UNDERWATER EDUCATION AND TECHNOLOGY AT THE UNIVERSITY OF MICHIGAN: A FIVE YEAR PROGRESS REPORT

Lee H. Somers, Ph.D.

Associate Research Oceanographer
Assistant Professor of Physical Education

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ABSTRACT

This report summarizes The University of Michigan's program in underwater technology and research. Nearly all such activities are directly or indirectly related to the Michigan Sea Grant Program's Underwater Technology Project.

Since 1970, more than 6,000 person-dives (5,000 person-hours underwater) have been made in the underwater program. The University has an Underwater Technology Laboratory which houses a hyperbaric chamber, a research laboratory, and a complete diving locker. Since 1972, there have been more than 919 man-pressurizations in the chamber, including 106 oxygen medical treatments. The program has extended scientific diving capabilities through the application of surface-supplied diving, research in cold weather diving, development of underwater research techniques, specialized training cruises and the publication of diving manuals. The program's underwater habitat served Great Lakes area researchers and students for three years in Grand Traverse Bay. In addition, the University's saturation diving team has completed two missions in the Hydrolab Underwater Habitat. Diving safety has been emphasized throughout the program's development. More than 1,000 students have received basic and specialized diver training. Occupational safety and health standards have been developed for scientific divers. The program has integrated the efforts of several University units into a functional underwater research and education program.

INTRODUCTION

The Michigan Sea Grant Program's Underwater Technology Project (formerly Underwater Operations) was initiated in the summer of 1969 to provide a diving support and supervisory capability for scientific and technical applications, and to develop the research, education, and advisory service aspects of underwater technology. The initial project objectives included:

1. Establish a lecture course in underwater technology, with emphasis on life-support systems, diving physiology, saturation diving, underwater work, manned submersibles and seafloor habitats.

2. Provide lectures on underwater technology for existing courses in oceanography, ocean engineering, etc.

3. Provide lectures and short courses dealing with various aspects of working in the underwater environment for various public, industrial, and governmental groups.

4. Establish a continuing program for the supervision and coordination of underwater activities at The University of Michigan.

5. Establish a facility for testing and maintaining University of Michigan diving equipment.

6. Provide qualified diving personnel for use on various research projects.

7. Provide diving services and/or advisory services to other university, governmental, and industrial organizations.

8. Conduct research and development activities in the field of underwater technology.

These objectives were supported primarily by Sea Grant funds. An extensive underwater education program, funded by the University, was simultaneously initiated. The primary objectives of this program, conducted by the Department of Physical Education, included:

1. Provide training courses in basic self-contained diving (SCUBA) for University students and staff.

2. Provide training courses in the instruction of scuba diving.

3. Provide advanced training in self-contained and surface-supplied diving for University students and staff with emphasis on research diving operations.

The Michigan Sea Grant Program and the Department of Physical Education cooperated in the sharing of personnel, equipment, and facilities.

Subsequently, a cooperative program which included research, education, and service was developed with the University's Medical Center. The Pulmonary Division of the University of Michigan Medical Center provides medical personnel, supplies, and equipment for all hyperbaric chamber activities. In addition, Medical Center physicians exam all active divers and diving trainees, and lecture at various courses conducted by the Michigan Sea Grant Program. The Michigan Sea Grant Program provides a hyperbaric

chamber and technical personnel for medical services and research. An annual Sea Grant/ Medical Center seminar on hyperbaric medicine is sponsored through the University's Department of Postgraduate Medicine for Michigan and Ohio area physicians.

As the Underwater Technology Project matured new areas of need were identified and additional emphasis was placed on education and advisory service activities. Recognizing an increasing public demand for sport diver safety education, hyperbaric chamber facility availability, community service lectures, and other activities related to the vast population of Great Lakes area sport divers, the Project is now moving toward an advisory services leadership role in this area. At the same time, a strong research and development program is being maintained to serve both the scientific community and the general public. Specific projects are planned to complement both factions. The *Research Diver's Manual,* originally developed for the scientific community, is now used extensively throughout the country for advanced sport diving and instructor training. The results of the Project's research on cold weather and under-ice diving for scientific studies were published by the National Association of Underwater Instructors as a manual for advanced specialty sport diving. This is currently the only major manual on the subject available to hundreds of thousands of sport divers who dive in cold waters of the United States and Canada.

The original objectives have been fulfilled, and the Underwater Technology Project has matured and evolved to meet the needs of both the scientific community and the general public. This report summarizes Project activities from the summer of 1969 to the spring of 1975. It includes a prospectus on the future of underwater technology, education, and advisory services at The University of Michigan.

DIVING AT THE UNIVERSITY OF MICHIGAN

The early history of scuba diving at The University of Michigan is obscure. In the late 1950's and early 1960's some individuals connected with fisheries and zoology research were using scuba in their research. However, no records of these activities are known to be available. In 1960, the University's Great Lakes Research Division recorded some diving activity in ship logbooks. The following data are available:

Year	No. of Dives	Man-Hours (Estimated)
1960	40	20
1961	0	0
1962	6	3
1963	42	21
1964	48	34
1965	71	31

Starting in 1965, records of Great Lakes Research Division and Department of Meteorology and Oceanography diving activities are available:

Year	No. of Dives	Man-Hours
1966	327	202
1967	334	166
1968	238	90
1969	566	294

Unfortunately, records for diving activities performed by other units of the University were not maintained. In 1970 the Diving Safety Committee assumed responsibility for surveillance of diving activities and the following figures are recorded:

	1970	1971	1972	1973	1974	1975[h]
Certified Research Divers	12	16	10	18	24	62
Man-Dives[f,g]	439	220	930[a]	745	777	–
Man-Hours Underwater[f,g]	620	378	417[a]	553	1128	–
Field Trip Man-Dives	–	325	210	173	319	468
Field Trip Man-Hours Underwater	–	195	159	115	247	371
Research Diver Course Man-Dives	–	–	117	666[b]	418[c]	–
Research Diver Course Man-Hours	–	–	110	382[b]	238[c]	–
Phy. Education Man-Dives[d,e]	62	65	60	65	68	–
Phy. Education Man-Hours[d,e]	24	33	30	33	34	–

a – Including Hydrolab saturation dive

b – Including Sea Grant personnel

c – Excluding Sea Grant personnel

d – Many students complete open water dives off campus with other instructors, and are not included in these figures

e – Estimated

f – Estimates were used for some individuals who have left campus and/or failed to turn in dive report forms

g – Excluding dives in U-M hyperbaric chamber

h – Figures for 1975 include only the number of divers qualified under University regulations as of 20 May, and times only for the spring Caribbean field trip (29 participants)

UNDERWATER TECHNOLOGY LABORATORY

An Underwater Technology Laboratory, a facility of the Underwater Technology Project, was established at The University of Michigan in January 1972. The main facility is in 1038 G.G. Brown Building on the University's North Campus. This laboratory is

equipped with a double-compartment hyperbaric chamber, a small temperature controllable research hyperbaric chamber, low- and high- pressure air systems, work benches, assorted tools, and cabinets for storage of project equipment. A machine shop with additional power tools, welding equipment, etc., is conveniently located in rooms adjacent to the laboratory and are used under cooperative agreement with the College of Engineering's Department of Mechanical Engineering. Air for chamber operation is provided by two 550 ft^3/min air compressors located elsewhere in the G.G. Brown Building. A large (45 ft x 13.5 ft x 15 ft) pool, housed in the same building, is available for equipment evaluation, experimentation, and training under cooperative agreement with the Department of Naval Architecture and Marine Engineering. Office space and a limited amount of laboratory space for the director and assistants is located in the adjacent Space Research Building of the Department of Atmospheric and Oceanic Science. Activities involving swim testing of equipment and procedures are conducted at the Margaret Bell Pool on Main Campus. The Department of Physical Education maintains a complete scuba diving locker at this facility.

The main facility is used for equipment evaluation, modification, and construction; hyperbaric research; a base of operation for project activities; and supporting educational activities.

HYPERBARIC CHAMBER

The magnitude of diving activities at The University of Michigan necessitated the availability of a hyperbaric chamber for potential use in the treatment of diving accident victims. A two-compartment hyperbaric chamber, similar to the portable type used in support of offshore oil-field diving operations, was acquired by the Michigan Sea Grant Program in January, 1972 and is currently housed at the program's Underwater Technology Laboratory on the University's North Campus. The 12-foot cylindrical chamber has a diameter of 54 inches and can accomodate two or three persons at a time. It is equipped with an overboard discharge oxygen breathing system, portable oxygen analyzer, external lighting, telephone communications, and other standard portable hyperbaric chamber equipment. A well stocked medical locker is maintained at the laboratory. The chamber's outer compartment or lock allows transfer in or out of personnel, medical supplies, food, body waste and other materials or equipment without affecting inner compartment pressure. Primary air for pressurization and ventilation is supplied by two high-capacity, low pressure compressors. Emergency air is contained in a series of high-pressure cylinders. Routine chamber operating pressures to an equivalent depth of 230 feet of seawater are used for research and training: maximum operating pressure is 130 pounds per square inch or 292 feet of seawater. The chamber is built in accordance with code specifications of the American Society of Mechanical Engineers and is U.S. Coast Guard approved.

The hyperbaric chamber is used for diving equipment research, physiology research, therapy, diver training, safety demonstrations and as a complement to other University courses and programs. Medical supervision and staff is provided by the Pulmonary Division of The University of Michigan Medical Center; technical personnel are provided by the Underwater Technology Laboratory. Trained medical and technical personnel are available on call 24 hours a day for emergencies.

The chamber is currently the only routinely operational unit in the State of Michigan for handling diving casualties. In addition, the chamber services divers from portions of Ohio, Indiana, and Ontario. The year 1974 saw an increase in hyperbaric chamber usage, with more than 540 man-pressurizations including 92 hyperbaric oxygenization treatments.

The following is a summary of hyperbaric chamber activity for 1972 through 1974:

	1972	1973	1974	Total
Pressurizations	99	47	167	313
Man-pressurizations	239	135	545	919
Man-hours under pressure	122	153	461	736
Oxygen treatments	5	9	92	106

Hyperbaric oxygen for the treatment of various medical conditions has increased significantly. The following is a summary of 106 treatments through December 1974:

	1972	1973	1974	Total
Air embolism: diver	3	1	1	5
Decompression sickness: diver	0	1	3	4
Carbon monoxide poisoning	1	0	0	1
Gas gangrene	1	7	11	19
Osteoradionecrosis	0	0	77	77

A hyperbaric chamber attendant's course was developed in 1973 and taught by Underwater Technology Laboratory and University Medical Center personnel. During 1973 and 1974 approximately 40 students and faculty received training in chamber operation and maintenance. A manual titled *The University of Michigan Hyperbaric Chamber Attendant's Handbook* was written for this course by Lee H. Somers, Ph.D. and Martin J. Nemiroff, M.D. Copies may be obtained from the Michigan Sea Grant Program.

Hyperbaric research anticipated for 1975 includes blood oxygenation studies, decompression meter evaluation, small chamber fire-extinguishing apparatus development and the evaluation of several instruments and procedures for medical support. The hyperbaric chamber attendant's course will be offered as a university physical education course in the Fall Term of 1975, and a number of chamber demonstrations are scheduled.

The chamber was acquired with funds granted by the Office of Sea Grant, National Oceanic and Atmospheric Administration, U.S. Department of Commerce. Currently, partial financial support for the operation of the chamber is provided by the Michigan Sea Grant Program. In December of 1974 the Michigan Skin Diving Council awarded The University of Michigan a $3,000 grant for the maintenance of the hyperbaric chamber facilities.

SURFACE-SUPPLIED DIVING

Self-contained diving techniques have been used by scientists for more than two decades. Self-contained underwater breathing apparatus allows the diver the

advantages of portability, underwater mobility, and simplicity of operation. In addition, training in the use of open-circuit scuba is readily available for most research personnel. In order to utilize the advantages of scuba, the diver has sacrificed dive duration, physical (thermal) comfort, reliable communication capabilities and safety under limited visibility conditions. Furthermore, efficiency of self-contained diving is limited by the requirement to commit two divers to all missions for safety purposes. Frequently the underwater task could be as effectively accomplished by a single diver. Under the limited visibility conditions common to the lower Great Lakes, two scuba divers may easily become separated and be of little or no assistance to each other in an emergency.

Inherent disadvantages and limitations imposed by the use of open-circuit scuba, along with recent improvements in other types of diving equipment, prompted University of Michigan researchers to investigate the applications of surface-supplied diving techniques to underwater studies. This investigation resulted in the conversion to surface-supplied free flow/demand masks, hot water circulating suits, and hard wire communications units for many University projects. Recent developments in lightweight equipment allow the diver to retain freedom of movement, within the range of his umbilical assembly, comparable to that of a scuba diver. With this equipment, mission capabilities are greatly extended, data acquisition improved, and higher standards of safety maintained. Operational efficiency and cost-benefit factors are significantly improved.

Conversion to surface-supplied apparatus involved coping with the following:

1. Non-commercial or non-military diving training programs in the use of surface-supplied diving equipment were not readily available to scientific personnel. A training program, built on a scuba diving background, had to be developed to meet the needs of the scientific diver. The training program is included in the information on research diver training courses.

2. Diving manuals available in 1970 which included information on surface-supplied diving were considered unsatisfactory for the type of equipment and the type of training program used in the scientific community. Consequently, the *Research Diver's Manual* was prepared. A new publication oriented toward surface-supplied diving is currently in preparation.

3. Commercial and military surface-supplied equipment is primarily oriented around large ship operations and heavy support equipment. Project studies were directed at ways to increase compactness and portability of surface-supplied equipment and accessories. Some equipment modifications and development were required.

4. Many scuba diving scientists were, at first, reluctant to accept the surface-supplied gear due to the changeover requirements, lack of training programs, and their unfamiliarity with this equipment. A number of schools and agencies are now using some surface-supplied diving or anticipating its introduction into programs in the near future.

Specific projects pursued in addition to the above include:

1. Unisuit evaluations to depths of 200 ft. using surface-supplied mask and helmets in small boat operational mode.

2. Design and construction of an air control-communications console.

3. Evaluation of "live-boating" techniques for application in scientific studies.

4. Cold climate applications.

Work currently being conducted includes:

1. Emergency system evaluations (with considerations of design improvement).

2. Development of a compact air control-communications unit.

COLD WEATHER DIVING

Research divers are frequently required to work under adverse winter conditions in northern lakes and polar areas. Direct underwater observation, sampling, photography or equipment installation and maintenance by divers working under thick ice cover are common activities. Currently most underwater operations of this nature are still conducted using standard open-circuit scuba and wet type diving suits. Diver performance is relatively inefficient and safety factors are marginal. Dive durations are relatively limited and divers, as well as support personnel, suffer various physiological and psychological effects of cold stress. Consequently, the application of research diving techniques under such conditions are generally limited.

The Michigan Sea Grant Program started cold water research in 1970 with an evaluation of existing diving apparatus and techniques. The principal investigator participated in the MacInnis Foundation Arctic I Expedition in order to acquire first-hand information on conducting research above the Arctic Circle.

Initial results indicated that immediate modifications in techniques would be required for safe and efficient cold water work. The University divers were among the first in the scientific community to use hot-water circulating suits in conjunction with surface-supplied diving equipment. Concurrently, the variable volume dry suit was introduced into the program and a series of experimental dives were made in the cold waters of Grand Traverse Bay to depths from 40 to 200 ft. These early tests included the use of the new Swedish variable volume dry suits with scuba, lightweight helmets, and free-flow demand mask. Safety and training procedures were established through this project. Continued research has led to equipment and procedural modifications. The results of much of this work are published in the *Research Diver's Manual* and *Cold Weather and Under Ice Scuba Diving.*

This year (1974-75) a new cold weather diving system is being designed at the Underwater Technology Laboratory. The design criteria include portability, simplicity, maximum personnel protection, safety, and efficiency. Essentially, the system includes a specially designed shelter, surface-supplied diving equipment, heated suits, gas supply equipment, generators, and all associated equipment necessary to operate under hostile cold weather conditions. The shelter is being designed to also serve as a shipping container for use on exposed ship decks as well as in cargo-type aircraft.

This system should have immediate application in under-ice scientific studies at The University of Michigan. Most significant is the potential use of the system in the high Arctic for environmental impact studies. It is anticipated that this system will be relatively low cost and will significantly increase both the safety and efficiency of underwater researchers working in the hostile northern environments.

SCUBA DESIGN PROJECT

Self-contained underwater breathing apparatus (scuba) of the open-circuit type has developed as the major item of life support equipment for research and sport diving. Although The University of Michigan has worked extensively with surface-supplied diving apparatus in The Great Lakes, University researchers working in the Caribbean have used scuba exclusively. It is evident that scuba will remain the dominant system during this decade and probably in future decades. Consequently, scuba and associated equipment has been evaluated continuously during the term of this program.

In 1974 a cooperative effort between the Underwater Technology Laboratory Director and a student from the University's Department of Industrial Design was initiated to utilize the data compiled on scuba and new industrial design ideas to modify and/or develop an improved scuba system. Recent developments in conventional scuba were re-evaluated. Major areas of evaluation included system configuration, size and weight; buoyancy control sub-system; system monitoring; breathing characteristics; emergency breathing sub-systems; techniques of diver self and second party rescue; harness; lifesaving sub-system; diver weighting; system swimming resistance; fit; comfort; durability; portability; air supply; and safety. Preliminary design criteria were established and a modified scuba was designed on paper in early 1975. A wooden/plastic full size model of the proposed scuba was completed in April 1975 and detailed drawings are now being prepared for development of a working prototype. A discussion of initial phases of the project is currently being organized into a technical report.

UNDERWATER RESEARCH AND WORK TECHNIQUES

At present there are no comprehensive manuals or reports available that include details on underwater research techniques. Since the conception of the Underwater Operations Project, data has been accumulated on this subject. Various procedures for underwater sampling, observation, and equipment installation have been used on selected projects. In addition, several thousand scientific papers and abstracts have been reviewed in order to determine the actual involvement of scuba diving in marine science research and to extract the underwater procedures used by various scientists. The results of the initial portion of this survey were presented at the 6th International Conference on Underwater Education and will be released in the conference proceedings. The details of specific underwater scientific procedures are being compiled in the form of a technical report.

Underwater work techniques have also been evaluated, developed, and/or modified. Specific techniques that are within the scope of the non-commercial diver have been selected and are currently being prepared in technical report format. Both of these papers will be completed for publication later this year.

UNDERWATER HABITATS AND SATURATION DIVING

Lakelab Operations

Michigan Sea Grant Program researchers designed and had constructed a simple, inexpensive, underwater habitat for use in project activities. The habitat, Lakelab, was

placed in Grand Traverse Bay, Lake Michigan in August 1972. Activities aided by the habitat include diver engineering studies and educational programs. It has been used for saturation diver training and as a testing facility for equipment, procedures, and techniques used in saturation diving. In addition, the habitat has been used in association with biological and fisheries research.

Lakelab is hexagonal in shape, 10 feet across its widest dimension and seven feet high inside, allowing ample room for both comfort and placement of research apparatus. The 9,000 pound structure rests in 30 feet of water approximately eight feet off the bottom on three adjustable legs, and is stabilized by approximately 48,000 pounds of ballast. It has two 16 and one 30 inch diameter acrylic plastic viewports. The larger viewport is designed as a flange to mate with modular units. Divers enter through a large (28 in. x 58 in.) rectangular hatch in the bottom. Compressed air and communications are connected to the habitat from a shore-based control van through an umbilical assembly.

The habitat has been used primarily as a summer operations base for project activities; however, it was used during the winter of 1973-74 in fisheries research. Since 1972 a total of six advanced research diver training courses have been conducted at the facility and nearly 200 students, scientists, diving instructors, etc., have visited the facility.

The habitat is scheduled for relocation in the spring of 1975. Future use of the habitat is dependent upon specific research activity funding and program priorities.

Sublimnos Underwater Habitat: 1969-70

University of Michigan researchers, under Sea Grant sponsorship, utilized the Sublimnos underwater habitat to conduct a series of exercises and experiments to aid in evaluating the potential usefulness of a small-sized habitat in scientific research. The work was conducted in Little Dunks Bay in Georgian Bay, Lake Huron, at an operational depth of 30 feet. The work included a nutrient enrichment experiment on phytoplankton, *in situ* measurements of productivity rates of benthic algae, a study of the spatial distribution of macrobenthic invertebrates, day-night behavior and ecological relationships of selected aquatic organisms, and underwater mapping.

Special attention was given to the evaluation of equipment and techniques including habitat design and utility, lightweight diving helmets and masks, closed-circuit mixed gas scuba, diving suits, coring equipment, etc. The habitat proved to be useful in extending diving time and efficiency for certain activities. Details of the initial Sublimnos dives are published in *Underwater Habitats for Scientific Research in the Great Lakes* by L. Somers and R. Anderson (1970). The experience and evaluation results acquired during the Sublimnos dives were valuable to the subsequent Sea Grant Underwater Technology Project activities.

Prinul

In 1973 the principal investigator from the Michigan Sea Grant Underwater Technology Laboratory worked for one month in Puerto Rico with the Puerto Rico International Undersea Laboratory (Prinul) research team. The primary objective of this cooperative effort was the exchange of information on habitat engineering problems, habitat operations, and diver training. Dr. Somers was trained to serve as a habitat engineer on an undersea mission. This program proved valuable to the University's work in habitat design, diver training, undersea scientific studies, habitat operations, etc. The information has been beneficial to both research and education functions.

Hydrolab Saturation Dive: 1972

In May 1972, three University of Michigan researchers participated in a five-day saturation dive utilizing the Hydrolab underwater habitat, located on the seafloor off Freeport, Grand Bahama. Daily excursion dives were made from the habitat to depths ranging from 50 feet to 95 feet at distances often exceeding 600 feet from the habitat. The team conducted an integrated program of biological and geological studies combined with habitat and saturation diving evaluations. The concept of saturation diving from a standpoint of diver selection, performance, and scientific accomplishments was appraised. Scientific studies included ecology of comatulid crinoids and zonation of infralittoral marine algae. The mission statistics are as follows:

Total man-hours saturation: 332.5
Total man-hours saturation plus decompression: 365.25
Total man-hours excursion dive time: 56
Total man-excursion dives: 54

Saturation team members included Dr. Lee H. Somers (team leader and project director), Dr. Donald B. Macurda, and Dr. Gordon McBride. Primary funding for the project was made available by the Manned Undersea Science and Technology Office, National Oceanic and Atmospheric Administration (Grant No. NG-23-72). Additional support for the project director was provided through the Michigan Sea Grant Program.

Hydrolab Saturation Dive: 1974

In September of 1974, four University of Michigan researchers returned for a second saturation diving mission at Hydrolab. Project Director Dr. D. B. Macurda and Diving Supervisor Lee H. Somers were accompanied by Dr. James Porter and Dr. Gordon McBride. Daily excursions were made to depths of 150 feet over 1,000 feet from the habitat. The objectives of the mission were fourfold: 1) to determine the distribution of crinoids in depths of 40 to 150 feet, 2) to determine the photosynthetic and respiratory activity of the coral *Montastrea cavernos* and its photosynthetic algae, and to determine the principal food resources of this coral and the times at which it actively fees, 3) to determine the oxygen production and uptake in various algae, and 4) to determine the behavioral activities of the tube worm *Spirobranchus gigantus* and those organisms which might be predators upon it. The mission statistics are as follows:

Total man-hours saturation: 606.8
Total man-hours saturation plus decompression: 662.8
Total man-hours excursion dive time: 132.8
Total man-excursion dives: 114

Primary funding for the project was made available by the Manned Undersea Science and Technology Office, National Oceanic and Atmospheric Administration. Additional support for Dr. Somers was provided through the Michigan Sea Grant Program.

The Hydrolab saturation dives have been a significant factor in the underwater program at the University. Knowledge gained through Sea Grant underwater technology and education research proved extremely valuable on these dives. In turn, these dives have provided a new facet of underwater research. The University now has a skilled saturation diving team with nearly 1,000 man-hours of saturation experience.

Since 1969 the Underwater Technology Project has worked cooperatively with other Sea Grant programs, University of Michigan, and State of Michigan projects which required diving expertise in order to conduct underwater studies. Such activities are mutually beneficial for both parties. The high cost and lack of scientific background frequently precludes the use of commercial or semi-commercial divers; use of non-professional recreational divers may present both operational and insurance problems. Consequently, the availability of qualified research divers for use on various projects becomes highly desirable from a standpoint of qualification, scientific knowledge, insurance, etc. On the other hand, much of the Underwater Technology Project's equipment evaluation, educational research, procedural development research, training exercise development, and personnel experience advancement may be easily integrated with other project activities. This reduces the need for simulated exercises and promotes research under actual working conditions. The following are selected cooperative projects which have proved to be of significance in the development of underwater technology at The University of Michigan:

Wave Pressure Measurements in Lake Erie

In 1969-70 Underwater Technology Project personnel assisted Dr. Alan Cole of The University of Michigan in the study of wave pressure on breakwaters in Lake Erie. Dr. Cole's work was funded by the U.S. Lake Survey. Prior to the establishment of the Underwater Technology Project, Dr. Somers developed methods for installing underwater wave pressure sensors, acquired the necessary equipment, and installed and/or supervised installation of the breakwater sensors and an offshore weather tower. After the establishment of the Sea Grant Program, Dr. Somers worked in maintenance of the system, salvage of the weather tower, and removal of a considerable amount of valuable sensor equipment from under the ice. This work provided significant contributions in the area of underwater techniques and equipment research. Specific areas of Sea Grant research included under ice work, applications of a high velocity stud driver, recovery of sizeable objects using simple, inexpensive equipment and limited surface support, and evaluation of surface-supplied diving from small (less than 14 feet in length) boats.

Hibernating Frog Observations

In 1970 Underwater Technology Project personnel assisted Dr. George Nace of the Department of Zoology in looking for hibernating frogs in ice-covered inland lakes and ponds. A number of observation and collecting dives were made under ice up to 20 inches thick. From the underwater operations viewpoint, valuable information was gained on ice diving techniques, human performance, thermal protection, and equipment performance. Much of this information was later published in Dr. Somers' *Cold Weather and Under Ice Scuba Diving.*

Ferromanganese Nodule Deposit: Field Research

Underwater techniques were used to study and sample ferromanganese nodule deposits in Green Bay, Lake Michigan, during 1970-72. The nodule research was under the direction of Dr. Edward Callender who was funded, in part, through the Michigan Sea Grant Program. Dr. Lee H. Somers directed diving operations. At each station a diver photographically documented the occurrence of nodules, took undisturbed cores, made detailed bottom observations, collected samples of cobbles and boulders, and, using an air lift, collected large quantities of surficial sediment. The air lift sampling techniques, in this case, were highly satisfactory and saved many hours of work when compared to the conventional shipboard sampling techniques used previously.

This was the first major project to utilize surface-supplied diving techniques instead of conventional scuba diving. The results were immediately evident in terms of operational efficiency, diver comfort, improvement of data acquisition, and diver safety. Several papers have been published by Dr. Callender and his associates based on the results of this work, and the diving aspects have been published by Dr. Somers in conference proceedings and the *Research Diver's Manual.* The information gained on surface-supplied diving and underwater research techniques has been used extensively in the development of new projects and publications.

Circulation Studies in Grand Traverse Bay

Underwater equipment, techniques and procedures were developed under the auspices of the Underwater Technology Project to aid Dr. Edward Monahan in the study of subsurface circulation in Grant Traverse Bay, Lake Michigan, during 1970-72. Activities included the placement, inspection, and servicing of current meter installations. The project provided equipment, personnel, and technical advice. The results of this work have been published by Dr. Monahan and his associates.

Bottom Morphology Project: Lake Superior

Professor C. S. Clay of the University of Wisconsin's Department of Geology and Geophysics requested the aid of research divers in the investigation of unusual bottom morphology in Lake Superior discovered during acoustical surveys. The Michigan Sea Grant Program provided research divers and equipment for this work in August 1971. Dr. Somers directed the diving operations and made a "live-boat" dive (support vessel underway, drifting or under power) to a depth of in excess of 180 feet. The results of this work have been published by Professor Clay and his associates.

Lake Trout Egg Planting Project

In 1973-74 the Michigan Sea Grant Program provided divers and equipment to assist the State of Michigan Department of Natural Resources in the study of lake trout propagation. Divers placed 24 lots of green eggs underwater in the vicinity of Lakelab. These lots of eggs were sampled on a monthly basis throughout the winter. In addition, the divers made egg observations during the winter on Dahlia Shoal in Lake Michigan.

Many research divers have been trained under the auspices of the Michigan Sea Grant Program, and a considerable amount of the underwater work by other University units is now performed by these divers. This has released the Sea Grant Underwater Technology Laboratory personnel from these services except when specific diving equipment and techniques or highly qualified divers are required. The Underwater Technology Project monitors all University diving and frequently serves in an advisory or consultant role.

UNDERWATER EDUCATION

Advanced Research Diver Training Course

The advanced research diver training program began in 1972. The intensive week-long training course covers advanced scuba diving, surface-supplied diving, habitat diving, underwater research techniques, underwater work and related topics. Emphasis is placed on providing specific diver training and exercises designed to transform novice scuba divers into working research divers. Approximately 60 students have received training in the six courses conducted to date. The details of this program will be published in *Research Diver Training Program.*

In addition to the students from The University of Michigan, a number of students from other states including Washington, Rhode Island, Wisconsin, and California have attended the course. Several U.S. Lake Survey Center divers have received advanced training in this program. Each year there are more applicants than can be accepted. Consequently, a new program for training instructors of research diving and diving coordinators for university and agency diving operations has been planned.

Underwater Technology Course

An advanced undergraduate-graduate level course in underwater technology was initiated in the Winter Term 1970 as an offering of the Department of Meteorology and Oceanography (now Atmospheric and Oceanic Science) and the Department of Naval Architecture and Marine Engineering. The course has been taught annually since 1970. It is a survey course with emphasis on manned undersea activities in oceanography and ocean engineering. Basic information on human performance underwater, life-support, hyperbaric physiology and operational diving is presented as a background for a discussion of diving apparatus, diving systems and tools for underwater use. Design considerations and application of diving apparatus, deck decompression chamber-submersible decompression chamber systems, underwater habitats, research submersibles, and underwater tools are major discussion topics. The course includes a cooperative class project each term. In 1974 the class designed a relatively complex mobile underwater laboratory. In addition to serving as a technical elective for oceanography and engineering students, the course is now recognized as meeting science distribution requirements for students in the College of Literature, Science, and the Arts.

Hyperbaric Chamber Attendants Course

The increase in the use of the hyperbaric chamber at the Underwater Technology Laboratory produced a demand for qualified chamber attendants and operators. Consequently, a special training course was developed to train University faculty and students in chamber operation and maintenance. In addition, the trainees receive instruction in basic hyperbaric medicine, assisting physicians, attending patients, and reading decompression and treatment tables. The course outline and other information is included in a text prepared for this course, *The University of Michigan Hyperbaric Chamber Attendant's Handbook.* This course is taught in cooperation with the Pulmonary Division of the University Medical Center. Approximately 30 persons have completed training to date. In Fall 1975 the course will be offered as an official physical education course.

Caribbean Marine Environments Course

Since 1971 the Michigan Sea Grant Program has supported the principal investigator of the underwater technology project as an instructor and diving supervisor for an advanced undergraduate-graduate level course on Caribbean marine biology, ecology, and geology. Each Winter Term the University sponsors a course field trip to the Bahamas or a Caribbean Island. The students receive approximately 15 hours of lecture prior to the trip, diving instruction (if required) and a seven to nine day field trip. Each must complete a research project during the trip. All participants must be qualified scuba divers. Generally 150 to 200 man-hours are spent making underwater observations during the field trip.

Physical Education Diving Program

Courses in basic scuba diving and scuba diving instructor training are taught each Fall and Winter Term under the auspices of the Department of Physical Education. The

basic course content is directed toward the academic and skill requirements of research diving, exceeding those of the standard recreational scuba course. Nearly all faculty and students who require diving skills to complement their research acquire their training through this program. Approximately 50 percent of the students enrolled in the scuba courses are science or engineering students who indicate that they are acquiring this training for potential future professional application. From September 1969 to December 1974, 742 students have been trained in basic scuba diving.

The diving program and diving locker are supported by State and University funds allotted to the Department of Physical Education. However, the director of the Underwater Technology Laboratory is also the principal instructor and coordinator of the physical education scuba diving program, and other Sea Grant personnel are employed on a part-time basis in the physical education program. The hyperbaric chamber and specialty equipment from the Underwater Technology Laboratory diving locker are used to complement this program.

In the fall of 1975 several diving related courses will be added to the physical education program. These include Instructor Aide and Hyperbaric Chamber Attendant. The Scuba Instructor course will be divided into two separate courses: *Scuba Instructor: Theory,* and *Scuba Instructor: Practice Teaching.*

DIVING SAFETY COMMITTEE

An early objective of the Underwater Technology Project was to establish a program for supervision and coordination of underwater activities at the University. During the late 1960's the amount of University sponsored diving by students and staff increased significantly. With the addition of Michigan Sea Grant Program diving and the Department of Physical Education diver training program, the development of a Diving Safety Committee became a necessity. The current Diving Safety Committee, comprised of three to five individuals and chaired by the director of the Underwater Technology Laboratory, is a subcommittee of the University Safety Policy Committee. The chairman currently serves as the University Diving Coordinator. The committee also supervises operation of the hyperbaric chamber.

Regulations and procedures for University diving were initially formulated under the Sea Grant Program and published in the *Diving Safety Bulletin* in 1971. Continuing research in the area of diving safety has resulted in a new publication, *Safety Code for Underwater Diving and Hyperbaric Chamber Operation,* by Lee H. Somers. A special record book titled *Diver Record and Qualification Book* complements the safety code publication.

The need for continued supervision and surveillance of diving and related activities is evident. In 1975 several more diver and hyperbaric chamber attendant courses are being added to the physical education curriculum. Each year a multi-disciplinary course, Caribbean Marine Environments, sponsors a field trip to the Caribbean to study underwater aspects of biology and geology; all participants must be qualified divers. The amount and level of hyperbaric chamber activity is increasing each year. Finally, an increasing number of staff and students are becoming involved in underwater research activities. The Diving Safety Committee is vital to the University's safety program.

SAFETY PAMPHLET SERIES

The close alliance between various facets of the recreational diving community and the Michigan Sea Grant Program has cultivated an increasing interest on behalf of the University in recreational scuba diving safety education. In addition to numerous lectures and hyperbaric chamber demonstrations provided for the sport diving community as a Sea Grant advisory service activity, a series of diving safety pamphlets is being prepared for periodic public distribution. The first of this series is a pamphlet titled *The Deep Diving Syndrome.* This pamphlet discusses the apparent increase in deep diving among sport divers, decompression sickness, the underlying causes of the deep diving emphasis, and calls upon the divers to reassess their values relative to deep diving. Future pamphlets proposed include:

Cold Weather Diving
Bends
Fitness and the Diver
Dive Planning
Watermanship and the Diver
Recreational Diving in Michigan
Ascent

A pamphlet on the University's hyperbaric chamber facility is also distributed as a service of the Michigan Sea Grant Program.

FUNDING

The research, education and advisory service functions of the Underwater Technology Laboratory have been funded under grants from the National Sea Grant Program since 1969. Budget figures by fiscal year are as follows:

1969-70	$ 28,500
1970-71	21,500
1971-71	41,600
1972-73	40,000
1973-74	41,100
1974-75	35,000

Other funds have been received for Sea Grant related underwater activities from the Manned Undersea Science and Technology Office of the National Oceanic and Atmospheric Administration. The two grants directly supporting the Hydrolab saturation dives totaled $6,300, plus the habitat charges (approximately $6,000 total). Dr. Somers was project director for one grant and co-researcher for the other.

The Project was recently awarded a $3,000 grant from the Michigan Skin Diving Council for maintenance of the hyperbaric chamber.

DIVING LOCKER

Since the conception of the Underwater Operations Project efforts have been made to develop a relatively complete diving locker to support scientific diving at The University of Michigan. The following is a partial listing of equipment available in the Underwater Techology Laboratory diving locker.

Helmets and Masks

1 Helmet, Aquadyne Mixed-Gas
1 Mask, Aquadyne (with Head Protector and Emergency Manifold)
3 Mask, KMB (with Head Protector)
2 Mask, Desco Shallow-Water
1 Mask, Desco Demand

Diving Dresses

2 Hot water
2 Unisuit Variable-Volume
1 Wet-type (Bailey)
3 Navy Shallow-Water
1 Dry-type (Belaqua)
1 Wet-type (Imperial)

Surface-Supplied Diving Support Equipment and Accessories

1 Air Control-Communications Console
1 Umbilical Assembly, 150 ft. (Air Hose, Pneumo Hose, Communications Wire, and Snap Unit)
1 Umbilical Assembly, 100 ft (Same)
2 Communications Units, KMC-10
500 ft. Hot water Hose
1 Water Heater Unit
1 Air Control Console
1 Miller Heavy Weight Belt
2 Harness
2 Victor Regulators
2 Pr. Deep-Sea Shoes
1 Deep-Sea Weight Belt

Air Supply Equipment

2 Compressor, HP Mako 8 CFM Electric
1 Compressor, HP Hyper Air 16 CFM Diesel
3 Cylinder Assemblies (Each: 6 Cylinders, Cradle, Manifold, and Fittings)
1 Compressor Assembly, LP Corken Electric (Assembly includes two 17 CFM/100 psi compressors, two electric motors, and volume tank)
1 Compressor Assembly, LP Mako Electric (Assembly includes four 3.5 CFM compressors and two electric motors)
1 Volume Tank

Scuba Equipment

1 Regulator: MR-12
4 Scuba Cylinders (71.2 CF)
5 Scuba Backpacks
1 Regulator: Mistral
1 Regulator: Aquamaster
1 Regulator: D-400
1 Scuba Cylinder (45 CF)
3 Pressure gauges

Scuba Diving Accessories

1 Flotation Vest: Nemrod
1 Flotation Vest: Fenzy
2 Flotation Vest: Waverly
1 Flotation Vest: Scuba Pro
2 Decompression Meters
1 Shark Dart
3 Lights (DB-500)
1 Light (DB-600)
3 Depth Gauges

Photography Equipment

1 Nikon-F Camera
1 Sportfinder for Nikon-F
1 Nikon Lens: 24 mm
1 Ocean-Eye Camera Housing w/Carrying Case
1 Nikon Movie Camera: Super 8
1 Housing for Nikon Movie Camera
1 Strobe Unit: Subsea Mark 50
1 Movie Projector
1 Extension tube for Nikonos
2 Nikonos Underwater Cameras
1 Sekonic Light Meter
2 Flash Units for Nikonos
1 Nikonos Close-Up Kit
3 Carrying Cases for Camera Equipment

Other

2 Stopwatches: Heuer
1 Double-Lock Hyperbaric Chamber and Accessories
1 Oxygen Analyzer
1 Trailer
1 Chain Hoist: 3 T.
1 Underwater Habitat
2 Oxygen Inhalator
1 Oxygen Unit

The above list includes only the major items. In addition there are numerous small scuba and surface-supplied diving accessories, high and low pressure fittings and hoses, tools, etc. The physical education diving locker, also used in project work, includes 17 scuba diving outfits (cylinders, backpacks, regulators, flotation vests, fins, masks, snorkels, and weight belts). Finally, each of the divers working for the project furnishes a significant amount of personal gear.

APPENDIX I

RESUME OF PRINCIPAL INVESTIGATOR

LEE H. SOMERS

BORN: Urbana, Illinois, February 18, 1938

EDUCATION AND DEGREES

BS	Physical Education	University of Illinois 1961
MS	Geology	University of Illinois 1965
Ph.D.	Oceanography	University of Michigan 1969

EMPLOYMENT

The University of Illinois, Department of Geology: Research and Teaching Assistant, 1961-1965

The University of Michigan, Great Lakes Research Division: Graduate Student Assistant, Summer 1964; Assistant in Research, 1965-1966; Assistant Research Geologist, 1966-1967

The University of Michigan, Department of Atmospheric and Oceanic Science: Assistant Research Geologist, 1968; Associate Research Oceanographer, 1969—; Lecturer, 1972—

The University of Michigan, Department of Physical Education: Assistant Professor, 1969—

COURSES TAUGHT

A.O.S.	203	Introductory Oceanography
A.O.S.	469	(N.A. 469) Underwater Operations
A.O.S.	306	Geophysical Data Laboratory I
A.O.S.	307	Geophysical Data Laboratory II
A.O.S.	428	Caribbean Marine Environments
A.O.S.	499	Individual Directed Studies
A.O.S.	701	Individual Directed Studies
P.E.	111	Basic Skin and SCUBA Diving
P.E.	114	SCUBA Instructor Preparation
P.E.	115	SCUBA Instructor Aide
P.E.	116	SCUBA Instructor Practice Teaching
P.E.	117	Hyperbaric Chamber Attendant
P.E.	256	Aquatics Leadership
Geol.	429	Geology Field Course (Marine Geology and Biology of Modern Carbonate Rock Environments)
Ed.	F399	Organized Camping
Ed.	F617	Underwater Education

DOCTORAL COMMITTEES

E. Seibel, Department of Atmospheric and Oceanic Science (1972)

PROFESSIONAL & HONORARY SOCIETY MEMBERSHIPS

American Association of Health, Physical Education and Recreation
American Society of Limnology and Oceanography
Marine Technology Society
National Association of Underwater Instructors (Elected Board of Directors, 1971)
Phi Epsilon Kappa
Professional Association of Diving Instructors
Sigma Xi
Society of Economic Paleontologists and Mineralogists
Undersea Medical Society

NATIONAL AND INTERNATIONAL COMMITTEES

YMCA National SCUBA Committee (1971-1972)
Marine Technology Society: Committee on Man's Undersea Activities (1970-72)
American National Institute of Standards, Z-86 Committee on Underwater Safety - Task Group 4: Equipment (Chairman)
American Association of Health, Physical Education and Recreation, Skin and SCUBA Diving Professional Standards (1971-1975) (Chairman 1972)
Confederation Mondiale des Activites Subaquatiques: Scientific Committee (Member: 1973- present)

UNIVERSITY COMMITTEES

Diving Safety Committee (1970- present) (Chairman)

PROFESSIONAL EXPERIENCE (SELECTED ACTIVITIES IN ADDITION TO TEACHING)

Study of nearshore sedimentation in Lake Michigan, 1963: Geologist
Study of ecology in Florida Keys, 1963: Geologist and research diver
Study of ecology and sedimentation in Bahama Islands, 1964-1965; Geologist and diving officer
Geological studies in Lake Michigan, 1964-1965: Geologist and research diver
Field work on project "Geological Studies in Lake Michigan" (NSF GA-352, Dr. J. L. Hough, Project Director) 1966-1969: Chief Scientist
Project SUBMICH, geological observation dives using the STAR II Submersible, 1967
1968 South Atlantic Cruise of USC & GSS DISCOVERER (ESSA): Scientist
Bathymetry and sediments of West African continental margin: ESSA contract E22-22-69 (N)
Project SUBLIMNOS (for University of Michigan activities), Georgian Bay, 1969: Senior Scientist and Diving Officer
MacInnis Foundation Arctic Expedition, 1970: Geologist and advisor for outfitting to work in the Arctic

Michigan Sea Grant, Underwater Operations Project, 1969–, (NSF Grants No. GH-50 and GH-98: Senior Scientist and Underwater Operations Specialist; DOC-Sea Grant 1971-71, Co-Project Director; Project Director 1972-73, 1973-74, 1974-75

Saturation Dives, May 1972 and September 1974: Hydrolab, Freeport, diving technology and marine biology studies (Grant from NOAA, Manned Undersea Science and Technology Office)

Project LAKELAB: Underwater habitat in Grand Traverse Bay (1972-74)

Scuba Diving Instructor: Certified by National Association of Underwater Instructors, Professional Association of Diving Instructors, and Young Men's Christian Association; CPR certification, Michigan Heart Association; Watersafety Instructor, ARC; lecturer at Scuba Instructor Workshops and Course 1964– present; director of several programs including NAUI-Ann Arbor 1970

Diving Officer or Coordinator: University of Illinois, Department of Geology (1963-1965); University of Michigan, Great Lakes Research Division (1965-1967); Department of Meteorology and Oceanography (1967-1970); University of Michigan Diving Coordinator (1970 – present)

Research Diver Course Director (Michigan Sea Grant Program) 1972 – present (6 courses)

Professional consulting and services: Potomac Research Incorporated; Healthways; U.S. Bureau of Commercial Fisheries; U.S. Department of Commerce; Canada Centre for Inland Waters; Great Lakes Diving Consultants; Western Michigan University; Rolex of America; Consumers Power Company; William Brother Pipeline Co.; CFC Products Incorporated

PUBLICATIONS

Somers, L. "Small Scale Variations in Nearshore Sediments: Vicinity of Sleeping Bear Point, Lake Michigan," M.S. thesis, Urbana: Department of Geology, University of Illinois, 1965.

Somers, L. "Diving Regulations and Procedures Manual," Ann Arbor: Great Lakes Research Division, University of Michigan, 1966.

Somers, L. "Nearshore Slope Studies in Lake Michigan: 1964-1966," p. 254 in *Studies on the Environment and Eutrophication of Lake Michigan,* by J. Ayers and D. Chandler (ed.), Special Publication 30, Ann Arbor: Great Lakes Research Division, University of Michigan, 1967.

Somers, L. "The Representativeness of Random Bottom Samples in Four Selected Locations in Lake Michigan," pp. 255-258 in *Studies on the Environment and Eutrophication of Lake Michigan,* by J. Ayers and D. Chandler (ed.), Special Publication 30, Ann Arbor: Great Lakes Research Division, University of Michigan, 1967.

Somers, L. "Diving Techniques as Applied to Geological Investigations of the Great Lakes," pp. 149-156 in *Proceedings of the 10th Conference on Great Lakes Research* by F. Elder and M. Everett (ed.), Ann Arbor: International Association for Great Lakes Research, 1967.

Somers, L. "A Research Dive in the Great Lakes," *Limnos* 1(2): 2-5, 1968.

Somers, L. "Comments on Training Scuba Instructors," *Journal of Physical Education* 65(4): 115-117, 1968.

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Somers, L. "Preliminary Report on Geological Studies in Northern Lake Michigan Using Underwater Observation Techniques," pp. 239-44 in *Proceedings of the 11th Conference on Great Lakes Research* by D. Anderson and J. Seddon (ed.), Ann Arbor: International Association for Great Lakes Research, 1968.

Somers, L. and Josephson, P., "Bottom Sediment of Southwestern Lake Michigan," pp. 245-252 in *Proceedings of the 11th Conference on Great Lakes Research* by D. Anderson and J. Seddon (ed.), Ann Arbor: International Association for Great Lakes Research, 1968.

Somers, L., Tetzloff, C. and Anderson, R. "Operation SUBMICH," pp. 650-663 in *Proceedings of the 11th Conference on Great Lakes Research* by D. Anderson and J. Seddon (ed.), Ann Arbor: International Association for Great Lakes Research, 1968.

Dietz, R. Knebel, H., and Somers, L. "Cayar Submarine Canyon," *Bulletin of the Geological Society of America* 79: 1821-1828, 1968.

Somers, L. "Does it Work?," *Limnos* 2(3): 25, 1969.

Somers, L. "The RAD Concept," *Undersea Journal* 2(2): 7, 1969.

Somers, L. "Bathymetry of the Western African Continental Margin: Senegal to Ivory Coast," Ph.D. thesis, Ann Arbor: Department of Meteorology and Oceanography, University of Michigan, 1969.

Somers, L. "Underwater Habitats and Science," *Undercurrents* 2(9): 16-21, 1970.

Somers, L. "Automatic Decompression Computer," *Undersea Journal* 3(2): 4-5, 1970.

Somers, L. "The Role of the Sport Diving Instructor in Training Research Divers," p. 7 in *Abstracts of the First Conference on Underwater Education*, Colton, Calif.: National Association of Underwater Instructors, 1970.

Somers, L. "Advanced Underwater Techniques Utilized in Great Lakes Research," p. 691 in *Abstracts of the Geological Society of America Conference* 2(7): 1970.

Somers, L. and Anderson, R. "Underwater Habitats for Scientific Research in the Great Lakes," pp. 1041-1049 in *Proceedings of the 13th Conference on Great Lakes Research* by D. Anderson and J. Seddon (ed.), Ann Arbor: International Association for Great Lakes Research, 1970.

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Somers, L. "Cave Diving Equipment and Procedures," Technical Report 10, Ann Arbor: Sea Grant Program, University of Michigan, 1971.

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Somers, L. "Lakelab Underwater Habitat," pp. 1046-1051 in *Proceedings of the 16th Conference on Great Lakes Research* by N. Rukavina, J. Seddon, and P. Casey (ed.), Ann Arbor: International Association for Great Lakes Research, 1973.

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Somers, L. *Underwater Education and Technology at the University of Michigan: A Five Year Progress Report,* Technical Report 44, Ann Arbor: Sea Grant Program, University of Michigan, 1975.

Somers, L. *Safety Code for Underwater Diving and Hyperbaric Chamber Operation,* Ann Arbor: Sea Grant Program, University of Michigan 1975.

Somers, L. *Skin and Scuba Diving and Associated Rescue Techniques for Lifeguards and Watersafety Instructors,* Ann Arbor: Sea Grant Program, University of Michigan, 1975.

Nemiroff, M. and Somers, L. *Common Underwater Medical Emergencies,* slide/cassette presentation, Ann Arbor: University of Michigan Medical Center, Office of Educational Resources, Independent Studies Unit, 1975.

Nemiroff, M., Somers, L. and Anderson, R. "A Five-Year Study of Prevention of Scuba Diving Morbidity in a University Training Program," in *The Journal of the American College Medical Health Association* (in press).

I Intro to class.

A) Intro

1. Course Standards &