ATOLL RESEARCH BULLETIN

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ECONOMIC DEVELOPMENT OF CORAL ATOLLS

At the first meeting of the Research Council of the South Pacific Commission in May, 1949, the limited, precarious resources of the low islands native people of the S.P.C. Area were recognized, and a plan outlined for their economic improvement. In almost any instance the island population is running close to the limit which possible production has dictated. We are not here concerned with those few, temporarily successful islands where phosphates have given present security. It is the atoll of sharply limited production which we regard as the most deserving of assistance in agriculture, and in economic security.

It is the wish of normal people everywhere to be self sufficient. The atoll people are like that. It is only out of the surplus they can take from their subsistence needs that they acquire money and can participate in the goods the world has to offer. As a general rule their cash comes from copra, from mats or other fibre products, or from shell.

Economic development implies a train of improvements. There is first the greater production in island grown food; the coconut, the breadfruit, taros, sweet potatoes, vegetables and fruits; in swine and poultry. This means increased production per plant. There are no more acres to be added, no more rainfall to be secured, no more earth to be developed. The improvement lies in the biological sciences and the arts of agriculture. To do these things we must know much more about the conditions as they are, the potentials of plants and soils, of animals and feeds, and how to control waste.

The first plan was to study the economic situation in a representative atoll or group of atolls. The island of Tarawa (1°30'N., 173°00'E.) was selected in the Gilberts and Ellice Colony for this pilot project. For administrative reasons the work did not get under way in 1949. The second meeting of the Research Council in August 1950 reviewed the plans, confirmed the original intent, noted the interest of the South Pacific Conference which requested the Commission to give all possible priority to this project, and recommended a budget of £2,800 Sterling.

In December 1950 Dr. Rene Catala and Mme. Catala were employed by the Commission to undertake the economic survey of atolls in the Gilberts. A small agricultural station is proposed which will have a continuing status under the control of the Fiji Experiment Station. Dr. Catala is experienced in tropical agriculture, is an expert in marine ecology, and understands and is sympathetic to the life and necessities of the atoll people. He has obtained leave of absence from the Institut Francais d'Oceanie for this undertaking.

The time is short and the financial resources of the Commission are small. The survey is the beginning of what must be a long program of research and improvement. We are attempting to do for the atoll people in a short time what they cannot immediately do for themselves, but we must extend no false hopes, and make no promises we cannot abundantly keep.

H. G. MacMillan

Pacific Science Board
National Research Council

Symposium on Coral Atoll Research
Honolulu, 5 and 6 February 1951

GEOLOGY AND GROUND WATER OF ATOLLS

The geological problem of the origin of coral reefs and atolls has been one of recurrent interest and great durability, commencing with the famous subsidence theory of Darwin (1837). Both geologists and biologists in the century since Darwin's publication have accumulated facts according to their opportunities and contributed to the discussion. Several divergent theories have been developed including Semper's lagoon-solution theory, Daly's glacial-control theory, and the antecedent-platform theory invoked by Ladd and Hoffmeister, with the greater number of workers supporting either the subsidence or the glacial-control theory. In recent years it has become apparent that for the various observed conditions no single answer may be sufficient, and that the merits of the leading hypotheses vary according to the age of the atoll and its location.

Of necessity the earlier work was largely limited to individual deductions based on the sea-level plans of atolls, very incomplete knowledge of their submarine slopes, and deductions only as to their structure. Increase in the number and accuracy of soundings, both around atolls and over the seamounts that appear to be closely related, has come through improvement in sounding techniques, particularly with the development of the sonic method. There has been increasing emphasis on the ecology of the reef-forming organisms and the environmental aspects of the various processes of erosion and sedimentation. Drilling on Funa-futi, later on the Great Barrier Reef and Kita-Daito-Zima, and last on Bikini has contributed data on the local structure but has not resolved the problem. Various geophysical techniques have been the most recent to be applied, as particularly at Bikini.

Until recently comparatively little attention has been given to the details of structure in the sections of the atolls above and at small depth below sea level in their relation tothe ecology of the subaerial organisms including man.

Three chief lines of study need to be continued:

1. Deep drilling and other crustal sounding investigation by geophysical techniques and bottom coring, under both atolls and seamounts;

2. Geological mapping, both subaerial and submarine, combined with analysis and evaluation of processes;

3. Ecological studies on the islands, on the reefs, and in the lagoons and oceans.

The results of all three must be combined with contemporary tectonic and paleogeographic knowledge to promote understanding of coral reef origins.

Present knowledge of the ground-water hydrology of coral atolls is limited to a few scattered spot observations and a detailed but short-period series of measurements on one island. Apparently with sufficient rainfall, the larger islands of an atoll are capable of maintaining lenses of fresh ground water,

generally of the Ghyben-Herzberg type, though subsurface structure may in some cases introduce complexities in their functioning. Recent studies indicate an important control of vegetation and human ecology by ground-water composition.

Research considered desirable inthe ground-water hydrology of atolls may be outlined as follows:

1. Shallow subsurface exploration to determine in detail the rock types and structure and the shape and nature of the fresh-water lens on enough islands to indicate the expectable range of conditions;

2. Long-term observations on islands with a variety of climates to determine the reaction of the lenses in size, shape, and salinity to tidal and other sea-surface fluctuations and to short-term and seasonal changes in rainfall;

3. Long-tefm measurement of rainfall on enough islands to indicate the distribution of rainfall over the ocean, and compilation of available rainfall data;

4. Pumping tests to determine the safe yield of fresh ground water from atoll islands;

5. Checking and extension of the studies on the ecological controls made by ground water.

Doak C. Cox
Dan A. Davis
Chester K. Wentworth

MARINE ECOLOGY

For purposes of discussing and planning coral atoll research in marine biology the field may be divided into four categories, each highly significant when standing alone but inextricably associated with the others. These are (1) marine biology in relation to native welfare, (2) conservation of marine resources, (3) commercial exploitation of tropical Pacific marine resources, and (4) significant biological problems related to coral atolls.

The first, welfare of native populations, should hold the ranking position in planned investigations of coral atolls. High population densities, infertile soil for agricultural activities, absence of adequate natural resources, and lack of technical knowledge among indigent natives focus greater attention upon the renewable resources available in the marine environment. To this end information should be obtained on native uses of marine products as subsistence or food resources, as implement and decorative resources, and as export or income resources. With respect to subsistence or food resources the following major items must be considered: species used, catch statistics, analysis of marine food requirements per person, methods of collecting or fishing, means of prepatation and preservation of marine products, use of marine organisms for fertilizer or as food for domestic animals, poisonous species, conservation practices, comparison of inhabited and uninhabited islets in regard to the abundance of desirable species, etc. With respect to income resources a broad survey of the abundance of exportable items should be made and then followed up with an economic appraisal of costs of production, available markets, and transportation problems.

From the standpoint of conservation the marine environments are in a healthy condition generally. However, should certain commercial activities ensue, there would be definite need for studies basic to conservation. We need not dwell long upon this subject as pertinent items are considered under other headings.

Commercial exploitation of marine resources is inevitable, indeed, a rather good start in this regard was made by the Japanese prior to 1941. Many problems arise which should be tackled ahead of extensive commercial developments while time is available to legislate conservation measures, rather than to follow with ineffective remedial action in the wake of overexploitation. Studies on the relation of atolls and other mid-oceanic islands to concentrations of tuna and tuna-like fishes, on baitfish species and their abundance in the lagoons of all atolls, on the biology and population characteristics of baitfish, methods of catching baitfish, and possible native participation in a baitfish fishery, on poisonous commercial fishes, on the abundance and biology of trochus and other shells of commercial importance, on the abundance and biology of spiny lobsters, etc.

Coral atolls in particular and the tropical Pacific in general are considered to be the finest natural laboratories for a legion of fundamental biological and oceanographic problems. Important among these are (1) the effect of atolls on the surrounding oceanic environment, from the standpoint of vertical

water movements, concentration of nutrient salts, biotic effects of the dispersal of larval forms produced by inshore or lagoon organisms, and phyto- and zooplankton production, (2) systematics and accompanying zoogeographic interpretations of the Indo-Pacific faunal complex, (3) effects of steady climatic conditions on annual or seasonal rhythms, (4) biology of corals, (5) landward progression of marine species via ocean beaches, (6) ecological aspects of coral reefs, (7) comparative studies on lagoon vs. oceanic plankton, etc.

The foregoing synopses provide a general idea of the nature of marine biological problems of importance to coral atoll research. Since time does not permit a full discussion of them all, those placed on the agenda are considered most timely and stand the best chance of success at the current time with present facilities. Stress should be placed on worthy problems for investigation, rather than on the detailed methods of accomplishing the task.

Agenda

Note: those marked with an asterisk can be accomplished by members of an atoll research team during summer periods.

Native welfare

*1. General inventory of useful species.
*2. Use of marine products for subsistence and income resources.
*3. Methods of collecting and fishing.

Commercial fishing

*1. Baitfish resources.
*2. Reef fish and shellfish resources.
3. Abundance of economically important pelagic fishes in the vicinity of atolls.

Biological problems

*1. Ecology of coral reefs.
*2. Systematics and zoogeography.
3. Animal rhythms in the tropics.
4. Effect of atolls on the oceanic environment.

R. W. Hiatt

LAND ECOLOGY OF CORAL ATOLLS

Ecology is rather an approach than a subject-matter. Factual information from almost all other sciences makes up the raw material utilized by the ecologist, and, in its highest expression, ecology is an integration of all of these subject-matters around the central idea of their interrelationships, with special emphasis on those involving living things.

A natural consequence of this diversity of subject-matter is a tendency for the vast accumulation of information to swamp and obscure the basic patterns of relationship, and to delay the emergence of principles. At the same time, without the enormous amount of information, the actual true patterns of relationship cannot be determined or verified, and the essential complexity of natural situations is not realized.

To lessen this dilemma, it may be useful, as ecological information and thought on a given area or situation develops, to construct, from time to time, tentative or theoretical patterns of relationships and processes embodying and expressing what appears to be likely from the information actually at hand. These patterns can form frameworks around which new data may be assembled as they accumulate, and which may be modified, torn down and reconstructed as the facts demand. They serve to keep the basic relationships in their proper place of importance as information piles up and the picture becomes more complex. One of the most outstanding examples of this was the formulation of Darwin's theory on the formation of coral atolls. This, though dealing largely with a geological subject-matter, was one of the outstanding ecological generalizations of all time. It has been assailed mightily, modified as new data were secured, but has provided a framework for the thinking in an important segment of both marine geology and marine ecology.

It is proposed here to outline briefly a tentative historical ecological approach to terrestrial problems on atolls. Arbitrarily, because it provides a satisfactory geological framework, simplifying the time relationships to where they do not obscure the problem, and because it provides an automatic solution for certain otherwise difficult biological problems before they can even be raised, one of the several alternative geological theories on the origin of land on atolls is adopted. This does not imply acceptance of this theory or loss of sight of its purely tentative nature, and if it were to be abandoned, the only aspect of the pattern here proposed for the land ecology that would have to be modified would be the time relations. Certain other problems, also, would then arise and need solution.

This geological framework postulated, during the post-glacial xerothermic period, an all-time maximum sea-level two or three meters higher than the present one. Postulated also, as a logical consequence, is a wide distribution, in tropical seas, of sea-level banks, living reefs, awash, with no permanent land, excepting possibly occasional isolated dry-land atolls resulting from local elevation.

It postulates, also, a subsequent world-wide lowering of sea-level to the present one, possibly coincident with the accumulation of the Greenland and Antarctic ice-caps.

This would have produced a large series of relatively uniform examples of a new habitat, the atoll islet, available for colonization by plants and animals and for primary vegetation development.

The outstanding characteristics of this habitat were as follows: physically it was flat exposed reef-rock, probably partially covered by rock debris, foramniferal sand, and shells of mollusks. Its drainage was practically perfect down to sea level, its relief very low or none at all. It had a high instability of substratum under influence of wind, storms, and waves, an extremely high insolation, and high surface temperatures. Chemically it was very saline, calcareous, basic, low in iron, high in magnesium and nitrogen, with a little organic matter but no humus. This makes up, on the whole, a highly inhospitable environment for most organisms.

Immediately upon emergence from the sea certain processes commenced which gradually altered this habitat, the alteration being more marked or more rapid in some examples than in others, depending on the climatic and geographic area in which they were situated. The more obvious of these processes may be itemized, with remarks on their effects:

1. Leaching out of the salinity by rainwater, but its continual renewal to some extent by spray and storm waves, as well as diffusion from below sea-level. The more this process proceeds the more species of plants are able to gain a foothold.

2. Piling up of clastic material on seaward sides of islets by storm waves,

3. Piling up of foramniferal sand and finely divided fragments of all kinds of organic calcium carbonate on the lagoon side, and their shifting by wind.

4. Establishment of individuals of the most extremely halophytic of strand plants from seeds cast up by waves or brought by seabirds - such species as Scaevola frutescens, Messerschmidia argentea, Ipomoea pes-caprae, Boerhavia diffusa, Triumfetta procumbens, etc.

5. Visits of sea birds, augmenting the phosphorus and nitrogen content of substratum.

a. Colonization by land-crustacea with planktonic larvae.

6. Gradual building up of a thin lens of fresh or brackish water in the substratum.

7. Weathering of rock by solution and by physical abrasion, resulting in some compaction of soil. Materials exuded from roots of plants, or released by their decomposition might augment this process, as might the actual physical penetration by the roots of porous fragments.

8. Accumulation of fine wind-blown material, caught by plants, resulting in the formation of small dunes and in the gradual assorting of the material from coarse fragments on the windward side to finer and finer sediments to the lee or usually the lagoon beach.

9. Formation of "beach-rock" by cementation of sediments under influence of fresh water, resulting in increased stabilization of substratum.

10. Development of simple plant communities by increase of first colonists and the addition of others with time, possibly several grasses, Fimbristylis, Pandanus tectorius, Suriana maritima, Tribulus cistoides, Wedelia biflora, Ipomoea tuba, and in wetter atolls, Pisonia grandis, Ochrosia parviflora, Barringtonia asiatica, Terminalia samoensis, etc. Most of these are current borne, but the grasses and sedge may be carried by wind and Pisonia certainly by sea birds. These would bring about increased stability of the substratum, which would, in turn, permit increased integration of the communities.

11. Occasional arrival and establishment of terrestrial animal colonists, also fungi, with consequent slow development of a soil biota, and terrestrial biotic communities.

12. Production, over long periods of time, of depressions in the centers of islets, possibly by solution and removal or redeposition in finer form of coarser calcareous material by rainwater and tidal and temperature fluctuations of freshwater lens. If the tidal fluctuation is slight and the material fairly compact, the depressions are muddy; if the fluctuation and water movement is greater, they will be clear and rock-lined.

13. Development and multiplication of the plant communities and their gradual integration into a vegetation. This involves the modification of the environment toward a more stable and more favorable type, also the arrival and establishment of additional species, particularly those whose existence is made possible by the operation of the various processes that help modify the environment, and environmental factors that are dependent on these processes. Some of these are the addition of humus, shade, accumulation of sand, accumulation of guano, stirring by land-crabs, decrease of salinity, protection from wind, formation of muddy depressions, etc. Community development would culminate, theoretically, in the establishment of a more or less mesophytic forest of Pisonia, Ochrosia, Ficus, Calophyllum, Guettarda, Pandanus, Hibiscus, with epiphytic and terrestrial herbs, ferns, mosses, and wood-destroying fungi.

14. Development, under influence of mesophytic forest and soil biota, of a brown forest soil.

15. Gradual development, under the influence of varying salinity, slight variations of surface and elevation, gradation of size of materials from seaward boulder-rampart inward, and distribution of wet depressions, of a pattern in the arrangement of the plant communities that, while subject to much local variation, as well as regional variation due to climate, is rather characteristic of atoll vegetation.

The development of a normally complex flora and fauna, and consequently, of a normally complex vegetation and mosaic of biotic communities, is drastically controlled by a series of limiting factors inherent in the atoll environment and situation. These may be enumerated, noting such of their effects as may not be obvious.

1. Barrier of sea water and distance from sources of suitable species. This would vary in intensity with location, but would certainly be at least somewhat of a retarding factor to every group of organisms except sea birds and land crustacea with planktonic larvae.

2. Proximity of sea, with consequent high average level of salinity. A great many organisms simply cannot tolerate, physiologically, this condition.

3. High temperature, preventing much humus accumulation except under saturated conditions. The soils take a long time to become fit for the growth of most plants.

4. Uniformity of topography, original substratum, and early biotic colonization, limiting the number of ecological niches available.

5. Iron deficiency, due to high pH and possible lack of iron in original material. Many plants cannot thrive without more available iron.

6. High average incidence of typhoons and hurricanes with attendant destruction of biotic communities and frequently destruction or severe alteration of the substratum itself.

7. Probable short length of geological life of any given land surface. This lessens or eliminates the gradual accumulation, with time, of suitable species by chance, and greatly lessens the chance of local endemic species developing.

8. Relative youth of this habitat as a whole. This, also, would preclude any complexity that is dependent on great lengths of time.

The next era in the history of atolls started with the arrival of man. He came needing food and space in which to live, as well as materials for his arts and manufactures. These had to be supplied by the environment. A certain amount of direct alteration of the environment was inevitable.

With him came rats, lizards, flies, coconuts, breadfruit, Morinda, Eugenia, taro and taro-like plants, and possibly Tacca, and, at least in some regions, pigs and dogs. The introduction of these dependents of man undoubtedly resulted in the rapid destruction of many colonists which were precariously near the limits of their tolerance of this environment, or which were the natural prey of the animals, as well as the possible increase of certain ones for which the conditions were improved by the changes.

There was a gradual destruction of the most mesophytic vegetation on the most fertile soil, and substitution for it of forest of coconut palms or of a coconut-breadfruit forest with a sparse understory of Pandanus, Morinda, etc. Taros were planted in the muddy depressions, and gradually these were enlarged and elaborated into excavations.

The sea bird populations were reduced by the rats, hogs, and dogs, and their breeding areas were restricted to certain islets. This resulted in a reduction of the flow of phosphates and nitrogen to the soils of most islets.

As populations increased, the taro excavations were enlarged and their muddy soil turned into a muck by throwing in coconut refuse and other organic materials to increase the humus content. Other plants are brought to the atolls from nearby high islands and cultivated in these swamps. They become, in many regions, a basic part of the food supply, though in drier atolls, this method of taro culture did not prove feasible.

The populations tended to increase and exert pressure on the environment, but there was much fluctuation because of wars, typhoons, and other disasters.

Many of the driest atolls could not support a human population and were never successfully colonized or were later abandoned.

The arrival of European man brought on another era. Human diseases and disease carrying insects were introduced, and the native populations decreased rapidly in most areas. More aggressive species of rats were introduced, resulting in further reduction of native biota. Insects that attacked coconuts arrived in some places.

There was a rapid increase in coconut plantations and destruction of the native forest on the less fertile soils. Both this forest and the native coconut plantation were replaced in many areas by more orderly and efficient commercial plantations. The practice of burning organic refuse was introduced in some places, resulting in a less fertile soil. The diet and requirements of the natives began to undergo a change, with substitution of foods that could be bought with the proceeds of the sale of copra for those produced by the people or caught in the sea. The same occurred to an even greater extent in articles manufactured for other uses than food.

The series of world wars accentuated these tendencies in some areas, retarded them in others, and on many islands converted large areas into barren, unproductive air-strips or bases.

Ecological relationships on atolls are now in the midst of changes whose direction and probable effects must be studied to be understood.

This generalized picture of atoll ecology, from a historical slant, suffers most seriously from underemphasis of the regional differences resulting from variation in amount and seasonal distribution of rainfall and from distance from large land masses which serve as a source of colonizing plant and animal species.

These differences may be epitomized by saying that in drier regions the development of communities cannot go on to the stage attained on the wetter atills, that the faunas and floras are much smaller, the vegetation sparser and more scrubby, human influence is usually less or negligible, sea birds are much more numerous; the farther an atoll is from large land masses the smaller will its fauna and flora be in comparison with otherwise similar atolls that are closer to such land areas.

Though the picture presented here may seem to some to represent adequate knowledge and understanding, it must not be forgotten that it is purely theoretical, based, to be sure, on observations on many atolls, but on no direct historical evidence. Research is needed on all points of it to confirm or alter the propositions made here. The most urgent needs seem to be more complete inventories of the biotas and descriptions of the vegetation of most of the atolls, and a few strategically placed detailed and thorough studies of all aspects of atolls of widely different types and geographic areas.

It must be reiterated that atoll ecology is dependent on data from all other fields of atoll research, and that deficiencies in the information on any other aspect will reflect themselves in less reliable understanding of the ecology.

F. R. Fosberg

MAN IN THE CULTURE-ENVIRONMENT RELATIONSHIP

Coral atoll research may be related to the problems of human existence in a practical sense or in a theoretical sense. The practical approach is concerned with short-term studies of specific island communities under stress conditions which, in the Pacific, may be due to (1) the need for rehabilitation in areas disrupted by the war, (2) the limitations of food and other resources where populations are increasing beyond the capacity of the local environment to support them, and (3) the changing cultural and environmental conditions as provoked by the encroachment of Western civilization. The theoretical approach may result in significant contributions to a more complete understanding of the interaction and interrelationships which exist between man, his culture, and his natural environment. Some general principles may be formulated about the processes and dynamics of human adjustment to environmental conditions.

Coral atolls are notoriously small in land area and poor in natural resources. A delicate balance between man and nature must exist inevitably in such marginal regions. In order to recommend changes in stress situations, it is essential to understand the factors which operate to produce imbalance, and the processes whereby harmonious adjustment between human populations and their environments can be achieved. In coral atolls, the environmental conditions are relatively simple and comprehensible, and because of their relative isolation lend themselves better to study and analysis of operative factors for adjustment. A series of coral atoll studies in different regions and with different populations could well provide the laboratory conditions desired by scientists for controlled studies of culture-environment interrelationships. Anthropologists have long denied the dictatorial role of natural environment in the shaping of cultures. There is need, however, for reexamination of basic similarities where they occur in cultural adjustments to a given environment. There is need also for cooperative scientific research inthe various disciplines to supplement the anthropogeographic investigations which in themselves cannot explain the human situation in its total environmental framework.

In specific situations, such as Arno Atoll and its Marshallese inhabitants, specific data were required in anticipation of administrative measures to be undertaken in the interests of the islanders' welfare. The 1950 Arno expedition resulted in a general, though still somewhat superficial, understanding of the major problems in cultural adjustment of Arnoese to their environment. With more time available in the future, local differences within the atoll can be studied more intensively, as can also the more exact relationships between Arnoese individuals and communities and the various components of their environment. Recommendations have been made for ameliorative measures in the case of the Arnoese, but there is need for further research at Arno to study the efficacy of such measures as may have been enacted, and the accuracy of the observations on the basis of which these measures were recommended. Other short-term studies are required of coral atoll situations in the Carolines, the Gilberts, and the Tuamotus, in order that more can be learned about the use and adaptation of local beliefs, attitudes, habits, and institutions for improving the welfare of island peoples in these surroundings. Suggested focal points for investigation by teams of scientists from various disciplines are:

the relation between population dynamics and the functioning of land tenure systems;
land use in relation to spatial factors and the presence of various types of island resources;
conservation of food resources in anticipation of seasonal shortages and famine periods;
regulation of population growth in relation to current technological utilization of resources; and
cultural changes as reflected in changes in the natural environment.

Proposed agenda:

1. Short-term, practical research:
   - Areas in need of attention due to stress conditions.
   - Manner of making recommendations of specific measures to ameliorate conditions of stress.
   - Follow-up on efficacy of measures enacted.

2. Long-term, theoretical research:
   - Standardization of field procedures and topics for investigation, for comparative purposes, in any series of coral atoll studies.
   - Representative atolls which might be studied.
   - Theoretical problems to be investigated within the framework of culture-environment relationships.

3. Cooperative research techniques and methods.

Leonard Mason

Pacific Science Board
National Research Council

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CORAL ATOLL BIBLIOGRAPHY

The following are topics proposed for discussion during the symposium:

1. Importance. (This has been covered fully in Dr. Fosberg's paper prepared for the symposium in Washington)

2. Scope of atoll bibliography.

a. Definition of "atolls." (It has been suggested that raised and sunken atolls be excluded; likewise atoll-like barrier reefs, such as Truk, and coral islands on the Great Barrier Reef and near continental masses. This leaves what W. M. Davis calls "sea-level atolls." Even these range from the isolated, low, sand or "pancake" islet, without lagoon, like Jarvis, Vostok, Baker, Kili, etc., to the lagoon surrounded by a reef without land. Further discussion on this is desired.)

b. Geographical location. All atolls are located between the "Tropics" and chiefly in the Pacific and Indian Oceans. Report will be given on the catalog of atolls which has been compiled by the writer.

c. Subjects to be included. Discussion of Dr. Fosberg's major categories.

(1) Marine geology. (Under this seems to be included all the voluminous literature on the formation of coral reefs and atolls and their foundations, which subjects are included, up to 1928, but without abstracts, in W. M. Davis' large book. Need here is to abstract those pertinent to this bibliography listed here and all which have appeared since.)

(2) Marine ecology. (Many papers in this large field have a place in this bibliography; the problem is to determine which, and to abstract and index these.)

(3) Land ecology. (Dr. Fosberg notes such subdivisions as geography, land geology, climatology, water supply, soils, fauna, flora - including economic plants, and uses made of natural resources by the people.)

(4) Anthropology. (This covers all phases of human culture, history, and administration. It approaches (2) and (3) in man's utilization of plant and animal life, both on land and in the sea.)

3. Progress on atoll bibliography prepared to date:

a. Report by Dr. Fosberg on work done by the Pacific Vegetation Project.

b. Report on bibliographic facilities available in Hawaii.

c. Bibliographic data on atolls known elsewhere.

4. Remaining to be done:

a. Continued search for and abstracting of pertinent abstracts.
b. Completion of an inclusive subject index.
c. Reproduction and distribution of product.
d. Provisions for supplements.

E. H. Bryan, Jr.