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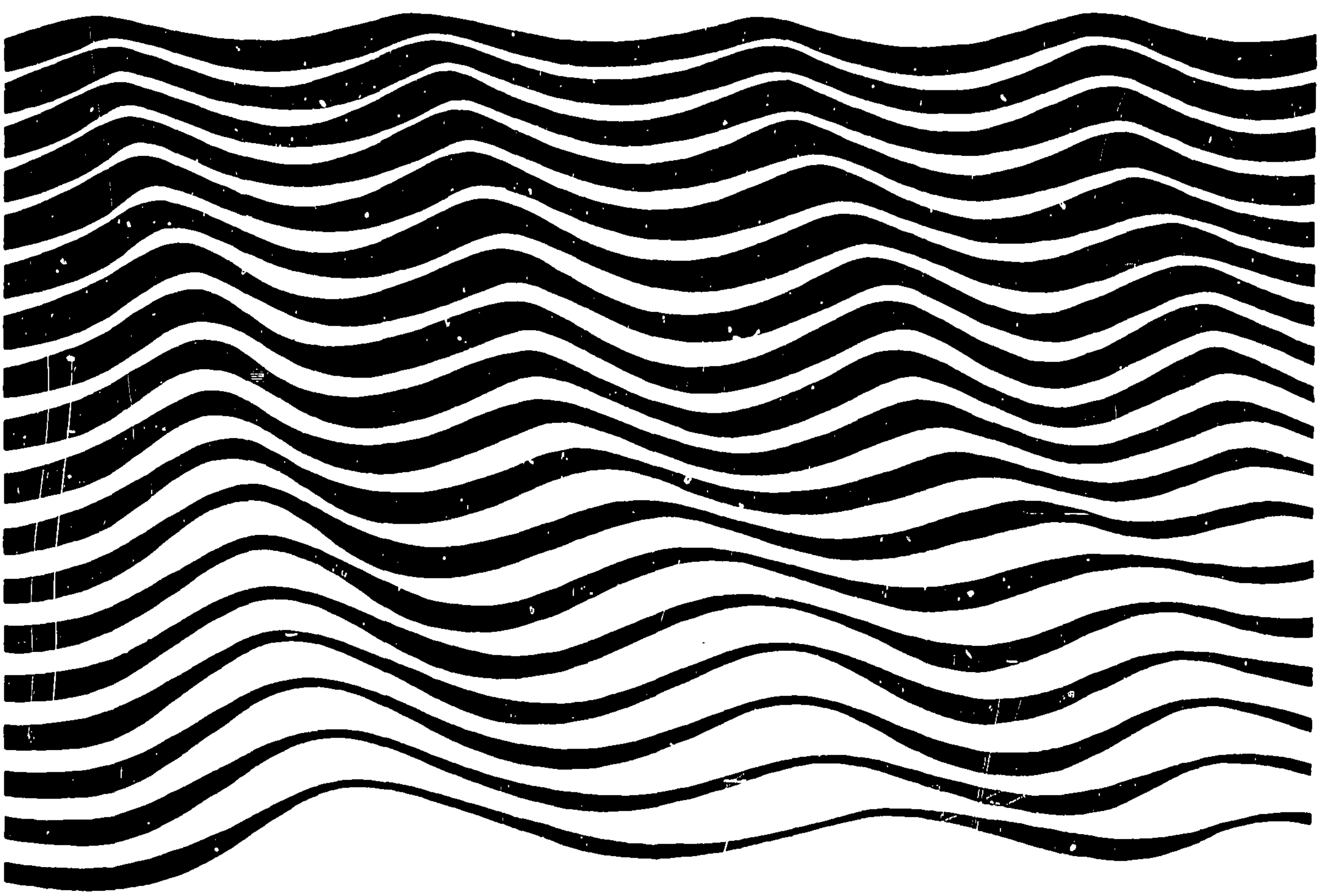
Syllabus for training marine technicians

Report of an IOC/Unesco workshop held in Miami, Florida, 22-26 May 1978



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Syllabus for training marine technicians

Report of an IOC/Unesco workshop on the preparation of a syllabus for training marine technicians

Atlantic Oceanographic and Meteorological Laboratories, National Oceanic and Atmospheric Administration, Miami, Florida, 22-26 May 1978

Unesco 1979

PREFACE

Unesco Reports in Marine Science are issued by the Unesco Division of Marine Sciences. The series includes papers designed to serve specific programme needs and to report on project development. Collaborative activities of the Division and the Intergovernmental Oceanographic Commission, particularly in the field of training and education, are also represented in the series.

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INTRODUCTION

Being aware of the indispensable role that technical personnel have in support of scientific research and engineering activities in the marine environment, the Intergovernmental Oceanographic Commission, in collaboration with the Division of Marine Sciences of Unesco, organized a Workshop on the Preparation of a Syallabus for Training Marine Technicians (May, 1978. See Appendices I and II for a listing of the participants and a brief background to the events and concerns that led to the decision to hold the Workshop). It is hoped that it will serve as an effective guide in developing marine training facilities and techniques for the benefit of the peoples of developing coastal countries of the world and that it will also contribute to preserving trust, respect and mutually beneficial co-operation amongst nations.

The background information and scenario for this type of effort is generally recognized and familiar to all. There is an urgent need to nurture communications between peoples and nations through scientific research, technology transfer, trade, travel and cultural exchange, and with three quarters of the Earth under an ocean cover, the activities which take place within the marine environment have a very important role to play in answer to these needs. For many young people of all nations, eager and ambitious for rewarding and fulfilling life-time careers, marine career orientation and training may provide a valuable opportunity. To maintain the viability of the multiple aspects of human endeavour having to do with the ocean, the provision of trained, competent and dedicated marine technicians is of vital importance to all countries of the world.

The establishment and subsequent development of a viable, effective marine science infrastructure in any country, whether industrialized or developing, requires at least the following three basic elements:

a) the existence of research and/or academic institutions, public and/or private, with well equipped facilities (laboratories, classrooms, equipment, materials, transportation, and, most importantly, a well endowed reference library and properly equipped research vessels) for carrying out marine scientific research and/or teaching;

b) a decisive national commitment to support and fund at a functional level the scientific and teaching activities of the institutions;and

c) a critical mass of trained personnel consisting of scientists, teachers, technicians, and administrative support personnel.

The co-existence of these three elements is an absolute necessity, although their relative strength varies a great deal among the different countries of the world and even within the various institutions of individual countries. This report is concerned with the last of those elements: trained staff, and, in particular, with the training of marine technicians.

In general, the formation of an adequate cadre of native scientists in the relatively new disciplines of marine scientific research is a rather lengthy procedure that - in the case of developing countries - more often than not requires sending students abroad to receive graduate and/or post-doctoral training for several years in teaching/research institutions of more advanced countries. As a result of the time delay implicit in this procedure, newly-emerging institutions are frequently obliged to hire foreign scientists during their initial development phase, later on to be supplemented or replaced by native scientists following their eventual return to their own countries.

In contrast to this, the need for local marine technicians must be satisfied from the very beginning, a situation to which the solution is usually sought through basic on-the-job training of local secondary school graduates or students. Yet the empirical training that must be provided is often insufficient and lacking in depth. This is because of the sparsity of the instructional materials at the disposal of those doing the teaching and the fact that new research centres often have limitations in the scope of their routine investigations. The frequent result is that such technicians soon face serious difficulties in just keeping pace with the technical tasks inherent in the natural growth in sophistication of their institutions.

The purpose of the syllabus is to provide realistic guidance for the training, development and production of capable marine technicians to satisfy the pressing needs of developing countries for this type of personnel. In view of the necessity to provide sufficient flexibility in the syllabus to enable it to be useful to countries with divergent needs, resources and capabilities, a modular concept is utilized throughout as far as possible. It is hoped that this concept has permeated the outlining of the subjects for study, time allocations for given subject areas, field work assignments, physical facilities, training aids, textbooks, instructor qualifications, and recommended procedures for implementing the programme.

The implementation of the programme under the very flexible modular concept may range from the barest minimum in staff, equipment and facilities to the maximum expansion and sophistication of which the training institution is capable. This ranges from the rudimentary sand and stick diagrams through chalk and blackboard to the most sophisticated multi-media, custom-designed classrooms, and from the simplest observations near the seashore to active participation in activites such as research cruises, industrial fishing, laboratory analyses, and computer utilization. Any of the subject material in this syllabus may be presented with a minimum of inexpensive equipment and supplies at the disposal of the instructors. References could be photocopies for low-priced hand-out literature, and mock-ups and other training aids can easily be hand-fabricated using inexpensive materials readily available in local areas. In conclusion, it is intended that once the needs of a country or region are carefully assessed the training programme can be tailored to individual, local, national or regional requirements utilizing the flexibility of the modular approach.

The syllabus recommended herein will be useful for the local training of marine technicians rather than for training abroad, since it can be adapted to any locale and locality utilizing available resources to the maximum degree, including instructors, training aids and materials. This syllabus, again taking advantage of the flexibility and response to individual student needs and capabilities of the module-course system, attempts to provide an increasing order of complexity in dealing with the subject material. In addition to being an open-ended programme that allows a variable response based upon the individual student qualifications and abilities, it should be responsive to research centres and industrial user requirements commensurate with student characteristics. The proposed syllabus is action-oriented, and stresses an appropriate combination of "hands-on", practical or laboratory work with theoretical, classroom instruction in a mutually supporting fashion, and emphasizes close correlations between the two.

Based upon the consensus of the workshop that all technical personnel working in or in proximity to marine environments should have some training at sea, the syllabus provides a module common to the three types of marine technicians proposed for that purpose, with sequential modules covering the specialization fields in which the personnel are to be trained. These fields include pertinent aspects of the basic sciences in support of oceanographic endeavours, i.e., biology, chemistry, physics, geology, meteorology and the applied science of engineering. Additional specialist subjects pertaining to industrial and commercial applications are addressed through the inclusion in the various courses of such skills as seamanship, marine safety, first aid, fire fighting navigation, marine engineering, marine economics, fishing techniques, instrumentation, diving, marine electronics, and other similar subject matters as required.

It should be kept in mind, when applying or adapting this syllabus, that the first step in developing an occupational programme such as this is to make a survey of the local, national and regional needs and resources, in order to ascertain whether or not the programme is desirable and feasible. Some of the questions to be addressed by the survey team are the following:

a) definition of a marine technician in local terms;

b) the number and types of marine technicians needed or likely to be needed on a national basis for the next five years;

c) the number of potential students for the proposed programme, including those from neighbouring countries, during the five-year period;

d) assessment of the physical facilities, equipment and materials available and needed with an accurate estimate of the cost involved for the first five years;

e) the number, field of expertise, level and availability of the instructors required for the programme;

f) identification of the junior college, technological institute, or vocational or trade school where the programme is to take place;

g) identification of the sources of financial support for the programme, at least for the first five years;

h) the types of marine technicians to be trained, the skills to be developed, and the level at which the different courses are to be taught;

i) definition of entrance requirements, course content, evaluation procedures, length of the programme, graduation requirements, and degree(s) to be granted;

j) determination of the acceptability of the courses included in the programme as credit towards four-year degrees in upper division colleges and universities.

The workshop participants have tried to provide an answer to at least some of those queries by means of the present report and recommendations, but specific solutions compatible with local conditions can be proposed only through direct acquaintance with a given scenario. Nonetheless, it is hoped that this document may prove useful to those IOC Member States planning to develop a training programme to satisfy their marine technician needs.

DEFINITION OF MARINE TECHNICIAN

As we mentioned earlier, the Workshop considers it advisable to arrive at a definition of the term "marine technician" before an occupational programme based on this proposed syllabus may be planned. This definition must be made in accordance to the type and degree of sophistication of the technical tasks the marine technician will be expected to carry out and be compatible with exisiting local conditions in the marine field. Even though at first glance a proper definition may appear as of secondary importance, it must be remembered that once it is adopted and incorporated into national legislation, marine technicians will be divided into various categories according to qualifications, duties and responsibilities and that this, in turn, will determine salary levels, employment classification and advancement opportunities.

According to the occupational criteria adopted by the Department of Health, Education and Welfare of the United States[1] (cited by G.L. Chan[2]) the universal requirements for a person engaged in any technical occupation must include the following five general abilities:

"1. Facility with mathematics; ability to use algebra and some trigonometry as tools in the development of ideas that make use of scientific and engineering principles.

2. Proficiency in the application of physical science principles, including the basic concepts and laws of physics and chemistry that pertain to the individual's field of technology.

3. An understanding of the materials and processes commonly used in the technology.

4. An extensive knowledge of a field of specialization with an understanding of the engineering and scientific activities that distinguish the technology of the field. The degree of competency and the depth of understanding should be sufficient to enable the individual to do such work as detailed design using established design procedures.

5. Communication skills that include the ability to interpret, analyze, and transmit facts and ideas graphically, orally, and in writing".

There exists a considerable diversity in the jobs available in the marine technology field and, consequently, in the knowledge and skills needed to ensure that the various assigned duties are discharged efficiently. Despite this diversity, the general abilities listed above appear to be applicable in all cases. In the design of an occupational programme, however, the relative weight that must be given to the different subjects to be taught and skills to be developed will vary depending upon the type of marine technician desired.

The term "marine technician" encompasses various groups of personnel whose technical knowledge, skills and methods permit them to work, either at sea or ashore, in technological activities for the exploration and exploitation of the marine environment. Marine technicians thus give the necessary support to marine scientists, engineers and industries. Job openings for marine technicians are avilable in the following fields : scientific research in marine biology, physical and chemical oceanography, and marine geology and geophysics; fisheries, aquaculture and sea food processing; offshore petroleum and natural gas exploration and production; mining and natural products extraction; boat operation and maintenance; aquarium and museum management; coastal area management; recreational activities, etc. Some of the typical tasks commonly carried out by marine technicians are to:

a) plan or participate in research cruises to make observations and record biological, geological, geophysical, chemical, physical, and meteorological data;

b) sort, classify and preserve biological and geological samples;

c) apply analytical techniques in the laboratory for the determination of the chemical characteristics of collected samples;

d) process the oceanographic data collected in the field, including carrying out numerical calculations and the preparation of tables, graphs and chart plots;

e) operate, maintain and make routine repairs of the various types of oceanographic equipment and instrumentation;

f) use machine tools for mechanical, electrical and carpentry jobs;

g) carry out underwater work with a thorough familiarization with diving and related techniques;

h) be responsible for small boat handling, rigging, knot tying, wire and rope splicing, etc.;

i) participate in population and environmental surveys in the marine and fresh-water environments;

j) use techniques related to fisheries and aquaculture, such as fish capture, fish tagging, handling and repair of fishing gear, building of rafts, ponds and other structures for farming marine organisms;

Care should be taken not to be misled by the word "marine" preceding "technician" because, although it is essential that the technician can perform satisfactorily under marine conditions, there are many instances in which the work is done ashore all or most of the time. This is especially true in the developed countries where the degree of specialization is such that many marine technicians are permanently shore-based. For the developing countries, however, it is desirable that the marine technician be as versatile as possible, although it is recognized that a team of technicians in which the team members contribute complementary knowledge and skills is a far better answer than having the so-called jack-of-all-trades technicians. Special attention should also be given by developed and developing countries alike to having a continuous training programme for their marine technicians, in order to keep them up to date regarding modern methodologies and equipment.

To conclude this section it must be pointed out that, despite their points of agreement, the definition of a marine technician must not be confused with that of marine technology. According to Scott and Herrera[3] "marine technology may be characterized as the combination of types of knowledge about the marine environment and its resources indispensable to carrying out the necessary operations for transforming factors of production (existing renewable and non-renewable resources) into products (food, energy, minerals), the use of that knowledge (fisheries, offshore mineral exploitation, shipping, etc.) or the provision of services (weather prediction, ship routeing, nautical systems, etc.)." To achieve the purpose mentioned in this definition requires the joint efforts of marine scientists, engineers, industrialists, administrators and marine technicians.

CAREER POTENTIALS FOR MARINE TECHNICIANS

During the past decade, the combination of increased participation of developing countries in international affairs, significant technological breakthroughs in offshore oil and mineral production, and the negotiating sessions of the Third United Nations Conference on the Law of the Sea, has created a general awareness of the potential importance of the resources of the oceans as an element for enhancing the economic and social development of the countries of the world. Knowing that scientific advancement and technological development go hand in hand, many developing countries are concerned about their weak scientific and technological infrastructures and wish to remedy that situation through, among other things: the training of qualified personnel at all levels, the modernization of their marine-related industries, the improvement of their ways of negotiating the transfer of technology and the upgrading of their research and educational institutions. As a result, many opportunities for profitable careers are being opened for marine technicians in these countries.

The career potentials for marine technicians in the developing countries are not nearly as varied as those encountered by their colleagues in the industrialized nations. Despite that undeniable fact, the Workshop has considered it useful to offer a sample listing of the potential career spectrum for marine technicians on the basis of the situation existing in the developed countries. In the preparation of the list, the Workshop has borrowed liberally from similar lists of job openings found in Berryman[4] and Banerjee[5]. In the opinion of the participants, the descriptions of duties for the different types of marine technicians that follow are of general applicability, although it is realized that the actual tasks to be performed under a given category will vary over a wide range from one place to another.

Oceanographic Laboratory

These technicians assist in chemical, physical and biological analyses of a variety of properties in sea water, marine organisms and/or geological samples. They are responsible for maintaining cleanliness and orderliness in the laboratory, ashore and afloat, and for keeping up the inventory of the laboratory stock. They also calibrate and operate measuring and surveying instruments, assist in the acquisition, recording and processing of data, plots, graphs and profiles, and reduce processed chemical and physical oceanography station data to a standard format.

Marine Survey

These technicians operate various types of standard surveying and measuring instruments such as corers, grab samplers, wave staffs, tide gauges, current meters, STD and CTD probes, meteorological equipment, depth recorders, sextants, theodolites and geophysical instruments. Their work could be conducted in either coastal, inland or marine environments where information on sea water and bottom properties, bathymetry, shorelines, ocean dynamics, atmospheric conditions and similar subjects is needed. They also assist with data processing and, in many instances, with the analysis and interpretation of the original data.

Hydrology

These technicians gather data on water quality, availability, movement and distribution and resources in fresh water bodies. They take water samples, carry out field and laboratory analyses, measure physical parameters, and operate and maintain the sampling and measuring equipment used in fresh water hydrology. Their tasks may also include assisting in studies on fishery stocks, aquaculture, control of unwanted fauna and flora affecting fish, as well as sedimentation studies.

Marine Engineering

These technicians support engineering and scientific efforts to perform work in the machine shop on deck and under water. They assist in the design, fabrication, installation and maintenance of equipment in the ocean environment. They are expected to assist various hydraulic, structural and general research engineers in setting up and conducting experiments, including data reduction, machine computations, marine engines and motors used in marine engineering.

Oceanographic Instrumentation

These technicians assist in the handling, use, maintenance, calibration and repair of instruments employed in measuring the physical, chemical, geological and biological properties of the marine environment. They are also involved in the determination of instrument accuracy, the modification of existing equipment and the design of auxiliary apparatus. In addition, they read and record data from these instruments and keep maintenance logs for each.

Marine Electronics

These technicians are trained to assist in the fabrication, operation, servicing, maintenance and repair of shipboard electronic instrumentation and oceanographic electronic equipment in support of the various ocean science disciplines and marine-based industries. On board research vessels these technicians are responsible for instrument maintenance, wiring, connections and splicing, and basic trouble-shooting. They are familiar with electronic navigation instrumentation.

Physical Sciences

These technicians assist physical scientists and engineers in the application of scientific theories to solve problems in either basic or applied research. They may collect and analyze data pertaining to the various scientific disciplines, provide graphs, tables and completed charts of specific areas of research and, in some instances, may be involved in the running of computer programmes or simulation experiments aimed at modelling natural phenomena.

Statistical Analysis

These technicians utilize mathematical and numerical techniques and methods to collect, organize, compute and analyze data in a variety of scientific fields, including the disciplines of marine sciences and ocean engineering.

They evaluate the reliability of data sources, and present the information in the form of tables and graphs for easy use and subsequent interpretation by the marine scientists, engineers and industrialists.

Biological

These technicians assist the marine biologist in the identification, acquisition, classification, preservation, and ecological study of marine organisms, and the measurement of marine environmental parameters in the field. Their tasks may include collaborating in anatomy and physiology studies, as well as the use of chemical and microbiological techniques to study life cycles and their relationship to an organism's changes.

Fisheries

These technicians assist the fishery biologist in the study of commercially important aquatic organisms inhabiting sea water or fresh water environments. They assist in the study of life cycles of organisms, population and environmental surveys, anatomical characteristics, and may participate in the construction and use of fishing gear, fish farming, hatcheries, management of fisheries resources and in performing quantitative determinations of the interrelationships between species of commercial interest and their natural environment.

Water Pollution

These technicians work with marine scientists and sanitary engineers in the determination of the extent of pollution in bays, lagoons, estuaries, rivers and lakes and are involved in research concerning monitoring, control and abatement of pollution from domestic, industrial and agricultural sources, as well as in their environmental impact. They carry out field analyses, laboratory testing, biological surveys, sediment sampling and other similar tasks.

Deck Support

These technicians are members of the scientific support party on board an oceanographic research vessel. Their tasks require familiarization with a broad range of surveying and measuring devices, and the collection of water, bottom and biological samples. They are skilled in rigging, storing cargo and gear and in the handling of deck equipment such as oceanographic winches and booms.

Underwater

These technicians are trained qualified divers, thoroughly familiar with all types of commercial diving apparati, mixed gas diving, underwater tools, and safety procedures. Their assistance is indispensable in oil fields, rigging pipelines and wellheads, etc. They may assist in testing underwater communication systems, photographic equipment, underwater closed circuit television and other electronic equipment for observing undersea phenomena. They may carry out geological and biological sampling in shallow waters.

AIMS AND OBJECTIVES

After giving careful consideration to the particular resources and needs in the field of marine technician training of the IOC Member States, especially the developing countries who sorely need this type of personnel, the Workshop decided to prepare a syllabus which could be readily utilized for the training of three main categories of technical personnel in two-year occupational education programmes:

- Marine Survey Technician
- Marine Engineering Technician
- Biology and Fisheries Technician

In addition, it was intended to give enough flexibility to the syllabus in order that the emphasis could easily be shifted to specific subject areas in response to existing needs. A flexible syllabus would also allow for variation in the depth of treatment of the various subjects in accordance with the capabilities and interests of the student body.

Member States wishing to initiate courses for training marine technicians may have slightly different aims and objectives. There are however, some aims and objectives that should be considered common to any programme derived from an application of this syllabus, among which the following are worthy of mention:

1. To provide the training required for students to become qualified marine technicians by means of well planned, properly presented instruction in the classroom, laboratory, field and job-site situations, and with as much active participation from the students as possible.

2. To train qualified marine technicians as an essential part of the trained manpower requirements for infrastructure development of oceanographic research centres and other public and private endeavours dealing with the marine environment, in order to provide the required support for the activities of marine scientists, engineers and industrialists.

3. To provide the students with a clear, realistic understanding of the likelihood of swift job entry, career potential, and further education and training possibilities for graduates of this occupational education programme.

4. To familiarize the students with the necessary qualifications for the various categories of marine technicians, such as assisting in planning the technical and logistic aspects of research cruises, maintaining and operating all types of oceanographic equipment, handling small boats, diving, collecting and preserving samples, performing laboratory analyses, and reducing data.

5. To acquaint the students with the main characteristics of the oceans, including the water itself, its physical-chemical characteristics and dynamics, the marine organisms, the ocean sediments, the renewable and non-renewable marine resources, and the ever present problem of marine pollution.

6. To teach the students to recognize, develop and investigate a technical probler and to prepare a comprehensive report on the results obtained in a concise, understandable manner.

7. To impress the students with the need for accurate laboratory and field work record-keeping and notebook organization, and to familiarize them with the analysis and interpreation of manuals of instruction, and data and written reports.

8. To train the student in the necessary techniques for the proper maintenance, diagnostic testing, calibration, trouble-shooting, routine repair and, if possible, desigr of simple oceanographic and related equipment and instrumentation.

9. To develop a positive attitude toward acceptance of responsibility and authority to enable the students to perform, to the best of their abilities, the demanding tasks expected to be carried out by marine technicians afloat and ashore.

10. To appreciate the important advantages of teamwork and the need for leadership and authority, in addition to co-operation, as means for developing confidence and reliability in the performance of the duties of marine technicians.

11. To develop a keen awareness of the necessity to obey safety regulations and procedures when carrying out often hazardous technical tasks, under normal as well as adverse conditions, in order to prevent the occurence of mishaps.

12. To increase the level of proficiency and to develop the abilities to function efficiently with limited guidance and supervision, as well as to plan and carry out projects in designated technical support areas with accuracy.

13. To develop the mathematical competency required to solve problems encountered in various technical undertakings and the necessary ability to use formulae, equations, charts, graphs, tables, and desk calculators or computer terminals in the solution of technical problems.

14. To develop the ability to perform certain basic seamanship tasks using accepted procedures and under conditions normally encountered by a marine technician, such as rigging, basic navigation, piloting duties, and small boat handling.

15. To familiarize the students with the tools, instruments and techniques for effective machine shop operation, stressing the importance of accuracy in measuring, and with shop safety precautions.

16. To acquaint the students with the techniques for making preliminary design, report and sketch drawings, and with the symbols and signs used in technical drawings, charts and maps.

17. To develop the specific skills required for accepted and safe shallow water diving, including a recognition of the physical limitations and hazards associated with diving operations.

18. To provide the students with the knowledge and skills needed to assume the responsibilities involved in supporting research scientists in the fields of marine biology and fisheries in pursuit of an optimum utilization of marine living resources.

Note: The above aims and objectives are not exhaustive, have not been listed in any particular order of importance and, whereas some are general in nature, others refer to the development of attitudes, skills or abilities.

ESTABLISHMENT OF A PROGRAMME FOR TRAINING MARINE TECHNICIANS

In establishing a training programme for marine technicians along the lines proposed in this syllabus, the institution(s) involved will be obliged to follow a certain sequence that will in large part be dictated by specific local conditions. In general, however, the participants in the Workshop recommend the following successive steps for the fruitful use of the present syllabus:

1. Survey of needs and resources following the suggestions given in the section Introduction to the Syllabus.

2. Determination of desired programme characteristics

   2.1 Delineation of objectives

   2.2 Requirements for admission

   2.3 Length of the programme

   2.4 Requirements for graduation

   2.5 Degree(s) or certificate(s) to be granted

   2.6 Faculty needs

   2.7 Resource needs

3. Critical examination of the syllabus prepared by the Workshop

   3.1 Agreement with objectives of desired programme

   3.2 Selection of courses from the syllabus

   3.3 Changes to be made in the courses selected, if any

   3.4 Preparation of outlines for other courses needed but not included in the syllabus, if any

4. Adoption of a syllabus for the programme

   4.1 Determination of final aims and objectives

   4.2 Preparation of course descriptions and lesson plans

   4.3 Determination of programme characteristics

      4.3.1 Level of the courses

      4.3.2 Identification of a common module (core) and specialized modules, and of compulsory and optional courses

      4.3.3 Number of hours per week for lectures, laboratory and field work

4.4 Identification of instructors, textbooks, training aids, facilities and equipment

5. Approval and funding for the programme

6. Inception and announcement of the programme

In the following pages four examples are presented of course outlines for Marine Survey Technicians A and B (emphasizing physical oceanography and marine geology, respectively), Marine Engineering Technician and Biology and Fisheries Technician. In each case, the common module is composed of those courses to be taught during the first semester:

- General Oceanography I
- Technical Skills
- Basic Seamanship
- Technical Mathematics I
- Report Writing

In this connection, several points should be clarifiied:

a) these are only examples of course outlines on the basis of a four-semester plus one summer session (two-year) programme. The same course content could easily be re-arranged for a three trimester per year two-year programme without an intervening summer session;

b) these course outlines are representative of "maximum" loads advised for the proposed two-year programme and can be made lighter either by decreasing the number of courses to be taken by the students or by diminishing their level of complexity and/or the evaluation requirements for their successful completion;

c) the desired emphasis to be given to individual students, on the basis of their professional expectations, can best be accomplished in the usual way through faculty advisers who can help students plan their programmes according to anticipated course offerings;

d) although in the four examples given the courses General Oceanography II and Graphics are common to the three types of marine technicians, those courses are not to be taken as part of the common module defined above as they could be replaced by other compulsory or optional courses being offered;

e) institutions in developing countries wishing to start a programme for training local marine technicians need not follow outlines such as those proposed herein, but should instead apply the system they consider best in their particular cases.

MARINE SURVEY TECHNICIAN A

First Semester

General Oceanography I

Technical Skills

Basic Seamanship

Technical Mathematics I

Report Writing

Second Semester

General Oceanography II

Physical Oceanographic Techniques I

Chemical Methods

Technical Mathematics II

Graphics

Summer

Basic Diving

Basic Navigation

Third Semester

Applied Physics

Physical Oceanographic Techniques II

Marine Geology Methods I

Data Processing

Fourth Semester

Marine Meteorological Observations

Advanced Chemical Methods

Technical Mathematics III

Computer Programming

or

Instrument Calibration and Repair

MARINE SURVEY TECHNICIAN B

First Semester

General Oceanography I

Technical Skills

Basic Seamanship

Technical Mathematics I

Report Writing

Second Semester

General Oceanography II

Physical Oceanographic Techniques I

Marine Geology Methods I

Technical Mathematics II

Graphics

Summer

Basic Diving

Basic Navigation

Third Semester

Applied Physics

Marine Geology Methods II

Chemical Methods

Marine Fauna and Flora

Fourth Semester

Geophysical Methods

Advanced Chemical Methods

Marine Meteorological Observations

Technical Mathematics III

or

Computer Programming

MARINE ENGINEERING TECHNICIAN

First Semester

General Oceanography I
Technical Skills
Basic Seamanship
Technical Mathematics I
Report Writing

Second Semester

General Oceanography II
Marine Engineering Technology
Advanced Seamanship
Technical Mathematics II
Graphics

Summer

Basic Diving
Basic Navigation

Third Semester

Applied Physics
Applied Electricity
Advanced Diving
Advanced Navigation

Fourth Semester

Engineering Electronics
Hydraulics and Pneumatics
Instrument Calibration and Repair
Material Properties and Testing

BIOLOGY AND FISHERIES TECHNICIAN

First Semester

General Oceanography I

Technical Skills

Basic Seamanship

Technical Mathematics I

Report Writing

Second Semester

General Oceanography II

Marine Engineering Technology

Marine Fauna and Flora

Technical Mathematics II

Graphics

Summer

Basic Diving

Basic Navigation

Third Semester

Biology of Commercial Species

Fishing Methods I

Aquaculture I

Sea Food Processing Technology

Technical Mathematics III

Fourth Semester

Living Resources Management

Fishing Methods II

Aquaculture II

Fisheries Economics

Chemical Methods

Course Descriptions:

General Oceanography I, II

The Earth. The lithosphere, atmosphere and hydrosphere. Geomorphology of the oceans. Marine sediments. Water types and water masses. Physical and chemical properties of sea water. General circulation of the atmosphere. The seas in motion: horizontal currents, up-welling and sinking, waves and tides. Life in the sea: plankton, nekton and benthos. Marine resources and their rational use. Environmental protection. Instrumentation for marine scientific research, its proper use and maintenance. Practical exercises.

Lecture: 3 hrs/week each semester

Laboratory: 3 hrs/week each semester

Physical Oceanographic Techniques I

Measurement of basic oceanographic parameters, turbidity and water motions. Temperature and salinity (density), pressure. Basic concepts of sampling theory (time and space scales). Lagrangian versus Eulerian measurements. Time series measurements. Nansen bottles with reversing thermometers, bathythermographs (mechanical and expendable). Secchi discs. T-S diagrams. Thermometric depth calculations. The dynamic method of calculating ocean currents. Use of current meters, drift bottles, free-drifting current drogues, tethered current poles, wave staffs, tide gauges, etc. Data processing, standard data reporting forms and data centre manuals. Interpolations and quality control.

Lecture: 2 hrs/week

Laboratory: 4 hrs/week

Field work: as required

Physical Oceanographic Techniques II

The subject matter to be covered in this course should be tailored to specific local needs and will depend upon the types of equipment available. It may include aircraft and satellite measurement systems for use in physical oceanography, radiometers, marine acoustics, Swallow floats, cyclosondes, STD and CTD probes, buoy-mounted and bottom-mounted sensors, acoustic release mechanisms for bottom-mounted pressure gauges and current meter arrays, geomagneticelectrokinetographs (GEK), instrumented air-sea interaction towers, taut wire subsurface arrays, etc. This type of training might have to be carried out in marine science institutions of developed countries.

Lecture: To be decided

Laboratory: To be decided

Field work: To be decided

Marine Meteorological Observations

Shipboard and shore observational techniques: surface wind speed and direction, barometric pressure, air temperature, relative humidity, sea surface temperature, sea state (wind wave and swell direction, period, height). Upper air profiles of temperature, relative humidity and winds aloft. Use of anemometers, barometers, air and water thermometers, sling psychrometers, rain gauges, radio-sondes and rawinsondes. Influence of the ship's interference upon shipboard measurements of temperature, wind and rainfall. Reduction, tabulation and coding of weather data for radio transmission and maintenance of ship's weather log.

Lecture: 1 hr/week

Laboratory: 2 hrs/week

Field work: as required

Chemical Methods

Basic chemical concepts (non-descriptive approach). Use of pipettes, burettes, filters, etc. Weighing of reagents and preparation of solutions. Equivalent weights. Normal and molar solutions. Use of balances. Prevention of sample contamination. Theory and use of titration equipment. Dissolved oxygen determination by the Winkler method. Use of spectrophotometers, salinometers, pH-meters, O_2-meters, etc. Manual methods for nutrient determination. Laboratory safety.

Lecture: 2 hrs/week

Laboratory: 3 hrs/week

Advanced Chemical Methods

The subject matter to be covered in this course should be tailored to specific local needs and will depend upon the types of equipment available. Sophisticated instrumentation (such as gas chromatographs, atomic absorption spectrophotometers, scintillation counters, multi-channel nutrient analyzers) may not be readily available, in which case the possibility of utilizing the facilities provided by manufacturers may be explored should the need for such measurements arise.

Lecture: To be decided

Laboratory: as required

Marine Geology Methods I

Design, construction and maintenance of sampling equipment, including gravity corers, piston corers, rock and sediment dredges, grab samplers, box corers. Principles, use and maintenance of survey equipment, echosounders, wave staffs, tide gauges, current crosses. Bathymetric surveying and substrata mapping, including the use of shoreline control and aircraft photographs and satellite images. Sample preparation in the laboratory. Analytical principles and techniques: sediment grain size (sieves, settling tubes, pipettes), geochemical (e.g. carbonates, organic carbon content), mineralogical separations and slide preparation. Preparation of samples for microbiological identification.

Laboratory: 6 hrs/week

Field work: as required

Marine Geology Methods II

Geotechnical principles and methods. Techniques and instrumentation to determine sediment porosity, permeability, compaction shear strength, etc. Techniques for the determination of mass sediment transport: acoustic tracking, hydrophotometry, nephalometry, etc. Instrumentation for measuring nearshore environmental parameters. Underwater geological mapping by divers. Bottom photography. Photomicrography. Data recording. Calculations. Special techniques, apparatus and instrumentation for sample analyses such as rapid sediment analyser, mass physical properties and advanced geochemical methods, special slide preparation. Data collection, storage and retrieval. Calculations and presentation of data.

Laboratory: 6 hrs/week

Field work: as required

Geophysical Methods

Introductory theory related to the geophysical structure and behaviour of the Earth. Seismology, gravity and magnetics. Geophysical instrumentation: acoustic transducers, reflection and refraction seismic systems, gravity meters (static and ship borne), magnetometers (air-borne, ship-borne, proton precession). Operating principles and field maintenance. Data recording.

Lecture: 2 hrs/week

Laboratory: 3 hrs/week

Field work: as required

Technical Mathematics I

Arithmetic review. Basic algebraic equations. Real numbers. Sets and subsets. Algebraic fractions. Scientific notation. Linear equations. Systems of linear simultaneous equations. Exponents. Roots. Quadratic equations. Use of tables. Interpolation techniques. Graphs. Formulation and solution of practical problems.

Lecture: 3 hrs/week

Technical Mathematics II

Introduction to trigonometry. Sine and cosine curves. Simple harmonic motion. Complex numbers. Logarithms. Analytical geometry. Introduction to statistics. Applications.

Lecture: 3 hrs/week

Technical Mathematics III

Introduction to calculus. Limits, continuity, derivatives and integration of functions. Applications of differentiation and integration including velocity and acceleration, maximum and minimum, related rates, area, arc length and curvature. Series. Matrices.

Lecture: 3 hrs/week

Applied Physics

Basic principles of mechanics, thermodynamics, electromagnetism, acoustics and optics. Theory and experiment, with emphasis on the measurement of properties of direct application to oceanography.

Lecture: 3 hrs/week

Laboratory: 3 hrs/week

Data Processing

Concepts of data processing and computer programming. Use of the formats and procedures applied within the International Oceanographic Data Exchange System coordinated by the IOC. Principles of systems and equipment configurations. Peripheral equipment. Input and output devices. Computers and Central Processing Units (CPU). Data cards. Number systems. Computer and equipment operation and maintenance. Safety aspects.

Lecture: 2 hrs/week

Laboratory: 4 hrs/week

Computer Programming

Syntax and rules of the FORTRAN IV language. Development of programme skills and efficiency. Students are required to code programmes for scientific applications dealing with the marine environment.

Lecture: 2 hrs/week

Laboratory: 4 hrs/week

Report Writing

This course deals with objective expository writing. Lecture and interpretation of written technical information. Written communication of technical information including research techniques, elaboration of summaries, graphic presentation and drafting of conclusions.

Lecture: 3 hrs/week

Graphics

Introduction to mechanical drawing and illustrations. Biological drawing. Use of instruments and prepared illustration aid materials. Photography, its principles. Use of cameras, films, light meters, etc. Processing and reproduction of photographs. Preparation of slides and other types of visual aids.

Laboratory: 4 hrs/week

Technical Skills

Blue print reading and sketching. Slide rule applications. Shop safety. Use of hand and power tools. Simple measuring instruments. Materials used in marine applications. Metal joining techniques. Flame cutting techniques. Preventive maintenance. First aid.

Lecture: 2 hrs/week

Laboratory: 3 hrs/week

Field work: as required

Marine Engineering Technology

Machine tools, (lathe, milling machines, planers, shapers, band and circular saws, drill press, etc.). Operation and maintenance of diesel and gasoline engines. Compressors and pumps. Refrigeration and air conditioning. Plumbing methods. Vessel maintenance and repair.

Lecture: 2 hrs/week

Laboratory: 4 hrs/week

Applied Electricity

Introduction to electricity. Sources of electrical energy. Batteries as electrical sources. Direct current circuits. Series circuits. Parallel circuits. Direct current meters. Electromagnetism. Alternating current and voltage. Motors and generators. Capacitance, inductance and impedance. Safety.

Lecture: 2 hrs/week

Laboratory: 2 hrs/week

Engineering Electronics

Theory, construction, characteristics and applications of the various electron tubes and semi-conductor devices, including the newer solid state devices (oscilloscopes, recorders, amplifiers, etc.). Operation, maintenance and trouble-shooting.

Lecture: 3 hrs/week

Laboratory: 3 hrs/week

Material Properties and Testing

Physical, chemical and mechanical properties of materials used in marine applications. Ductile and brittle materials. Techniques of quality control, including use of inspection tools and instruments, assessment of mechanical properties by destructive and non-destructive testing, prediction and sampling inspection. Corrosion and fouling. Analyses and protective coatings.

Lecture: 2 hrs/week

Laboratory: 2 hrs/week

Hydraulics and Pneumatics

Concepts of fluid mechanics. Flow of air and water as applied to marine systems. Calibration of metering devices. Pipe friction. Elementary hydraulic tests. Friction and energy losses. Devices for making fluid measurements. Maintenance procedures for hydraulic and pneumatic components (rams, seals, hose and piping, fittings).

Lecture: 2 hrs/week

Laboratory: 4 hrs/week

Instrument Calibration and Repair

Introduction to the theory of calibration. Standards. Accuracy and precision. Intercalibration. Validity of results. Mechanical repairs. Minor electronic repairs. Maintenance of equipment logs and determination of mean time to failure. Techniques of field and laboratory improvisation.

Lecture: 1 hr/week

Laboratory: 3 hrs/week

Field work: as required

Basic Seamanship

Shipboard familiarization and terminology. Safety inspections and emergency drills. First aid and cardio-pulmonary resuscitation. Swimming and water safety. Vessel types, classification and construction. Damage control. Nautical charts. Pilotage and coastal navigation. Aids to navigation. Magnetic and gyrocompasses. Publications and navigational instruments. Ropes, cables and cordage; knotting and splicing. Properties of wire rope. Rules of the nautical road and collision regulations. Shipboard cooking. Food supply and storage. Principles of vessel handling (single, twin, multiple propellers). Life rafts and life boats. Safety equipment. Small boat handling and equipment.

Lecture: 2 hrs/week

Laboratory: 4 hrs/week

Field work: as required

Advanced Seamanship

Rigging and block and tackle. Cargo handling and storage. Ground tackle. Anchoring and mooring. Special aspects of vessel handling, docking and mooring, towing and salvage. Communications, radio, semaphore, flashing light, international code flags, Morse code. Basic shipbound electronic equipment such as radio, radar, LORAN. Radio Direction Finder, hyperbolic navigation systems, depth recorders. Preventive maintenance. Deck machinery, winches, etc. Weather. Fire fighting. Principles of sailing. Practical navigation problems.

Lecture: 2 hrs/week

Laboratory: 4 hrs/week

Field work: as required

Basic Diving

Swimming. Water safety. Life saving. First aid and cardiopulmonary resuscitation. Diving physics. Medical aspects of diving. Underwater physiology. Fundamentals of compressed gases as related to SCUBA operations. Basic skin and SCUBA diving equipment. Development of diving skills. Underwater environment and marine life. Planning of the dive. Familiarization with diving tables such as the U.S. Navy diving tables, the NOAA Diving Manual, and those tables developed in other countries. Diving safety.

Lecture: 2 hrs/week

Laboratory: 4 hrs/week

Field work: as required (shallow water)

Advanced Diving

Underwater work. Underwater search. Underwater measurement and survey. Underwater photography. Introduction to commercial and deep sea diving. Salvage operations. Marine damage survey work. Diving safety. Principles of recompression chamber operations.

Lecture: 2 hrs/week

Laboratory: 4 hrs/week

Field work: as required (shallow water)

Basic Navigation

Introduction. The practice of navigation at sea. The Earth and its co-ordinates. Nautical chart symbols and abbreviations. Chart projections and interpretation. Navigational publications. Sailing directions. Aids to navigation. Dead reckoning and current sailing. Currents and tides. Compasses. The navigator's instruments. Elements of pilotage. Tactical characteristics in pilotage. Graphic solution for relative motion problems. The pilotage team. Radar navigation. Electronics. Basic electronic navigation systems. Principles of celestial navigation. Identification of celestial bodies. The marine sextant: its use, adjustment and corrections. Time. Almanacs.

Lecture: 2 hrs/week

Laboratory: 4 hrs/week

Field work: as required

Advanced Navigation

Sight reduction. Celestial lines of position. The complete celestial solution. Celestial navigation: special cases and phenomena. Compass error at sea. Radio astronomy and navigation. Doppler navigation. Inertial navigation. Satellite navigation. Advanced celestial observing instruments. Navigational computers. Lifeboat navigation. Polar navigation. Bathymetric navigation. Optimum track routeing. Air navigation. Abbreviations and symbols.

Lecture: 2 hrs/week

Laboratory: 4 hrs/week

Field work: as required

Marine Fauna and Flora

Survey of animals and plants of the sea. Morphology, anatomy, taxonomy, distribution and relative abundance of major groups. Sampling, collection and preservation techniques for plankton, nekton and benthos. Development of reference collections.

Lecture: 2 hrs/week

Laboratory: 2 hrs/week

Field work: as required

Biology of Commercial Species

Methods for the determination of the biological characteristics of edible marine organisms: growth, mortality, reproduction, spawning, fecundity, migration, food and feeding habits, prey-predator relationships, parasites and diseases. Analysis of the effect of environmental factors on the distribution and abundance of exploited stock. Energy transfer. Life history. Laboratory and field techniques.

Lecture: 2 hrs/week

Laboratory: 2 hrs/week

Field work: as required

Living Resources Management

Development and conservation of coastal and offshore fisheries. Zoning, classification and identification of use of inland waters and coastal areas. Formulation and enforcement of local fishery laws and regulations.

Lecture: 2 hrs/week

Fishing Methods I

Design, construction, maintenance and repair of commercial, artisanal and indigenous fishing gear, e.g. purse seine, bottom and mid-water trawls, long lines, gill nets, hook and line, muro-ami, fish spear, fish traps.

Lecture: 2 hrs/week

Laboratory: 2 hrs/week

Field work: as required

Fishing Methods II

Fishing navigation methods and operation of commercial and artisanal mobile and stationary fishing gear. Arrangements should be made for the participation of the students in commercial fishing boat operations.

Lecture: 2 hrs/week

Laboratory: 2 hrs/week

Field work: as required

Aquaculture I

Brackish water and fresh water aquaculture methods for fin fish. Fish pond, cage and pen construction, pond fertilization, plankton culture, feed formulation, parasites and diseases, hatchery and fish pond management, pen and cage culture in marine coves, estuaries, lakes and rivers. Water quality.

Water management.

Lecture: 2 hrs/week

Laboratory: 2 hrs/week

Field work: as required

Aquaculture II

Brackish water and fresh water aquaculture techniques for invertebrates such as oysters, mussels, clams, scallops, shrimps, sea urchins, sea weeds. Susceptibility of cultured invertebrates to biological changes and environmental stresses.

Lecture: 2 hrs/week

Laboratory: 2 hrs/week

Field work: as required

Sea Food Processing Technology

Traditional and advanced methods of processing fish and fishery products such as salting, drying, smoking, pickling, chilling, freezing, canning, fish protein concentrates and fish meal processing. Onboard handling. Product development. Quality controls.

Lecture: 3 hrs/week

Laboratory: 3 hrs/week

Field work: as required

Fisheries Economics

Fisheries statistical data collection. Catch per unit effort. Cost-benefit analysis of fisheries enterprises. Marketing and distribution. Flow systems monitoring. Fishery infrastructure operation, e.g. fishing ports, fish markets, ice plants and cold storage facilities.

Lecture: 3 hrs/week

Field work: as required

PREPARATION OF COURSE OUTLINES

Time limitations for the meeting and the possibility of space limitations for the publication of the final report precluded the Workshop participants from offering more than concise course descriptions for the proposed syllabus for training marine technicians. Nonetheless, it was well understood that a more complete syllabus would be necessary for an actual application of the programme and that it should include for each course, as a minimum: details on the particular objectives pursued, a comprehensive course outline, the name of the textbook to be used and a list of recommended references. The course on Marine Electronics included in the syllabus for training marine technicians at Brazosport College, Lake Jackson, Texas, United States of America, as revised in January 1977, is reproduced here as example. The content of this course is roughly equivalent to that of the Applied Electricity course proposed by this Workshop. Those institutions wishing to start a marine technician training programme are advised to consider this as a useful model to be applied to each of the courses in their syllabus.

Brazosport College

Lake Jackson, Texas, U.S.A.

Course number: Elect. 133

Course Title: Marine Electronics

Credit: 3

Lecture hours per week: 2

Lab. hours per week: 2

Instructor: (name omitted)

<u>Description</u>: An introduction to t[illegible] marine electricity: an examination of its sources and a quantitative [illegible]sis of its behaviour in typical circuits.

Text: <u>Electricity and Electronic[illegible]ic</u>, Steinberg-Ford

I. Course Objectives

The following objectives will be met through class participation, instructor's assignments, and individual research:

A. The student will be able to describe the various sources of electrical energy as employed aboard ship, and know how these devices convert chemical and mechanical energy to electrical energy; also, the student will be able to describe the interrelationship of magnetism and electricity.

B. The student will be able to identify and differentiate between series and parallel circuits.

C. The student will be able to analyze, <u>quantitatively</u>, direct-current series and parallel circuits through use of Ohm's Law and Kirchoff's Laws.

D. The student will be able to differentiate between alternating (AC) current and voltage and direct (DC) current and voltage and to analyze <u>quantitatively</u> various alternating current circuits encountered.

E. The student will be able to describe the function of the following electronic equipment: two-way radiotelephone, radar, loran, radio direction finders, steering systems and gyro-compass.

F. The student will be able to describe the functions of various electrical measuring instruments used in practice: voltmeter, ammeter, ohmmeter, and wattmeter.

G. The student will learn that in all electrical and electronic work, soldering joints are essential for a good electrical contact, prevention against corrosion at the joint and addition of strength to the joint or splice.

H. In accomplishing the above objectives, the student will learn and b able to utilize the vocabulary and symbols encountered in electrical circuit analysis.

II. Content and Organization

A. Introduction to electricity

1. Theory of electron flow
2. The closed path, or simple circuit
3. Electrical pressure, or emf
4. The volt unit of potential difference
5. Resistance in the simple circuit

B. Sources of electrical energy

1. Static electricity
2. Batteries
3. Electromagnetism
4. Photoelectricity
5. Thermal emission

C. Batteries as electrical sources

1. "Wet cell"
2. "Dry cell"

D. Direct current circuits

1. Simple closed circuit with DC source
2. Ohm's Law E=IR
3. Series circuit
4. Parallel circuit
5. Electrical power

E. Series circuits

1. Addition of resistances in series
2. Series voltage drops
3. Total power in series circuit
4. "Open" circuit
5. Problem analysis

F. Parallel circuits

1. Addition of resistances in parallel
2. Total power in parallel circuits
3. Kirchoff's Laws
4. Problem analysis

G. Direct current meters

H. Electromagnetism

1. Magnetic flux
2. Relationship of magnetism and electricity
3. The DC generator
4. Transformers

I. Alternating current and voltage

1. AC generator
2. Sine wave
3. Phase angle
4. AC circuits with resistance

   a. Series
   b. Parallel

J. Motors

1. Principle of operation
2. DC motor
3. AC induction motor

K. Capacitance and Inductance

III. References and Supplementary Material

Electricity and Electronics Basic, Stenberg-Ford

Marine Radio and Electronics, Allan Lytel

Your Boat's Electrical System, Conrad Miller

IV. Student Evaluation:

Grades will be assigned in accordance with the grading system used at Brazosport College. Grades will be determined as follows:

Average of 3 major one hour tests	50%
Average of assignments in lab	30%
Final examination	20%

V. Meeting the Needs of Students

Any student requiring additional instruction may obtain assistance from the instructor at any time and additional reference material will be supplied or recommended as necessary.

VI. Course Evaluation and Improvement:

Students will submit to the instructor course evaluation forms to identify areas of instructor improvement. Also student suggestions and recommendations will be considered for inclusion of additional material in the overall lesson plan.

TIME FRAME CONSIDERATIONS

This syllabus was prepared under the assumption that the study programme would be completed in two years, but it is conceivable that certain institutions might wish to apply it to a different time frame. Exceptionally, a university might like to expand the programme to four years in order to award a B.S. in Marine Engineering or a comparable degree to successful candidates. In that case, the syllabus proposed herein would be insufficient for that purpose and a number of basic and specialized courses will have to be added. Often there may be a need to shorten the time frame owing to lack of resources and facilities for a two-year programme. This is either because it will be applied at a level lower than the junior college for students without secondary school diplomas, as may be the case in vocational schools, or simply because the shorter programme is what is really needed.

The determination of time allocations for the programme should under all circumstances be based on the following considerations:

a) respond to well defined local needs and possibilities;

b) be at a level harmonious with student capabilities, aspirations and past experiences;

c) be capable of producing the abilities and skill levels needed for particular job requirements;

d) keep a proper balance between classroom, laboratory, field work and job-site training;

e) permit the students to progress to the limit of their ambitions and capabilities; and

f) allow trained marine technicians to take refresher or up-grading courses.

There are three main time frames to which this syllabus for training marine technicians may be applied most successfully:

1. Two years, for a straightforward adoption of the syllabus along the lines proposed in this report;

2. One year, for a shortened but comprehensive programme (for which a certificate will be awarded) permitting an efficient discharge of basic marine technician duties upon completion;

3. Six months, which is the minimum time required for following the core courses and gaining some valuable on-the-job experience.

STAFF AND TEACHING FACILITIES

Teaching Staff

The success of an occupational educational programme, such as the one proposed in this report, will be dependent on several factors. It will depend to a large extent on having an adequate, full-time teaching staff with a thorough understanding of the aims, objectives and overall philosophy of the programme in what concerns their area of specialization. Also important is a dynamic system of upgrading, retraining and updating prospective or practicing teachers. The types of teachers needed for a programme of this nature have been characterized by Gillie and Pratt as follows:

> "Occupational curricula can be arbitrarily viewed as having three components: (1) the theoretical-cognitive elements (commonly found in some lecture courses); (2) the practical skill-development (primarily related to laboratory experiences); (3) work experiences (often found as work/study arrangements between the institution and several marine-related industries). A teacher is usually best suited for only one of these program components.
>
> Faculty for the theoretical-cognitive aspects of the curriculum would most likely be those with an academic background congruent with the types of subject materials needed. There is an inherent danger in this situation: academic teachers for this part of the program are likely to overestimate the cognitive-theoretical abilities of their students, and special measures should be taken to insure a continuous feedback between faculty and students to quickly correct such difficulties. Academic teachers must consider student abilities and adapt their presentations to fit the skill, capacities, and experiences of their students...
>
> Faculty members for the practical skill-development portion of the curriculum are, in many cases, not the same people who teach the academic parts of the program. They are generally less apt to have the traditional academic education and often have a richer background of experiences in work related to marine technology. Faculty members for skill development aspects of the program rely more heavily on their work experiences and less on their academic preparation."

The Workshop recognized that a cadre of teachers well versed in the most modern techniques and capable of problem-solving with relatively limited resources was a necessary condition for the establishment of marine technician training programmes in developing countries. In this respect, several possible mechanisms for assisting those countries have been brought to the attention of the Intergovernmental Oceanographic Commission and the Division of Marine Sciences of Unesco (see recommendation 5 below). Those mechanisms imply, in one way or another, technological transfers between developed and developing countries. The Workshop was somewhat concerned, however, about the potential danger of training native instructors abroad in techniques far too sophisticated for their own countries who, upon their eventual return, may find themselves handicapped by an inability to teach simpler ways of solving the problems likely to be encountered by marine technicians locally.

Teaching Facilities

The full development of a marine technician training programme on the basis of this syllabus would necessitate, among other things, laboratories, classrooms, machine shop, training vessels, equipment and instrumentation, library, training aids, regular supply of expendable materials, access to the facilities of local marine industries, and a number of other additional facilities such as offices, reproduction, storage space, washrooms and rest areas. It is overly optimistic to expect that developing countries will have facilities of this kind at their disposal for training marine technical personnel. One of the main purposes of this syllabus is to make it flexible enough through the modular system so that it could be used profitably by countries with diverging needs, resources and capabilities, even those with minimal staff, facilities and equipment. This means that the type of facilities required will depend upon the objectives of the programme, and that the cost of the equipment and its maintenance will be in direct proportion to the degree of sophistication desired. It is of no interest to include here a long list of the facilities required for an optimum utilization of the syllabus when it suffices to say that the course descriptions accomplish this purpose.

In most cases, a programme for training marine technicians in a developing country will be initiated using an existing college, technological institute, vocational school or even a marine research centre so that some building facilities, including laboratories, may be available from the beginning. Whereas vessels are considered essential for training personnel in fisheries or in ship operation and maintenance they do not have to be owned by the training institution; in fact, it is more advisable to use government-owned vessels or to involve the students in work/study projects with local marine industries. Even for those marine technicians whose training can be carried out in the absence of a vessel, ready access to the sea is necessary. It is obvious that there are many other ways to strengthen knowledge, e.g. through lectures illustrated with films or slides, simple experiments using inexpensive materials for practical and field work, seminars for discussion of local technical problems using press reports, visits to local marine industries, guided projects, manuals and guides prepared by the instructors, and the design and fabrication by the students of models, mock-ups and actual working pieces of equipment. In conclusion, the Workshop wanted to reiterate that properly planned practical work under real and/or simulated conditions is a condition *sine qua non* for a programme of this nature; this is because of the need to develop abilities and manual skills to enable the students to carry out their assigned technical tasks in an efficient manner.

RECOMMENDATIONS

The Workshop on the Preparation of a Syllabus for Training Marine Technicians:

1. *Recalling* that among the guidelines set down by the Steering Committee to plan this Workshop it was indicated that the syllabus for training marine technicians should be commensurate with the needs, resources and possibilities of the developing countries using it, as well as action-oriented and with theoretical and practical

training components of direct applicability to real-life situations,

Being of the opinion that, even though the syllabus herein offered has been prepared according to high international standards, the degree of sophistication in its actual application will depend greatly on existing facilities, available trained manpower and particular interests of each country,

Recommends that IOC Member States wishing to initiate courses for training marine technicians should consider the present syllabus only as a useful model to be analyzed and applied in the light of local conditions, but not necessarily to be copied indiscriminately.

2. Being aware that one of the primary difficulties faced by institutions wishing to develop a programme for training marine technicians is the sparsity of field and laboratory manuals and guides, as well as of complementary teaching aids, especially in languages other than English,

Recommends that as a first approach in trying to find a solution to this problem the Intergovernmental Oceanographic Commission and the Division of Marine Sciences of Unesco undertake the following tasks:

2.1 development of a multilingual bibliography, as complete as possible, of suitable manuals and reference materials covering field and laboratory techniques for the training and regular use of marine technical personnel, including translations in languages other than the original;

2.2 translation and subsequent publication of selected comprehensive manuals deemed appropriate for the training and actual working activities of marine technicians in the official languages of the Commission (English, French, Russian and Spanish) and also in Arabic;

2.3 awarding of consultants' contracts for the preparation of basic field and laboratory manuals and guides designed specifically for the use of marine technicians in developing countries;

2.4 identification, acquisition and distribution of demonstration equipment and audio-visual teaching aids to be used by institutions in developing countries in the training of marine technicians, such as surplus equipment, models, mock-ups, films, slides and charts.

3. Being conscious of the necessity of attaching a sufficient degree of social, economic and professional standing to the career of marine technician,

Being aware also of the valuable experiences gained by the two-year Occupational Education Programmes developed by one Member State for those who wish to prepare for careers requiring specialized study at the college level to satisfy an ever increasing demand for supporting personnel in scientific and technical fields,

Recommends that, when establishing formal courses for the training of marine technicians, IOC Member States should give careful consideration to the adoption of a system whereby:

3.1 secondary school graduates can be admitted as trainees and, after only one year of successful training, at the end of which they should be granted an official certificate, have been taught enough to enable them to obtain meaningful employment and effectively carry out their assigned technical functions;

3.2 upon successful completion of their two-year studies, the candidates are awarded a recognized degree similar or along the lines of the Associate in Science degree granted in occupational programmes, thus increasing their social standing and the possibility that they obtain adequate remunerations to enable them to remain in their chosen field;

3.3 whenever possible, courses approved at the two-year college level within the framework of the occupational education programme envisaged in this syllabus should be acceptable as credit towards four-year degrees in related fields by upper division colleges or universities;

3.4 in those developing countries wishing to conduct marine technical training a full department be formed, when both practicable and feasible, in an established junior college or vocational or trade school, in order that the training programme have appropriate academic accreditation at the national level from the moment of its inception.

4. Recognizing that effective marine technician training may easily be developed by a number of countries utilizing existing and appropriate facilities,

Cognizant of the fact that such facilities might lack certain training and education materials, equipment, instrumentation and supplies,

Urges IOC Member States interested in organizing marine technician training programmes to prepare early inventories of their available facilities; and

Strongly recommends that the Intergovernmental Oceanographic Commission, in close co-operation with other interested international agencies and donor Member States, take the necessary measures to remedy the inventory gaps that may thus be identified by all possible means, in particular through the use of the IOC Voluntary Assistance Programme (IOC-VAP).

5. Realizing that a necessary condition for the establishment of regular or *ad hoc* courses to train marine technicians is the existence of a cadre of teachers well versed in the most modern techniques and capable of problem-solving with relatively limited resources,

Recommends that the Intergovernmental Oceanographic Commission and the Division of Marine Sciences of Unesco examine the best ways to ensure the availability of adequate trained instructors to provide the marine technical teaching needed in developing countries. In this connection, the following possible mechanisms were proposed:

5.1 expert personnel from the developed countries could travel to developing countries (or regions) to give appropriate training to those who eventually would become the local instructors;

5.2 personnel from the developing countries could travel to developed countries in order to obtain the required training and upon returning to their own countries they could, in turn, teach the local instructors;

5.3 expert personnel from the developed countries could travel to developing countries as instructors themselves to teach the various courses in marine technology;

5.4 Unesco could organize courses in which potential instructors from the developing countries would participate in order to acquire the necessary know-how to become qualified instructors in marine technological aspects;

5.5 marine scientists within the developing countries could themselves undertake the training of local marine technicians using such technical manuals as may be available to supplement their own background in marine science;

5.6 under the umbrella of the ICSPRO agreement, the IOC could determine other possible mechanisms for training qualified instructors within the various programmes of the ICSPRO agencies (UN, Unesco, FAO, WMO and IMCO) to enable them in due course to train the local marine technicians.

6. Being conscious of the efforts and investments involved in developing a programme for training marine technicians,

Recognizing the dangers involved in producing a number of graduates in excess of the real employment needs,

Recommends that before establishing a programme of this nature IOC Member States should make a feasibility study to diagnose existing and potential employment possibilities locally, country-wise and regionally and on the basis of the results obtained decide whether to establish regular courses on a continuing basis or ad hoc courses, nationally or jointly with other countries in the region, or simply to postpone initiating the programme until such time when the job market has become more satisfactory.

7. Taking note of the fact that under the auspices of the Intergovernmental Oceanographic Commission a significant number of scientists and technicians from developing countries have received training in techniques of marine scientific research on board vessels of developed countries during the last few years and that, in general, such participation has proved useful in the opinion of all parties concerned,

Recommends that the Commission continue to provide support for this programme as an effective means for direct involvement in field research activities of importance to the countries in the region where the cruise takes place;

Further recommends that IOC Member States consider extending generous financial support to the shipboard fellowship scheme, and to the training of marine technicians in general, through contributions to the IOC Voluntary Assistance Programme.

8. Recalling that the Working Committee for TEMA, at its second session (UN Headquarters, New York, 18-23 July 1977) adopted recommendation TEMA-II.9 recognizing the general lack of adequately trained technical personnel essential for the support of scientists and engineers in marine science activities and on the basis of which it was advised that during 1978-1979 the Intergovernmental Oceanographic Commission organize workshops of one month's duration to train marine technicians in each of several regions, in conjunction with the Division of Marine Sciences of Unesco,

   Recommends that note be taken by these two bodies of the advisability of having marine technician training courses on a regional basis and that serious consideration be given to planning and/or supporting the establishment of regional centres for training marine technicians in South-east Asia, the Caribbean, the Indian Ocean and other geographical areas for the mutual benefit of the countries of those developing regions.

9. Recalling further that a large number of the participants in the TEMA-II meeting indicated that relatively little information regarding available programmes for marine technician training has been circulated,

   Recommends that the Intergovernmental Oceanographic Commission, in consultation with the Division of Marine Sciences of Unesco and the other ICSPRO agencies, compile and disseminate to IOC Member States a listing, as complete as possible and with a world-wide coverage, of those institutions which presently provide training in the area of marine technology, including among other things a description of entrance requirements, course length, degrees granted, and summaries of the different curricula employed.

10. Being aware of the training opportunities in marine and related technology that exist in established local industries throughout the world,

   Recommends that the Intergovernmental Oceanographic Commission by means of the National Training Contacts undertake a study, including if possible a country-by-country identification of potential opportunities, and determine on the basis of that study proper guidelines to be followed for the establishment of viable, mutually profitable collaboration arrangements to enable technicians in given countries to benefit from on-the-job training in those local industries.

Note: The above recommendations of the Workshop represent the collective considered advice of the Workshop participants. Their inclusion in this document does not imply acceptance by the governing bodies of Unesco or the Intergovernmental Oceanographic Commission.

APPENDIX I: BACKGROUND

For the last decade the Intergovernmental Oceanographic Commission has been aware that assistance in establishing viable mechanisms for training marine technical personnel to support the activities of marine scientists and engineers is of high priority to its Member States, in particular the developing countries. One of the items appearing on the agenda of the first meeting of the IOC Working Group on Training and Education (Paris, 2-4 December 1968) was a general discussion on the scope and scale of national and international needs for marine scientists and technical assistants, including means of encouraging entry to that field.

The joint session of the IOC Working Groups on Training and Education in Marine Science and on Mutual Assistance, held in Malta, 5-12 January 1971, defined one of the main aims of the Commission: to provide assistance to its members in creating and augumenting the scientific and technical staff in marine science in those countries where there is still a lack of trained personnel. The following points were among those on which agreement regarding the training of marine technicians was reached:

- it was recognized that the background of technicians would differ widely, depending upon the type of work in marine science and technology in which they would be assisting;

- training opportunities were urgently needed in many developing countries where technical schools were lacking and, in those cases where they did exist, it was advised that efforts be made to open them to nationals from neighbouring countries;

- the exchange of technicians between neighbouring countries should be facilitated, in order to help in mutual improvement of skills and comparability of practices;

- although it was agreed that a universal training of technicians was not possible, the need for high-level training in the operation and maintenance of sophisticated instruments was stressed;

- it was recommended that existing manuals useful for specialized technical training be included in the list of textbooks that was to be compiled by the Secretariat;

- on the basis of the above compilation, it was advised that the Secretariat prepare a short document describing the kind of technical skills required for the conduct of modern marine research, as well as a list of institutions offering special training suitable for marine technicians;

- sea-going experiences were recognized as an integral part of the training of marine scientists and technicians. In this regard, the opportunities for placing such personnel on board vessels of countries with large national research activities were taken as an effective means for realizing ship-board training.

The IOC Working Group on Training, Education and Mutual Assistance, at its first session (Paris, 7-13 March 1973), recognized that in carrying out various activities in the field of marine science every country will require people with special skills whose tasks would be the study of specific problems such as data processing, instrument design and maintenance and telecommunication, as well as specialized biological, chemical, physical, geological and geophysical methods. The group also agreed that the training of technicians could be achieved in one of the following ways:

a) training in the country by national or foreign experts;

b) taking part in various kinds of shipboard training;

c) on-the-job training in advanced services and countries.

The problems involved and the mechanisms to follow for training marine technicians were thoroughly discussed by IOC Member States in the regional ad hoc TEMA meetings convened during the 1975-1976 biennium (Mexico City, Mexico, 10-12 April 1975; Casablanca, Morocco, 3-5 June 1975; Manila, Philippines, 15-19 September 1975; Cairo, Arab Republic of Egypt, 4-8 January 1976; and Montevideo, Uruguay, 15-19 November 1976). Among the highlights of the recommendations of these regional meetings, the following may be mentioned:

- full use should be made of those facilities for training technicians in the marine sciences that presently exist in the various regions;

- the Secretary IOC should convene a group of experts on the training of marine technicians to produce a document comparable to the report of the Unesco Workshop on University Curricula - Marine Science Teaching at the University level (Unesco Technical Papers in Marine Science, No. 19);

- the Secretary IOC should convene a group of experts specialized in the training of marine technicians (fisheries, oceanography, etc.) to prepare pertinent educational materials and to advise on how those materials could be made available to the countries in the various regions;

- countries in the regions ought mutually to assist each other in the training of marine science personnel through the sharing of national training facilities and by undertaking jointly planned and staffed oceanographic cruises, using the vessel of one country in waters of interest to the other co-operating countries;

- the IOC ought to prepare a list, by disciplines, of institutions (universities, laboratories, etc.) located in and outside the regions having the capacity for and the interest in training technicians from developing countries either at the basic or at an advanced level;

- possible remedial actions to alleviate the difficulties of developing countries to maintain, service and make routine repairs of their laboratory instrumentation and ship-board equipment could be:

- that the instrument suppliers be asked to develop servicing manuals,
- that university workshops be utilized as far as possible for routine servicing and repair work,
- that IOC send an oceanographic equipment specialist to the regions for about six months to train personnel in this field;

- the IOC should provide financial support for sending technicians from developing countries to foreign institutions, to learn from the experience of technicans who are using sophisticated equipment such as STD probes, current meters, autoanalyzers, remote sensors, geophysical equipment, computers.

The second session of the IOC Working Committee for Training, Education and Mutual Assistance in the marine sciences (TEMA-II), held in New York, 18-23 July 1977, fully endorsed in concept the sense of the recommendations of the regional ad hoc TEMA meetings. The majority of the delegates indicated that most developing countries lack sufficient trained personnel at the marine technician's level. A number of participants stressed that training courses for marine technicians should be organized locally, reflect local problems, be directly related to exisiting programmes and be geared to the utilization of available equipment. This may require improvement of existing facilities. Others felt that it would be best to send their technicians abroad to be trained using the facilities of industrialized nations, but emphasized the fact that information on available marine technician training is not always easy to obtain. It was generally agreed that formal training courses are an excellent (though expensive) way to impart a great deal of information over a short time, but that they must of necessity be accompanied by on-the-job training.

After noting the suggestions of various specialized TEMA meetings regarding the training of marine technicians, the Working Committee recommended that national oceanographic committees or equivalent national bodies submit to the Secretary IOC proposed criteria for the technical level of instruction needed in support of the marine sciences. It was further recommended that after unified series of such criteria had been adopted by the IOC Executive Council that the IOC, in conjunction with the Division of Marine Sciences of Unesco, organise a series of workshops of one month's duration during 1978-1979 in each of several regions for training marine technicians.

As a follow-up to the TEMA recommendations, a Steering Committee met to organise an IOC/Unesco Workshop on the preparation of a Syllabus for Training Marine Technicians. The meeting was held on 18 November 1977, at the Atlantic Oceanographic and Meteorological Laboratories (AOML), NOAA at Virginia Key, Miami, Florida, United States of America. The following persons were in attendance: Captain Octavio A. Díaz González, Director General of Marine Science and Technology, Mexico, and Chairman of the Steering Committee; Dr. Harris B. Stewart, Jr., Director of the Atlantic Oceanographic and Meteorological Laboratories, and host of the meeting; Mr. Bud Burke, Director of Government Relations, Tracor Marine, Inc., and representative of ECOR; Mr. Joseph F. Zawodny, Chairman of the Marine Science Technology Department, Miami-Dade Junior College; and Dr. Luis E. Herrera, Assistant Secretary IOC.

The Chairman opened the meeting and in the discussion that followed the participants clarified the purpose of the workshop, namely that a group of experts on the training of marine technicians was to elaborate a syllabus that could serve as a basic model for marine technician training programmes in developing countries. The Steering Committee recognized that the syllabus for training marine technicians should have the following characteristics:

a) be commensurate with the needs, resources and possibilities of the developing countries for whose use it is intended;

b) be useful for the local training of marine technicians rather than for training abroad (the syllabus would thus mainly serve those countries willing to develop their own training capabilities);

c) have an increasing order of complexity in the treatment of subjects, from very simple operations at sea to more sophisticated undertakings such as the maintenance, repair and calibration of scientific equipment (this would give the syllabus enough flexibility to be applicable to countries in various stages of development);

d) be action-oriented, with theoretical and practical training components of direct applicability;

e) be open to qualified secondary school graduates who, after following the course for two years (i.e. up to the Junior College* level) would receive a certificate or a formal degree upon successful completion of their studies;

f) consist of a module common to all fields of specialization and several specialized modules to cover the various fields in which the marine technicians are to be trained: biological (including fisheries), physical, chemical, geological and ocean engineering;

g) include a complete list of references of institutes where marine technical training may be obtained, with the names of staff members involved in the programmes if at all possible;

h) be translated into Spanish, French and Arabic once a final version is available and then published and distributed to appropriate institutions in developing countries.

In addition, the Steering Committee recommended the place and dates for the Workshop (Atlantic Oceanographic and Meteorological Laboratories, National Oceanic and Atmospheric Administration, Virginia Key, Miami, Florida, U.S.A., 22-26 May 1978), made out a list of experts in the training of marine technicians to whom invitations to participate would be forwarded, and identified and made contact with the consultant (Mr. E.D. (Ned) Middleton, Jr.) to whom was entrusted the responsibility for the preparation of the basic paper to be examined during the Workshop.

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* Corresponds to the first two years of a Bachelor's degree programme.

The Workshop on the Preparation of a Syllabus for Training Marine Technicians was held 22-26 May 1978, at the Atlantic Oceanographic and Meteorological Laboratories, NOAA, with the persons indicated in the List of Participants in attendance. The following agenda was adopted:

1. Opening of the Workshop.

2. Election of officers (Chairman and Rapporteur).

3. Organizational aspects.

4. Preparation of the Syllabus for Training Marine Technicians.

5. Any other business.

6. Closure of the Workshop.

Dr. Harris B. Stewart, Jr. and Mr. Joseph F. Zawodny were elected as Chairman and Rapporteur, respectively.

The preceding report contains the ideas, conclusions and recommendations of the participants in the Workshop.

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APPENDIX III: REFERENCES

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Gillie, A.C.; Pratt, A.L. 1971. Marine Technology Programmes: where we are and where we are going. American Association of Junior Colleges, Washington, D.C.

Scott, D.P.D.; Herrera, L.E. Transfer of Technology in the Marine Sciences: international capabilities, limitations and problems. Paper presented at the Third General Assembly of the Engineering Committee on Oceanic Resources (ECOR), National Academy of Sciences, Washington, D.C. 3-6 May 1978 (pre-print, 19 p.).

APPENDIX IV :

SYLLABUS FOR HYDROGRAPHIC SURVEYORS

In issuing this syllabus, the IOC Secretariat wishes to draw attention to what they consider to be an omission - the requirements of marine technicians relative to hydrographic surveying. As this is a basic activity falling within the scope of marine technology, the Secretariat has decided to include examples of courses for Hydrographic Survey Technicians which are being given at the Royal Navy Hydrographic School of the United Kingdom.

HYDROGRAPHIC SURVEY TECHNICIAN

These technicians assist Hydrographic Surveying Officers in the production of nautical charts and other navigational aids for safe navigation at sea.

Survey Technician Grade II

Introduction to Hydrographic Surveying; survey control; introduction to Geodesy; use of mathematical tables; hand calculators and electronic calculators; tides, datums and transfers; tidal measurement; Poles and Gauges; Reduction of soundings; the sounding sextant; plotting instruments; station pointers and interpolators; Basic Echo Sounder theory; electronic position fixing systems; duties of crew in a Surveying Motor Boat; Coxwain of Surveying Motor Boat for sounding; take charge of Surveying Motor Boat for buoy fixing and bottoming evolutions; the Level and levelling; the Theodolite and observing procedures; coastlining by resection fixing and sextant traversing; instrumentation, optical, mechanical and electrical relevant to surveying; introduction to oceanography and oceanographic instrumentation; care and maintenance of instruments; recording for all forms of data collection; time and time signals.

Approx 350 hours   150 Theory
                    200 Practical

Survey Technician Grade I

Consolidation of all subjects in Grade II; ability to take charge of Surveying Motor Boat for all survey evolutions; tidal streams ocean currents and their measurement; Echo Sounders, bar checking, fault finding and rectification; levelling, theory and practical; Theodolite and observing horizontal and vertical angles; Tellurometer/Electronic distance measurement and its reduction; Geodesy; Gravity; Magnetics; Practical oceanography, salinometer and water bottle computations; Temperature, Salinity, Sound Velocity and Depth probes; Bathytermograph castings, cores, Grabs, Secchi Disc; preservation of samples; traversing, observation plotting and correction(Bowditch); large scale surveys; fixed angle plots; draughtsmanship; compilation of survey records; Computations, grid bearing and distance, false station correction, resection, intersection, computations on the grid, arc to chord correction, mathematical balancing of triangulation (by non-rigorous methods).

Approx 400 hours 250 Theory
150 Practical