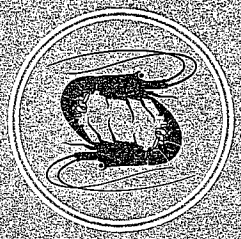
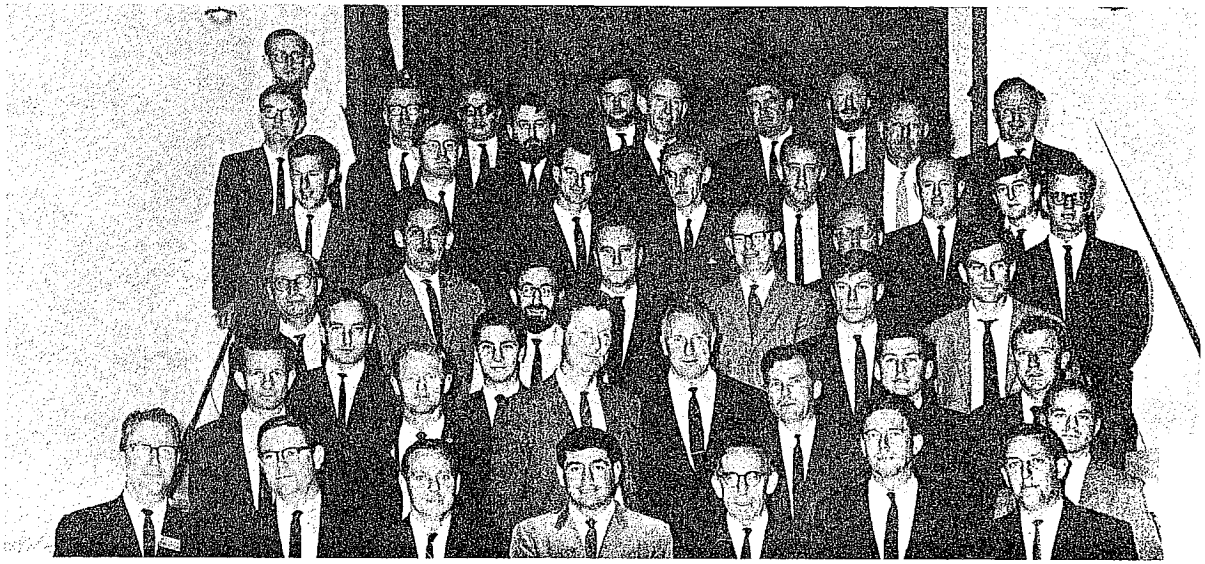
The Australian / New Zealand Meeting on Decapod Crustacea

Sydney, October 24 - 28, 1967

C. A. MOBBS



DIVISION OF FISHERIES AND OCEANOGRAPHY CIRCULAR NO. 5
COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANIZATION, AUSTRALIA 1969



KEY TO PHOTOGRAPH

1. Dr A.A. Racek
2. Dr J.C. Yaldwyn
3. Dr D.D. Francois
4. Dr C.B. Kensler
5. Dr G.L. Kesteven
6. Dr F. Talbot
7. B.F. Phillips
8. R.R. Pyne
9. R.J. Slack-Smith
10. M.G. Johnston
11. Dr E.F. Riek
12. A.M. Olsen
13. Dr R.J. MacIntyre
14. I. Smith
15. N. Ruello
16. Dr R.G. Chittleborough
17. Dr D.J.G. Griffin
18. Dr W.B. Malcolm
19. Prof. W. Stephenson
20. N.M. Haysom
21. Dr R.K. Dell
22. Dr R.B. Pike
23. R.D. Simpson
24. Dr D.R. Fielder
25. T. Meagher
26. J.H. Bradbury
27. A. Jones
28. R.G. Wear
29. J.H. Greenwood
30. D.H.S. Horn
31. Dr R.W. George
32. B. Campbell
33. A.E. Caton
34. C.A. Mobbs
35. I. Kirkegaard
36. D.C. Wolfe
37. W.L. Chan
38. Dr A.J. Bruce
39. R.H. Walker
40. D.D. Lynch
41. J.C.F. Wharton
42. D.J. Tuma
43. I.S.R. Munro
44. Dr J.M. Thomson

(Not present: Miss E.C. Pope)

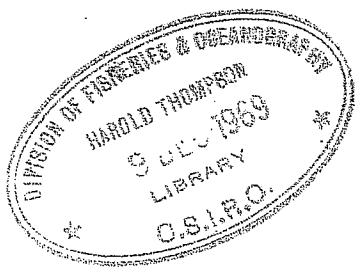
THE AUSTRALIAN/NEW ZEALAND MEETING ON DECAPOD CRUSTACEA

SYDNEY, OCTOBER 24-28, 1967

C.A. Mobbs

Division of Fisheries and Oceanography

Circular No. 5



Commonwealth Scientific and Industrial

Research Organization, Australia

Melbourne 1969

INTRODUCTION

The idea of holding this meeting first arose in the course of correspondence between Dr G.L. Kesteven, of the Division of Fisheries and Oceanography, CSIRO, and Dr R.B. Pike of the Marine Department, New Zealand, with the suggestion that an attempt should be made to arrange a meeting between Australians and New Zealanders engaged in research on crayfish. It was recognised that research on crayfish and prawns was assuming special importance because of the economic significance of these resources and that whilst work in progress had made important advances, it had uncovered a number of major problems whose investigation would call for both increased and more diversified research. For this reason, Dr Kesteven believed that steps ought to be taken to establish communication between the various research teams, to effect exchange of views and results between them so that in some measure the programmes might supplement one another.

On April 29, 1964 Dr Kesteven circulated to various research workers engaged on research on prawns, crayfish and crabs, a draft prospectus for a meeting together with a questionnaire seeking, in an informal approach their views on (1) whether the time was ripe to arrange such a meeting, (2) the scope the meeting should have, and (3) the place and time at which it should take place. The response to this questionnaire was overwhelmingly in favour of the meeting, with the belief that it would serve the purposes intended.

As convener of the meeting, Dr Kesteven believed that it would be useful if the meeting could be arranged by CSIRO in co-operation with those learned societies interested in the subject matter proposed for the meeting. The Australian Marine Sciences Association, the Australian Society of Limnology and the Ecological Society of Australia were invited to join in sponsorship of the meeting and to nominate someone to act on a steering committee, which would consist of the convener and a representative of each of the four sponsoring bodies. This Steering Committee first met on June 9, 1965.

Originally scheduled for February 11-14, 1966 the Decapod Crustacea Meeting was postponed by the Steering Committee until October, 1967. The Committee was influenced in this action by several considerations amongst which the most prominent was the representations by some prospective participants with respect to

timing. As well as giving a better prospect of securing overseas participation, the Committee recognised that deferment of the meeting would enable more detailed work to go into the preparation of background documents whose availability would greatly assist the meeting.

A revised prospectus was given general circulation on January 20, 1967 with the meeting scheduled for October 24-28, 1967 in the Hallstrom Lecture Theatre of the Australian Museum, Sydney. The agenda was arranged under the following sections with an organizer responsible for each:

Zoogeography

Life History

Ecology

Physiology

Behaviour

Exploitation

Conclusions and Future Prospects

In addition to contributed papers and research situation reports, the following background documents were distributed to prospective participants: (a) species synopses prepared by various research workers, (b) a dictionary to cover a range of terms which might be employed during the meeting, (c) for each section of the agenda, a review statement on the distribution of research activities in Australia and New Zealand and the status of present knowledge of decapod crustacea.

Attendance was open to all members of the sponsoring bodies and to other persons engaged in or having an interest in research on crustacea or in the application of the results of such research. The Steering Committee sought to achieve as wide a participation as possible of those concerned in this research. Where possible documents were distributed before the meeting to ensure that time would not be spent on the reading of papers but that the energies of the meeting might be directed more profitably towards discussing the major problems of research and to seeking some measure of co-ordination and supplementation amongst the various research programmes.

The meeting was officially opened on October 24, 1967 by Dr F. Talbot, of the Australian Museum, Sydney, and was attended by 44 marine scientists and research workers actively engaged in

or interested in research on prawns, crayfish and crabs. Participants included research workers from many Australian and New Zealand museums and universities, and from CSIRO, as well as from the New Zealand, New Guinea and all Australian fishery departments.

This meeting was unique in that this was the first occasion in which Australian and New Zealand research workers on prawns, crayfish and crabs had come together to discuss their specialised research. The programme was informal so that much attention could be given to the problems and practical difficulties of this research. Quite apart from the scientific exchanges which took place, the meeting provided opportunity to arrange increased co-operation between research workers throughout Australia and New Zealand. The participants' estimate of the meeting was that it was so useful that arrangements ought to be made to hold another meeting in three years' time and that a summary report of the first meeting should be issued to all interested persons. This paper is intended to serve as such a report.

CONVENER'S SUMMARY

On the morning of October 28, 1967 the Convener, Dr G.L. Kesteven presented to the meeting, in general session under the chairmanship of Dr R.B. Pike, the following summary:

By way of record, may I remind you that this meeting had its origin in letters from Richard Pike enquiring about Australian work on decapod crustacea in general but chiefly on crayfish, and that as early as April 1964 I circularized a number of people seeking their views on the desirability of holding this meeting; incidentally, something like 80% of the people to whom I sent that letter are here today, or have been here at this meeting, so that even then we had a fair idea of who was interested in this field. I think we can later return to a similar question - the desirability of holding another meeting.

In the circular letter I wrote, at that time somewhat bravely, it now seems to me: "in recent years there has been a considerable increase in research in Australia on prawns and crayfish, and we understand that New Zealand research has also expanded. This research is assuming special importance because of the economic significance of the crayfish industry and the potential economic significance of prawns. The work in progress at present has made important advances, but at the same time it has uncovered a number of major problems whose investigation will call for both increased and more diversified research. We can already see that the range of work required for some of these problems will be very considerable, and it becomes obvious that with the extension of research teams and initiation of projects in different parts of Australia, steps ought to be taken to establish communication between these teams to effect exchanges of views and results between them, so that in some measure the programmes would supplement one another."

This meeting has shown that there was much truth in those propositions, for we have already gained by the exchanges it has made possible, and I think that my task this morning, in summing up some of the points made in the papers and views expressed in the discussions, must be to lead to an examination of a proposition concerning what else we might do to promote these exchanges. We shall want to consider, I believe what we might do to secure such relations between the several programmes in progress as might be of benefit to each of the programmes separately and to

all of them as some integral whole for this part of the world.

When you gave me a brief to sum-up a meeting such as this you of course accepted the risk of being exposed to the private predilections of the person making the summing-up; I assume, since there have been no protests - as there could have been over the past four days - that you are quite prepared to let me have a major say at this stage. However, the plan for today's sessions also allows you opportunity to comment on my comments and to issue such reprimands you might think appropriate.*

One of the striking features of this meeting has been the way in which it has shown how difficult it is to deal with any one of the aspects we have chosen as major headings for discussion separately from the others. Already on the first day we discussed ecology, behaviour, physiology and exploitation in some respects, and on each day thereafter we went backwards and forwards over the several fields we had selected. One of the patterns proposed for the meeting would have had us deal with larval life, juvenile life and adult life separately, instead of dealing with ecology across these phases and then physiology and so on. Another suggestion was that we might have used the middle three days of our meeting to deal on each half day with some principal species in all its aspects. But so far as I can see, we should have met the same problem whichever pattern we had chosen: we should have been cutting backwards and forwards across any divisions we might have decided upon. Our experience has emphasized, I believe, perhaps to some extent involuntarily, the need to recognize this totality and integrality of biology. I do not believe that any other pattern could have served us much better than the one we chose.

Another major aspect to me is that we have in these five days gone from what was virtually 17th century naturalistic biology to the dawn, in our last session yesterday, of 21st century biotechnology in our field. We have traversed the history of biology in our discussions.

*At the final session of the meeting the convener was asked to indicate that he was aware that in the easy informality of the meeting (which so greatly contributed to its success) the participants often used their technical terms with somewhat less care than they would exercise in preparing a paper for publication. This he does, pointing out that his semantic animadversions were in principle, not a persona.

A third feature of our field which has been apparent in our discussions, is the incompleteness of our information concerning most of the species with which we are working; this is an especially serious feature, considering the urgency of some of the problems of the species that have commercial importance.

Zoogeography

Our first subject was zoogeography and in that subject we had a group of papers:

Griffin and Yaldwyn on Australian decapods;

Dell on the New Zealand brachyurans;

Yaldwyn on New Zealand macrurans and anomurans; and

Ray George on Panulirus;

Kensler on New Zealand crayfish; and

Riek on Australian freshwater crayfish;

and Racek gave us an impromptu resume of work on penaeids, drawing on the species synopses; then as integrating views we had papers on zoogeographic provinces by Elizabeth Pope and Ray George, and finally Bill Stephenson gave an account of numerical taxonomy.

Now, at first sight those first six papers, which in my ignorance, I suppose to be somewhat pure zoogeography, gave us a set of lists of names of species and genera and families; they gave us maps and diagrams; in fact, a collection of facts concerning the decapod fauna of this region. By "facts" however, I mean nothing more than verbal formulation of what we think we have seen. That is, when I here use the word "fact" I am not implying that everything written in those papers, or everything said in the discussions, that might be labelled "fact", actually and correctly corresponded to the things being talked about; instead I believe that we have yet to test the correspondence of "fact" and phenomenon, and to examine the adequacy of this set of facts, for our purposes. We have to examine how truly each fact conforms to the thing to which it refers. Moreover, we have to try to assess the proportion that our set of facts is of a total set of facts concerning each of these complexes, the total being that which our theory suggests we need for our purposes. In making that examination we have to decide what should constitute, for our purposes, a totality of facts concerning any complex or set of complexes, or any aspect of them.

It is obvious that in looking at the distribution of animals, that is, in studying zoogeography, we are not to be content with a set of facts concerning something static. If there is one fact of which we are quite sure and convinced it is that no living organism is fixed in one place, completely immobile, for all its life. We know that life is characterised by movement and change; and we cannot think that zoogeography can usefully give us something which would correspond to a gigantic still photograph of all organisms immobilised for our purposes at one instant in their several appropriate places; this would not for us mean much about these things as living organisms. We must want, I am sure, to include ontogenetic facts; we want moreover to look into the "why" of patterns that we might see. How were these patterns that we see formed, and what might be the further changes that might take place in the future? And insofar as it is true, as Andrewartha and Birch declare, that distribution and abundance are the two sides of one coin which is the whole of ecology, I believe that our entire symposium has been concerned with this totality of fact of each species as a living, moving entity and each of our main and most animated debates has really been an illumination of some aspect of this complex; the entity, the integrality of individual species.

I suppose that zoogeography as an account of dynamic complexes implies a knowledge of events and processes, but I think we all of us recognized on the first day that the language in which the zoogeographers are presenting their information to us is full of assumptions and preconceptions and of anthropomorphic projections. On a couple of the papers I noted some statements expressed in this kind of language, which I suppose must be a defect; statements such as that "species are lacking" as though we knew what species ought to be there; that "the niches are not filled", which is the same sort of thing; that "fauna is unbalanced"; that "there is a preferred habitat"; that "species X may have been derived from something". These relate to the point which Bill made at one stage when he took his gallup poll of the "ifs" and "woulds" and "shoulds" and "maybes". And then several times in one paper things such as "depth displacement of species X is most obvious" which implies that species X can be displaced by some other species and that we know the process by which it happens. In this sort of language contemporary ecotic* significances are imputed to these situations as though we know these significances, and ecotic and phylogenetic processes of the past

*As with 'biotic', this word is used as an adjective referring to what is studied rather than the study itself.

are presumed; I suggest that this kind of language emphasizes for us some of the incompleteness of our knowledge of these species.

In seeking to establish a picture of this fauna in dynamic sense, we recognized in one of our discussions that a species, or rather the distribution of a species, may be reported as to its range

over a long span of years, or

over a few years, or

during one year, or

during each of a number of seasons, or

in some period of days, or

during one day, or

at a particular moment.

Thus we have seven different classes of range. In addition we recognized that we may specify the particular sites at which individuals may be found, the habitats they occupy, the environment offered by each habitat, and the organism's niche within that habitat. Tim Meagher was at pains to draw to our attention that even if we had an account with respect to these seven different ranges and to this matter of where it lives as habitat, and what its ecotic significance is as to its niche, such an account would be incomplete if we made it only with respect to the adult. In fact most of our accounts are only with respect to the adult. Tim's contention has been that our account should be made separately of each - I use here a word I invented on Thursday night - aionomorph (meaning the form in each life phase) and we found in several of our discussions, but especially in the discussion of crayfish, that we were not really able to think usefully about the distribution of the adult unless we had some discussion of the processes by which the aionomorphs were moved about, by which they survived and subsequently settled in the places where we saw the adults. There are not many species about which we know all these things, and there are still fewer of which we know something of environmental elements and the processes whose result is the distribution that we observe.

Now, at this stage may I remind you, with relevance to the zoogeographic story in general and to later parts of our agenda, of Plato's famous cave simile "according to which those who are destitute of philosophy may be compared to prisoners in a cave able to look only in one direction because they are bound and who

have a fire behind them and a wall in front. Between them and the wall there is nothing. All that they can see are shadows of themselves and of objects behind them cast on the wall by the light of the fire. Inevitably they regard these shadows as real and have no notion of the objects of which they are due. At last some man succeeds in escaping from the cave to the light of the sun, and for the first time he sees real things and becomes aware that he had hitherto been deceived by shadows."

So far as zoogeography assembles facts with which to account for the dynamic of these complexes, we are deceived not only by shadows, but by conjured-up shadows as people make shadows with their hands at a candle. By this latter - this conjuring-up of shadows - I refer to the discussions we had (both under zoogeography and with respect to long term trends, with Mick Olsen's evidence concerning the Tasmanian fauna) of the distortions that result from our sampling. Our programmes are generally patchy and incomplete, and sometimes become over-intensive because of false factors, such as (I think again it was Bill Stephenson who drew attention to this, although Richard Pike, too, spoke of it) some popular, uncalibrated interest. Again, the evidence from our sampling programme is often distorted for us by our incomplete, inadequate or highly selective sampling equipment. As to accurate shadows of what is going on, I think the point is this: that we are very often looking at a cinematographic record of events, shadows indeed, and not looking at the immediate process which is causing to happen these things that we are observing. We referred to this particular distinction when we dealt in quite a lot of detail with the transport mechanisms by which phyllosoma and puerulus larvae of crayfish are distributed. We found that we had been making some pretty large assumptions as to the role of current systems observed on the east and west coasts of Australia. Don Francois in particular questioned the assumption that because we observed some crayfish larvae in east coast currents, and having information about the speed and direction of these currents, we then assumed first that all the larvae became passengers on these currents, and second that the patterns of distribution of the larvae were largely, if not wholly, in correspondence with the patterns of distribution and movements of the currents, whereas we do not yet have direct observations to permit either of these conclusions. The same kind of assumption is implicit in the arrows drawn by Elizabeth Pope in the northern part of Australia in her diagrams of the Australian shallow water marine provinces.

I believe our general consensus in these discussions was that whilst the zoogeographic maps and lists were useful summaries, and in some sense synoptic representation of these complexes, or at least of what we knew about them, we still needed to make much closer study of the processes that lie behind the patterns themselves. I think too that this was where we were trending when we were discussing Bill's three-dimensional model of his morphological examination of the species. We could see that it might be possible to expand further the array of information concerning each species and to modify the axes of the model in such a way that the lines and surfaces and volumes of the model would constitute a matrix from which we could understand what we see of the species that exist now, making some sort of postdiction of what their ancestors might have been, some prediction of what they might become or what we might be able to make them to become.

In sum, I think our zoogeographic review showed us that while we know we have got here a lot of species of decapod crustacea (to emphasize this I put together two of the tables from these papers of the Australian and New Zealand decapod crustacea) we still need to learn a lot more about them. Whether or not the evidence led to this, the review reminded me of questions I have often asked myself, and others, about zoogeography itself. These can be the first three of many questions I propose to put to you, perhaps to do some thinking about.

My first question is: are there any principles or laws in biology which have their origin strictly and exclusively in zoogeography? In fact, does zoogeography have anything to say in predictive sense?

Secondly, as though I had not asked the first question and presuming that zoogeography has some predictive power, can we make anything as to description of phylogenetic processes, strategy of current research, predictions as to patterns of distribution, of the differences between the Australian and New Zealand decapod fauna as summarized in Des Griffin's tables?

Thirdly, can we suppose that a dynamic zoogeography could be developed that would consider each species in terms of many ranges, not one, and in terms of its several aionomorphs and not just of the adults; and if we can suppose that such a zoogeography could grow,

what could we do to promote the emergence of such a zoogeography?

Life History

Then we moved on to life history and we were confronted almost at once with the same problem, of whether we were dealing with shadows. We went directly into some of these ontogenetic and short-term processes with respect to larval and juvenile stages, and we had contributions from Graham Chittleborough, from Mick Olsen, Wear, Kirkegaard, Slack-Smith, Fielder, Lynch, Riek and Lucas. It was in the course of these discussions, if my notes are right, that we encountered the problem of what we meant by "competition" and "displacement", with which now I want to associate the terms "endemism" and "sympatry", as being also terms that imply a knowledge far beyond the knowledge that we have when we use these terms.

At the risk of causing some irritation I want to interpolate here a brief note on this matter of semantics. I know that people often say that discussions frequently lose their way in a play with words. Yet, at the moment, as far as I know from my reading, the principal contemporary schools of philosophy are concerned with problems of semantics. I think that what has happened is that philosophers have recognized that we have now reached a stage where nothing lies beyond the reach of our observation and measurement, but that while making our technological advances we have neglected the task of creating the words to report our thoughts about these things. There is no doubt in my mind that technology has overrun our political skills; I believe it has also overrun our linguistic skills. I find this a fairly simple thing to understand in that to me a language is after all a sociological museum. If you scrutinize a dictionary you find, in the modifications that words have suffered in the course of time, some evidence of the modifications of the society that has used those words. Words become old-fashioned as the connotation of one century ceases to be relevant in another century, and to use a word with an outmoded connotation is to conjure up the sights and sounds and smells of the time when it was a la mode. In this I refer to the core connotation of a word and the aura of associated significance that surrounds it. I also refer to the fact that as the circumstances of life change we change our vocabulary by modifying old words and inventing new ones, because, among other things, we become impatient of a shabby aura of associated significance. Thus no one today would use the word "masher" when he wanted to talk about someone who was a "wolf". Hence we have two word-making forces in operation: first, that which adds words

as our experience widens; second, that which changes and substitutes words in response to the more intimate circumstances of society. The former is more deliberate and oriented than the latter, and can happen only through direct participation in the recognition of the concept for which a word stands.

Any people who have not had the experience out of which emerged certain concepts represented or symbolized by particular words in fact do not have the words at all. Thus, when I was stationed in South East Asia I often saw texts in Siamese or in Chinese in which appeared, in Roman script, English or German or French words, in the midst of their particular script, and these were there because the Siamese and Chinese had no word for the new concepts drawn from western scientific and technological activity in which, up till then, they had not participated. They did not have in their own language our basic terms from which to make up phrases that could adequately signify something in technology or modern science of which they themselves had had no experience. Recently in Mexico I found what seemed to me to be the same sort of thing; that there are some things in human life which apparently Spanish-speaking people have not experienced, and for which they had not got words. My Mexican colleagues and I had many debates concerning words such as, for example, "knack". Similarly, when we met the word "drill", they immediately talked about a drill that bores, but for drill, in the sense of drilling a child in grammar, they had no word, and I assume they had no concept of it.

My thesis then is this: science generally, and in particular our field, ecology, has lost power because our word-making and modifying processes have not kept pace with our ability to enter the physical world; this gap has been created by the forces that have promoted technological advance for these at the same time were and are hostile to ideas. The explanation is undoubtedly more involved than this, but of the depth of the problem there can be little doubt, as I can show by some elementary examples.

The dictionary for this meeting has an appendix presenting a discussion I offered on the term "taxon"; I think the term "taxon" is a magnificent thing, for it's neutrality in its reference to a range of other words. But, it is a special case. I have been puzzled for years over the fact that English at least and I think most languages, lack what I call "words of scale". For instance, if we want to talk about density as the number of animals in an area, we generally use the word "abundance", but sometimes we do not mean abundance, but instead its opposite. The same is

true in the engineers' use of the word "strength", when speaking of members of a building. Sometimes they mean the weakness of such members, but they still use the word "strength". Similarly for "wealth"; we talk about "wealth" when often we really want to talk about poverty, and we do not have a word to refer to the whole scale from poverty to wealth. These words of scale are lacking, and moreover some of the words we use have a connotation of a previous generation or even a previous century. To me "competition" is one of these, "population" is another and "niche" another, and I suggest that "endemic" and "sympatric" are both in the same state. The word "endemic", which appears so often in the zoogeographic papers of this meeting, has, I suggest, only very little value. Probably its value, or rather its intensity of intention, is largely a function of the size of the country to which you belong and the depth of your own chauvinism. If you belong to a small country your concept of endemism is of something that belongs to a very small area. But "endemism" means "belonging where it belongs, where it lives", and whether an animal lives in waters from Japan down to Australia or only in a small bay in New Zealand, it still lives where it lives and must in both cases be counted endemic. The word "sympatric" is, I believe, a circular word in that, as Ray used it in I forget which discussion, if you have two populations living in one single area, that is, if they are sympatric, then they must be of the one species. But, if it is true that two species cannot be sympatric, then one species cannot displace another. If "sympatric" means the sort of things that Ray George implied by his use of the word a species population could displace from one area only a population of the same species. The difficulty is the mutual dependence of the words "sympatric" and "species"; two populations can be specifically different if they are not sympatric, and sympatric if specifically different. Thus, if you opt for sympatry you at once yield your position on specific status; conversely, if you opt for specific status you exclude the possibility of sympatry. So that to use sympatry and allopatry as criteria of taxonomic status is to fall into tautology. And this is because "sympatry" is a shadow.

Now, in our discussion of life histories we again found inadequacies in our knowledge and it seemed to me that a major inadequacy was in systematic cataloguing, describing of the aionomorphs, so my questions with respect to life history begin with:

<u>can we in this meeting propose any practical measures to accelerate the identification of juvenile stages, the aionomorphs? Practical measures with</u>

respect to field and laboratory work, exchanges between institutions, collaboration between them, establishment of master collections, publication of descriptions and so forth.

My second question is: can we nominate any especially important matters for investigation with respect to the response of particular aionomorphs to particular factors or to the arrays of factors of particular situations? Can we usefully nominate things that might attract the attention of those who provide money for research.

Ecology

Then we went on to ecology for which we had few papers. There was a review by Brundritt which we took as read, a paper by Graham Chittleborough, and contributions by Olsen and Dell. We spent a lot of time discussing long term trends, and I think that Bill Stephenson adequately summarized this for us. He first of all said that it seemed that in many cases what appeared to be spread of a species was really a spread of knowledge, and if I understood him rightly, he summarized the discussion by saying that he was convinced that certain changes had taken place but that he considered the evidence to be far too tenuous to support any conclusions as to how these changes had come about, how long they would last and what long term effect they might have on the totality of the fauna. We discussed briefly the effects of weather. Then we discussed at somewhat greater length the matter of the role of food and this was, I believe, especially one of the shadow discussions, because we found that Graham was in fact discussing the consequences, or, even less, the possible consequences, of lack of food. Wear and others of us made suggestions to him that he should if possible go back more directly to the trophic relations themselves and measure food supply and its variations, and measure the direct and real consequence to the organism of variation in food supply; I do not suppose that in saying these things anybody was under any illusions that to carry out such work would be easy. I think also in this section, as it was true in our discussion of life history and of zoogeography, that we found that we were often in difficulties because our information about environmental factors and the places where we saw animals or saw them doing something was inadequate, which touched upon the matter of environmental frame of which I had spoken earlier. I had suggested that we lack in our research the service of regular neutral observation of key climatic elements which is

provided on land by meteorological bureaux. This then gives me the first of my questions with respect to our ecological discussions.

Can we, as a meeting, make any observations on the desirability, perhaps the urgency, of establishing for marine research an environmental frame corresponding to that which on land is provided by the Meteorological Bureau?

Next, which is a different approach - are there any especial advantages to be got from some particular strategy of research in ecology? As for example, by studying specific life histories, as against studies of relations, systems and principles?

Thirdly, can we make any suggestions as to experiments that might be conducted in field work on ecology?

I think we all know that ecology for a long time has been in quite grave disrepute because physicists and other technologists point their finger at us saying that we have no opportunity of making experiments or at least we devote ourselves very largely to describing complex situations and inventing terms to cloak our ignorance concerning these situations. There must of course be an element of truth in these charges, and I believe that it is now important for us to look for ways of designing and carrying out experiments in the field, manipulating the complexes we are describing, and seeking to analyse them.

Behaviour and Physiology

Then we went on to behaviour with which was linked material on physiology, and in both these fields there was very little documentation. I propose to deal with them together. We discussed sound production; we also discussed, with some hilarity, sexual behaviour; and we discussed migrations, and I think it was inevitable that these discussions should be quite inconclusive. Then yesterday morning we had with Mr Horn that, to me, very stimulating session on hormones. It seemed to me, listening to that discussion, that if the meeting had had nothing more than that session, probably the cost of the meeting would be justified. Graham reported to you that he had had to go to Japan to learn about the existence of this work; this underlies the importance of us thinking about how to make sure that exchanges take place much more effectively, much more rapidly in the future, and out of those discussions I formulated these questions which seem to

me to summarize a view that one can take on the evidence given in this meeting from papers and from our discussions, of our ignorance on these matters.

What is the place of behaviour research in any study of decapod crustacea? How important is it to us to know anything about stridulating organs and about sound production under water, how important might it be in any of the senses of this meeting for practical application or for development of the understanding of the biology of these species?

Next, how much descriptive and inventory (apographic) work, needs to be done in the field of decapod behaviour before we will be able to organize and carry out a programme into the processes of behaviour as such? What methods should be employed in such research, and what priorities could be assigned to different areas of subject matter?

Lastly, in the physiological field, for what phenomena at organismal level do we need now an account of underlying physiological processes?

Exploitation

Then yesterday afternoon we turned to the matter of exploitation, and Graham Chittleborough gave us an account of the western crayfish, Dick Slack-Smith gave us an account of Western Australian prawns, Richard Pike and Craig Kensler gave us an account of the New Zealand crayfishery and of some aspects of the cray population, and we had some discussion of Woodland's paper on population models, but more especially on mark and recapture methods.

Graham in his paper gave an account of how he had measured certain of the characteristics of the population of the western crayfish, of the structure or composition of its population, and of certain of the dynamic features; he gave an account of some of the problems that he had encountered in this work. Dick gave us an account of the model, his physical model, from which he developed an arithmetic model for calculation of some of the population properties. We had a challenge to this kind of work from Des Griffin and from Bill Stephenson, and you may remember that I summarized the four or five different elements in the repertoire of population research in fisheries, but we, in this work, still have certain major problems in the field of decapod crustacea.

Probably the most important one is the difficulty of age determination, and hence of developing a growth curve which has on the horizontal a true time scale; but after that probably the next most important problem concerns stock identity. In the case for instance of the king prawn of the east coast, do we have a series of separate and autonomous populations or is there in effect one continuous population, especially in the sense of drawing from one common pool of juveniles? Answers to these questions of stock identity could have a lot of influence on our strategy of research; they certainly could have a lot of influence on the techniques of management of the fishing operation, because if we have separate King prawn populations we would always have a certain risk that our fishermen might be able to do to the prawn stocks what the whalers did to separate species populations of whales in the Antarctic; that is, exploit and reduce to dangerous levels one population, and then move on to the next and then on to the next. In the whole of fisheries biology we are still beset by the problem that we do not know, nor have we any clue as to how to find out, what is the safe level to which a population may be reduced and below which it must not be reduced because to do so would create the possibility of the species being eliminated. In general I believe that fishery biologists are convinced that in the normal way of exploitation no species can be eliminated by a commercial fishery, since fishing ceases to be profitable or worth while long before a dangerous low level of the population is approached.

We think that this economic principle has served to protect a number of stocks of commercial importance in various parts of the world, but we have to recognize that the rapid increase in the efficiency of fish-searching and the very great increase in fishing power which modern technology has given us must make us somewhat less complacent about the safety of these stocks. It daily becomes obvious that more sensitive and more reliable methods of managing fishing operations will be needed, and that for these we shall need a great deal more information about our fish stocks. The new information which we shall need will be beyond the relatively simple arithmetic models developed over the past few decades and used with such skill in many parts of the world. We must go back now to the natural systems themselves and construct, with great care, models of the physical events taking place in these populations. These models will have to incorporate some reference to the biotic and abiotic relations of an individual with its habitat on the one hand and with its fellows on the other. It was for this reason that Dick Slack-Smith's model of the movement, growth and mortality of his prawn stocks was of

such interest to us. In making such models we shall need to have more of information such as that which we received in this meeting. From these discussions it seemed to me appropriate to put to you the following questions:

First, can we suggest a strategy for research directed toward resolving the problem of whether, for example, the stocks of southern crayfish all belong to one population and draw their recruitment from a common pool of larvae, or alternatively, constitute separate and autonomous populations?

Second, can we make any suggestions with respect to the techniques that might be employed in the marking of decapod crustacea and the patterns of marking operations?

Third, can we make any suggestions as to the techniques that might be employed in the study of the growth of decapod crustacea?

Fourth, can we make any suggestions as to the techniques that might be employed in the study of the recruitment of decapod crustacea?

Fifth, can we make any suggestions as to the techniques that might be employed in the study of the mortality of decapod crustacea?

Intervention

Our last session dealt with intervention and was mostly taken up with the illustrated talk given by Graham Chittleborough and with the questions put to him. It is clear from what he said that the Japanese have made a lot of progress in cultivation of invertebrates. Graham's talk was to be as a general introduction to this field, intended by the Steering Committee to be of somewhat wider scope than actually covered by Graham. The Steering Committee had it in mind that we should consider all forms of intervention in resources, both those under natural conditions and those of artificially established situations. One must keep one's mind open to the possibilities of modifying natural habitats such as the reefs occupied by crayfish. We can indeed think about modifying the food supply and about reducing predators. We can also think about protecting reproductive and nursery grounds and about transplantation and re-stocking practices. Certainly we can consider the entire range of fish culture and hatchery practice,

and between these two we can consider the possibilities of large scale fish farming in coastal waters such as bays and arms of the sea. But again, for this work we shall need to be armed with all that we can draw from studies such as those discussed in this meeting. For this section of our meeting I can only ask you whether there is any further comment you wish to make.

General

Finally, returning to my comment at the beginning of this review when I read from my first circular letter proposing the meeting, I have some questions to put to you concerning the possibility of further meeting and the desirability of action to follow up what had been originally intended with regard to this meeting. I may simply read to you:

First, are there any courses of action we might propose, with respect to facilitation of further exchanges between workers engaged in research on decapod crustacea, co-ordination of their activities, intercalibration and standardization of their methods, and so forth?

Second, can we propose some system for further development of the species synopses presented at this meeting, and for keeping them up-to-date and readily available to research workers, and for the preparation of other synopses?

Third, should we attempt to secure the publication of any or all of the documentation of this meeting? If so, what should be published, how, when, by whom?

Fourth, do we wish to have another of these meetings? If so, when, where, and under what arrangements?

RESOLUTIONS

At the conclusion of the Convener's Summary, the Meeting, in general session under the chairmanship of Dr R.B. Pike, considered the following questions which had been put by the Convener.

QUESTION 18: Are there any courses of action we might propose, with respect to facilitation of further exchanges between workers engaged in research on decapod crustacea, co-ordination of their activities, intercalibration and standardization of their methods, and so forth?

QUESTION 19: Can we propose some system for further development of the species synopses presented at this meeting, and for keeping them up-to-date and readily available to research workers, and for the preparation of other synopses?

QUESTION 20: Should we attempt to secure the publication of any or all of the documentation of this meeting? If so, what should be published, how, when, by whom?

QUESTION 21: Do we wish to have another of these meetings. If so, when, where, and under what arrangements?

The following resolutions arose during this consideration of the Convener's questions.

Next Meeting

The Meeting agreed that:

(1) another meeting on the same general lines should be held at a time to be fixed, not less than three years from the present meeting;

(2) the sponsoring organizations (including the New Zealand counterparts of the Australian organizations) be asked to nominate a steering committee, responsible for organization of the meeting in all its aspects;

(3) the committee should be asked to examine in principle the proposition in Question 18 and to look for ways in which they might promote exchange between workers in the field of decapod crustacea.

The meeting decided that the precise time and place of the next meeting should be left to the decision of the Steering Committee, but the meeting wished to draw to the Steering Committee's attention that the present time of the year was most suitable, particularly for university participants.

Species Synopses

The Meeting agreed:

(1) that it is up to those responsible for the synopses of the present meeting to bring these to publication as and when it might become appropriate to do so within the terms of the current species synopses arrangements;

(2) to suggest that, because they are very valuable, a similar set of revised synopses be provided for the next meeting;

(3) that it regards species synopses as a useful way of bringing material together and therefore urges CSIRO to make the synopses series an official series.

Publication of Meeting Documents

The Meeting decided:

(1) to record that it had noted the wording on the title page of each document:

"This paper has been distributed to meet the needs of this specific meeting and is not a formal publication"

(2) that no attempt should be made on behalf of the Meeting to publish any of the contributed papers.

The Meeting agreed:

(1) to request CSIRO to issue a report of the meeting; that this report should include details of attendance, time and place, the agenda, lists of documents, resolutions, section summaries, and the Convener's Summary;

(2) that Dr Kesteven's summary should be included in the report in abridged form;

(3) that a copy of Dr Kesteven's summary *in toto* should be distributed to all those who actually attended the meeting.

Group Discussions

The Meeting agreed:

(1) to consider the list of questions presented to the meeting by Dr Kesteven;

(2) to divide into three groups to consider, in the time available, some of these questions and to prepare documents for presentation to the plenary session of the meeting during the final session;

(3) that, after editing by Dr Kesteven and Mr Mobbs, summaries of the reports from the working groups should be included in the report.

REPORTS FROM WORKING GROUPS

Working groups met to consider some of the questions raised by Dr Kesteven in his summary. The questions were considered by Group 1 chiefly in relation to prawns and by Group II in relation to crayfish; Group III considered them in relation to zoogeography and systematics. The groups were constituted:

Group I	Group II	Group III
R.J. Slack-Smith (Chairman)	R.W. George (Chairman)	J.C. Yaldwyn (Chairman)
N.M. Haysom	A.E. Caton	J.H. Bradbury
I. Kirkegaard	C.B. Kensler	B. Campbell
N. Ruello	D.D. Lynch	R.K. Dell
I. Smith	R.J. MacIntyre	D.J.G. Griffin
D.J. Tuma	B.F. Phillips	T. Meagher
R.H. Walker	R.B. Pike	R.D. Simpson
	R.R. Pyne	W. Stephenson
	D.C. Wolfe	J.M. Thomson

REPORTS TO THE MEETING IN RESPONSE TO THE CONVENER'S QUESTIONS

QUESTION 1: Are there any principles or laws in biology which have their origin strictly and exclusively in zoogeography?

Group I: Possibly, but principles and laws in biology are more likely to come from ecological studies.

Group III: No.

QUESTION 2: Can we make anything as to description of phylogenetic processes, strategy of current research, predictions as to patterns of distribution, of the differences between the Australian and New Zealand decapod fauna?

Group I: We consider there is no overlap of New Zealand and Australian Penaeinae.

Group III: Yes. Work is underway but further work is needed on documenting these differences. Research along these lines probably has been stimulated by this meeting and might well follow these lines:

(a) history of the fauna;

(b) study of species occurring in both areas;

(c) documentation of invasions.

We can predict patterns of distribution from such work in the future, provided we have greatly increased environmental information. (Note: agreement was not universal on this latter point.)

QUESTION 3: Can we suppose that a dynamic zoogeography could be developed that would consider each species in terms of many ranges, not one, and in terms of its several aionomorphs* and not just of the adults; and if we can suppose that such a zoogeography could grow, what could we do to promote the emergence of such a zoogeography?

Group I: We regard this simply as an interesting concept only.

Group III: The word 'dynamic' in the term 'dynamic zoogeography' may be construed as having two meanings:

(a) more vigorous;

(b) temporal, i.e. changing with time.

Answer to question with sense (a): Yes. It is developing in New Zealand but not developing at the same rate in Australia.

Answer to question with sense (b): Yes, knowledge is increasing.

QUESTION 4: Can we in this meeting propose any practical measures to accelerate the identification of juvenile stages, the aionomorphs? Practical measures with respect to field and laboratory work, exchanges between institutions, collaboration between them, establishment of master collections, publication of descriptions and so forth.

Group I: Tuma is currently preparing a field guide to all Australian Penaeids, based on metamorphosis of genitalia; he will circulate the sections for Penaeus esculentis and Penaeus merguiensis when they are complete. (Note: he needs assistance from other workers.)

*The term "aionomorph" was coined by the Convener and is explained in his summary. See p. 11.

Kirkegaard is close to keying the genera of all stages from the protozoeal stage onwards; he is willing to circulate drawings when requested.

We recommend:

(a) the establishment at museums of comprehensive reference collections of all stages of prawns;

(b) the compilation of master keys similar to those of Galveston where there are figures through all stages at the genus level;

(c) that more work should be undertaken on laboratory rearing to check out life histories;

(d) the establishment of a master cross reference index of publications, with particular indication of availability to enable access to the nearest copy;

(e) the standardised usage of 'phase' as the term to describe protozoea, Mysis etc.; and the usage of 'stage' for aionomorphs within the phase.

Group III: We recommend that:

(a) no identified master collections of decapod larval stages should be abandoned, but that they should be offered to some museum-type institution;

(b) all practical measures should be taken to accelerate work on the systematics of Australasian decapods as a first steps towards the identification of juvenile stages.

We deplore the lack in Australia of sufficient publication mediums for papers on systematics.

QUESTION 5: Can we nominate any especially important matters for investigation with respect to the response of particular aionomorphs to particular factors or to the arrays of factors of particular situations?

Group I: We consider this an important sector of investigation - the real mechanism of larval transport. Tuma is using staining and short-term mark and recapture methods to investigate movements, but more work is required. The problem still remains: what triggers spawning, migration, etc.?

QUESTION 6: Can we, as a meeting, make any observations on the desirability, perhaps the urgency, of establishing for marine research an environmental frame corresponding to that which on land is provided by the Meteorological Bureau?

Group I: We consider it both desirable and urgent that an environmental frame be established. With the development of electronic, automated data collecting and transmitting buoys, advances in this field are becoming possible.

Group II: We recommend that the following should be sought or instituted:

(a) water current data in southern Australasian region;

(b) atlas of temperature profile;

(c) continuous fixed station, long-term temperature recording;

(d) development of a suitable and inexpensive method of temperature recording apparatus.

QUESTION 7: Are there any especial advantages to be got from some particular strategy of research in ecology? As for example, by studying specific life histories, as against studies of relations, systems and principles?

Group I: Whilst we must of necessity specialise in data collection and interpretation in particular fields, we recognise the need of a wide periphery of knowledge. The present meeting has been most useful in emphasising this need.

We recommend strongly the establishment of an annual meeting to function as a "prawn workshop";

(a) for the purposes of discussion and comparison of progress in work undertaken; and

(b) with a view to promoting:

(i) interchange and generation of ideas for future work

(ii) the employment of advances in methods.

QUESTION 8: Can we make any suggestions as to experiments that might be conducted in field work in ecology?

Group I: We suggest:

(a) direct underwater observation of individuals and populations;

(b) monitoring of pesticides and general pollution;

(c) development of bioassay techniques;

(d) repeat of previous population studies to gauge the effect of degradation of the environment.

QUESTION 9: What is the place of behaviour research in any study of decapod crustacea?

Group I: Although not much attention has been given to it previously, behaviour should have a high priority, particularly investigations of the behaviour of prawns when confronted with trawls. This meeting has revealed the gaps in our knowledge concerning behaviour.

Group II: We recommend the study of phyllosoma behaviour.

QUESTION 10: How much descriptive and inventory (apographic) work, needs to be done in the field of decapod behaviour before we will be able to organize and carry out a programme into the processes of behaviour as such?

Group I: We believe that, whilst projects using small numbers of animals may lead eventually to the elucidation of general principles, they do not assist in overcoming the immediate problems in fisheries research. Therefore, priority should be given to projects studying the behaviour of prawns in mass, e.g. problems concerning migration of larvae and adults.

Group II: We recommend the study of phyllosoma behaviour.

QUESTION 11: For what phenomena at organismal level do we need now an account of underlying physiological processes?

Group I: Growth and reproduction.

QUESTION 12: Can we suggest a strategy for research directed toward resolving the problem of whether, for example, the stocks of southern crayfish all belong to one population and draw their recruitment from a common pool of larvae, or alternatively, constitute separate and autonomous populations?

Group I: We suggest:

(a) higher intensity plankton sampling;

(b) mark tagging programme;

(c) biochemical separation of populations.

Group II: A suggested strategy for research for the period September-November, 1968:

(a) Institution of a sampling programme to determine the onset, duration and termination times of one biological event, namely egg carrying. Carefully selected fishermen should be provided with record books for documenting these events at the following localities:-

Australia: Southern Tasmania, King Island (Bass Strait), Flinders Island (Bass Strait), Kangaroo Island, far western South Australia.

New Zealand: The Bluff, Wellington, Auckland, Chatham Islands.

(b) Morphometric studies of adult and juvenile material for localities within the total range (Australia to New Zealand); samples would probably be sufficient, except from King Island and Flinders Island (six each).

(c) Blood protein analyses with the co-operation of the Biochemistry Department, University of New South Wales.

(d) Recording at least once per week of temperature at the bottom of the fishing grounds by selected fishermen using maximum/minimum thermometer on lead line.

QUESTION 13: Can we make any suggestions with respect to the techniques that might be employed in the marking of decapod crustacea and the patterns of marking operations?

Group I: Staining methods are adequate, but require further development. Other tagging methods require development and refinement.

QUESTION 14: Can we make any suggestions as to the techniques that might be employed in the study of the growth of decapod crustacea?

Group I: We suggest:

(a) marking,

(b) tagging,

(c) further extension of growth increment method,

(d) laboratory experiments.

QUESTION 15: Can we make any suggestions as to the techniques that might be employed in the study of the recruitment of decapod crustacea?

Group I: We suggest concentration on sampling of nursery areas, but this would require development of specialised sampling

equipment.

QUESTION 16: Can we make any suggestions as to the techniques that might be employed in the study of the mortality of decapod crustacea?

Group I: We suggest studies:

(a) of longevity in addition to conventional mortality studies;

(b) of any aging process if this occurs.

QUESTION 17: Do you wish to comment further on intervention?

Group I: We suggest the following courses of action:

(a) pond rearing of juveniles obtained from the field;

(b) protection of known and suspected nursery areas.

ADDITIONAL COMMENTS

Group II: We suggest that the following matters are important in an approach to research for the improvement of the Papuan crayfishery:

(a) species identification;

(b) investigation of:

(i) the distribution of fishing stocks,

(ii) breeding season, e.g. onset, duration, determination,

(iii) "folk lore";

(c) establishment of catch and effort statistics;

(d) exploration of possible fishing areas;

(e) development of:

(i) exploitation techniques,

(ii) marketing techniques.

Group III: A great deal of zoogeography, study of larvae stages - e.g. ecology, physiology etc. - is impossible unless more attention is given to systematics of Australian decapod crustacea.

SECTION REVIEW STATEMENTS

All those who had signified their interest in the Meeting were asked to complete, wherever possible, summary statement forms about each of the sections into which the Meeting was divided. From information in these completed summary statement forms and in the research situation reports and contributed papers, the Section Organizers prepared, as working documents for the Meeting, review statements in an attempt to assess the distribution of research activity and the status of present knowledge of decapod crustacea in Australia and New Zealand. The following statements have been prepared from these working documents.

Zoogeography

In Australia, 15 people are actively working on decapod systematics: Barnes, Hillary; Barnes, R.S.K.; Bishop; Bruce; Campbell; Francois; George, R.W.; Griffin; Lucas; Lynch; Racek; Riek; Ruello; Stephenson; Yaldwyn.

In New Zealand, Dell is working on Brachyura, including Galathea Expedition collections; Kensler is working on palinurids (Jasus only); Pike on Galatheidae (including Galathea Expedition collections); Mary Melrose is working on hymenosomids. As well, Griffin is working on New Zealand majids and Yaldwyn on New Zealand natants.

Outside Australia and New Zealand, 8 people have indicated to the meeting organizers that they are interested in, or working on, aspects of Australian decapod systematics; Banner and Banner (Alpheidae); Forest (Paguridae); George, M.J. (Penaeidae); Guinot (Xanthidae); Haig (Porcellanidae); Holthuis (Palinuridae, Scyllaridae); Serene (Sesarma).

The following 18 family groups are being worked on: Penaeidae, Palaemonidae (Pontoninae), Alpheidae, Palinuridae, Scyllaridae, Parastacidae, Paguridae, Porcellanidae, Raninidae, Calappidae, Leucosiidae, Majidae, Parthenopidae, Hymenosomidae, Xanthidae, Portunidae, Grapsidae, Ocypodidae.

In addition, Griffin is working on Mortensen and Galathea Expedition collections of Brachyura, mainly from the Coral Sea, N.S.W. and the Great Australian Bight; Yaldwyn and Griffin are

working on the decapods of the Port Phillip Survey; Racek is working on Dana and Galathea Expedition world-wide collections of penaeids (all subfamilies).

All authors are using standard morphological techniques, and Lucas is also using reproductive data. Stephenson, Racek, Meagher and Griffin have used morphometric techniques. Stephenson has attempted numerical taxonomic procedures on portunids.

Bishop, Campbell, Lucas and Riek all require more material from northern Australian waters. Riek also wants material from coastal Queensland and northern Tasmania; Lucas requires material from the Great Australian Bight. Only Stephenson and Nunn require improved publication facilities.

Life History

The results of recent life history studies on Australian and New Zealand decapod crustacea have application to "academic" as well as "applied" fields of research. First, they give a direct comparative appreciation of the multitude of ways in which a species can successfully maintain itself and, second, life history data are essential for both management of a natural resource and for the artificial culturing of the species.

Freshwater prawns and crayfish.- Life history studies are quite varied and include culturing of young in Queensland by Fielder, growth estimates as part of a total population study in New South Wales by Woodland, and general observations in Tasmania by Lynch.

With the possibility of future development of culturing freshwater species throughout Australia (and possibly New Zealand) these fields of research activity should provide essential basic data for such expansion. Brundritt's experience in studying Canadian freshwater crayfish could provide stimulating comparative analyses to assist in Australian programmes.

Marine prawns.- Most research on prawn life histories is directed towards the species of commercial importance but the earlier studies on commercial species by "non-applied" investigators such as Dakin and Dall must receive proper acknowledgment. On the east coast of Australia, combined team programmes are hastening the production of results which can be applied to the fisheries of Queensland and New South Wales but there is at present a lack of sufficient data. Large scale investigations are planned for the future by the various State and Commonwealth

agencies. Australian prawn fisheries (as indeed are all Australian crustacean fisheries) at the present time are based on the exploitation of natural resources, many of which are still to be discovered and developed. In the not too distant future, however, the possibility of large scale breeding and cultivation of prawns, such as the Japanese are at present developing, must be examined.

In SW. India, the backwater ricefield cultivation of marine and estuarine prawns immediately stimulates thought about the feasibility of prawn cultivation in New South Wales.

Crabs.- Life history studies have been conducted mainly on a variety of New Zealand species by Wear and Pike, whereas the studies by Lucas have been made on the Australian species of the one genus Halicarcinus. Most of the species which have been investigated have short or no free swimming larval stages. Wear has presented a review which should prompt discussion at the meeting.

Marine crayfish.- It appears that for Panulirus at least, larval life is both lengthy and hazardous. A study of recruitment paths back to the fishing grounds remains unsolved and here further knowledge of the habits of the separate stages and the current systems which transport them is an obvious must for future work. P. cygnus juveniles are difficult to "discover" and the Western Australian team of State and Commonwealth workers is endeavouring to further their knowledge on growth and longevity of the species. The ever-present problems of tagging and the interpretation of recapture data are evident for both P. cygnus and P. homarus. In SW. India this latter species is regarded as a very fast-growing species.

Larval distribution and recruitment for Jasus are less well known than for Panulirus although more is known about culturing the early larvae and the immediate post-larvae through the efforts of Batham and Kensler in New Zealand and Olsen in Tasmania. Since larval interchange between New Zealand and the lower east coast of Australia is not only possible but very likely, further information on the larval habits of Jasus, and Tasman circulation would be necessary for determining the meaning of the observed differences in the two regions.

TABLE 1

SUMMARY OF RESEARCH ON DECAPOD LIFE HISTORY

Compiled from information supplied to the section organizer

Species	Research Worker	Past Publs	Meeting Papers	Research Interest
FRESHWATER CRAYFISH AND PRAWNS				
Astacopsis gouldi	Lynch	ANZDC67/3/2		Tasmanian species
Cherax albidus	Woodland		2/16 4/22	Individual and population growth
Canadian *Orconectes* and *Cambarus*	Brundritt		4/5	Ecology mainly
Macrobranchium australiense	Fielder		4/7	Hatching and culturing
CRABS, ANOMURA, THALASSINIDS				
Petrolistes spp.) *Pagurus* sp.	Greenwood	1965 1966	4/10	Life history of 3 N.Z. spp. now completed
Portunus pelagicus	Meagher			Ph.D. topic, W.A.
Portunus sanguinolentus	George, M.J.			SW. India, General Biology
Southern Australian and N.Z. *Halicarcinus* spp.	Lucas		4/14	Completed Ph.D., W.A. Biology of the Aust. spp. *Halicarcinus*
Many N.Z. species mainly Brachyura	Wear	1964(2) 1965(4) 1966(2) 1967(2)	2/15 4/21	Comparative larval development and culture
Many species mainly Anomura	Pike	1952 1954 1957 1959(2)	4/16	Larvae of Galatheids and Paguroids of N.Z.

TABLE 1 (Cont.)

Species	Research Worker	Past Publs	Meeting Papers	Research Interest
		1960(3) 1961(3) 1964		
MARINE PRAWNS				
Penaeus latisulcatus	R. Slack-Smith			Shark Bay, life history and populations
Penaeus esculentus	R. Slack-Smith			do.
	Munro		4/24	East Coast, life history and populations
	Kirkegaard and Walker		4/20 3/10	
Penaeus merguiensis	Munro		4/24	
	Kirkegaard and Walker		3/11	do.
	Tuma	1967	(2/14 (4/19	
Metapenaeus bennettae Metapenaeus macleayi	Munro		4/24	
Parapenaeopsis sculptilis Penaeus longistylus Metapenaeus eboracensis Metapenaeus endeavouri	Kirkegaard and Walker		(3/6 ((3/7 ((3/8 ((3/9 (	do.
Penaeus plebejus	Kirkegaard and Walker; Ruello		(4/19 ((3/12 (	do.

TABLE 1 (Cont.)

Species	Research Worker	Past Publs	Meeting Papers	Research Interest
East Coast Prawns + *Aristeomorpha foliacea* *Hymenopenaeus siboga* *Solenocera* *Aristeus*	Racek	1955 1957 1959	3/1 4/17 3/4	Many biological aspects including development
SE. Queensland Prawns	Bruce Brundritt		4/3 4/4	SE. Queensland, life history and ecology
SW. India Prawns	George, M.J.	1962 1964 5 in press	4/8	SW. India, life history and ecology
MARINE CRAYFISH				
Jasus verreauxi	Chittleborough Kensler	 1967(2)	 4/13	Incidental Commercial, N.Z.
Jasus edwardsii	(Kensler ((((Pike (Batham	1967(2) 1967	2/9 2/10 2/11 4/13 4/16	do. do. Laboratory rearing phyllosoma
Jasus novaehollandiae	Fielder Olsen Chittleborough		 4/15	Completed Ph.D. Commercial, Tasmania Incidental
Panulirus penicillatus	Chittleborough			Recruitment, west Indian Ocean

TABLE 1 (Cont.)

Species	Research Worker	Past Publs	Meeting Papers	Research Interest
Panulirus cygnus	(Chittleborough	1966	2/3 2/5 4/6	Larval recruitment, growth and tagging
	(Phillips		4/6	Immediate post-larval stages
	(Bowen	1966	2/1 4/2	Growth, sub-adult recruitment and tagging
	(George, R.W.	1958 1962 1963 In press	4/9	Larval development and growth
Panulirus homarus	George, M.J.	3 in press	4/8	Growth and tagging, SW. India

Ecology

There is great variability in the extent to which research workers pursue ecological aspects in their studies of decapod crustacea. For many, it is sufficient simply to describe the habitat of the species or population under study. An understanding of the habitat preferred may enable a forecast to be made of the distribution of that species. When habitat preferences are known within a group of closely related species (ANZDC 67/2/7), zoogeographers may not only forecast which species will be found in a particular locality, but may also consider these ecological aspects together with morphological differences, in postulating evolutionary trends within that group.

Some have determined tolerance limits to environmental factors (either singly or in combination), thus defining habitat preferences more precisely (ANZDC 67/4/14). While this may assist in attaining an understanding of the distribution of a species or population, it tells little about the effects upon processes within a population, of environmental factors varying within the range of tolerance limits.

Some are studying changes in environmental conditions, either as rather random fluctuations or as cyclic trends, affecting the distribution of particular species from one time to another (ANZDC 67/4/9). Again the emphasis is upon distribution; in fact, the majority of the ecological aspects mentioned in the papers for this meeting are concerned with distribution rather than abundance of decapod crustacea.

Few people in the Australian-New Zealand region are looking at the effects of varying environmental stresses upon processes within decapod populations. At times there appears to be almost a tacit assumption that if a population is maintaining itself within the most favourable set of environmental conditions accessible to it, it is therefore exhibiting maximum reproductive efficiency, best growth, and minimum mortality. A process such as growth is then measured and regarded as the growth rate, as if this were a constant for the species, thus losing sight of the fact that the growth rate as measured represented achievement under the particular ecological conditions to which the population was exposed at that time and place. The surprisingly fast growth rates recorded for Panulirus homarus (ANZDC 67/2/19) may be such an instance, where growth was measured under near-optimal environmental conditions for that species; unfortunately the environmental studies have not been made. In the population of Panulirus cygnus, growth rate is not only slower than observed in P. homarus, but varies with time and locality (ANZDC 67/2/1 and 3). The causes of this variability are now being sought.

Environmental factors also limit population size (as well as its structure), numbers either fluctuating around some mean level or undergoing some cyclic trend. Although all this is accepted as obvious, an estimate of population size is sometimes regarded as the end point of a study, thereby overlooking the fact that this estimate, however accurate it may be, refers only to a single point in time and is applicable to a particular set of environmental conditions. Fluctuations in population size might well prove of greater importance than an estimate of the mean level.

Estimates of population size, or even of density, are all too few for decapod crustacea, so that practically nothing is known of natural fluctuations and of the environmental conditions which brought them about. This need not prevent discussion of which environmental factors are likely to be limiting survival and growth, and of how the influence of these factors can be measured.

The population ecologist need not turn his back on commercially exploited populations as something no longer worthy of his attention (ANZDC 67/2/16). Exploitation should be regarded simply as the addition to existing forms of predation of another predator, which affects not only population size and structure but possibly also growth, reproduction and recruitment. However, since exploitation is one of the few forms of predation which can be measured precisely and which often produces measurable changes in the population within short intervals of time, exploitation affords techniques for estimating population size, mortality and recruitment rates, etc., which are not available to the "pure" scientist when he confines his attention to unexploited populations.

Physiology

Of the people who indicated interest in this meeting, fourteen displayed some interest in physiology, by completing the appropriate summary statement form. Table 2 summarizes information contained in thirteen of these forms. (See pp. 44-5.)

Of these thirteen physiological studies, ten are simply parts of integrated ecological programmes. The other three aim at advancing knowledge of a specific physiological process. Apparently crustacean physiologists at present working in Australasia are primarily ecologists and only incidentally physiologists.

About half of the projects are in their early stages. Many of them are still at the level of describing gross changes and have not yet begun to explain underlying physiological processes. With a few exceptions these projects do not incorporate any of the more refined physiological instrumentation. Interest at the biochemical level is also uncommon.

There is great scope in Australasia for the study of crustacean physiology. It is strange that no laboratories have become interested in the workings of eye stalk hormones or in neurophysiology as applied to crustaceans. Very little critical work has been done on crustacean nutrition. No one has indicated a desire to work on the crustacean pheromones, the understanding of which may be fundamental to understanding crustacean reproduction. The physiology of sensory perception is largely not understood and studies on sensory mechanisms might very well be incorporated in any of the research programmes on commercial species.

TABLE 2

SUMMARY OF RESEARCH ON DECAPOD CRUSTACEAN PHYSIOLOGY

Compiled from information supplied to the section organizer

Research Worker	Species	Project Interest	Level of Study	Life History Stage	Orientation	Stage of Work
Dall, W.	*Metapenaeus bennettae*	Osmo-regulation	Whole animal	Adult	Basic physiology	Publication
Chittleborough, R.G. and Phillips, B.F.	*Panulirus cygnus*	Growth & moulting	Whole animal	Juvenile & Adult	Ecological	Preliminary
Griffin, D.J.G.	Ocypodidae	Salinity & Desiccation Tolerance	Whole animal	Adult	Ecological	Pre-publication
Horn, D.H.S.	*Jasus lalandei* *Cherax destructor*	Chemical processes in moulting	Cellular extract	Adult	Chemical	Publication
Lucas, J.S.	*Halicarcinas* spp.	(Growth, Repro-duction)a (Temp. and Salinity, Tolerance)b	Whole animal	Adult (a) Larva and Adult (b)	Ecological	Pre-publication

TABLE 2 (Cont.)

Lynch, D.D.	Astacopsis gouldi	Growth & reproduction	Whole animal	Adult	Basic physiology	Preliminary
MacIntyre, R.J.	Lyreidus tridentatus	(Respiration) (Feeding)[a] (Light) (Response)[b]	Whole animal	Adult (a) Larva (b)	Ecological	Pre-publication
Meagher, R.D.	Portunus pelagicus	Temp., Salinity Light, Oxygen, Tolerance	Whole animal	All stages	Ecological	Preliminary
Munro, I.S.R.	Penaeus merguiensis	Activity cycles	Whole animal	Adult	Ecological	Preliminary
Nunn, R.M.	Panulirus cygnus	Sound reception		Adult	Ecological	Not yet started
Ruello, N.V.	Penaeidae	Growth and reproduction	Whole animal & organs	All stages	Ecological	Preliminary
Tuma, D.J.	Penaeus spp. Metapenaeus spp.	Reproduction	Whole animal	Adult	Ecological	Preliminary
Woodland, D.J.	Cherax albidus	Respiration	Whole animal	All stages	Ecological	Pre-publication

Behaviour

Information supplied in summary statement forms indicates that there is in this field a lack of published work by Australian and New Zealand workers.

A comment on one of the forms, "my behaviour studies do not tabulate this way", points to a basic difficulty in approach. How is "behaviour" to be defined? Are behavioural studies concerned simply with what animals do, or should they be concerned with how animals react to biotic and environmental situations? But what of an individual's reactions to other individuals of the same or of different species? Although perhaps the last is more a matter for "ecology".

The crux of the matter, then, is that in the continual search for order in the seeming chaos of the biotic world, artificial boundaries are erected arbitrarily around studies. Once these boundaries are installed, the research worker often loses sight of the totality of an organism's existence, and work is carried out on one small segment of this totality to the exclusion of the remainder. For this reason some of the topics posed for discussion seem to overlap other sections of the Meeting. Such overlap is unavoidable because many of the problems confronting both "pure" and "applied" crustacean workers ought to be considered more broadly than the somewhat artificial division of this meeting into sections might suggest.

In view of the lack of published material some of the questions posed have a certain conjectural element, but it is hoped that the Meeting will encourage Australian and New Zealand workers to give more attention in future to this section of biology.

Exploitation

To exploit decapod resources, such as shrimps, prawns and crayfish, man employs two basic methods of capture - trawling and trapping. The method used on a particular species is determined by the behaviour pattern of that species. Whilst prawns are usually caught by trawl nets, crayfish are usually caught in a variety of trapping devices. Trawls retain varying proportions of the whole population of prawns, that is, they are non-selective for size of individuals (mesh considerations being ignored for the moment). On the other hand, traps catch only a small component of the immediate crayfish population, those either actively foraging for food or those which enter traps under some other motivation.

As a result of these basic differences in the methods of catching different decapod populations, individual catch figures tend to be larger and the overall yields rise more quickly for prawn fisheries than for crayfisheries. Prawn catches may rise very quickly because the whole of the prawn population is being exploited; the same explanation is equally applicable for the sudden decline in prawn yields. Fluctuations in total prawn catches are well-known the world over, but the reasons for these sudden fluctuations are often not so apparent. The cause might be overfishing or perhaps the behaviour pattern of the prawns might have changed, possibly as a consequence of some unsuspected environmental or other influence, or the prawns might simply have migrated. In many cases general behaviour patterns of prawn resources are not well known, and when a fishery develops virtually overnight on such resources, fishery biologists have little or no data on which to manage the fishery properly. Overfishing can result and in many cases in overseas prawn and shrimp fisheries, "bonanza" type fishing effort has been evident, with speculators reaping a rich reward whilst ruining a natural asset. In many such fisheries are the reasons for collapse of the fishery really known? Why was it so impotent to withstand such a sudden fishing onslaught?

With regard to the Chatham Is. trawl fishery for crayfish, for how long will this method of fishing remain economic and for how long can the stocks withstand such fishing pressure? Will this form of intensive fishing follow the same pattern as the trawling venture for crayfish on the upper west coast of the South Island of New Zealand? Can anyone supply the reason for the decline of that fishery? Was it due to excessive fishing mortality in that the trawl broke legs and otherwise mutilated the crayfish so that many of those uncaught died on the seabed? Is such excessive fishing mortality occurring now at the Chathams? The posing of these questions is not intended as a prelude to suggesting an approach to their solution but is intended simply to point to the need for basic studies in all phases of exploitation so that natural decapod resources can be exploited rationally and not ruined.

There seem to be no substantial rises in the catch yields from crayfish stocks in Australia; the present upsurge in the New Zealand catch of crayfish from the Chathams results from a geographical extension of an already exploited fishery. However, prawn fishery catches should rise somewhat following developments now taking place in Northern Australian waters. It is encouraging to see basic research being carried out first and then

exploitation taking place afterwards, instead of the reverse.

The following figures show the minor changes which have occurred in the yields of the main decapod fisheries in Australia.

	CATCH IN 10^6 lb	
	1955-6	1965-6
Southern crayfish	8.2	11.6
Western crayfish	10.9	17.8
Eastern crayfish	0.5	0.4
Shovel nosed lobster, mud crab, etc.	0.8	0.8
Prawns	6.6	12.5

The main exception to this generalised statement was the W.A. crayfish yield which rose to 20 million lb in 1962-3 and then fell to its present level of 17 million lb. The very slight rise in the southern crayfish was due in the opinion of the section organizer, to some geographical extensions of the fishery in Tasmanian and South Australian waters. This implies also a greater fishing effort. Some fishing units have moved their bases from more populous bases to small villages and towns nearer the crayfishing areas; thus there is also a sociological change in the exploitation of this resource.

The trends in New Zealand's crayfisheries have been fully reported in Meeting papers.

APPENDIX I

SPONSORING BODIES AND MEETING ORGANIZERS

Convener

Dr G.L. Kesteven

Sponsoring Organizations

The Meeting was convened by

CSIRO DIVISION OF FISHERIES AND OCEANOGRAPHY

under the aegis of

AUSTRALIAN MARINE SCIENCES ASSOCIATION,
AUSTRALIAN SOCIETY OF LIMNOLOGY

and

ECOLOGICAL SOCIETY OF AUSTRALIA

Steering Committee

Dr G.L. Kesteven	-	CSIRO (Convener)
Dr J.C. Yaldwyn	-	AMSA
Dr D.J.G. Griffin	-	AMSA (Alternate)
Dr D.D. Francois	-	ASL
Mr C.A. Mobbs	-	CSIRO (Secretary)

Section Organizers

Section 1 - Zoogeography:	Dr J.C. Yaldwyn and Dr D.J.G. Griffin
Section 2 - Life History:	Dr R.W. George
Section 3 - Ecology:	Dr R.G. Chittleborough
Section 4 - Physiology:	Dr D.R. Fielder
Section 5 - Behaviour:	Mr R.J. Slack-Smith
Section 6 - Exploitation:	Mr A.M. Olsen
Section 7 - Conclusions and Future Prospects:	Dr G.L. Kesteven

APPENDIX II

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APPENDIX III

MEETING PROGRAMMES

The following is an outline of the programme of the meeting. The numbers in brackets are the identification numbers of documents listed in Appendix IV.

October 24

OFFICIAL OPENING - Dr F. Talbot, Director, Australian Museum

INTRODUCTORY ADDRESS - Dr G.L. Kesteven, Convener

ZOOGEOGRAPHY - Australian decapods (ANZDC 67/2/23)
New Zealand brachyurans (ANZDC 67/2/6)
New Zealand macrurans and anomurans (ANZDC 67/2/24)
Provinces (ANZDC 67/2/25, 26)
Penaeids (Species Synopses)
Panulirus (ANZDC 67/2/7)
New Zealand crayfish (ANZDC 67/2/12)
Freshwater crayfish (ANZDC 67/2/13)
Numerical approaches (ANZDC 67/2/22)
Discussion: Numerical approaches, relative growth, and variation
General discussion on special topics or documents.

INFORMAL SOCIAL FUNCTION

October 25

LIFE HISTORY - Introduction (ANZDC 67/1/2A)
Section A of ANZDC 67/1/2B
Section B of ANZDC 67/1/2B
Section C of ANZDC 67/1/2B
Section D of ANZDC 67/1/2B

Reference Documents for Session

Contributed papers: ANZDC 67/2/3, 5, 9, 10, 11, 14, 15, 16, 19, 20
Species Synopses: ANZDC 67/3/1-5, 7-12
Research Situation Reports: ANZDC 67/4/7, 15, 16, 24

October 26

ECOLOGY – Review (ANZDC 67/1/3A)
Topic 1 of ANZDC 67/1/3B: considering long term trends in temperature, current systems, rainfall, silting, denudation, predators.
Topic 2 of ANZDC 67/1/3B: estuaries - crabs, prawn larvae; coastal populations - shifting of range, especially at fringes of area of distribution (banana prawns, Exmouth Gulf; W.A. crayfish, Bunbury; Jasus verreauxi distribution).
Topic 3 of ANZDC 67/1/3B: W.A. crayfish, freshwater crayfish.
Topic 4 of ANZDC 67/2/3B: decline in density leading to increased growth or lower mortality; exploitation changing habitat; exploitation changing predator-prey relations.

October 27

PHYSIOLOGY – Review (ANZDC 67/1/4A)
Moulting hormones (ANZDC 67/2/18)

BEHAVIOUR – Introduction (ANZDC 67/1/5A)
Question 1 of ANZDC 67/1/5B (ANZDC 67/2/2, 4, 5)
Question 2 of ANZDC 67/1/5B (ANZDC 67/2/3)
Question 3 of ANZDC 67/1/5B (ANZDC 67/2/5)
Question 4 of ANZDC 67/1/5B

EXPLOITATION – History and present levels and methods of exploitation

Review (ANZDC 67/1/6A)
W.A. prawn fishery (ANZDC 67/2/21)
Gulf prawn fishery
W.A. crayfishery
N.Z. crayfishery (ANZDC 67/2/8, 17)
Southern crayfishery

Theory of assessment of stock yields

Estimation of population parameters (ANZDC 67/2/16)

Prospects for increasing yields by intervention or culture

Culture of prawns

OFFICIAL DINNER

October 28

CONCLUSIONS AND FUTURE PROSPECTS - Convener's Summary
General Session - to discuss the Convener's Summary and to make decisions concerning future meetings, publications, etc. Working Groups - to consider questions raised by the Convener. General Session - to receive reports of working groups. Closing Session.

APPENDIX IV

LISTS OF MEETING DOCUMENTATION

Papers and working documents were prepared and distributed to meet the needs of the Meeting but were not regarded as formal publications. Indeed, the Meeting in its final session resolved that "no attempt should be made on behalf of the Meeting to publish any of the contributed papers". Except, therefore, for some at least of the species synopses which will be published by CSIRO Division of Fisheries and Oceanography, as part of its species synopses series, no papers can be distributed on behalf of the Meeting. Anyone seeking information on the content of any of the papers listed in this report should enquire directly of the author concerned; addresses are given in Appendix II.

I. WORKING DOCUMENTS

DICTIONARY OF TERMS	Part 1. Decapod Crustacean Morphology, compiled by R.G. Chittleborough
	Part 2. Systematics, compiled by D.D. Francois and J.C. Yaldwyn
	Part 3. Zoogeography, compiled by A.A. Racek
	Part 4. Crustacean Life History, compiled by I.R. Kirkegaard
	Part 5. Populations Research, compiled by G.L. Kesteven
ZOOGEOGRAPHY	
ANZDC 67/1/1A	Review Statement of Research Activity on the Systematics of Australian Decapods
LIFE HISTORY	
ANZDC 67/1/2A	Review Statement on Present Status of Knowledge of Life History of Australian and New Zealand Decapod Crustacea
ANZDC 67/1/2B	Research Topics for Discussion
ECOLOGY	
ANZDC 67/1/3A	Review Statement
ANZDC 67/1/3B	Discussion Topics

PHYSIOLOGY

ANZDC 67/1/4A — State of Australasian Research in Decapod Physiology 1967

BEHAVIOUR

ANZDC 67/1/5A — Notes on Decapod Crustacean Behaviour
ANZDC 67/1/5B — Questions for Discussion

EXPLOITATION

ANZDC 67/1/6A — Review Statement

CONCLUSIONS AND FUTURE PROSPECTS

ANZDC 67/1/7A — Australian and New Zealand Decapod Fauna
ANZDC 67/1/7B — Convener's Summary

II. CONTRIBUTED PAPERS

III. SPECIES SYNOPSES

IV. RESEARCH SITUATION REPORTS

ANZDC 67/4/16 . . . . . R.B. Pike
17 . . . . . A.A. Racek
18 . . . . . E.F. Riek
19 . . . . . D.J. Tuma
20 . . . . . R.H. Walker
21 . . . . . R.G. Wear
22 . . . . . D.J. Woodland
23 . . . . . J.C. Yaldwyn
24 . . . . . I.S.R. Munro