Chapter 8 -- Marine Ecology

INSTRUCTIONS FOR MARINE ECOLOGICAL WORK ON CORAL ATOLLS

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INTRODUCTION

These instructions are designed for studies of only a few months' duration and to cover the most important ecological features in a manner which permits comparison of atoll communities. The studies outlined may be made with a minimum of equipment and personnel, for only on rare occasions would an ecologist have an opportunity to take all the equipment and have all the assistance required to do a more intensive job. These instructions are, therefore, pointed toward meeting the problem of working in the field in the most practical manner possible with a minimum of equipment and assistance. Methods of collecting on coral reefs and of preserving animal species are discussed in separate sections of this handbook.

CHECK-LIST OF ESSENTIAL EQUIPMENT

Clothing

Canvas gloves (1 pair for each two weeks in the field)
Canvas wading shoes (1 pair for each three weeks in the field)
Swim trunks (several pairs)
T-shirts or other shirts (to be worn both in and out of the water)
Hat with good sun visor
Heavy shoes for hiking
Other suitable clothes for travel and casual wear

Drugs and first aid material

First aid kit (include ready-made bandages, gauze, adhesive tape, merthiolate, sulpha salve, and antibiotics)
Aspirin
Chlorine tablets for purifying drinking water
Sun-burn preventative

Collecting equipment

Inner tube and canvas float
Face masks (at least two)
Swim fins
Geology pick or similar instrument
Pinch bar, small
Swimming bag (canvas body, fish net bottom and heavy zippered top opening)
Canvas buckets
Dip nets ($\frac{1}{2}$ inch stretch mesh; 1 foot in diameter)
Shovel, short-handled
Cord, coil of small diameter cord or rope
Hunting knife and scabard
Kerosene mantle-type lanterns (take spare generators and alcohol for starting them)

Collecting equipment, (cont'd)

Flashlight (plenty of spare batteries and spare bulb)
Glass-bottom box (not essential if proficient with a face mask)
Shielded thermometers (three)
Portable tide guage (very useful, especially where tidal data are lacking)
Small framed mirror etched with carborundum
Rotenone, freshly ground cubé root (Fish-tox, a wettable preparation from Standard Supply Distributors, Wenatchee, Washington, is preferable
Hand leveling instrument
Metal rule, six foot

Preserving materials and equipment

Metal gallon and two gallon cans of non-corrosible material (make use of empty food cans temporarily in the field)
Formalin, five to ten gallons, preferably in small containers
Alcohol and glycerine (5%), two or three gallons
Magnesium sulphate, ten pounds
Chloretone, small bottle
Cheesecloth for wrapping specimens, two bolts
String for tying labels and specimens, one skein
Parchment paper for labels
Heavy manilla labels, 1" x 2"
Stainless steel leader wire for tying labels to coral specimens
Pliers, with cutter blades
Vials, homeopathic, one gross each of 1, 2 and 8 dram
Corks for vials
India ink and pens
Bakelite top bottles, 4 dram (for salinity samples)
Hypodermic syringe, 50 cc., and needle, 18 ga.

Field laboratory equipment

Reference books on taxonomy (see annotated list)
Long forceps
Dissecting instruments
Dividers
Foot rule, metric
Glass slides and coverslips
Syracuse watch glasses
Stacking dishes
Data books
Blank cards, several hundred
Pencils

INITIAL SURVEY OF REEFS

Land area on atolls is small but reef area is extensive and variable in composition. Since growth characteristics of coral species are closely linked to environmental conditions, especially as regards movement of water, it is to be assumed that a great variety of kinds of coral reefs, sand and muck flats, and gravel or boulder shores will be present. Naturally the complete ecology

of an atoll would not be understood without analyzing the interaction in and between each marine biotope. However, the time, distance from research centers, and limited personnel involved preclude such a complete study. The investigator must, therefore, size up the entire reef and shore area so that intelligent selection can be made of working areas.

Listed below on a pricrity basis are a few things to consider as criteria for selecting a special section of the reef or shore for investigation.

1. The area should be typical of a large proportion of the reefs and shores of the atoll. This means that minimally a section or sections would have to be selected from both the sea and lagoon reefs and across the island from shore to shore.

2. Extremely wide reefs should be avoided unless they are distinctly typical. Usually the same zonation may be found in narrower reefs, thus facilitating the collection of data in a briefer period of time.

3. The areas selected should be relatively free from heavy waves during periods when collections and observations are to be made.

4. The study areas should be as close to the base camp as practicable. Usually this is not entirely possible because of the differences in the sea and lagoon reefs. If the two study areas must be some distance apart, the base camp should be nearest the study area on the sea reef, because transportation along the sea reef about an atoll is often impossible, whereas native canoe transportation in the lagoon is feasible.

THE TRANSECT METHOD

Its Value

The ecological transect seems to provide the best working procedure for the study of coral reef areas. Not only is it possible by such concentration in area to secure a better qualitative picture but it is the only method by which a quantitative analysis may be made. The latter point is significant in that most invertebrates closely inhabit certain coral species and these coral species are zoned across the reef flat and down the sloping reef edges. Moreover, the fishes are tied ecologically to particular facies in the reef biotope and such relationships are best illustrated by treatment of data gathered from particular quadrats within the transect. Any other means of collecting data will fall short of the critical analyses made possible by the transect method. It is desirable, once the collections and observations in the transects have been made, to make general observations on other reefs and shores for purposes of general comparisons with the more detailed data. In this way a better understanding of similarities and differences from one region to another will be secured.

Procedure in Laying Out Transects

From a point at the upper edge of the beach where the terrestrial flora meets the sand or rocks, lay out a line down the beach and across the reef to its outer edge. Place markers at equal intervals along this line. These may be at 50, 100 or 200 foot intervals, but keep them equal. Use sticks well propped up by rocks, or use piles of rocks for markers. Now move horizontally from this line 50 or 100 feet and place similar markers along a similar line. This will segregate the beach and reef area into square or rectangular quadrats of equal area. Give each quadrat a code number in your notes. All collections and observations should be made within these quadrats and the specimens should be labeled as to the quadrat in which they were taken.

Collecting Data

Physical and chemical data

Temperature readings and samples of water for salinity determinations must be taken in each quadrat during both high and low water, and during morning and afternoon periods in order to measure the limits of variation. If especially low tides occur, every effort should be made to get temperature and salinity data. Tidepools in the intertidal zone should be visited for such collections approximately hourly on especially warm days.

TEMPERATURE readings should be taken in each quadrat with a shielded thermometer held at the upper level of the coral heads. During low tides this may be done by wading, but often at high tide the readings must be taken while swimming. In the latter case the best method is to wear a face mask, lower yourself to the coral and hold there, with one hand grasping the coral and the other holding the thermometer in place. After a half to one minute read the thermometer in place. For recording in the water one may use a small framed mirror, the face of which has been etched with carborundum so that a lead pencil will mark it. Use an ordinary pencil wrapped with electricians rubber tape. Tie the mirror and pencil onto the inner tube float which should always be tied to the observer with a short rope. The code numbers for the quadrats can be written on the mirror before entering the water, then only the thermometer reading need be recorded while swimming or wading. For the quadrat which includes the outer edge of the reef and the descending reef slope, a surface reading should be taken with the thermometer held about two feet below the surface. A deeper reading down the slope should be taken because it will represent the closest to oceanic or mid-lagoon conditions that the investigator will be able to get on the transect. The simplest way is to skin-dive down as far as you can, hold onto a rock or coral head with one hand and hold the thermometer in the other. Read the temperature after a half to one minute at that level. With a little practice one should be able to lower himself fifteen to twenty feet for this purpose.

SALINITY samples should be collected concurrently with the temperature records. The volume of sea water collected depends upon the method used to determine salinity. Experience has shown that the Wheatstone Bridge and similar electro-chemical indicators are not suitable for work in the field under conditions met on atolls, since the high humidity soon shorts out the mechanism.

However, it is often desirable to know something of the characteristics of the water while in the field. The only suitable method for making these determinations is the silver nitrate titration method, so take along sufficient 0.5 Molar Ag NO_3, 5% potassium chromate, and the necessary glassware to make a few determinations in the field. Use 25 or 50 cc. medicine bottles with bakelite screw tops for the water samples. Place labels containing the date, tide and quadrat code number in the bottle before entering the water. These bottles may be packed in small compact containers and returned to your institutional laboratory for titration later.

OXYGEN and HYDROGEN ION concentrations need not be recorded in ecological studies on coral reefs, since they are without significant variation.

PHYSIOGRAPHIC features such as levels of reef rock and tops of coral growths in certain instances are significant in relating coral zonation to environmental factors. These data may be determined by establishing an arbitrary bench mark, if an official one is not present, and mapping the contours with a hand-leveling instrument and a jury-rigged surveyor's staff. In certain localities tidal records will be unavailable, and in other localities such records as are available are grossly inaccurate. In order to establish the tidal information desired, and incidentally to refer the bench mark used in ascertaining the reef contours to tidal data, it is desirable to construct and take along a portable tide guage. The type described by Wentworth (Jour. Washington Acad. Sci., 1936, 26(9): 347-352) has proved simple to construct, easy to operate and sufficiently accurate.

<u>Biological data</u>

FISH are collected adequately only by the use of rotenone or <u>Fish-tox</u>. (See instructions for collecting fish.) Rotenone may be obtained in ground, powdered form in a concentration of about 5% at almost any firm, manufacturing insecticides. If the powdered form is to be used. it must be freshly ground and used in a few weeks. <u>Fish-tox</u> is more satisfactory for longer periods in the field. Two persons can poison an area of about 7,500 to 10,000 square feet and do a fair job of picking up the fish. A smaller area is preferable. Do not poison the area if the tide is too low, as most of the fish found in the quadrat when the tide is higher will have gone over the edge of the reef. It is best to poison about mid-tide as it is receding. This will leave adequate depth of water and the force of the waves and the surge will be subsiding rather than increasing, factors of great importance in picking up the dead and dying fish.

The fish should be collected quadrat by quadrat, taken back to the field laboratory and processed, and those not preserved or used otherwise should be returned to the water where they will be quickly devoured. An important point to have in mind is that the natives will be greatly interested in this phenomenal method of collecting fish. Great care should be taken not to poison fish indiscriminately or too near human habitation, because native subsistence depends to a great extent on the reef fishes and you must maintain happy public relations with them. Always give the natives edible fish which you do not wish to keep for later study. Local native customs will dictate how the distribution of fish will be made.

Invertebrates should be collected or noted quadrat by quadrat also. Instructions for collecting in particular types of marine environments and for special groups of animals will be found in another section of this handbook.

ANALYSIS OF DATA

Physical and chemical data

All physical and chemical data should be analyzed and presented in the usual acceptable manner, keeping in mind that comparisons and correlations will provide the most useful data for interpretation of biological phenomena. Raw data should always be tabulated and included in an appendix to any report. Graphic means of presentation are usually best for summary analyses in the main body of the report.

Fauna and flora

Two considerations should be prominent in handling these data. First, the animals present should be identified with accuracy, preferably checked at least by leading taxonomic specialists. Second, their ecological relationships should be described.

The first consideration does not require elaboration, except to say that specimens should be preserved for identification in the best manner possible under field conditions.

Collections made as quantitatively as possible in quadrats described in a transect naturally lend themselves to analysis in a number of ways. Quantitative and qualitative patterns of distribution by phylogenetic groups and by species may be made in relation to physiographic features, physical and chemical aspects of the environment and special biocoenoses within the general coral reef biotope. Zonation horizontally and vertically is readily designated. Biological phenomena on lagoon reefs may be compared directly with sea reefs, and various exposures of reefs on which such transects are made may be readily compared for a better understanding of factors underlying distribution and abundance of reef species.

Useful Field References

Generally speaking, positive identification in the field is difficult and should not be a prime objective of the investigator. However, it is desirable, where possible, to make tentative determinations. Unfortunately, the Pacific region is singularly lacking in faunal and floral handbooks, so recourse must be made to original taxonomic papers. The following list is highly selected for field use and omits monographic works or less extensive works which would not prove practicable to carry into or use in the field.

Fish

Hiyama, Y. 1943. Poisonous fishes of the South Seas. (In Japanese). 136 pp.

Illustrations are excellent and valuable in dealing with fishermen. A translation is available, but it is not needed.

Schultz, L. P. 1943. Fishes of the Phoenix and Samoan Islands collected in 1939 during the expedition of the U.S.S. "Bushnell". Smithsonian Institution Bull. 180: 316 pp.

Currently a basic work for any taxonomic study. Has good keys which incorporate descriptions of the fishes. Does not cover certain large groups such as the scarids, lutjanids, and serranids, and other literature should be used for them.

Smith, J.L.B. 1949. The sea fishes of Southern Africa. Central News Agency, South Africa, 550 pp.

Beautifully illustrated and contains a key to all species listed. While it covers many fishes not found in the Central Pacific, it is nevertheless invaluable to an investigator not well-versed in Central Pacific forms.

Tinker, S. W. 1944. Hawaiian fishes. Tongg, Honolulu, 404 pp.

Illustrations make this useful in dealing with fishermen.

Umali, A. F. 1950. Key to the families of common commercial fishes in the Philippines. Research Report 21, U. S. Fish and Wildlife Service, U. S. Dept. of Interior, 47 pp.

This key to the families should prove very useful to an investigator not familiar with Central Pacific forms.

Weber, M. W. C. and L. F. de Beaufort. 1911-1940. The fishes of the Indo-Australian Archipelago. Vol. I- IX, E. J. Brill, Leiden.

This series of nine volumes serves to supplement Schultz in regions west of Samoa. It is considered basic, although its keys and descriptions are not always adequate.

Invertebrates

Echinodermata

Clark, H. L. 1914. Hawaiian and other Pacific Echini. Mus. Comp. Zool., Mem. 46(1): 1-78.

_____ 1917. Ibid., 46(2): 79-283.

The most concise account of Pacific Echini. Mortensen's monograph is recent and more complete, but is hardly a field reference.

Clark, A. H. 1949. Ophiuroidea of the Hawaiian Islands. B. P. Bishop Mus., Bull. 195: 133 pp.

Includes many widespread Indo-Pacific species.

Fisher, W. K. 1907. The holothurians of the Hawaiian Islands. U. S. Nat. Mus., Proc. 32 (1555): 637-748.

Includes many widespread Indo-Pacific species (except apodous holothurians).

Fisher, W. K. 1919. Starfishes of the Philippine seas and adjacent waters. U. S. Nat. Mus., Bull. 100(3): 712 pp.

The best general account of widespread Indo-Pacific species.

Mollusca

Hatai, K. 1941. Recent marine shell bearing Mollusca of the South Seas islands. Inst. Geol. and Paleon., Tohuku Imp. Univ., Sendai, Japan. One vol. and atlas of plates.

Fine illustrations for field identification but quite incomplete. Other volumes are to follow.

Hirase, S. 1936. A collection of Japanese shells. 5th ed. Matsumura Sanshodo, Tokyo, 217 pp.

An excellent treatise with photos in color of many common gastropods and pelecypods of the Indo-Pacific area. The nomenclature should be checked with specialists.

Robson, G. C. 1929. A monograph of the recent Cephalopoda. Part I. Octopodinae. British Museum, London.

_____ 1932. Ibid., Part II. Octopoda. (except Octopodinae). Op. cit.

This is the best treatment of the Octopoda. Unfortunately there is no similar treatise available for the Decapoda.

Arthropoda

Kemp, Stanley 1913. An account of the Crustacea Stomatopoda of the Indo-Pacific region. Indian Mus., Mem. 4: 217 pp.

Most useful taxonomic account of Indo-Pacific stomatopods.

Miyake, S. 1943. Studies on the crab-shaped Anomura of Nippon and adjacent waters. Dept. Agric., Kyushu Imp. Univ., Jour. 7(3): 49-158.

Excellent account of many of the porcellanid crabs of the Indo-Pacific.

Pilsbury, H. A. 1916. The sessile barnacles. U. S. Nat. Mus., Bull. 93: 1-366.

Sakai, Fune. 1936. Studies on the crabs of Japan. I. Dromiacea. Zool. Inst., Tokyo Univ. Lit. Sci., Sci. Rep. (B) 3(supp. 1): 66 pp.

_____ 1937. Ibid., II. Oxystomata. Op. cit. (suppl. 2): 67-192.

_____ 1938. Ibid., III. Brachygnatha, Oxyrhyncha. Yokendo, Ltd., Tokyo, 193-364 pp.

_____ 1939. Ibid., IV. Brachygnatha, Brachyrhyncha. Op. cit., 365-741 pp.

These volumes are the most useful in identifying crabs in the Central Pacific area.