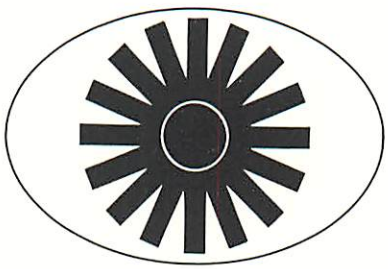
OCEAN ENGINEERING PROGRAMS
PRESENT STATUS
AND
FUTURE DEVELOPMENT



by

John B. Herbich

TEES

TEXAS ENGINEERING EXPERIMENT STATION
TEXAS A&M UNIVERSITY
COLLEGE STATION TEXAS 77843

Partially Supported by the National Science Foundation
Sea Grant Program
Institutional Grant GH-59 to
Texas A&M University

Coastal and Ocean Engineering Division
Report No. 125 - COE

June 1970

TAMU-SG-70-111

Event Number 148

AMERICAN SOCIETY FOR ENGINEERING EDUCATION
ANNUAL MEETING, JUNE 22-25, 1970

THE OHIO STATE UNIVERSITY
COLUMBUS, OHIO 43210

OCEAN ENGINEERING PROGRAMS - PRESENT STATUS AND FUTURE DEVELOPMENT

John B. Herbich
Professor and Head
Coastal and Ocean Engineering Division
Texas A&M University
College Station, Texas 77843

Abstract

The nature of an ocean engineering graduate program as well as its relation to existing disciplines is briefly discussed. Ocean engineering programs are at a developmental stage at many institutions and a concerted effort needs to be made to give them definition and rough bounds. However, care must be taken not to constrain a certain amount of evolution at various institutions by prematurely establishing a specified and rigid educational program.

Existing programs in ocean engineering (mostly on graduate level) were reviewed and are summarized in the paper. Information related to degree programs, number of courses, number of faculty and students, degrees awarded is presented. Since research plays an important part in any graduate program, a tabulation of research projects is also given.

OCEAN ENGINEERING PROGRAMS - PRESENT STATUS AND FUTURE DEVELOPMENT

Introduction

General Comment

Much is being said and written about the subject of Ocean Engineering. Since these are a number of definitions regarding the term and, since some say that the term has not been properly defined, the discussion will probably continue for sometime.

In discussing the subject of ocean engineering one may ask whether we mean "engineering in the ocean" or "engineering of the ocean", or both. The "aeronautical engineering", for example may mean "engineering in air", while "environmental engineering to some will mean engineering of the environment." "Engineering in the ocean" will probably mean any engineering work in ocean environment to most people, while "engineering of the ocean may mean such exotic work as melting of the icebergs or modifying ocean currents, or such minor work as installation of a submerged barrier to prevent salinity intrusion into an artificial bay. If one listens to various technical presentations under a general label of "ocean engineering" one will become aware that the trend is to include engineering both of and in the ocean.

Qualifications of Ocean Engineers

What sort of qualifications do ocean engineers need? Vine[1] said that "A good ocean engineer is one who is constructively interested in problem solving at sea and who can make things work at sea." The last part of the statement is probably the most important since work in the ocean is basically work in a hostile environment.

Need for Ocean Engineers

New educational programs are emerging with the objective of satisfying the need for engineers specially trained to meet the technological problems in the ocean and to assist in the development of marine resources. That the need exists, is obvious from discussions with Industry involved in work along the shore, offshore and in deep ocean. The need has been most frequently identified by witnesses at the hearings of the Lemmon Interim Committee on Oceanography of the Texas Legislature. The greatest need mentioned is for trained technicians and for four year applied ocean engineering graduates. Need also exists for graduates at the master (both Master of Science and Master of Engineering) as well as at the doctorate levels (both Ph.D. and Doctor of Engineering).

Sea Grant Program Support

There is no doubt that the Sea Grant Program, sponsored by the National Science Foundation, provided an impetus and triggered a faster

development of ocean engineering educational programs. The Sea Grant Program also provided means for increased number of research programs in ocean engineering and it is not a coincidence that the majority of institutions listed in Tables 1 and 2 are receiving either institutional grants or project grants from the Sea Grant office.

Contents of Ocean Engineering Programs

General Comment

Various existing engineering disciplines have a natural involvement in the ocean. The chemical engineer is interested in developing processes for desalting water, extracting chemicals from the ocean, and studying the chemical interactions that take place in the ocean. Civil engineering is concerned with structures, soils, hydromechanics, measurement, transportation of people and goods, oil pollution at sea, development of new water resources, behavior of materials, and development of certain types of systems. Electrical engineers seek improved means of communication in the ocean and better types of instrumentation to perform electronically various measuring functions needed in the ocean. Mechanical engineers are involved in the development of mechanical devices, power sources, and materials to operate and withstand the ocean environment. Petroleum engineers have been involved in oil exploration and exploitation offshore.

These disciplines have had broad technological interests that have naturally expanded into the ocean environment. Naval architecture

and marine engineering existed prior to the invention of the word "ocean engineer" and may now be considered part of ocean engineering.

The "Core" of Ocean Engineering

It appears that there is a "core" consisting of subject matter which will be common to all types of ocean engineering programs. What this core should consist of was described by Calhoun, Samson and Herbich in 1968.[2]

One can look upon the "core" in ocean engineering as being quite broad-based. It is truly inter-disciplinary in nature, cutting across not only the various engineering disciplines but also across the colleges (notably engineering and science or geoscience).

The course material which any ocean engineer should have in his educational program is summarized below (from paper presented in 1968[2]).

(1) Knowledge About the Ocean Environment and Its Measurable Parameters

(a) Principles of fluid flow

(b) Elements of wave motion (shallow, intermediate and deep water)

(c) Physical Oceanography

(d) Chemical Oceanography

(e) Geological Oceanography

(2) Knowledge About the Behavior of Materials Within Ocean Environment

(a) Properties of materials

(b) Corrosion of materials

(c) Suitability of materials for static structures

(d) Suitability of materials for submersible vehicles

(3) Knowledge About the Interaction of Humans with the Ocean Environment

(a) "Saturation" diving

(b) Biomedical systems to provide life support, health maintenance and environmental control

(c) Human factors and performance

(4) Knowledge About the Transfer and Communication Characteristics of the Ocean

(a) Principles of underwater acoustics

(b) Electroacoustic technology

(c) Acoustics of submerged structures

(d) Underwater optics

(e) Underwater television

(5) Knowledge About Operational, Instrumentation and Other Hardware Capabilities Within the Ocean

(a) Capabilities of research submersibles

(b) Undersea installation

(c) Salvage (diving and lifting systems)

(d) Performance characteristics of measuring devices

(e) Timing and digital counting systems

(f) Data processing techniques

For typical cases a master's program would contain from 40 to 60 percent core material, while a doctorate program would contain about 40 percent core work.

Specialization in Ocean Engineering

There are a great number of specialization areas in ocean engineering. These may be listed as follows:

(1) Ocean and Coastal Engineering Structures

(a) Shore, offshore and deep ocean

(b) Buoys

(c) Pipelines

(d) Foundations

(2) Marine Engineering

(a) Surface ships

(b) Submersibles

(c) Dredgers

(3) Physical Phenomena

(a) Gravity waves

(b) Storms and hurricanes

(c) Surges

(d) Forecasting

(e) Sediment movement

(4) Instrumentation

(a) Transducers

(b) Operation amplifiers for measurement and control manipulation

(c) Transmission and recording of data

(5) Acoustics

(a) Communications in the Ocean

(6) Materials and corrosion

(a) Metallic and non-metallic solid materials

(b) Laminated and composite materials

(c) Chemical corrosion

(d) Electrolytical corrosion

(e) Biological fouling

(7) Pollution

(a) Oil pollution

(b) Chemical pollution

(c) Biological pollution

(8) Aquaculture

(a) Fish farming

(b) Shrimp farming

(c) Seaweed farming

Existing Ocean Engineering Programs

General Comment

University curricula in marine sciences and related fields[3] lists some twenty-one institutions as offering a program in ocean engineering. Most of these institutions are listed in Table 1. In addition a brief letter survey followed by telephone conversations with non-respondents provided information regarding the undergraduate programs, student enrollment, degrees awarded in 1967-68, 1968-69 and 1969-70 academic year, and number of research projects. All the information obtained in this study is presented in Table I.

It appears that all of the institutions listed are seriously engaged in developing graduate programs in ocean engineering. Only one institution is giving baccaulaurate degrees in ocean engineering but four institutions may or intend to develop undergraduate programs.

Degrees Offered

The majority of institutions give an ocean engineering major through the existing traditional engineering departments, however the number of institutions giving a degree in ocean engineering is increasing. The tabulation below summarizes the various degree programs offered:

INSTITUTION	DEGREE IN OCEAN ENGINEERING						DEGREE IN OTHER DISCIPLINES					B.S. IN OCEAN ENGINEERING PROPOSED?	B.S. IN OCEAN ENGINEERING IN 1971-72	NUMBER OF COURSES			PROFESSORIAL FACULTY	STUDENTS ENROLLED			M.S. DEGREES AWARDED			Ph.D. DEGREES AWARDED			NUMBER OF CURRENT RESEARCH PROJECTS
	O.E.	M.S.	M.E.	Sc.D.	Ph.D.	D.ENGR.	M.S.	M.E.	Sc.D.	Ph.D.	D.ENGR.			OCN. ENGR.	PHYS. OCN.	RELATED FIELDS		M.S.	M.E.	Ph.D.	67-68	68-69	69-70	67-68	68-69	69-70	
ALASKA		✓										NO	—	2	3	11	5	—	—	—	—	—	—	—	—	—	—
UNIV. CALIF. AT BERKELEY							✓	✓		✓	✓	NO	—	3	1	22	37	15†	15†	25	—	**	**	4	**	**	8
CATHOLIC UNIV.		✓			✓	✓	✓			✓	✓	NO	—	1	5	36	24	43	—	32	—	7	10	—	4	5	6†
DELAWARE		✓			✓							NO	—	7	—	11	4	10	—	1	0	0	3	—	—	1	10
FLORIDA		✓			*		✓			✓		NO	--	5	8	14	4	10	—	5	—	2	—	—	1	—	20
FLORIDA ATLANTIC		*										63 B.S. DEGREES SINCE 1965	—	2	5	19	12	—	—	—	—	—	—	—	—	—	5
HAWAII		✓					✓	✓				NO	—	10	6	30	8	12	—	—	5	3	6	—	—	—	7
HOUSTON		✓			✓		✓			✓		NO	—	4	—	40	8	13	—	3	2	4	1	—	—	—	4
M.I.T.	✓	✓							✓	✓		**	—	9	7	40	31	**									**
MASSACHUSETTS		✓								✓		MAYBE	NO	17	1	20	27	1	—	2	—	1	1	—	—	—	8
MIAMI		✓					✓			✓		NO	—	9	17	12	9	32	—	—	8	7	3	—	—	—	4
MICHIGAN		*			*		✓	✓		✓		NO	—	7	3	27	13	**	**	5	2†	4†	4†	—	—	2	5
NEW HAMPSHIRE							✓					NO	—	2	—	34	19	15	—	—	6	13	10	—	—	—	9
NEW YORK							✓					**	—	8	12	6	9	**									**
OREGON STATE		✓	✓		✓		✓			✓		NO	—	1	15	40	21	4†	4†	9	—	—	2	—	—	—	11
RHODE ISLAND		✓			✓							NO	—	12	4	14	12	42	—	22	2	5	8	—	—	—	15†
UNIV. OF SOU. CALIF.		✓										NO	—	4	1	25	16	10†	—	—	—	—	2	—	—	—	4
STEVENS INST.			✓							✓		NO	—	4	12	22	9	8	30	7	—	1	2	—	—	—	2
TEXAS A&M		*	*		*	*	✓	✓		✓		YES	YES	11	11	28	10	9	3	9	3	3	5	—	—	3	16
UNIV. OF TEXAS							✓			✓		YES	MAYBE	7	2	30	28	3	—	13	2	6	9	5	2	9	12
WASHINGTON							✓			✓		NO	—	2	12	12	13	**									**
TOTAL: 21	1	7	1	0	4	1	15	4	1	14	2	2	1	125	124	456	300	227†	52†	133†	30†	56†	68†	9†	7†	20†	146†

TABLE I. GRADUATE PROGRAMS IN OCEAN ENGINEERING

* PROPOSED
** INFORMATION NOT AVAILABLE
† APPROXIMATE

Degree in Ocean Engineering	No. of Institution
Ocean Engineer	1
M.S.	7
Master of Engineering (M. Engr.)	1
Sc.D.	0
Ph.D.	4
D. Engr.	1

Degree in Other Disciplines	No. of Institution
M.S.	15
M. Engr.	4
Sc.D.	1
Ph.D.	14
D. Engr.	2

Courses in Ocean Engineering Programs

The courses may be sub-divided into three categories:

(a) Ocean Engineering

(b) Physical Oceanography

(c) Related Fields

It appears that about the same number of courses are offered in ocean engineering (125) as in physical oceanography (124) at the twenty-one institutions listed. The number of related courses is quite large (456).

There are some 300 faculty of professorial rank engaged in teaching these courses either on full-time or part-time basis.

Students

There are some 227 students currently enrolled in studying for a Master of Science degree, 52 students pursuing a study program for a Master of Engineering degree and there are about 133 doctoral students.

The number of graduate degrees awarded is gradually increasing as shown below:

Year	Master Degrees Awarded	Ph.D. Degrees
1967-68	30	9
1968-69	56	7
1969-70	68	20

Research in Ocean Engineering

Since research is an integral part of any graduate program for M.S. or Ph.D. degrees, a study was made as to the number of research projects underway and the involvement of graduate students in research. The results of the study are summarized in Table 2. It appears that the majority of research is conducted in the area of physical phenomena and in coastal and ocean engineering followed by marine engineering, acoustics, pollution, instrumentation and corrosion and materials. A number of projects were in other categories and are listed under "miscellaneous."

INSTITUTION	STUDY AREAS OF CURRENT RESEARCH AND OF M.S. AND Ph.D. DEGREES AWARDED SINCE 1 JULY 1966							
	OCEAN AND COASTAL ENGINEERING (STRUCTURES AND BUOY)	MARINE ENGINEERING (SHIPS AND SUBMERSIBLES)	PHYSICAL PHENOMENA	INSTRUMENTATION	ACOUSTICS	CORROSION AND MATERIALS	POLLUTION	MISCELLANEOUS
	RESEARCH PROJ. / DEGREE STUDIES							
ALASKA	—	—	—	—	—	—	—	—
UNIV CALIF AT BERKELEY	— / 3	8 / 10	— / 5	—	—	—	—	—
CATHOLIC UNIV.	1 / 4	— / 1	1 / 4	— / 1	1 / 13	1 / 1	1 / **	1 / 1
DELAWARE	6 / 6	1 / 1	2 / 2	—	—	1 / 1	—	1 / 1
FLORIDA	9† / 3	—	9† / —	—	—	—	2 / **	—
FLORIDA ATLANTIC	—	—	—	—	—	—	—	5 / —
HAWAII	— / 2	1 / —	4 / 2	—	—	—	—	2 / 2
HOUSTON	2 / 1	— / 3	1 / 2	1 / 1	—	—	—	—
* M.I.T.	— / 3	1 / 3	— / 6	—	—	—	—	—
MASSACHUSETTS	2 / —	2 / 1	—	—	1 / —	3 / —	—	—
MIAMI	—	— / 1	— / 6	— / 2	1 / —	1 / 8	—	2 / 2
MICHIGAN	—	3 / 1	1 / —	—	—	—	—	—
NEW HAMPSHIRE	3 / 6	2 / —	—	3 / 4	1 / —	—	—	— / 1
* NEW YORK	—	—	3 / —	—	—	—	—	—
OREGON STATE	2 / 1	1 / —	2 / 2	—	2 / —	—	4 / **	1 / —
RHODE ISLAND	1 / 1	2 / 3	2 / 4	5 / 1	— / 2	— / 1	—	4 / 1
UNIV. OF SOU. CALIF.	—	—	—	—	—	—	—	4 / **
STEVENS INST.	1 / —	— / 1	1 / —	—	—	—	—	—
TEXAS A&M	7 / 5	—	6 / 3	—	— / 1	— / 1	3 / 2	—
UNIV. OF TEXAS	1 / —	—	—	—	6 / 4	—	—	—
* WASHINGTON	—	—	4 / 1	—	—	—	—	—
TOTAL: 21	35† / 35	19 / 26	36† / 37	9 / 9	12 / 20	6 / 11	10 / 2†	20 / 8†

TABLE 2. RESEARCH EFFORT IN OCEAN ENGINEERING

† APPROXIMATE

* DATA OBTAINED FROM HYDRAULIC RESEARCH IN THE U.S. 1968

** DATA UNAVAILABLE

In reviewing the various brochures describing programs in ocean engineering it becomes quite apparent that the initial development in any given institution was in the area of greatest strength which existed at that institution when the ocean engineering program was initiated. For example, if a given institution had a strong program in marine engineering, the bulk of ocean engineering program was in the marine engineering area. This is as it should be in the initial development.

Future Development

It appears that ocean engineering has been recognized as a separate engineering discipline. However, in this stage of its evolution ocean engineering is not a singular, well-defined and bounded area of engineering. Ocean engineering contains a very broad spectrum of engineering activities in the ocean and will probably remain so for sometime to come.

The existing graduate programs will no doubt be expanded to include areas not covered at present. However, it would be a mistake for all institutions to have a similar program superficially covering all areas of ocean engineering rather than providing in-depth coverage of certain areas in which they are strong.

Industry needs ocean engineers at B.S. level as well as graduate levels.[5] This need will in time call for initiation of undergraduate programs in ocean engineering. The development of undergraduate

programs will follow a path taken by petroleum, nuclear or aeronautical programs in the past. Industry, Government and Education will need ocean engineers with graduate degrees, the educational institutions will respond to this call and establish or continue development of ocean engineering programs.

Conclusions

1. Ocean engineering programs are at a developmental stage at many institutions.
2. The ocean engineering programs will expand at both the graduate and undergraduate level in response to needs of Industry, Government and Education. Industry is interested in more applications-oriented programs, particularly at the undergraduate level.
3. There are over 400 students pursuing a graduate program in ocean engineering.
4. Over 150 master's degrees and over 35 doctoral degrees in some area of specialization of ocean engineering were awarded during the last three academic years.
5. National Science Foundation Sea Grant Program provided assistance in development of ocean engineering educational programs.

6. Research effort in ocean engineering not only assists in educational programs but also fosters accelerated development of marine resources.

Acknowledgement

Assistance of Mr. Curtis Mason, a graduate student at Texas A&M University in preparation of tables is gratefully acknowledged.

This study was partially supported by the National Science Foundation Sea Grant Program, Institutional Grant GH-59 to Texas A&M University.

REFERENCES

1. Vine, A. C., "Qualifications Ocean Engineers Need", a graphic digest "Manpower for Oceanography", Ocean Industry, March, April, May, 1968.

2. Calhoun, Jr., J. C., Samson, Jr., C. H. and Herbich, J. B., "What is Core in Ocean Engineering?", Paper presented at the ASEE National meeting at Los Angeles, June 17-20, 1968.

3. "University Curricula in the Marine Sciences and Related Fields", Academic Years 1969-70 and 1970-71, National Council on Marine Resources and Engineering Development, 1969.

4. Kulin, G., Editor, "Hydraulic Research in the United States, 1968", National Bureau of Standards Special Publication 316, June 1969.

5. "The Industrial View", A Consensus Report of "Marine Resources: The Industrial View", Texas A&M University Sea Grant Program Report No. SG-70-107, April 1970.