# A SURVEY OF ACADEMIC QUALIFICATIONS FOR FISHERY BIOLOGISTS AND OF INSTITUTIONAL FACILITIES FOR TRAINING FISHERY BIOLOGISTS

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ABSTRACT

The perplexity of students, prospective students, and educators concerning requisite academic training for fishery biology has prompted a survey to provide basic and comparative data.

A questionnaire was circulated among the 68 fishery biologists employed by the Fish and Wildlife Service and an almost equal number of fishery biologists in the employ of various States, Provinces and private institutions which requested an evaluation of academic subjects in relation to undergraduate and early postgraduate training for eight phases of fishery biology. The results consist of a composite evaluation of fundamental courses as essential, desirable, optional, or not necessary expressed on a percentage basis.

Instruction in the form of specialized courses in fishery subjects and hydrobiology in the United States and Canada was determined by means of a second questionnaire submitted to a qualified faculty member of each of 80 of the principal universities and colleges. Forty-three schools now provide some instruction and facilities. The questionnaire also provided information on number of faculty, facilities and supervision for research, museum collections of aquatic animals, and biological stations.

## INTRODUCTION

Among the thousands of inquiries from citizens received each year by the former Bureau of Fisheries and by the present Fish and Wildlife Service of the U. S. Department of the Interior are many requests for recommendations concerning the academic training necessary for biological positions in the Division of Fishery Biology. Other requests seek information relative to the universities and colleges in North America where specialized instruction and training in fishery subjects may be obtained.

In the past, any suggestions that were offered concerning academic training usually had to be made from a more or less personal viewpoint and obviously were unsatisfactory both from the standpoint of the Service and from that of the recipient. To provide a more reliable basis for answering the inquiries, a questionnaire was circulated among the 68 fishery biologists now employed by the Fish and Wildlife Service and 65 additional biologists in the employ of the various States, Canadian Provinces, and independent research institutions. The men receiving questionnaires were all experienced in investigations and hence well-qualified to evaluate the importance of academic training. The replies to the questionnaires (123 in all) provided such an interesting fund of information that it has been decided to make it available generally through publication in the *Transactions of the American Fisheries Society.*

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For many years the former Bureau of Fisheries circulated in mimeographed form the results of a survey of instructional facilities that appeared in a report of the Committee on Aquiculture of the Division of Biology, National Research Council.[1] Since that information is now considerably out of date and because it embraced only some of the fresh-water phases of fishery biology it was believed that a new survey should be conducted that would encompass all of the various branches of present-day fishery biology, both marine and fresh-water. Recently, a questionnaire was submitted to members of the faculties of 80 of the leading universities and colleges in the United States and Canada which inquired concerning the course work, instructional and research facilities, museum collections, and biological stations supported by each. The replies to that questionnaire have supplied the data for a second part of this report, instructional and research facilities for training fishery biologists.

The cooperation of Mr. Charles E. Jackson, Assistant Director of the Fish and Wildlife Service, who submitted the questionnaire to academic institutions and the assistance of Mr. Elmer Higgins, Chief of the Division of Fishery Biology of the Service, who aided in the drafting of the questionnaires and submitted the questionnaire to fishery biologists are gratefully acknowledged.

## The Field of Fishery Biology

The field of fishery biology has developed during recent years from a single line of endeavor into at least eight phases. In attempting to make a "break-down" classification of fishery biology, it is admitted that any system is more or less arbitrary and will be open to criticism from one viewpoint or another. The division of labor among the fishery biologists of the Fish and Wildlife Service appears to fall into at least eight classifications, which, however, are not mutually exclusive. In filling out questionnaires concerning recommendations for undergraduate and early postgraduate course work, many indicated that their answers were applicable to two or more phases. Thus, in the tabulations that follow there is some duplication so that the 123 questionnaires returned actually totalled 136 when they were distributed among the 8 phases of fishery biology as follows:

1. Marine fishery biology (41 replies)
2. Fresh-water fishery biology (55 replies)
3. Aquiculture (16 replies)
4. Fish pathology (13 replies)
5. Aquatic physiology (8 replies)
6. Oyster culture and physiology (9 replies)
7. Ichthyology (15 replies)
8. Oceanography (8 replies)

[1]Science, Vol 71, 1930, pp. 265-266.

Although, as has been stated, these various phases may be assumed to indicate the specialties of fishery biologists, all investigators should have and do have training adequate to enable them to work in the immediately related phases. For example, marine fishery biology necessitates some knowledge of oceanography; fresh-water fishery biology implies also some knowledge of aquicultural methods, especially to the extent that "fish-management" work in interior lakes and streams enters into the duties of the investigator; aquiculture and fish pathology are a necessary combination for successful experimental fish-cultural work; both marine fishery biology and fresh-water fishery biology require some acquaintance with systematic ichthyology; and present-day systematic ichthyology has gone far beyond the sphere of pure taxonomy and relies upon natural history and ecology (as comprehended in fishery biology) for the analysis and interpretation of speciation and racial affinities. Aquatic physiology, which infers studies of water quality as related to the detection and measurement of the effects of natural, altered, or contaminated environments upon fishes and aquatic invertebrates, is allied closely to fishery biology and some aspects of aquiculture.

## Undergraduate and Early Postgraduate Training

The recommendations for basic training in the various subjects common to the curricula of the larger colleges and universities are presented in Tables 1 to 4. In filling out the questionnaire the biologist was asked to evaluate the importance of the various subjects by designating them as *essential* (E), *desirable* (D), *optional* (O), or *not necessary* (NN). The recommendations have been computed on a percentage basis, for example in Table 1, for marine fishery biology, 2 per cent of the 41 questionnaires indicated that bacteriology was essential, 34 per cent held it to be desirable, 42 per cent optional, and 22 per cent not necessary. Without further explanation it is believed that the results of Tables 1 to 4 can be interpreted by the student, prospective student, or educator as indicating what subjects form or should form indispensable or desirable items in the collegiate training of a fishery biologist. If the value in the *essential* (E) column is 50 per cent or more it may be inferred that the prospective student must have training in that subject.

In addition to the subjects listed in the tables some of those who returned questionnaires recommended additional courses as essential or desirable, which should, for the most part, be pursued during advanced postgraduate study. These are listed below.

*Marine fishery biology.*—Physiological chemistry (biochemistry), histology, navigation, microtechnique, public speaking, logic (all desirable).

*Fresh-water fishery biology.*—Physiological chemistry (biochemistry), histology, surveying, microtechnique, business administration, public speaking, logic, advanced water analysis, algae (all desirable).

*Table 1.—The relative importance of various academic subjects to training for marine and fresh-water fishery biology expressed as percentages of the total number of questionnaires related to each phase*

[E, essential; D, desirable; O, optional; NN, not necessary]

| Subject | Marine fishery biology (41) | | | | Fresh-water fishery biology (55) | | | |
|---|---|---|---|---|---|---|---|---|
| | E | D | O | NN | E | D | O | NN |
| Bacteriology | 2 | 34 | 42 | 22 | 16 | 52 | 25 | 7 |
| Botany | | | | | | | | |
| Elementary | 54 | 37 | 9 | .... | 84 | 11 | 5 | .... |
| Phanerogamic | 5 | 17 | 55 | 23 | 13 | 34 | 42 | 11 |
| Cryptogamic | 12 | 37 | 37 | 14 | 22 | 42 | 31 | 5 |
| Chemistry | | | | | | | | |
| Elementary | 100 | .... | .... | .... | 95 | 5 | .... | .... |
| Qualitative | 39 | 49 | 10 | 2 | 35 | 53 | 7 | 5 |
| Quantitative | 37 | 41 | 17 | 2 | 31 | 48 | 16 | 5 |
| Physical | 24 | 20 | 32 | 24 | 13 | 20 | 42 | 25 |
| Organic | 30 | 34 | 34 | 2 | 24 | 51 | 20 | 5 |
| Economics | 20 | 34 | 26 | 20 | 11 | 24 | 41 | 24 |
| English composition | 90 | 10 | .... | .... | 85 | 15 | .... | .... |
| French | 17 | 63 | 15 | 5 | 25 | 51 | 16 | 8 |
| Geology | | | | | | | | |
| Elementary | 10 | 34 | 34 | 22 | 35 | 36 | 25 | 4 |
| Palaeontology | .... | 10 | 56 | 34 | .... | 18 | 51 | 31 |
| German | 44 | 40 | 7 | .... | 54 | 40 | 4 | 2 |
| Geography | 2 | 27 | 44 | 27 | 9 | 31 | 40 | 20 |
| Mathematics | | | | | | | | |
| Trigonometry | 63 | 27 | 10 | .... | 44 | 38 | 11 | 7 |
| Analyt. geometry | 39 | 49 | 10 | 2 | 29 | 31 | 22 | 18 |
| Calculus | 19 | 44 | 15 | 2 | 25 | 31 | 27 | 17 |
| Statistics | 90 | 10 | .... | .... | 84 | 16 | .... | .... |
| Physics | 61 | 32 | 5 | 2 | 69 | 24 | 5 | 2 |
| Physiology | 54 | 42 | 4 | .... | 65 | 33 | 2 | .... |
| Zoology | | | | | | | | |
| Elementary | 100 | .... | .... | .... | 100 | .... | .... | .... |
| Comp. anatomy | 78 | 10 | 12 | .... | 64 | 27 | 9 | .... |
| Embryology | 71 | 27 | 2 | .... | 64 | 27 | 5 | 4 |
| Invertebrate | 76 | 22 | 2 | .... | 80 | 20 | .... | .... |
| Entomology | 15 | 34 | 36 | 15 | 62 | 29 | 9 | .... |
| Parasitology | 7 | 68 | 20 | 5 | 25 | 50 | 25 | .... |
| Protozoology | 9 | 54 | 32 | 5 | 18 | 53 | 29 | .... |
| Genetics | 24 | 42 | 22 | 12 | 23 | 46 | 23 | 8 |
| Systematic | 66 | 27 | 5 | 2 | 55 | 36 | 9 | .... |
| Ecology | 66 | 24 | .... | .... | 75 | 25 | .... | .... |
| Limnology | 24 | 54 | 20 | 2 | 89 | 7 | 4 | .... |
| Oceanography | 39 | 51 | 10 | .... | 10 | 48 | 20 | 22 |



*Table 2.—The relative importance of various academic subjects to training for aquiculture and fish pathology expressed as percentages of the total number of questionnaires related to each phase*

[E, essential; D, desirable; O, optional; NN, not necessary]

| Subject | Aquiculture (18) | | | | Fish pathology (13) | | | |
|---|---|---|---|---|---|---|---|---|
| | E | D | O | NN | E | D | O | NN |
| Bacteriology | 25 | 56 | 19 | .... | 70 | 15 | 15 | .... |
| Botany | | | | | | | | |
| Elementary | 88 | 6 | 6 | .... | 100 | .... | .... | .... |
| Phanerogamic | 12 | 44 | 25 | 19 | 23 | 23 | 15 | 39 |
| Cryptogamic | 25 | 31 | 25 | 19 | 31 | 23 | 15 | 31 |
| Chemistry | | | | | | | | |
| Elementary | 100 | .... | .... | .... | 92 | 8 | .... | .... |
| Qualitative | 63 | 31 | 6 | .... | 68 | 16 | 16 | .... |
| Quantitative | 50 | 25 | 25 | .... | 61 | 23 | 16 | .... |
| Physical | 13 | 6 | 56 | 25 | 23 | .... | 46 | 31 |
| Organic | 44 | 31 | 25 | .... | 54 | 23 | 23 | .... |
| Economics | .. | 44 | 31 | 25 | 7 | 31 | 31 | 31 |
| English composition | 81 | 19 | .... | .... | 76 | 8 | 8 | 8 |
| French | 31 | 31 | 25 | 13 | 61 | 23 | 8 | 8 |
| Geology | | | | | | | | |
| Elementary | 50 | 31 | 19 | .... | .... | 38 | 31 | 31 |
| Palaeontology | .... | 19 | 19 | 62 | .... | .... | 15 | 85 |
| German | 50 | 44 | 6 | .... | .... | 31 | 31 | 38 |
| Geography | .... | 50 | 44 | 6 | 46 | 54 | .... | .... |
| Mathematics | | | | | | | | |
| Trigonometry | 19 | 50 | 25 | 6 | 15 | 46 | 24 | 15 |
| Analyt. geometry | 13 | 25 | 25 | 37 | 8 | 23 | 31 | 38 |
| Calculus | 6 | 38 | 31 | 25 | .... | 24 | 24 | 52 |
| Statistics | 31 | 19 | .... | .... | 69 | 15 | 8 | 8 |
| Physics | 75 | 19 | 6 | .... | 62 | 22 | 8 | 8 |
| Physiology | 75 | 25 | .... | .... | 84 | 8 | 8 | .... |
| Zoology | | | | | | | | |
| Elementary | 100 | .... | .... | .... | 100 | .... | .... | .... |
| Comp. anatomy | 50 | 50 | .... | .... | 54 | 38 | 8 | .... |
| Embryology | 50 | 44 | .... | 6 | 54 | 31 | 15 | .... |
| Invertebrate | 63 | 37 | .... | .... | 61 | 31 | 8 | .... |
| Entomology | 63 | 25 | 12 | .... | 54 | 23 | 23 | .... |
| Parasitology | 44 | 56 | .... | .... | 77 | 23 | .... | .... |
| Protozoology | 12 | 70 | 12 | 6 | 69 | 31 | .... | .... |
| Genetics | 6 | 75 | 19 | .... | 38 | 23 | 31 | 8 |
| Systematic | 31 | 38 | 25 | 6 | 46 | 23 | 23 | 8 |
| Ecology | 62 | 38 | .... | .... | 70 | 15 | 15 | .... |
| Limnology | 94 | .... | 6 | .... | 77 | 15 | 8 | .... |
| Oceanography | 6 | 38 | 38 | 18 | .... | 8 | 46 | 46 |

*Table 3.—The relative importance of various academic subjects to training for aquatic physiology and oyster culture and physiology expressed as percentages of the total number of questionnaires related to each phase*

[E, essential; D, desirable; O, optional; NN, not necessary]

| Subject | Aquatic physiology (8) | | | | Oyster culture and physiology (9) | | | |
|---|---|---|---|---|---|---|---|---|
| | E | D | O | NN | E | D | O | NN |
| Bacteriology | 100 | .... | .... | .... | 33 | 44 | 23 | .... |
| Botany | | | | | | | | |
| Elementary | 100 | .... | .... | .... | 89 | .... | .... | 11 |
| Phanerogamic | 12 | 75 | .... | .... | 11 | 67 | 11 | 11 |
| Cryptogamic | 25 | 75 | .... | .... | 56 | 33 | .... | 11 |
| Chemistry | | | | | | | | |
| Elementary | 100 | .... | .... | .... | 100 | .... | .... | .... |
| Qualitative | 62 | 38 | .... | .... | 66 | 34 | .... | .... |
| Quantitative | 75 | 25 | .... | .... | 66 | 34 | .... | .... |
| Physical | 62 | 38 | .... | .... | 44 | 44 | 12 | .... |
| Organic | 62 | 38 | .... | .... | 56 | 44 | .... | .... |
| Economics | 12 | 25 | 63 | .... | 11 | 11 | 33 | 45 |
| English composition | 88 | 12 | .... | .... | 89 | 11 | .... | .... |
| French | 50 | 25 | 25 | .... | 22 | 67 | 11 | .... |
| Geology | | | | | | | | |
| Elementary | 38 | 50 | 12 | .... | 67 | 22 | 11 | .... |
| Palaeontology | .... | .... | 100 | .... | .... | 22 | 33 | 45 |
| German | 74 | 13 | 13 | .... | 78 | 22 | .... | .... |
| Geography | 25 | 25 | 25 | 25 | .... | .... | 44 | 56 |
| Mathematics | | | | | | | | |
| Trigonometry | 50 | 50 | .... | .... | 67 | 33 | .... | .... |
| Analyt. geometry | 62 | 25 | 13 | .... | 33 | 45 | 22 | .... |
| Calculus | 37 | 50 | 13 | .... | 33 | 67 | .... | .... |
| Statistics | 75 | .... | 25 | .... | 56 | 33 | 11 | .... |
| Physics | 100 | .... | .... | .... | 89 | 11 | .... | .... |
| Physiology | 100 | .... | .... | .... | 100 | .... | .... | .... |
| Zoology | | | | | | | | |
| Elementary | 100 | .... | .... | .... | 100 | .... | .... | .... |
| Comp. anatomy | 88 | 12 | .... | .... | 67 | 11 | 11 | 11 |
| Embryology | 88 | 12 | .... | .... | 78 | 11 | 11 | .... |
| Invertebrate | 75 | 25 | .... | .... | 100 | .... | .... | .... |
| Entomology | 50 | 37 | 13 | .... | 22 | 22 | 11 | 45 |
| Parasitology | 25 | 75 | .... | .... | 22 | 22 | 11 | 45 |
| Protozoology | 25 | 50 | 25 | .... | 22 | 67 | 11 | .... |
| Genetics | 24 | 38 | 38 | .... | 22 | 22 | 45 | 11 |
| Systematic | 38 | 38 | 12 | 12 | 11 | 44 | 12 | .... |
| Ecology | 50 | 25 | 25 | .... | 44 | 44 | .... | 12 |
| Limnology | 75 | 25 | .... | .... | 44 | 44 | 12 | .... |
| Oceanography | .... | 75 | 25 | .... | 56 | 33 | 11 | .... |



*Table 4.—The relative importance of various academic subjects to training for ichthyology and oceanography expressed as percentages of the total number of questionnaires related to each phase*

[E, essential; D, desirable; O, optional; NN, not necessary]

| Subject | Ichthyology (15) | | | | Oceanography (8) | | | |
|---|---|---|---|---|---|---|---|---|
| | E | D | O | NN | E | D | O | NN |
| Bacteriology | 20 | 33 | 33 | 14 | 13 | 62 | 25 | .... |
| Botany | | | | | | | | |
| Elementary | 73 | 27 | .... | .... | 76 | 12 | 12 | .... |
| Phanerogamic | .... | 53 | 47 | .... | .... | 38 | 50 | 12 |
| Cryptogamic | 14 | 53 | 33 | .... | 25 | 38 | 37 | .... |
| Chemistry | | | | | | | | |
| Elementary | 93 | 7 | .... | .... | 100 | .... | .... | .... |
| Qualitative | 20 | 66 | 7 | 7 | 62 | 38 | .... | .... |
| Quantitative | 13 | 60 | 20 | 7 | 62 | 38 | .... | .... |
| Physical | 7 | 33 | 33 | 27 | 50 | 25 | 25 | .... |
| Organic | 13 | 47 | 33 | 7 | 25 | 50 | 13 | 12 |
| Economics | .... | 33 | 33 | 33 | .... | 25 | 38 | 37 |
| English composition | 80 | 20 | .... | .... | 75 | 25 | .... | .... |
| French | 20 | 60 | 20 | .... | 38 | 50 | 12 | .... |
| Geology | | | | | | | | |
| Elementary | 33 | 40 | 20 | 7 | 25 | 25 | 50 | .... |
| Palaeontology | .... | 40 | 33 | 27 | .... | 25 | 63 | 12 |
| German | 53 | 47 | .... | .... | 75 | 25 | .... | .... |
| Geography | 7 | 33 | 47 | 13 | 13 | 25 | 50 | 12 |
| Mathematics | | | | | | | | |
| Trigonometry | 47 | 33 | 20 | .... | 63 | 25 | 12 | .... |
| Analyt. geometry | 33 | 41 | 13 | 13 | 50 | 38 | 12 | .... |
| Calculus | 27 | 46 | 27 | .... | 50 | 38 | 12 | .... |
| Statistics | 60 | 40 | .... | .... | 63 | 25 | 12 | .... |
| Physics | 40 | 33 | 20 | 7 | 63 | 37 | .... | .... |
| Physiology | 53 | 47 | .... | .... | 63 | 37 | .... | .... |
| Zoology | | | | | | | | |
| Elementary | 100 | .... | .... | .... | 100 | .... | .... | .... |
| Comp. anatomy | 60 | 20 | 20 | .... | 50 | 13 | 25 | 12 |
| Embryology | 60 | 33 | 7 | .... | 50 | 25 | 13 | 12 |
| Invertebrate | 53 | 40 | 7 | .... | 50 | 37 | 13 | .... |
| Entomology | 27 | 40 | 33 | .... | 13 | 37 | 13 | 37 |
| Parasitology | 27 | 40 | 33 | .... | .... | 63 | 25 | 12 |
| Protozoology | 13 | 40 | 47 | .... | .... | 75 | 25 | .... |
| Genetics | 20 | 47 | 33 | .... | 13 | 50 | 12 | 25 |
| Systematic | 80 | 20 | .... | .... | 50 | 25 | 13 | 12 |
| Ecology | 80 | 20 | .... | .... | 38 | 38 | 12 | 12 |
| Limnology | 66 | 27 | 7 | .... | 63 | 25 | 12 | .... |
| Oceanography | 27 | 46 | 27 | .... | 100 | .... | .... | .... |

*Aquiculture.*—Physiological chemistry (biochemistry), histology (desirable); water chemistry, nutrition (essential).

*Fish pathology.*—Physiological chemistry (biochemistry), medical pathology, histology, cytology, microtechnique (essential); pharmacology, serology (desirable).

*Aquatic physiology.*—Physiological chemistry (biochemistry), advanced physics, advanced physiology, plant physiology, advanced organic and inorganic chemistry, histology, cytology, microtechnique (essential); pharmacology, toxicology, nutrition, endocrinology, sanitary engineering (desirable).

*Oyster culture and physiology.*—Physiological chemistry (biochemistry), histology, cytology, microtechnique (essential); pathology, toxicology, nutrition, endocrinology (desirable).

*Ichthyology.*—Histology, microtechnique, logic, systematic botany (desirable).

*Oceanography.*—Advanced physics, navigation (essential); marine algae, meteorology, advanced calculus, advanced statistics (desirable).

The questionnaires were criticized by several persons who responded because they contained no specialized fishery or conservation courses. These were intentionally omitted because many universities and colleges offer none or have only irregular and scattered instruction and on the other hand the actual subject matter of such courses is so extremely variable that it would be difficult to include them in these lists. Specialized fishery courses for the most part are advanced studies requiring fundamental training in the physical and biological sciences. The second part of this paper will attempt to indicate to what extent specialized instruction is available at different North American institutions.

## The Ideal Biological Training

The tendency to overspecialize during undergraduate days was noted by several who responded to the questionnaire. It was indicated that frequently students who become good research men in their respective fields nevertheless lack fundamental training in certain cultural subjects and in cognate fields. Some investigators called attention to the rather widespread deficiency among biologists and other scientists in the proper use of the English language and the lack of facility in writing good scientific papers. It will be noted in Tables 1 to 4 that the vast majority of the responses indicated English composition as essential and almost all of the small remainder considered it desirable. Several of the men who direct research activities of others stated that the biologists should have training in English composition and English literature beyond the minimum required for graduation by most universities and colleges. Institutions, in the opinion of a few, should be encouraged to provide substantial instruction in the proper use of bibliographic sources, in the analysis and

tabulation of data, and in the proper preparation of manuscripts for publication.

French and German were the only foreign languages listed in the questionnaire because, traditionally, candidates for the doctorate almost universally, and for the master's degree in some institutions, are required to pass examinations in those subjects. Undoubtedly German is very useful to the majority of fishery workers. On the other hand, various of the questionnaires indicated that another foreign language might be substituted for French with profit since Norwegian, Danish, Russian, Italian and even Japanese appear to be equally or more useful to the fishery biologist. Some institutions permit the substitution of one of these languages for French in meeting the language requirements for the doctorate.

No 4-year course will enable a student to acquire all of the essential and desirable special courses in addition to the necessary training in cultural fields. One or more years of postgraduate study should be undertaken if possible. It is hoped that the results of this questionnaire will provide a basis for judging the relative merits of various fields of instruction in the academic preparation for a career as a professional fishery biologist. Lest the student or prospective student be discouraged by the seemingly insurmountable array of course work, let him reflect upon the statements made by Dr. A. G. Huntsman, Director of the Fisheries Research Board of Canada, on the back of his questionnaire:

> "A fishery investigator, if he is to have a good chance of solving the problems with which he is confronted, requires a general training in the sciences and related fields with some cultural subjects as is very well appreciated. While special courses . . . . are definitely valuable I believe the most important matters are that he have such a thorough background in biology (zoology, botany and physiology) and physics that he can really tackle the common problem of an organism in a changing, largely physical, environment. If he is really able to investigate both the fish and its environment he is apt to go very far."

## Courses in Fishery Biology

The number of academic institutions in the United States that offer specialized courses related to fishery biology has increased considerably during the last 15 years due to the growth of fishery science as a recognized profession and the ever-increasing number of opportunities for employment in the field. A questionnaire was sent to 80 of the leading institutions in the United States and Canada during May, 1940. Selection of the list of schools was made rather arbitrarily upon the basis of the size of the enrollment and membership in the American Association of Universities and Colleges. The replies indicated that only 43 institutions in the United States and Canada have any

facilities for training fishery biologists through special instruction and supervision, and that a smaller number have the necessary facilities for the development of specialists in the various branches of fishery biology. No claims are made for the completeness of the tabulations because some institutions that possibly should have appeared on the list may have failed to return the questionnaire. Time did not permit any follow-up procedure, but since the purposes of the survey were described in detail in a letter that accompanied each questionnaire it is felt that any institution that had special courses or facilities would have responded voluntarily. For the most part the data presented are exactly as submitted. Some personal judgment had to be exercised in coordinating the responses on a small number of the questionnaires so that they could be adapted to a condensed tabular presentation. Only those institutions that offer special courses and/or opportunities and facilities for research have been included in the tabulations and all negative replies were discarded without mention. Some few schools not mentioned herein indicated that while they offered no courses in the special fields at present they planned to do so as soon as the financial means of providing faculty members and facilities become available.

The number of regular and occasional courses in various subjects related to fishery biology is shown in Table 5 where the institutions have been arranged alphabetically by States. When it was difficult to determine the precise number of courses offered from the information supplied, the minimum number is indicated followed by a plus sign. The letter "V" is used to indicate that while no regularly scheduled courses are offered, personal guidance for individual study and/or instruction are available if there is sufficient demand. The classification of courses is that assigned by officials of the institutions and hence no claims can be made for the comparableness of subject matter in courses at different schools.

The number of faculty members teaching specialized fishery courses at the various schools is indicated in Table 6, differentiated as professors and instructors. Laboratory assistants have not been included. Sometimes the same faculty member teaches more than one or even the majority of the courses listed for a particular school. The availability of supervision and facilities for individual problem work and independent research is indicated by the letter "R." This evaluation of facilities is based upon statements of officials for personal knowledge is confined to but a small number of schools.

## Biological Stations and Museum Collections

The fairly large number of summer biological stations and the two marine and one fresh-water station open throughout the year provide an opportunity for the fishery investigator to conduct research work on field problems and to pursue course work in some instances as well.

*Table 5.—Number of courses in subjects related to fishery biology in the curricula of academic institutio*

[Occasional courses indicated in parentheses, personal guidance or instruction on demand indicated by V, variable]

| State or Province | Institution | Marine fishery biology | Fresh-water fishery biology | Systematic ichthyology | Physiology | Fish pathology | Fish parasitology | General parasitology | Limnology | Oceanography | Fish culture |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Ala. | Alabama Polytechnic Institute | .. | .. | 2 | 1 | .. | .. | 2 | .. | .. | .. |
| Calif. | Stanford University | 3 (1) | 2 (1) | 2 (1) | 4 + | .. | .. | .. | 1 (1) | 2 (1) | .. |
| Calif. | University of California | 1 | .. | .. | 2 + | .. | .. | .. | .. | 2 | .. |
| Colo. | University of Colorado | .. | .. | .. | 3 + | .. | .. | 1 | 1 | .. | .. |
| Conn. | Yale University | 1 | .. | .. | 1 | .. | .. | 1 | 1 | 1 | .. |
| Fla. | University of Florida | .. | 1 | .. | .. | .. | .. | 1 | (1) | .. | .. |
| Ill. | University of Illinois | .. | V | V (1) | 1 + | V | .. | 2 | V | .. | .. |
| Ind. | Indiana University | .. | 1 | .. | 1 | .. | .. | .. | 1 | .. | .. |
| Iowa | Iowa State College | .. | 2 | 1 | 3 | .. | .. | 2 | .. | .. | .. |
| Iowa | State University of Iowa | .. | V | .. | .. | .. | .. | .. | V | .. | .. |
| Kan. | University of Kansas | .. | .. | V | .. | .. | .. | 1 | 1 | .. | .. |
| Ky. | University of Kentucky | .. | V | V | .. | .. | .. | 1 | .. | .. | .. |
| La. | Louisiana State University | 2 | 2 | .. | 6 | .. | 2 | 2 | .. | .. | .. |
| Maine | University of Maine | V | .. | 1 | 1 | .. | .. | 1 | .. | .. | 1 |
| Md. | University of Maryland | 1 | .. | 1 | 2 | .. | .. | .. | 1 | .. | 1 |
| Mass. | Harvard University | V | .. | V | 4 | V | .. | 1 | 1 | 1 | 1 |
| Mass. | Massachusetts State College | .. | .. | .. | .. | .. | .. | .. | .. | .. | V |
| Mich. | University of Michigan | V | 2 | 3 | 3 + | .. | .. | 3 | 3 | .. | .. |
| Minn. | University of Minnesota | .. | 1 | 2 | 2 | .. | .. | 3 | 1 | .. | .. |
| Mo. | University of Missouri | .. | V | .. | 6 + | .. | .. | 1 | V | .. | .. |
| Mont. | University of Montana | .. | 1 | 1 | 1 | .. | .. | 1 | .. | .. | .. |
| Neb. | University of Nebraska | .. | V | .. | 4 | .. | .. | 3 | .. | .. | .. |
| N. H. | University of New Hampshire | 1 | .. | 1 | .. | .. | .. | .. | 1 | 1 | .. |
| N. J. | Rutgers University | .. | .. | .. | 3 | .. | .. | 1 | 1 | .. | .. |
| N. Y. | Cornell University | .. | 2 | 2 | 2 | .. | .. | 2 | 1 | .. | 1 |
| N. Y. | N. Y. State College of Forestry | .. | 1 | V | .. | V | V | 1 | .. | .. | .. |
| N. Y. | University of Rochester | .. | V | V | 2 | .. | .. | 2 | .. | 1 | .. |
| N. C. | Duke University | 1 | V | V | 1 | .. | 1 | .. | 1 (1) | 1 | .. |
| N. C. | University of North Carolina | V | V | 1 | 2 | .. | .. | 1 | 1 | .. | 1 |
| Ohio | Ohio State University | .. | 1 | 1 | 2 + | .. | V | 1 + | 1 + | 1 | .. |
| Ont. | University of Toronto | 1 | 1 + | 1 + | 3 | .. | (1) | 1 | .. | .. | .. |
| Ore. | Oregon State College | .. | .. | 1 | V | .. | .. | .. | .. | V | .. |
| R. I. | Rhode Island State College | V | .. | V | 1 | .. | .. | 1 | 1 | .. | V |
| Sask. | University of Saskatchewan | .. | 1 | 1 | 1 | .. | .. | 3 | 1 | .. | .. |
| Tenn. | University of Tennessee | .. | .. | .. | 5 | .. | .. | .. | .. | .. | 1 |
| Texas | A. & M. College of Texas | .. | V | 1 | .. | .. | .. | 1 | V | .. | .. |
| Utah | University of Utah | .. | V | V | .. | .. | .. | 1 | 1 | .. | .. |
| Utah | Utah State Agri. College | .. | V | .. | .. | .. | .. | 1 | V | .. | .. |
| Va. | University of Virginia | .. | .. | .. | .. | .. | .. | 1 | 1 | 3 + | 3 |
| Wash. | University of Washington | 2 + | 3 + | 2 | 4 + | 1 | 1 | 1 | V | .. | .. |
| W. Va. | University of West Virginia | .. | V | .. | .. | .. | .. | 2 | 2 | .. | .. |
| Wis. | University of Wisconsin | .. | V | .. | 1 | .. | .. | 2 | .. | .. | .. |
| Wyo. | University of Wyoming | .. | 1 | .. | 3 | .. | .. | 3 | .. | .. | .. |

*Table 6.—Number of faculty teaching fishery biology and related courses at various academic institutions*

[Numbers outside of parentheses, professors; numbers within parentheses, instructors; R, supervision and facilities for independent research]

| State or Province | Institution | Marine fishery biology | Freshwater fishery biology | Systematic ichthyology | Physiology | Fish pathology | Fish parasitology | General parasitology | Limnology | Oceanography | Fish culture |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Ala. | Alabama Polytechnic Institute | .. | .. R | 1 | 1 | .. | .. | 1 | .. | .. | .. R |
| Calif. | Stanford University | 4 R | 2 R | 3 R | 7 R | .. | .. | .. | 4 R | 2 R | .. |
| Calif. | University of California | 1 | .. | .. | .. | .. | .. | .. | .. | 3 (3) R | .. |
| Colo. | University of Colorado | .. | .. R | .. | 2 (1) R | .. | .. R | 1 R | 1 R | .. | .. |
| Conn. | Yale University | 1 (1) R | .. | .. | 1 R | .. | .. | 1 R | 1 R | 1 R | .. |
| Fla. | University of Florida | .. | 1 R | (1) | .. | .. | .. | 1 | 1 R | 1 R | .. |
| Ill. | University of Illinois | .. | .. | .. | 2 R | 1 R | .. | 3 R | 3 R | .. | .. |
| Ind. | Indiana University | .. | 1 R | .. | 1 R | .. | .. | 1 R | 1 R | .. | .. |
| Iowa | Iowa State College | .. | (1) R | (1) R | 2 R | .. | .. R | 1 R | .. | .. | .. |
| Iowa | State University of Iowa | .. | 1 | .. | .. | .. | .. | .. | 1 | .. | .. |
| Kan. | University of Kansas | .. | .. | 1 | .. | .. | .. | 1 R | 1 R | .. | .. |
| Ky. | University of Kentucky | .. | .. | .. | .. | .. | .. | (1) | .. | .. | .. |
| La. | Louisiana State University | 3 R | 3 R | .. | 4 R | .. | .. | 2 R | .. | .. | .. (1) |
| Maine | University of Maine | .. | .. | (1) R | 1 | .. | .. | 1 R | .. | .. | 1 R |
| Md. | University of Maryland | 1 R | .. | 1 (1) R | 1 R | .. | .. | .. | .. | 1 R | 1 R |
| Mass. | Harvard University | .. R | .. | .. R | 5 (1) R | .. R | .. | 1 R | 1 R | 1 R | .. |
| Mass. | Massachusetts State College | .. | .. | .. | .. | .. | .. | .. | .. | .. | 1 |
| Mich. | University of Michigan | .. R | 1 (1) R | 2 (1) R | 3 + R | .. | .. R | 4 R | 2 R | .. | .. |
| Minn. | University of Minnesota | .. | 1 R | 2 R | 1 (1) R | .. | .. | 1 (1) R | 1 R | .. | .. |
| Mo. | University of Missouri | .. | 1 | .. | 6 + R | .. | .. | 1 R | 1 R | .. | .. |
| Mont. | University of Montana | .. | 1 R | 1 R | 1 | .. | .. | (1) | 1 (1) R | .. | .. |
| Neb. | University of Nebraska | .. | 1 R | .. | 4 R | .. | .. | 1 (1) R | .. | .. | .. |
| N. H. | University of New Hampshire | 2 (1) R | .. R | 2 R | .. | .. | .. | .. | 1 R | 1 R | .. |
| N. J. | Rutgers University | .. | .. | .. | 2 | .. | .. | 1 R | 1 R | .. | .. |
| N. Y. | Cornell University | .. | 1 (1) R | 1 (1) R | 5 R | .. | .. | 2 R | 1 (1) R | .. | 1 R |
| N. Y. | N. Y. State College of Forestry | .. | 1 R | 1 | .. | .. | .. | 1 | .. | .. | .. |
| N. Y. | University of Rochester | .. | .. | 1 R | .. | .. | .. | .. | .. | .. | .. |
| N. C. | Duke University | 1 R | .. R | .. R | 1 (2) R | .. | .. R | 1 R | .. | 1 R | .. |
| N. C. | University of North Carolina | 1 | 1 | 1 | 1 | .. | 1 R | .. | 1 R | 1 R | .. |
| Ohio | Ohio State University | .. | 1 R | 1 R | 2 R | .. | 1 R | 1 R | 1 R | .. | 1 R |
| Ont. | University of Toronto | 1 R | 2 (3) R | 1 R | .. | .. R | .. R | 1 R | 2 (3) R | 1 R | .. |
| Ore. | Oregon State College | .. | .. | 1 (1) R | 2 (1) R | .. | 1 R | 2 R | .. | .. | .. |
| R. I. | Rhode Island State College | 2 (1) R | .. | 1 R | 1 R | .. | .. | .. | .. | 2 (1) R | .. |
| Sask. | University of Saskatchewan | .. | 1 R | 1 | 2 | .. | .. | 1 R | 1 R | .. | 1 |
| Tenn. | University of Tennessee | .. | .. | .. | 1 (3) R | .. | .. | 1 (2) R | 1 (1) R | .. | .. |
| Texas | A. & M. College of Texas | .. | 1 | 1 R | .. | .. | .. | .. | .. | .. | 1 R |
| Utah | University of Utah | .. | .. | 1 R | .. | .. | .. | 1 R | 1 R | .. | .. |
| Utah | Utah State Agri. College | .. | 1 | .. | .. | .. | .. | 1 R | 1 R | .. | .. |
| Va. | University of Virginia | .. | 1 | .. | .. | .. | .. | 1 R | 1 R | .. | .. |
| Wash. | University of Washington | 2 (1) R | 2 (1) R | (1) R | 4 + R | 1 R | 1 R | 1 R | 1 R | 3 + R | 2 R |
| W. Va. | University of West Virginia | .. | 1 | .. | .. | .. | .. R | 1 R | 1 | .. | .. |
| Wis. | University of Wisconsin | .. | 1 R | .. | 1 R | .. | .. | 1 R | 1 R | .. | .. |
| Wyo. | University of Wyoming | .. | 1 | .. | 1 | .. | .. | 1 R | .. | .. | .. |



*Table 7.—List of biological stations for teaching purposes and/or research affiliated with academic institutions in the United States and Canada, list of collections of fishes, and highest degrees conferred by institutions*

| State or Province | Supporting institution | Biological Station | Purpose[1] | Open | Museum collections[2] | Highest degree conferred[3] |
|---|---|---|---|---|---|---|
| Ala. | Alabama Polytechnic Institute | None | ..... | ..... | I—local | M |
| Calif. | Stanford University | Hopkins Marine Station | C R | All year | I—extensive | D |
| Calif. | University of California | Scripps Institution of Oceanography | C R | All year | I—moderate | D |
| Colo. | University of Colorado | 25 miles NW of Boulder | C | Summer | I—local | D |
| Conn. | Yale University | None | ..... | ..... | I—moderate | D |
| Fla. | University of Florida | Welaka | R | Summer | I—local | D |
| Ill. | University of Illinois | None—summer field courses | ..... | ..... | I—moderate | D |
| Ind. | Indiana University | Winona Lake | C R | Summer | None | D |
| Iowa | Iowa State College | None | ..... | ..... | I—local | D |
| Iowa | State University of Iowa | Iowa Lakeside Laboratory | C R | Summer | None | D |
| Kan. | University of Kansas | None | ..... | ..... | I—local | D |
| Ky. | University of Kentucky | None | ..... | ..... | I—local | M |
| La. | Louisiana State University | Grand Isle | C R | Summer | I—local | M |
| Maine | University of Maine | Lamoine | R | Summer | None | M |
| Md. | University of Maryland | Chesapeake Biological Laboratory | R | Summer | S—local | M |
| Mass. | Massachusetts State College | None | ..... | ..... | I—local | M |
| Mass. | Harvard University | None | ..... | ..... | I—extensive | D |
| Mass. | ——— | Marine Biological Laboratory | C R | Summer | S—local | I |
| Mass. | ——— | Woods Hole Oceanographic Institution | R | Summer | S—local | I |
| Mich. | University of Michigan | Douglas Lake | C R | Summer | I—extensive | D |
| Minn. | University of Minnesota | Itasca State Park | C R | Summer | I—local | D |
| Mo. | University of Missouri | None | ..... | ..... | I—local | D |
| Mont. | University of Montana | Flathead Lake[4] | C R | Summer | I—local | M |
| Neb. | University of Nebraska | None | ..... | ..... | I—local | M |
| N. H. | University of New Hampshire | Isle of Shoals | C R | Summer | I—local | M |
| N. J. | Rutgers University | New Brunswick | R | Summer | None | M |
| N. Y. | Cornell University | None | ..... | ..... | I—moderate | D |
| N. Y. | N. Y. State College of Forestry | Huntington Wildlife Station | C | Summer | I—local | D |
| N. Y. | University of Rochester | None | ..... | ..... | I—local | D |
| N. C. | Duke University | Beaufort | C R | Summer | None | D |
| N. C. | University of North Carolina | Highlands | R | Summer | I—local | D |
| Ohio | Ohio State University | Franz Theodore Stone Laboratory | C[5] R | All year | I—local | D |
| Ont. | University of Toronto | Algonquin Park | R | Summer | I—moderate | D |
| Ore. | Oregon State College | Coos Bay | C R | Summer | I—local | D |
| R. I. | Rhode Island State College | Narragansett Marine Laboratory | R | Summer | S—local | M |
| Sask. | University of Saskatchewan | Prince Albert National Park | R | Summer | I—local | M |
| Tenn. | University of Tennessee | None | ..... | ..... | None | M |
| Texas | A. & M. College of Texas | None | ..... | ..... | I—local | D |
| Utah | University of Utah | None | ..... | ..... | I—local | D |
| Utah | Utah State Agri. College | None | ..... | ..... | None | M |
| Va. | University of Virginia | Mt. Lake | C R | Summer | None | D |
| Wash. | University of Washington | Friday Harbor | C R | Summer | I—moderate | D |
| W. Va. | University of West Virginia | None | ..... | ..... | I—local | M |
| Wis. | University of Wisconsin | Trout Lake | R | Summer | I—local | D |
| Wyo. | University of Wyoming | Medicine Bow National Forest | C R | Summer | I—local | M |

[1]R—research; C—course work.
[2]I—institution; S—biological station.
[3]M—M.A. or M.S., D—Ph.D.
[4]Temporarily discontinued.
[5]Courses in summer only.

These biological stations are listed in Table 7 opposite the names of the institutions with which they are affiliated, or if independent no institution name appears.

Study collections of preserved fishes, amphibians and invertebrates are essential for research and training of biological investigators. The location of such museum collections in connection with institutions and laboratories is also indicated in Table 7. An attempt has been made to denote roughly the scope of the collections by the use of a simple adjective, but the evaluations depend principally on the descriptive data supplied by officials. This list does not include museums not affiliated with academic institutions or biological stations. Thus several large museum collections such as those of the U. S. National Museum, the American Museum of Natural History, and the Field Museum, or others, have not been mentioned, although they have large study collections of fishes and other aquatic organisms available for the use of qualified and properly accredited investigators.

## Postgraduate Study and Degrees

The courses listed in Tables 5 and 6 are open only to advanced or postgraduate students in the majority of instances. All require a varying number of prerequisite elementary and intermediate courses in the same or in cognate fields. The calibre of the research facilities and supervision at any institution frequently determines what advanced degrees the institution awards. The highest degree conferred at the various schools mentioned in the lists where courses and research in special phases of fishery biology may be pursued is indicated by symbol in the right-hand column of Table 7.

## Conclusion

The survey of academic qualifications has attempted to present objectively the recommendations for undergraduate and postgraduate training of fishery biologists in the light of the experience and judgment of men in the field. Its only purpose is to provide the student, prospective student, and educator with some form of guidance in planning an adequate biological education for entrance into the field of professional fishery biology.

A survey of specialized course work, research facilities, number of faculty, biological stations and museum collections was designed to serve as a guide to students who seek information concerning the specialized fishery biology courses that are available at different institutions and by such a composite presentation may be assisted in their attempts to determine which school provides instruction and facilities in conformity with their interests and objectives.

Finally, it is urged emphatically that the comparative data should not constitute a sole basis for decision concerning any institution.

Other, more intrinsic factors, should be considered with regard to each school a student contemplates attending. He should by all means correspond with faculty members and obtain detailed descriptions of courses and facilities before he makes a decision. He should visit the institution if possible before making a definite decision to enroll. It must be remembered that there are a great number of very good schools in the United States and Canada qualified to provide an excellent foundation for fishery biology that have not as yet included any pure fishery or hydrobiological courses in their curricula.

This survey has not included the subjects of short courses in field methods, or fish culture which may be offered to persons who are not interested in a complete college education or in a career as a biological specialist. Likewise, the growing fields of marketing and technology that represent another form of specialized education for work related to the fisheries are not considered. All these, practical fish culture, field methods, marketing and technology, might be similarly surveyed by persons intimately associated with them.