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THE SMITHSONIAN OCEANOGRAPHIC SORTING CENTER A RESPONSE TO THE INTERNATIONAL INDIAN OCEAN EXPEDITION*

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ABSTRACT

The Smithsonian Oceanographic Sorting Center (SOSC) was established in December of 1962 in Washington, D. C. The Center came into existence as a service unit to receive, sort and distribute to specialists the mass of uncommitted natural history material expected from United States participation in the International Indian Ocean Expedition (IIOE). The bulk of samples received were collected on the cruises of the research vessels, ANTON BRUUN and TE VEGA, supported by the National Science Foundation.

The vast amount of records handled by SOSC has necessitated initiating an automatic data processing (ADP) system. A catalogue has been prepared on taxonomic names, reduced-data and field-data-log formats have been devised, and code systems for institutions, expeditions, vessels and collecting gear have been developed. Many tons of material, comprising 5,965 samples, were received by SOSC from the IIOE. Over 4,500 samples have been sorted into 3,653,000 specimens. About 1.5 million IIOE specimens have been despatched in 759 shipments to approximately 140 specialists in U. S. A. and 17 foreign countries. Based on training for, and experience gained in, sorting IIOE collections, SOSC has pursued an active program in processing samples from all of the world's seas.

INTRODUCTION

OCEANS and their basins are a vast frontier for exploration. Knowledge and intelligent exploitation of these resources are of inestimable value in understanding evolutionary processes of our earth and providing minerals and foods for exploding human populations. Ocean studies have expanded rapidly during the past 25 years and have resulted in an increased number of research vessels and oceanic expeditions. The collection, handling and distribution of samples and data taken during these expeditions have become an ever-increasing burden to marine scientists. Each sample represents a unique place and time in a changing environment, is generally irreplacable, and collected at considerable expense and difficulty. Because of the difficulty, time and expense often required to process a natural-history collection, the components may not be available to study for years—if at all. Frequently, only a segment or taxonomic group of special interest is sorted from a sample, and much of the material is never utilised or made available to other investigators.

The Smithsonian Oceanographic Sorting Center (SOSC) was established in Washington, D. C., as a national service facility in December of 1962. Its primary mission was to aid ocean studies by accelerating the systematic processing of biological and geological collections and distributing the sorted groups to interested

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scientists around the world. Policy guide lines for operating the Center were developed by 46 leading scientists with an interest in taxonomy at a ' Conference on Distribution of Specimens ' held in Washington, D. C., in December of 1963. The conferees provided recommendations on the necessity of technical research on curatorial matters, techniques and level of specimen sorting, disposition of sorted specimens to qualified specialists, and the intermediary function in curating and redistributing ' defunct ' collections still possessing scientific value. Perhaps the most important suggestion was that SOSC establish advisory committees to aid in evaluating specimen requests and to maintain a salutary degree of control over the activities of the Center.

Receipt of Collections

The Smithsonian Oceanographic Sorting Center was conceived as a service center to receive, sort and distribute the mass of uncommitted natural history material expected from the United States' participation in the International Indian Ocean Expedition (IIOE). The bulk of IIOE samples received by the Center was collected on the cruises of the research vessels Anton Bruun and Te Vega, supported by the National Science Foundation. In addition to the extensive collections received from the IIOE, the Center has received material from over 100 other major collection sources, representing polar, temperate, and tropical habitats, and including both coastal and deep-sea specimens. Several important ' defunct ' collections have been sent to SOSC from the Great Lakes of North America, the Gulf of Alaska and the South China Sea. The Center is currently receiving extensive collections from the U. S. Antarctic Research Program of the National Science Foundation. The present holdings of unsorted material would require about 275 man-years to process. Specimen shipments arrive in a bewildering variety of containers such as boxes, bags, cans, fibredrums, metal barrels, freezer trucks, and in sizes from a small parcel containing a single vial to crane-lifted sea vans.

Responsibilities of the Center begin at the time of specimen collection, continue through the processing of samples and distribution of specimens and data until the material is identified, reported in scientific publications and finally deposited in a museum collection. If requested, SOSC may provide field data sheets and notebooks for shore collecting, record forms for collections from shipboard, and labels and other accessories for recording essential collection data. Suggested preservation and packaging techniques and also collection, curatorial and shipping supplies for handling of specimens are made available when possible to cruises and expeditions. A shipment received at the Center is assigned a reference number for purposes of inventory and allocating shelf-storage space. Incoming shipments are unpacked, checked against invoices and field record sheets, labels and preservative replaced where necessary, and collection material placed in proper containers. Unsorted collections remain but temporarily at the Center for processing until sorted fractions or subsamples can be despatched to investigators for research or be transferred to a permanent home in a scientific collection or museum. The Center does not retain title to any material it receives, and sorted specimens are distributed according to commitments made by expedition leaders and collection donors or by suggestions of SOSC Advisory Committees.

Sorting of Samples

The heterogeneous collections processed by the Center require a division of labour and skills; thus, newly-received samples are taken from the unpacking table or temporary holding shelves to the various sorting sections for processing. Although the bulk of the samples sent to SOSC for sorting are marine, the Center also processes brackish, fresh-water and terrestrial collections. Sorting at SOSC is a balance between the capabilities of the technicians and the requirements of receiving specialists. Generally macroalgae are requested from the Center in taxonomic units from family to genus level, invertebrates in units from phylum to family, and larger fishes at family or genus level. Because of their minute size and the special fixing and mounting requirements by phytoplanktologists, phytoplankton is not sorted at the Center, but is despatched in subsamples. Zooplankton is sorted to about 60 categories and larger benthic invertebrates to 120 or more groups. Since the youngest stages of fishes are difficult to identify, they are usually categorised only as ' larval fishes ', while juvenile and adult fishes can be sorted to species level. Only preliminary efforts have been made to sort shells and shell fragments from marine sediments; cores are split longitudinally for study and distribution. Oceanic rocks are examined for physiography, mineralogy and lithology; rocks are cut and slices ground to prepare thin sections, which are described according to lithology prior to distribution to specialists. Samples are processed in the appropriate sorting sections, where each specimen category and count is recorded on a work sheet containing the pertinent collection or field data. The completed work sheets are delivered to the Records Section, where permanent specimen labels are prepared on automatic typewriters and the correlated sorting and field data are captured on punched paper tapes for feeding into magnetic computers.

Botany Section

The microscopic algae or phytoplankton samples, which have been collected by very fine-mesh nets, are split into halves at SOSC. One half of each unsorted sample is transferred to the Invertebrates Section for zooplankton analysis, and the other is destained for microalgae specialists. Subsamples may be drawn from the unsorted phytoplankton samples as long as the supply lasts. A plastic, peel-a-way blood-sampler-syringe is used to draw a 10 cc subsample. The plastic syringe is dipped into a quick-drying adhesive, which forms a liquid-tight coating. The coating is easily peeled off when the specialist is ready to use the subsample. This reasonably-accurate and quick method of obtaining and holding a subsample of phytoplankton reduces the possibility of sample contamination or container fracture during shipment.

Macroscopic algae are received by the Center preserved in formaldehyde solution or in dried condition in plant presses. The collections are sorted to genus level where possible. A portion of each sorted sample is placed in 7% buffered formaldehyde solution for microscopic analysis, while the remainder—when sample size permits—is mounted and dried on herbarium sheets for gross examination. Coralline algae are first washed in water, air dried and then separated into crustose and articulated forms. A cross section of each piece of air-dried coralline algae is stored also in glycerine-formaldehyde solution for microscopic analysis. Marine fungi are kept in liquid preservative only, while marine angiosperms are sorted to genus and mounted on standard herbarium sheets. Increasing numbers of terres-

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trial plants are being received at the Center. Lichens and bryophytes are air dried for preservation. Currently the Botany Section is distributing plant specimens to 26 specialists : one for marine fungi, one for marine angiosperms, two for bryophytes, three for lichens, five for microalgae and 14 for macroalgae.

Invertebrates Section

Collections of zooplankton, macrobenthos and meiobenthos are channeled into the Invertebrate Section for processing. A whole zooplankton sample generally consists of half a liter or more of minute organisms, while a midwater-trawl sample often exceeds several liters. Half a liter of tropical plankton may contain tens of thousands of organisms, and sorting such a whole sample to about 60 categories could require up to two months of skillful work. Recognition of zooplankton is complicated by morphological differences between young forms and adults, between sexes, and among larval stages of the same species. In order to accelerate the sorting of plankton samples, technicians must work with statistically-representative subsamples instead of with whole samples. The settled volume of each whole sample of zooplankton is measured quickly by a scale. The whole sample is then poured out into a tray where all large or conspicuous organisms are removed until the zooplankton is relatively homogeneous. This residue is successively subsampled in a Folsom Plankton Splitter to obtain a subsample of approximately 10 cc settled volume, which can usually be sorted completely in one day. If a whole sample is 14 cc or less, it is sorted in its entirety. Zooplankton is usually sorted under a binocular stereomicroscope, using fine flexible forceps, wire loops, broaches, or pipettes to remove the minute organisms without damaging them. A residue is left which is composed of copepods, debris, and phytoplankton. Since the copepods are usually numerous in the subsample and it is too time consuming to count them all, their number is estimated. When the subsample has been processed and the organisms in the component groups counted, the numbers of animals present in the whole sample can be estimated to compute natural populations.

Benthic collections sent from the field are generally sieved through a one-millimeter aperture screen. Usually all of the organisms retained on the screen are sorted. However, if the sample consists of a large mass of rather small mixed organisms and sediments of homogeneous size and larger than one millimeter, this fraction is then subsampled by a sediment sample splitter, and only a subsample is sorted. The portion of the benthic sample passing through the one-millimeter screen is saved for further analysis.

Some bottom samples consisting of mud or other fine sediments are collected largely for their content of meiofauna, animals ranging in size from 0.002 to 1.0 mm and living interstitially within fine sediment mixtures. SOSC has made only preliminary studies on sorting and subsampling meiobenthos. The time required to sort a several-liter sample of mud or fine sand for about 35 taxonomic groups of meiofauna could take an experienced technician several months. Thus, it is necessary to subsample large meiobenthos samples. A trained technician can sort about an average of 4,000 specimens of meiofauna in a week. A semi-automatic technique has been investigated for washing a meiobenthos subsample gently in a gravity-fed elutriating column composed of a series of plastic containers with wire mesh of 500, 250, 125, 64 and 32 microns.

Vertebrates Section

Vertebrate collections processed at the Center are comprised largely of fishes although a few small collections of snakes, lizards, birds and mammals have been received and distributed. Sea snakes have been sent to two specialists and caecilians to a third. To date, collections of vertebrates other than fishes have been very small and fortuitous, and have been turned over in large part to the U. S. National Museum collections. Fish collections have come to the Center from all of the major seas of the world and represent shore, pelagic and benthic habitats. The sorted taxa represent over half the known families of fishes. Juvenile and adult fishes are generally sorted down to a species level, but are identified to genus or family, depending on the specialist's needs.

Geology Section

Geology samples processed at SOSC consist mainly of rocks and some sediments taken by trawling and dredging hauls on the sea floor and also an increasing number of marine sediment cores. Each rock specimen is inventoried by megascopic techniques on the basis of lithology, location, physiographic setting, and salient mineralogical and textural features. Individual rocks are cut by a diamond-bladed saw, and rock slices are ground and polished on grinding laps to prepare thin-sections. These are examined by a petrographic microscope to make microscopic identifications of the rock specimens. The optical petrographic identification along with other inventory data are correlated with such supplementary information as deep-sea photographs and seismic reflection profiles, and the whole program is automated to provide a current catalogue of samples. A computer readout of a rock sample inventory lists data on numbers, location, sampling, pertinent supplementary information, physical parameters of sample, lithologic categories, lab work performed, and present sample location. A bibliographic search has been made on oceanic rocks and over 200 papers have been abstracted in catalogue form for easy location of rocks in a particular region, depth, topographic feature or lithology. Sediment cores received at SOSC are split or sectioned longitudinally for distribution to specialists. The Center has received over 13,600 negatives of deep-sea photographs taken in the Southern Ocean, and more than 21,000 black and white and color prints have been made and distributed. Biological and geological features exhibited by each photograph are recorded on key-punch cards, which can provide a rapid selection of photographs recording specific data.

Curatorial Section

The broad heading of curatorial investigation encompasses the many aspects of care, handling and supervision of collections from the time they are collected and preserved through the later events of shipping, sorting, labelling and storage. From its inception, SOSC has been charged with the proper care of natural history collections, and has been encouraged to investigate collecting techniques, formats of field data sheets and biological sampling records for use on ships, specimen narcotants and relaxing agents, fixatives and post-fixatives, labels and tags, storage containers and closures, and specimen packaging and shipping techniques. The large quantity and variety of containers required by SOSC along with stresses due to shipping and frequent handling of specimens, have discouraged the use of the expensive, traditional,

museum-type jars. The Center has explored using low cost commerical jars with improved polypropylene-polyethylene closures with satisfactory results. It has investigated papers for labels and tags, printer's inks, typewriter ribbons, and notebooks and pens for recording data in the field.

The SOSC staff has explored preliminary preservation techniques during several cruises and expeditions; however, serious experimentation in this area has been prevented by lack of fresh test material and by availability only of valuable specimens already committed to specialists. In Washington, D. C. under the auspices of SOSC, the 1968 meeting on zooplankton preservation was held by Working Group 23, an international scientific body established by the Special Committee on Oceanic Research and advisory to the Intergovernmental Oceanographic Commission of UNESCO. Under the guidance of WG 23, the Center is engaged in a series of experiments to test fixatives, post-fixatives and buffers used in preserving marine zooplankton. One approach to improving post-fixing fluids has been investigating the control of pH by the use of oxalates, determining if specimens deteriorate under substantial reduction of the formaldehyde percentage, and employing other bactericides such as propylene phenoxetol. Special plankton sampling is planned for the series of long-range tests. The Curatorial Section is preparing a bibliography on narcotizing and relaxing agents, fixing and preserving solutions, inhibitors for growth of fungi and bacteria, and techniques in cytology and histology. The preservation studies on zooplankton are being expanded to include larger invertebrates and fishes. Test animals preserved in various ways will be examined periodically for gross appearance of the body and appendages, and also for detailed tissue and cell structure by histological procedures and electronmicroscopy.

Records Section

The accumulation and dispersal of data are basic functions of the Center. Section work sheets call attention to taxonomic groups likely to be encountered during sorting and aid in the enumeration of data, and master lists maintain a daily and station-by-station report of sorting progress. Records-keeping tasks were assigned to the registrar and section supervisors during the first few years of operation, and technician-sorters prepared their own manually-typed labels. In order to accelerate and improve efficiency in handling of data and label preparation, these functions were taken over largely by the Records Section in 1966. Specimen-label formats were designed for automatic typewriters that could duplicate data at 100 words a minute and reduce error during transcription. Each automatic typewriter is programmed to code and punch typed data onto a paper tape as a by-product of label preparation, and these data are transferred to magnetic tape to provide an inventory of collections processed at SOSC.

Much of the impetus to develop an automatic data-processing system at the Center resulted from financial support provided by the Office of Antarctic Programs of the National Science Foundation to maintain a centralised record of all marine and terrestrial specimens collected in the Antarctic Region, as well as a file of Antarctic collecting permits which serve as a preliminary record of material removed from Antarctica. This ADP system is designed to correlate sorting data with environmental and field data from expedition and ships' collection logs. Code systems have been devised for names of institutions, collecting gear, vessels and expeditions. Computer-printed readouts provide for rapid retrieval of data correlating such parameters as station number, location, date, vessel, collector, depth

and gear type used, with the kinds and numbers of specimens sorted from each sample. The ADP system is open-ended so that data received subsequent to specimen-shipping can be entered into the computer, such as current location of SOSC-sorted specimens, species determinations by specialists and publications including material processed at the Center. As specialists send lower-taxa identifications and bibliographic data, the computer inventory will become more and more valuable to scientists in providing ecological and distributional information on material processed by the Center. Automatic computer plotting of the geographic distribution of specific taxa has already been demonstrated by a pilot project at SOSC, based on the distribution of fish eggs and larvae found in samples taken aboard the research vessel, USNS ELTANIN. The National Oceanographic Data Center (NODC) and SOSC have collaborated to produce a system whereby physical and hydrographic data compiled by NODC can be quickly collated with biological data from SOSC, so that this correlated information can be retrieved by a request to either Center.

TRAINING OF PERSONNEL

Each section at SOSC is comprised of a supervisor and technicians. Generally new employees are not familiar with the techniques of sorting, so they must be trained at the section level, since each section has its own unique problems and solutions. Trainees usually require several months of on-the-job instruction in the careful handling and identification of specimen groups before they can work more or less independently. Instruction is carried out under supervisors and senior technicians and is supplemented with occasional lectures by consultants. Most training is based on recognition of external morphological characters, since dissection is not permitted on specimens destined for systematic studies. Training tools include pictorial atlases prepared at SOSC, general identification manuals, text and reference books, and photographic files of infrequently-seen specimens. Consultant scientists have offered information and training to SOSC staff in the handling of specific marine organisms and sediments and in developing an automatic data-processing system for records. Consultant services have represented such specialised areas as sorting and identification of tropical plankton, copepods, microalgae, foraminiferans, larval fishes, shrimps, decapod crustacean larvae, meiofauna, higher marine fungi found in macroalgae, and marine sediments. Also, aid has been given generously to SOSC by specialists from the Museum of Natural History, U. S. National Museum.

During its early operation, the Center believed that only a person with a college background and some training in biology could become a proficient sorter. Experience has demonstrated this idea to be unfounded, for many unskilled new recruits with limited education but a desire to learn, have become valued technicians. Also, time has shown that women sorters are generally preferable because they appear to possess more patience in spending long hours at a dissecting microscope and an ability to pay close attention to detail. Some SOSC-trained technicians have moved to responsible positions in natural history museum work. In 1968 certificates were awarded to 53 technicians who had completed a period of basic training in the processing of marine specimens at the Center.

ACCOMPLISHMENTS

The Smithsonian Oceanographic Sorting Center has been in operation about eight years. Expanding activities and requirements of work and storage space resulted in movement of the Center in 1964 to Building 159 at the old Naval Weapons Plant in Washington, D. C. The Center now occupies approximately 43,000 square feet and employs about 45 persons. The International Indian Ocean Expedition provided SOSC with over 4,500 samples, which have been sorted into nearly 3.7 million specimens. About 1.5 million IIOE specimens have been sent in 759 shipments to 140 specialists in the U. S. A. and 17 other countries. Based on training for, and experience gained in, sorting IIOE collections, SOSC has pursued an active program in processing samples from all of the world's seas. As of July 1, 1970, the Center has received 559 collections from more than 100 national and international sources. The total number of specimens sorted by SOSC since 1963 approaches 25.3 million. Over 8.5 million specimens have been distributed in 2,236 shipments to 366 specialists. These scientists represent about 150 institutions and agencies located in 32 states and 26 foreign countries. In addition to shipment of specimens, SOSC has despatched 548 support shipments consisting of supplies and collecting gear for expeditions, cruise reports, data summaries, and charts. SOSC personnel have participated in 41 cruises and expeditions with an involved time of 2,057 man-days. Although certain functions at SOSC duplicate traditional practices in museums and marine laboratories, the international interest in biological oceanography has emphasised the sorting-service concept. Sorting centers have been established in Canada, India, Japan, Singapore and Tunisia.

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