

Botany Department, Auckland University

Carp and Consumption of Weed (V.J. Chapman)

Two imported grasscarp were kept in a cage in a pond at Auckland University. They were provided with weighed quantities of weeds over 14 day trial periods, and the weed remaining weighed at the end. Plants were grown alongside outside the cage to determine growth rate.

RESULTS

<u>Weed Species</u>	<u>Daily Consumption</u> <u>2 carp</u>	<u>Initial</u> <u>wet wt.</u>	<u>Amount eaten</u> <u>wet wt.</u>	<u>%</u>	<u>Growth</u> <u>of weed</u>
<u>Lagarosiphon</u>	20.4 grs	500 grs	251.4 grs	50.1	33.9 grs
<u>Egeria densa</u>	44.1 grs	500 grs	450.8 grs	87.8	31.85grs
<u>Ceratophyllum</u>	8.3 grs	500 grs	213.6 grs	42.6	25.14grs

When the carp were in the pond at the Zoological Garden it was noted that Egeria was consumed more rapidly than Lagarosiphon.

It is clear that their preference for food is Egeria - Lagarosiphon - Ceratophyllum in that order.

In the case of Lagarosiphon above, two first year carp, maintaining their consumption, would eat 6.5 kg wet wt weed per year. With increasing age and size consumption would increase. Consumption of Lagarosiphon in April, when the weed is still growing, is seven times the amount of weed produced, with Egeria it is 14 times the amount of weed produced, with Ceratophyllum it is 8 times the amount of weed produced.

There is no doubt that the carp will consume all three weeds in considerable quantity.

Preliminary investigations into the nutritional requirements of Nitella hooker

(M.B. Sterling)

Studies of the nutritional requirements of the species are being carried out under a D.S.I.R. grant.

Nitella hookeri reproduces vegetatively in the New Zealand lakes. Small fragments (yellow - pale green in colour) break off from the parent plant and sink to the bottom. On coming in contact with the mud or silt, the plant produces rhizoids. Rhizoids arise from nodal cells and each nodal cell is potentially capable of producing rhizoids on contact with a substrate. Plants will survive in a floating condition but require to be attached to a substrate before any appreciable growth can occur. Difficulties arose in obtaining pure cultures. Nitella supports a large epiphytic flora of blue-green and green algae. However, by placing the alga in an aquarium with a certain species of snail (Physa fontinalis) it was found that the snails attacked and eventually removed all the epiphytes (except the bacteria). Bacterial contamination has been removed by sub-culturing.

CULTURING TECHNIQUES

Vegetative fragments are mounted in autoclaved agar. Agar plus plants are covered by culture media. The plants are grown in conditions of controlled temperature, daylength, and light intensity. By these techniques plants grow up to five times their original size within a 35-day experimental period. Plants produce transparent rhizoids which penetrate through the agar - Culture media are changed every second day to avoid depletion due to uptake of ions by the plant. At the end of the experimental period plants are removed from the agar and "floated" onto glass slides. Agar is washed from the rhizoids and measurements made of: The total linear increment of growth for each plant; Increase in the number of nodes; Increase in the numbers of internodes; Increases in fresh weight, dry weight; Number and mean length of rhizoids produced.

Experiments are being carried out to ascertain what effects various concentrations of phosphate and iron have on plant growth. Other experiments involving the effects of light intensity, light quality, temperature and daylength are also being carried out.

Preliminary Results

Initial results have shown that the most favourable phosphate concentration is 10^{-4} M. The plant grows best under low light conditions (50 foot candles) and at temperatures of 20°C . There is an increase in growth when increasing iron concentrations from 0 - 15 ppm. The ratio of calcium to phosphate appears to be significant but magnesium concentrations can be varied with little effect. There is strong interaction between iron and phosphate when together in the media resulting in a slower growth rate of the plants. It is possible that Nitella takes up iron in the reduced state from the muds and silts (uptake being through the rhizoids). Therefore efforts will be made to maintain iron in the reduced state in the agar surrounding the rhizoids. Little growth occurred when non-rhizoidal plants were grown in a medium containing iron.

Report on Ceratophyllum demersum (Julie L. Carr)

(This is the final of a series of reports to the Hydro-electric Commission Miss Carr's M.Sc. thesis in 1967 was based on this work).

The production of Ceratophyllum, with respect to various factors, was investigated using an artificial laboratory stream, a Warburg constant volume respirometer and a C-14 method expressly designed for the study.

Season: Plants were collected at intervals throughout the year and experimented on in the laboratory using the Warburg apparatus. Production (photosynthesis) of Ceratophyllum was shown to rise to a maximum during the late winter and spring. In this period the day length is increasing, the temperature of the lake water is relatively low at 13°C , and the nutrient content of the lake water is high. In the summer with the onset of warmer temperatures, still longer day lengths, higher light intensities, and fall off in nutrients, the production of Ceratophyllum declines and becomes minimal about midsummer.

Day Length: Production measured by increases in wet weight and stem length is maximal under a 12 hour day length, i.e. a day length characteristic of spring and autumn. The next best day length is one of 16 hours i.e. summer.

Light Intensity: Ceratophyllum has been found to be a shade plant i.e. one which cannot tolerate the high light intensities found on the surface of the lake. In short term experiments in the Warburg apparatus the plant's pigment system is saturated with light of 4,000 f.c. (40% full sunlight), but in long term experiments the best light intensity for production has been shown to lie between 550 f.c. and 1,500 f.c. (5.5 - 15% full sunlight). In Lake Ohakuri the depth at which 5.5 - 15.0% of full sunlight remains lies between 2 - 4 metres.

Light Quality: The experiments measuring this criterion were performed using the artificial laboratory stream and sheets of coloured cellophane.

Sunlight contains a high proportion of red light. Red light is absorbed completely in the surface layers of the water but blue light penetrates to greater depths. The internode length (the distance between the whorls of leaves) is controlled by the amount of blue light present in the environment, small amounts of blue light causing long internode lengths and visa versa. Production,

measured by wet weight increase, is adversely affected by full sunlight but is favoured by the red light climate found under the surface of the water. Therefore the quality of the light present on the surface of the lake adversely affects production.

Temperature: The temperature for maximum production, as shown by short term experiments in the Warburg apparatus is 20°C . The range of temperature within which photosynthesis of leaves occurs is $10 - 30^{\circ}\text{C}$. Results of seasonal experiments show that maximum production (photosynthesis) in nature occurs when the lake water temperature is 13°C . Although short term experiments cannot allow us to elucidate the effect of prolonged temperatures, it seems unlikely that 13°C would be the maximum temperature for vegetative growth. Also it appears that high summer water temperatures cause a fall off in production with respect to season. Prolonged high temperatures of 28°C found in weed beds in midsummer undoubtedly damage the plants causing vegetative portions to rot away. Flowering and fruit maturation occur at temperatures above 20°C and 24°C respectively. Although temperatures in Lake Ohakuri reach this level only flowers have been found in New Zealand. There is no reason why the fruits should not mature here, and it is suggested that careful observations in the field will reveal the presence of mature fruits in New Zealand.

Depth: Plants were collected at various depths in Lake Ohakuri and experimented on in the laboratory using the Warburg apparatus. Maximum production (photosynthesis) of Ceratophyllum was found to lie between 2.5 and 5.0 metres depth.

An examination of the pigment system and analysis together with the photosynthetic experiments with respect to depth showed that Ceratophyllum is a shade plant. By definition, shade plants are adversely affected by full

sunlight. In Ceratophyllum it is suggested that the greatest amount of photosynthetically active pigment in the plant is found in all parts of plants between 2.5 and 5.0 metres depth, which is the region of maximum production. This region is also shown to be the depth at which the light intensity is favourable for photosynthesis and where the chlorophyll a to chlorophyll b ratio becomes stable with a high proportion of chlorophyll b in the system. Temperatures also tend to be the most favourable at approximately 5.0 metres depth in the weed beds.

Current (Water Flow): Current was measured using both the Warburg apparatus (photosynthesis) and the artificial stream (growth measured by wet weight and length increases).

Current is important where nutrient availability is concerned. Completely still water is not favourable for production but neither is a noticeably flowing current. The maximum production due to current is probably somewhere within the range 0.05 cm/sec to 1.58 cm/sec water flow. Ceratophyllum is therefore a plant of slow moving backwaters, and bays of rivers, ponds and pools.

pH: Ceratophyllum grows best at low pH values, i.e. pH 5.00, where there is a high proportion of free carbon dioxide in the environment. Lake and river waters are generally around neutrality. Stagnant conditions, found in the shallow parts of lakes and in ponds and impoundments are usually associated with high pH value. At pH 7, the production of Ceratophyllum is still quite rapid, but above pH 8 there is a very rapid fall off in production.

Parts of the Plant: The first mature leaves from the region approximately 6 cm behind a bud show the greatest production (photosynthesis). The production becomes progressively lower in buds, leaves (from one foot behind the apex)

and stems respectively.

By definition a turion is an organ adapted for overwintering, which develops in the late autumn in response to low temperatures. The bud, whether separated or not separated from the parent plant is not resistant to the cold. As a result of my studying Ceratophyllum I have come to the conclusion that the plant does not produce true turions but that the buds of Ceratophyllum are resistant to heat and high light intensities. If the plant is considered to produce true turions at all it would appear that in New Zealand water temperatures are not low enough to promote the development of true turions. In the height of summer, when much of the submerged vegetation starts to rot away, the buds survive longer than the parent plant. The fruits of Ceratophyllum however have been shown by other workers to be more resistant to low temperatures of winter than the buds.

Seasonal Cycle: In late winter the nutrient supply is high and at low temperatures and short day lengths the productivity of the sparse population of Ceratophyllum depends mostly upon the temperature and light conditions. In spring the nutrient supply starts being depleted, the day becoming longer and the light intensity progressively higher. The plants of Ceratophyllum grow towards the surface of the water and the bulk and weight of the plant increases. In spring, with maximum production, the weed beds will eventually be crowded with vigorous fronds of Ceratophyllum. The old stems from last season rot away and the plants float on and below the surface in close mats of intertwining stems. In summer the light climate at the water surface is high in light from the red end of the spectrum, the light intensity reaches maximum values on many days, the water temperature in the weed beds is high, the nutrient content in t

weed beds is low and is not being replaced, the water is stagnant and therefore lacking in free carbon dioxide and the pH is alkaline. All parts of plants at the surface are adversely affected by these conditions. One result is inactivation of the chlorophyll from prolonged exposure to pigment saturation condition of high intensity sunlight. In the mat of weed generally there is metabolic heat inhibition from the high water temperatures, lack of nutrients, and also a carbon dioxide starvation because the major portion of the carbon dioxide is present as the bicarbonate ion. Under summer conditions therefore, the vegetative portions of the plant in the surface weed mats die, and the species survive only by virtue of the heat and light resistance of the buds in temperate region and the setting of seed and maturation of fruit under tropical conditions. The remaining stems of Ceratophyllum below the surface mats, although subjected to lower temperatures (20.0°C in March at 10 feet) and moving water (but the nutrient content is less than that present in spring), are shaded from the light to a much greater degree than they would be if there was no mat of weed above, and could probably survive if they are not buried under the mass of rotting vegetation from the mats or swept away by a faster flowing current caused by autumn and winter rainfall.

Weed Control: Since control of this weed is important from the point of view of dam operation, the results of this study suggest that if chemical control is to be used, provided the chemical reaches to the weed bed depth, it should be applied in late winter in order to combat the upsurge in productivity. If chemicals such as diquat are to be used, as they would reach only to the surface layers of the water in Hydro lakes such as Lake Ohakuri where there is a stream flowing over a still lake, it is suggested that its application should be carried

out at the end of the summer before the weed beds are totally disintegrated so that it may kill any buds or fruit that may have formed as a result of the adverse summer conditions. Mechanical harvesters would be best employed in early summer when the old stems of Ceratophyllum have started to rot and the plant has formed mats, but before the buds become separated from the parent plant or before the fruit has had time to mature.

Fisheries Research Division, Marine Department, Wellington

The Director, Mr G.D. Waugh, spent three weeks in Japan this winter, during which time he visited a number of Government and University fishery institutions. Most of his interviews were with sea-fishery scientists, but he visited two laboratories which dealt with freshwater studies. At Bentinjima, on L. Hamana, he was able to see an example of large-scale eel farming. Some 30,000 tons of 2 year old eels are taken from L. Hamana farms annually and a considerable amount of research is carried out on the fish. He also visited the Nikko Laboratory on L. Chuzenji, at which three major studies are being carried out: (a) biology and migrations of the salmon Onchorrhynchus nerka in the lake; (b) I.B.P. programme on lake productivity; (c) hybridisation experiments with 11 Salmonid species. The Nikko Laboratory has produced a vaccine against the fungal disease Furunculosis. The vaccine is said to reduce infection from an original 90% down to 45% incidence.

Mr C.L. Hopkins has continued his work on a trout nursery stream in the Wairarapa. Data are now being collected from the headwaters above the region normally inhabited by trout. It is hoped that a general picture of the fauna of the whole stream can eventually be presented.

Dr R.M. McDowall has returned to the Wellington Laboratory after obtaining his Ph.D. at Harvard University. His previous work at the laboratory dealt with the whitebait Galaxias maculatus. His new programme is being planned with the Director.

Lake Studies by N.Z.O.I.

The N.Z. Oceanographic Institute in collaboration with Marine Department, Fisheries Research Division, is carrying out bathymetric and thermometric surveys of selected lakes. Initially these have been made in the Rotorua region to provide background for the chemical and biological studies of Lakes Rotorua and Rotoiti and of some of the smaller lakes, Okataina, Rotoehu, Blue Lake, Green Lake, Rotomahana, Tarawera, Rotoma, Rerewhakaitu, Rotokawau, Okareka, Ngapouri, Okaro and Ngahewa. Bathymetric maps are being published (Okataina, Rotoma and Blue Lakes have been printed, Rotorua is at colour proof stage and prints of the remainder are available). A comparison of the thermal characteristics of this group of lakes has been made by J. Irwin and is in press.

Two of the North Island hydro lakes Ohakuri and Atiamuri have also been examined.

In the South Island, Lake Manapouri and the small Canterbury lakes Grasmere and Pearson have been examined in collaboration with Zoology Department, Canterbury University and further lakes will be examined as individual interests arise. The work on Lake Manapouri extends measurements of depth, temperature, oxygen and tritium made two years earlier in West Arm. The results of this and the present survey are being prepared for publication. Bathymetric charts are in press for these lakes.

A checklist of New Zealand lakes is nearing completion.

Zoology Department, Victoria University

Mr S. Moore is preparing to publish descriptions of seven species of Deleatidium (Ephemeroptera, Leptophlebiidae) in the Victoria University Zoology Department Journal. Two of the species are new, and all the descriptions include adult and nymphal stages. Some nymphal ecology is discussed in relation to water velocity preferences. Overseas Deleatidium species are discussed in relation to the N.Z. ones.

NOTES AND NEWS

A committee has been convened to examine the organisation of Government wildlife and fisheries research (omitting noxious animals research). The members are Mr J.K. Hunn, Dr R.K. Dell, Mr R.F. Stead, and a secretary. It is apparently recognised that the present system in which several Departments overlap in their research programme is unsatisfactory. The committee is expected to make recommendations for alteration to the present system, possibly by amalgamating certain groups under one Department, or in some other way reorganising their fields of endeavour.

Dr M.J. Winterbourne, formerly of Massey University, has left for Canada on a Post-Doctoral Fellowship.

Dr D. Spiller of the D.S.I.R. has been appointed as Secretary to the National Research Council.

Requests for Material

Dr P.A. Tyler (Department of Botany, University of Tasmania, Box 252 at Hobart G.P.O., Tasmania, 8001) would be grateful if anyone who has recorded Micrasterias hardyi or the related forms, M. mahabuleshwarensis and M. americana would contact him.

Miss M.H. Barclay (Zoology Department, University of Auckland) is interested in specimens of freshwater harpacticoid copepods and Dr Chapman is interested in cyclopoid copepods.

Mr G.A. McFarlane, Canterbury Museum, is working on a revision of the caddisfly genus Hydropsyche and would particularly like specimens of larvae from north of Helensville as one species from this region is imperfectly known. He is also anxious to obtain specimens of related groups from Fiji and New Caledonia and would be glad to hear of any contacts in either of these two places.

BOOK REVIEWThe Trout

By W.E. Frost and M.E. Brown (The New Naturalist)

London: Collins, 1967. pp. 286 + 46 plates. \$3.20

Although the stated aim of the New Naturalist series is to interest the general reader in the wildlife of Britain, the present volume contains much that is relevant to the local scene and will prove useful and interesting to the general reader here. For the serious student of fish the lack of specific references on particular points may prove disconcerting and it is hard to believe that inclusion of these would have detracted from the book. The book is about brown trout only and should have been given this title.

The first chapter deals briefly but competently with the anatomy and physiology although it is not clear what is meant by the statement on p.23 that there are valves inside the mouth. The relationship between conversion efficiency and level of food supply (p.30) is interesting and reference to the evidence would have been helpful.

In chapter 2 the taxonomy is considered, and the quotation by Gunther at the head of this chapter should be given due weight. On p.48 it is stated that the rainbow trout is indigenous to tributaries of the Sacramento River, but in fact the rainbow trout has a natural distribution from Mexico to Alaska. In addition, spots on the caudal fin are sometimes found in brown trout and this feature cannot be relied on by itself to separate brown and rainbow trout.

The map on p.49 indicates incorrectly that there are no established populations of brown trout in the North Island of New Zealand.

The definition of a species on p.50 would not be accepted by modern students of animal evolution, but the authors use this definition to support their views on the polytypic status of Salmo trutta.

The relationships between sea trout and brown trout are discussed, but the authors have not reached any consistent conclusion. On p.51 it is stated: "There are therefore no real grounds for considering sea trout as anything more than brown trout in which the migratory habit is very well developed". Yet on p.116, the work of Huets is quoted indicating a genetic difference affecting the temperature dependence of embryonic development.

The nature of the relationship between brown trout and sea trout is not understood and the authors should have stated this, rather than imply that the

problem is not important.

In discussing Lochleven trout on p.54, the authors quote Day (1887) who reports a fisherman's statement that these fish do not eat molluscs or crustacea; they consider that this would explain the absence of red spots. In fact Lochleven trout take planktonic crustacea in large numbers as the reviewer has noted for himself, and it is surprising that the authors were unable to obtain more recent sources of information than Day.

In chapter 3, distribution and introductions are discussed and it is interesting to note the way in which this species has followed the British flag to the cooler parts of the world. A number of details concerning the introductions to New Zealand are incorrect: they state that the parents of the Tasmanian introduction came from the R. Itchen and Hungerford (presumably the Kennet). In fact, as the reviewer has noted (1954), the parents of the Tasmanian stock came from the R. Itchen, Hampshire, the R. Wey, and the R. Wycombe, Buckinghamshire. Also on p.57, the 15,000 eggs on the Lincolnshire in 1865 were from sea trout not brown trout. On p.58 it is stated that the first successful hatch of trout eggs in New Zealand was in Otago, 1868, but the credit must go to Canterbury in 1867.

Chapter 4 gives a competent description of the life history, and although the details refer to Britain, the New Zealand reader can easily readjust the months. The description of spawning is detailed and the high mortality in the first year of life is rightly emphasised.

A useful chapter on age and growth follows with condition factors, scale reading and growth rates well discussed. New Zealand readers are warned that determination of age of river trout by means of scales is unreliable and should

be used in conjunction with other methods. It follows that attempts to estimate growth rates using scales alone are ill-advised (Allen, 1951).

In the next chapter an account is given of Alm's work which indicates genotypic differences in colouration and breeding behaviour between river and lake trout from Sweden. The work of Donaldson and Davis also indicates the existence of genotypic variation within a given stock for various characters, an entirely expected result. Despite this evidence the authors state (p.115) that "Most of the colour varieties appear to be the result of environmental influences such as the food supply and the colour of the background". No evidence is quoted to support this statement and it is difficult to equate with Alm's work. Despite this lack of evidence the authors are prepared to assert further down the same page that "... most of the striking differences observed between wild populations are probably the result of environmental differences". While trout do show a wide range of phenotypic response for certain characters, this should not lead to the view that genotypic components of variance are unimportant.

On p.116 the report of Skrochowska's work is misleading and further work in Poland has not shown a loss of migratory behaviour in sea trout (Zarnecki, 1967).

Chapter 6 is interesting but there appear to be marked differences between New Zealand and Britain. Rivers of low velocity characterised by cyprinids in Britain are said to possess few trout, but this type of river in New Zealand does not show a very marked reduction in trout numbers, and the absence of cyprinids here may be a factor. A good discussion of temperature follows but the author of the table on lethal temperatures is not in the list of references

The relationship between water hardness and growth shown for Britain does not appear to apply in New Zealand on the information available.

A useful chapter on feeding follows and much of it is applicable to the trout in New Zealand. Table 31 (p.196) should read "decreasing hardness".

The last two chapters appealed to this reviewer as the best part of the book. The importance of territory is rightly stressed as a regulating mechanism. Parasites are given some emphasis and it should be noted that contrary to the statement on p.221, the trout here are not free from internal parasites (Stokell, 1936). The comments on the relations between stocking policies and the angler's bag are sound, but in view of the painfully overcrowded rivers in some parts of the world, the authors might have mentioned the only final solution where too many anglers chase too few fish. This is to recognise frankly that fishing is for pleasure and that the best policy is to return all fish alive to the river. Management can then concentrate on manipulation of the population structure, without the endless expense of liberations.

The book is relatively free from typographical errors, the plates are of good quality, and the price represents good value for money. While it is in no sense the last word on Salmo trutta, and although New Zealand readers cannot apply all the statements to the local scene, the book does provide a good introduction to this fascinating fish.

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