UNDERGRADUATE EDUCATION OF FISHERY SCIENTISTS[1]

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The requisite preparation and training for the profession of fishery scientist[3] has received much attention from faculties giving instruction related to fishery problems and from a number of people who have examined the educational problem in some depth, notably Deason (1941), McHugh (1968), Paulik (1968), and Carlander (1970). Almost everyone has been dissatisfied with the curricula available. Those of us who are concerned are well advised to ask what we can do to improve our preparation of fishery scientists for their roles in society as scientists and as citizens.

The traditional approach to fishery science was through training in natural history, especially in ichthyology and limnology. The first special courses in fisheries in North America were developed in aquaculture and fishing. Later, courses were offered in the biology and ecology of fishes and in fishery management. It was recognized generally, however, that most of the training of fishery scientists should be in biology and a degree in fisheries was equated with a degree in either biology or zoology by many agencies that employed fishery scientists.

The traditional approach is now being challenged from many directions. The problems of public fishery management are only part of the immensely complex problems of environmental management, the solution of which involves predominantly the management of people. The proliferation of specialized courses in biology causes many fishery students to wonder whether most of them are useful. The diversity of fishery jobs stimulates others to inquire what set of courses should be taken for each. It is now accepted generally that an undergraduate biology major is not the best preparation for most fishery jobs, and the basic question is asked—What is the best education for each kind of fishery job?

ROLE OF FISHERY SCIENTISTS

The common division of fishery science into management and research fails completely to indicate the diversity of jobs that are filled by fishery scientists. Carlander (1959) in his survey of technical fishery careers used the categories: (1) fish culture; (2) management; (3) survey and trouble shooting; (4) research; (5) education; and (6) administration. Later (1970) he listed a sampling of fishery courses and included a number of additional subjects that might well be job categories: (1) pond and lake management; (2) hatchery management; (3) fishery technology and economics; (4) pollution biology; and (5) population dynamics. Obviously, the category of fishery technology can be separated into commercial fishing and fish processing technology and the category of fish culture can be extended to include shellfish culture.

A much more diverse group of categories is included in Hall's (1969) review of fishery occupations on an international basis. He considers that most of the personnel engaged in the following fishery activities require a high degree of special fishery knowledge: (1) seagoing and other personnel in the primary sector; (2) processing, distribution, and marketing personnel; (3) management, government administration, enforcement and development personnel; (4) research and education personnel; and (5) economists and statisticians. In addition he lists

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[3] Included in this category are all fishery resource workers who normally are required to have a baccalaureate degree or higher for the job they hold.

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ancillary industries associated with the construction of gear, vessels, processing equipment, and harbors and reservoirs that require personnel with an awareness of fishery problems. Obviously, only part of the occupations in both lists requires a science degree—the topic of this discussion.

Further, an examination of the publications of any major fishery agency reveals many diverse research topics, each of which could be discussed adequately by an individual only after years of specialized experience in graduate school or on the job. For example, recent issues of the *Journal* and *Bulletin* of the Fisheries Research Board of Canada include lengthy articles in each of the following areas of study: (1) biochemistry of pesticides, heavy metals, etc.; (2) fish and invertebrate physiology; (3) animal behavior; (4) ecology; (5) population dynamics; (6) life histories of animals of many phyla; (7) ichthyology; (8) genetics; (9) hydraulic engineering; (10) marine biology; (11) limnology; (12) oceanography; (13) microbiology; (14) pathology; (15) mathematics; (16) resource economics; and (17) fishery business administration.

This list could be expanded considerably but with little reinforcement of the conclusion that specialists on many topics contribute to fishery knowledge and aid in fishery decisions. Obviously, many problems must be studied by teams of experts who can apply their individual skills to a problem in which they share a common interest and concern.

Still further evidence of diversity may be found among employers of fishery scientists. Government fishery agencies are the principal employers, but nonfishery agencies and industry appear to be offering more and more jobs. Outdoor recreation agencies; water control and water quality agencies; soil, range, and forest resource agencies; and industries that use water are finding increasingly that they have enough fishery problems to warrant hiring fishery scientists. In addition, the fishery agencies are finding that the management of the fishery resources requires that they participate frequently in decisions about the use of water and land. It is apparent that many fishery scientists need at least to be aware of if not expert in the problems of using other natural resources.

THE CHOICE OF BACCALAUREATE DEGREE, MASTER, OR DOCTORATE

Soon after an aspiring fishery scientist has embarked on his education he faces a decision about when to stop and seek a job. He will probably be advised to seek graduate work if his scholarship is adequate and if he can finance it. If he does he will be a part of the one-fifth of the biologists who have recently sought advanced degrees (Terman, 1971). The brilliant student can get a fellowship or assistantship, so his decision may depend on whether he wants to spend the extra time; but to other students graduate work may require a major sacrifice. Will the added breadth of knowledge or specialization be worth the time and cost?

The roles of fishery scientists are not clearly separable according to terminal degree attained by them, but most of those with a baccalaureate are in fishery management and most of those with a doctorate are in teaching or research (Table 1). Many of those with a baccalaureate, however, are engaged in research or administration. Those with a master are engaged extensively in research, management, and administration; but a larger proportion of them than of the other two groups are in research and administration.

The divisions among fishery research, management, and administration are blurred, however, in other ways. All three require an ability to investigate problems but research will probably involve the solution of sophisticated scientific problems; management, a mixture of scientific, technical, and social problems; and administration, a mixture of social, economic, and political problems. All three require an understanding of the general environmental problems of our society, but these will probably be of greatest concern in administration. All three require an ability to communicate, but with different audiences. Additional blurring occurs because most fishery scientists divide their time among research, administration, and management or teaching.

TABLE 1.—Breakdown of respondents from Pacific Fishery Biologists by types of professional activities and fishery, highest degree attained, major subject, employer, and institution of origin.[1]

Item	Duties ≥40%[2]					Type of fishery ≥60%[3]	
	Fishery research	Fishery management	Teaching	Administration	Others	Recreational	Commercial
N 324	116	100	19	95	33	117	134
Highest degree							
B.S. 183	60	74	0	26	10	73	76
M.S. 85	33	22	1	32	11	34	36
Ph.D. 54	23	3	18	16	3	9	22
Years since last degree							
<10 126	57	47	10	19	17	53	46
10-29 115	38	35	5	36	10	40	52
>19 79	18	17	3	40	6	22	36
Major subject							
Fisheries 225	82	72	12	64	22	84	98
Biology, zoology 73	27	22	6	22	6	27	26
Employer							
NMFS 48	33	4	0	13	2	1	42
BSFW 24	5	3	3	8	7	11	4
State fisheries 154	46	78	0	41	9	79	49
Nonfisheries 30	2	8	1	14	9	13	4
Canada fisheries 14	4	5	0	7	1	4	8
Universities 32	13	0	15	7	2	4	14
Industry 7	4	2	0	1	2	3	1
Institution							
Univ. Washington 81	38	21	6	26	1	14	54
Oregon State Univ. 65	12	33	2	19	10	33	18
Other large univ. 73	27	21	3	22	5	30	29
Two or more univ. 63	23	12	7	23	10	23	19

[1] Nonresponses and certain minor categories have been omitted.
[2] The respondents who indicated a division of duties of 60-40 or 50-50 are included in two categories.
[3] The respondents who indicated a division between the two fisheries of 50-50 have been omitted.

Another separation of functions is between investigative and decision making activities. It may be assumed that research is predominantly investigative, administration is predominantly decision making, and management is both investigative and decision making.

In actual practice it appears that a majority of the fishery scientists in western North America have no more than a baccalaureate and are engaged in fishery management and administration. The responses (324) to a recent questionnaire to members of Pacific Fishery Biologists (PFB) indicated that 56% had only a baccalaureate degree, 26% had added only a master, and 17% had a doctorate. When queried about their activities 36% of the respondents said they were engaged in fishery research for 40% or more of their time, 31% in fishery management, 29% in fishery administration, 6% in teaching, and 10% in other activities, most of which were water management. (Some said they were engaged for 40% or more of their time in each of two activities and hence were counted twice in the above breakdown.)

It should be noted that the overall projections of supply vs. demand for Ph.D.'s indicate an oversupply for the needs of basic research and teaching and an expectation by many of a search for employment elsewhere (Cartter, 1971; Terman, 1971). The natural resource agencies and offices should expect an influx of Ph.D.'s trained in other areas during the 1970's.

The role of a person with a terminal master degree appears to be primarily in research and administration. A higher proportion of the members of PFB with a master degree than of those with either a baccalaureate or doctorate were engaged in administration, and the proportion of them that were engaged in research was nearly as high as the proportion of those with a doctorate so engaged. The master's training provides either the breadth of education that gives a person a wide choice of jobs or a special education for a particular job. It appears to be

especially useful to the person who works after earning a baccalaureate and then decides to obtain more education for clearly defined reasons.

Thus, the demand for fishery scientists will probably remain, as it has been, predominantly for baccalaureates; and this demand will coincide with the inclination of a majority of students to earn no more than the baccalaureate. The implications for the fishery educator seem clear —prepare an undergraduate student for a job if he intends to terminate his formal schooling with a baccalaureate and prepare him for graduate work if he plans immediately to work for an advanced degree. "Preparing a student for a job" does not mean training him extensively in techniques that he could learn as well or better on the job; rather it means preparing him as a scientist and citizen so that he can choose among a reasonable number of job alternatives and progress rapidly in the job that he finds.

SURVEY OF OPINION REGARDING FISHERY CURRICULA

Opinions and criticism of fishery curricula are frequently expressed by two groups of people, both of which should be regarded as biased: fishery faculty and employers. Fishery faculty tend to be oriented toward basic research and the necessity for doctorate degrees, which most of them have. They may even suggest that persons who get only a baccalaureate degree are likely to be only research technicians. Employers are necessarily concerned with the immediate problems of getting a job done and having employees who can do the job well with a minimum of added training. They are usually less interested in the capability of a new employee to grow in skill and take over major responsibility at a later date. Consequently, it was deemed useful to obtain opinions from others.

During the spring of 1971 it was possible to sample the opinions of members of the PFB with respect to fishery curricula. Membership in the organization, according to the bylaws, is "limited to graduates of universities of recognized standing who possess a degree in the biological sciences who are professionally engaged in fishery biological research and who have completed at least one year's cumulative service in research with some organization following graduation provided that employment in an organization in one of the following areas shall be necessary for membership: Alaska, British Columbia, Washington, Oregon, California, Idaho, and Hawaii." The organization included 751 active members in May 1970, a considerable fraction of the estimated 5,500 fishery biologists who were employed in the United States on July 1, 1970 (Martin, 1971).[4] The members were affiliated with one provincial and six state departments of fisheries or fish and game, two Federal fishery agencies, three Canadian fishery agencies, nine nonfishery government agencies, seven nonfishery industries with environmental problems, twelve colleges and universities, and the California Academy of Sciences (Table 1). Either notably absent or scantily represented were fishery scientists employed either in aquaculture or in the fishing industry. Probably underrepresented were fishery management biologists because of the requirement by PFB for professional engagement in fishery research. Subject to these qualifications the organization probably represented quite fairly at the time the fishery scientists in the western United States. Also canvassed were persons on the mailing list for the Northwest Fish Culturists Conference and student groups at the University of Washington.

The opinions about most useful and least useful subjects required somewhat arbitrary and subjective classification of the subjects into not more than 10 groups, as follows:

0) Function and methods
1) Biological sciences
2) Chemistry, physics, and mathematics
3) Natural resource sciences and management
4) Social sciences
5) Engineering and technology
6) Administration
7) Humanities and liberal arts
8) Communications
9) Other fields

[4] Martin, R. G. 1971. Potential employment market. *In* Items for fishery scientists from the Sport Fishing Institute. Jan.-Feb. 1971.

In the interest of saving space, no more than five subjects were coded for any one reply. When two or more subjects listed under the same code number were named, that code number was listed two or more times. When the answer was "all biology courses," however, the biology code number was listed once.

Further comments were classified in groups under the following general headings:

0) Miscellaneous comments or no comment
1) Increase practice and experience
2) Improve quality of courses
3) Improve curriculum
4) Help select and understand jobs
5) Arrange continuing education

COMPARATIVE USEFULNESS OF SUBJECTS

After the data had been coded, they were sorted and listed by the computer. The number of times that each subject was mentioned by respondents in each category was determined, and the total was computed as a percentage of the number of respondents.

The percentage of respondents that mentioned a subject as most useful, as least useful, or one that the respondent wished he had added to his college courses or taken in greater depth is regarded as an index of the usefulness of the subject. Inclusion in the most useful or the least useful category depended on inclusion of the subject in the respondent's training. The subjects of average usefulness were not mentioned, and there is no way of considering such a status from the data. The last class of subjects, subjects that the respondent wished he had added or taken in greater depth, is, of course, not limited to subjects taken in the university; but presumably many respondents would think first of subjects that they had taken but not as completely as they might have.

One of the difficulties in evaluating answers was the distinction between a general course, for example, in biology, and a collection of advanced courses that might also be called by the same name, in the example given, biology. Some respondents made this distinction clear; others did not, especially some who had taken their college work many years ago.

The outstanding characteristic of the responses is the inclusion of almost every subject among someone's most useful subjects and someone else's least useful subjects. It appears that subjects considered by most people to be very useful were ranked as the least useful by a few people who had special difficulties with a course, such as a quarrel with the instructor or a bad grade. Accordingly, it is felt that a designation of a subject as least useful by 1 or 2% of the respondents is not of particular significance unless the course was one that relatively few respondents would be expected to take.

The rating of subject groups is shown in Table 2. The groups are ranked starting with the one that was considered to be most useful by the greatest percentage of respondents and ending with the one that was considered to be least useful by the greatest percentage of respondents. Only the top twelve in any category have been ranked. The results are discussed in the following paragraphs.

The ranking of English-scientific writing as the most useful group of subjects may surprise many scientists, especially the younger ones who are preoccupied with learning science, but undoubtedly it reflects the broad experience of the applied scientists, who have repeatedly faced the need to communicate their findings. Only a few respondents rated these subjects as the least useful, and some of these specified that they objected to English literature or creative writing courses.

Public speaking, another method of communication, ranked eleventh among the subjects listed as the most useful and fifth among the subjects that should have been added or taken in greater depth. Those rankings probably reflect the failure of many fishery scientists to take public speaking and their general need for it later.

Communication in a foreign language was at the other end of the scale, however, first among the courses rated as least useful. Such courses are apparently a waste of time for most students but are needed by a few.

The next surprise for those who consider fisheries as essentially biology is the second place

TABLE 2.—Percent of responses naming undergraduate subjects as most useful, least useful, or one that should have been added or taken in greater depth.

Subject group	Most useful		Least useful		Should have been added or taken in greater depth	
	% of respondents	Rank	% of respondents	Rank	% of respondents	Rank
English, scientific writing	44	1	3	--	21	2
Biostatistics, population dynamics, computer use	34	2	2	--	44	1
Zoology	30	3	2	--	1	--
Fisheries, fishery biology	27	4	1	--	5	12
Mathematics, calculus	27	5	4	11	20	3
Chemistry, inorganic	23	6	12	4	5	--
Oceanography, limnology, pollution study	16	7	0	--	12	4
Ecology	16	8	0	--	8	10
Ichthyology, systematics	16	9	3	--	2	--
Physiology, cytology, embryology, morphology, etc.	13	10	6	8	9	9
Public speaking	10	11	1	--	12	5
Fishery management	10	12	1	--	4	--
Aquacultural sciences	8	--	4	12	7	11
Economics	4	--	4	--	12	6
Administration	0	--	1	--	12	7
Physics	6	--	5	10	2	--
Agriculture	0	--	5	9	0	--
Chemistry, organic	2	--	6	7	5	--
Advanced biology	2	--	6	6	3	--
Botany	7	--	7	5	4	--
Social sciences (except economics)	1	--	14	3	10	8
Humanities, liberal arts	3	--	16	2	4	--
Foreign language	2	--	21	1	2	--

ranking of biostatistics-population dynamics-computer use and the fifth place rating of mathematics-calculus. Both of these subject groups ranked even higher among those that the respondents wished they had added or taken in greater depth.

Biology, botany, and zoology courses varied greatly in their usefulness. General zoology ranked third among those listed as the most useful, ichthyology and systematic zoology ranked ninth, and a group of advanced zoology courses ranked tenth, largely because of the inclusion of the physiology of resource animals. Other advanced zoology courses and botany were more frequently among those listed as the least useful than among the most. Many respondents noted these as "too specialized" or "memory type" courses that they objected to. On the other hand, a few people rated them most useful.

Chemistry courses were viewed much like biology courses. The general courses were ranked relatively useful, but the advanced courses were rated not useful by more respondents than those who considered them useful.

The natural resource sciences also varied greatly in their usefulness. Fisheries and fish biology courses ranked fourth among those listed as most useful and fishery management twelfth. Aquacultural science, including pathology, parasitology, nutrition, and genetics as applied to fishery resource animals, varied greatly in usefulness (sample population was underrepresented in aquaculture). Apparently these are specialized courses, needed only by a few people. Other natural resource sciences, such as wildlife science or management, forestry, soil science, and land management, also varied in their usefulness.

The opinions about the usefulness of the social sciences were anomalous. Almost all of the social sciences except economics were rated least useful if they were mentioned and yet many respondents wished they had taken more social science courses. The apparent explanation for

this dichotomy is the current upsurge in recognition of the social problems and the lack of relevance of the earlier social science courses. Economics as a general subject was also judged least useful by some respondents, but resource economics was valued by many and was ranked sixth among those that respondents wished they had added or taken in greater depth.

Less divergent were the opinions about humanities and the liberal arts. This set of subjects ranked second among those listed as least useful. A very small proportion of the respondents valued them highly, and some explained that courses in music and literature were especially useful in their life but not in their professions.

Courses in administration were rarely mentioned as useful but ranked seventh among the subjects that the respondents wished they had taken. Apparently such courses were seldom taken by the respondents but are needed, especially by many of the older fishery scientists.

VOLUNTARY OPINIONS REGARDING THE CURRICULUM

The respondents were asked to comment freely on the training of fishery scientists, and about one-third did so. The opinions were classified and the categories ranked (Table 3).

Most of the opinions expressed related to the need for extending and improving the curriculum. These include six of the eight items enumerated in Table 3, and these eight items include all comments mentioned by more than 2% of the respondents. The other two groups of comments indicate a desire for greater relevance and more practice and experience.

The prevailing views about improving the curriculum almost always suggested that something should be added but rarely suggested what should be eliminated. It follows that more effort should be made to relate the curriculum to future roles of fishery scientists as well as to provide ways of acquiring the courses used by only a small proportion of the scientists through night school, seminars, or home study.

TABLE 3.—Voluntary opinions regarding the curriculum expressed by respondents and their ranking.

Opinion	Percent
Develop more technical skills	8
Develop more communication skills	7
Develop more business, administration skills	6
Include more environmental courses	6
Have greater relevancy to real problems in courses	6
Increase practice and experience	6
Have less specialization	5
Emphasize scientific methods	5

PROPORTION OF SPECIALIZED FISHERY COURSES IN THE CURRICULUM

The members of PFB were also asked for their opinions about the proportion of specialized fishery courses in the curriculum in various years with various terminal degrees.

The replies were highly varied, but the average opinion (Table 4) was that the beginning curriculum should contain very few specialized fishery courses and that the final years should contain 50 to 60% specialized fishery courses. The final years are, of course, the junior-senior years of the baccalaureate program and the graduate years of the master and doctorate programs. Clearly the average opinion indicated a different upper class curriculum for the student who ends with a baccalaureate than for the student who plans graduate work at the outset.

TABLE 4.—Average opinions of the percentage of the fishery curriculum that should be comprised of specialized fishery courses.

	Terminal degree		
	B.S.	M.S.	Ph.D.
N	279	209	195
Lower class	16	10	10
Upper class	52	27	24
Graduate		56	59

GROUP COMPARISONS

The diverse opinions about the subjects suggest immediately an inquiry into the relation of the subjects' usefulness to the respondents' professional activities. The respondents can be divided into groups according to position, title, employer, activity, kind of fishery, final degree, major topic of study, and number of years since last degree (Table 1). The groups that can be

chosen by students during their undergraduate years deserve special examination.

Highest Degree

A major decision that a student should make sometime during his upper class years is whether to continue with graduate work. In the past these choices were probably between research or teaching and management or administration, but the careers have not been as neatly divided, nor are they likely to be in the future as more Ph.D.s go into management and administration.

Respondents holding baccalaureate and doctorate degrees differed primarily in their opinions regarding the basic vs. applied sciences. A higher proportion of those with a doctorate degree than of those with a baccalaureate rated biology, mathematics, and foreign language as their most useful subject. More would have added advanced biology, mathematics, and geology. More would improve the curriculum by giving more attention to scientific methods and less to specialization. A higher proportion of those with only a baccalaureate rated fisheries-fishery biology, fishery management, wildlife science, and biostatistics-population dynamics-computer sciences as their most useful subject, and a higher proportion would have added ecology, fisheries-fishery biology, administration, English composition, and public speaking. They suggested especially increased practice or experience and addition of communication and administration skills to the curriculum. The average opinions of those with a master as their highest degree were frequently intermediate between those with a baccalaureate and those with a doctorate except that a higher proportion of them listed advanced biology, advanced chemistry, physics, and forestry as the least useful subject and would have added economics and administration more often than either of the other groups. A higher proportion of them also suggested improving the curriculum by adding environmental courses.

Activity

The members of PFB were asked in the questionnaire to indicate the proportion of time spent in research, management, teaching, administration, or other activities. Almost all divided their time between two or more of these categories, and it was decided to separate the opinions of those who said they were devoting 40% or more of their time to any one activity. These activities might be chosen by the student; therefore, the professional opinions would be useful to him.

The researchers valued quantitative methods more highly than the others did. A larger proportion of this group listed mathematics-calculus and biostatistics-population dynamics as the most valuable subject, and social sciences and humanities-liberal arts as the least valuable. The proportion of them that recommended increased practice and experience in the curriculum was also greater.

The managers valued natural history and communications. A larger proportion of them rated ichthyology-systematics, ecology, fishery management, and public speaking as the most valuable subject. A smaller proportion of them than of the other two groups rated mathematics-calculus as the most valuable subject. A larger proportion of them also ranked biology, advanced chemistry, and physics as the least valuable course, but add aquacultural sciences, and recommended that courses have greater relevance to real life problems and that the curriculum include more communication skills.

The administrators valued general biology and wished they had taken more courses in the social sciences and administration. A larger proportion of them rated biology and invertebrate zoology-marine biology as the most valuable subject, wished they had taken more biology, social sciences, and administration, and recommended that the curriculum be improved by the addition of administration courses.

The teachers (although the sample was small) tended to be extreme in their opinion of several subjects. A larger proportion of them ranked the basic sciences—zoology, ecology, advanced zoology, chemistry, and oceanography-limnology—as the most valuable subject and a smaller proportion of them rated the applied biological sciences, the social sciences, and public speaking as the most valuable subject. Somewhat anomalously, a larger proportion of them recommend-

ed that the courses have greater relevance to real problems, emphasize more technical skills, more scientific methods, and be less specialized.

Type of Fishery

A preponderance of the fishery scientists work mostly with either recreational fisheries or commercial fisheries. Most of those working for the state fishery or fish and game agencies, the Bureau of Sport Fisheries and Wildlife, and the nonfishery agencies were concerned with recreational fisheries; and most of those working for the National Marine Fisheries Service and for universities were concerned with commercial fisheries. The balance included a few who divided their time equally between recreational and commercial fisheries and some who were extensively engaged in environmental problems.

The recreational fishery scientists valued natural history and environmental and communication subjects. A larger proportion of them than of the commercial fishery scientists rated ecology, ichthyology-systematic zoology, invertebrate zoology-marine biology, fishery management, oceanography-limnology, aquacultural science, and public speaking as their most valuable subject, wished they had added such subjects, and suggested that courses should have greater relevance to actual problems and the curriculum should have more environmental courses.

The commercial fishery scientists valued quantitative methods, fisheries, and economics. A larger proportion of them rated mathematics-calculus, fisheries-fishery biology, biostatistics-population dynamics-computer use, and economics as their most useful subject, wished they had added these subjects, and commented on the need to improve the curriculum by the addition of business and administration courses.

Fisheries vs. Biology-Zoology Major

More than 90% of the PFB respondents had majored in either fisheries, biology, or zoology. Those who had majored in fisheries frequently had minored in biology, zoology, or chemistry. Regardless of major, however, the distribution among duties and types of fisheries was almost the same.

A higher proportion of the fishery majors listed ichthyology-systematic zoology, mathematics-calculus, fisheries-fishery biology, fishery management, wildlife management, English composition, and public speaking as their most valuable subject, wished they had taken more ecology, ethology, psychology, and economics, and commented on the need for courses with greater relevance to real problems and on the need to add environmental courses.

On the other hand, a larger proportion of the biology-zoology majors listed ecology, physiology, and invertebrate zoology-marine biology as their most valuable subject, wished they had taken more calculus, geology-hydrology, and fishery management, and suggested less specialization in the curriculum.

Shifts in Opinions with Passage of Time

Information on the years since the last degree enabled a breakdown into three decade groups <10, 10-19, and >19 years with considerable numbers in each. Interpretation of the different opinions is difficult, however, because of changes in curricula, changes in status of the respondents with age, and dimmed memories.

The oldest group tended to cling to the traditional sciences and communications. A larger proportion of them rated biology, zoology, botany, chemistry, physics, English composition, and public speaking as the most valuable subject, wished they had had more of these subjects, and wished they had added more administration.

On the other hand, the youngest group valued more highly the environmental, quantitative, and applied sciences. A larger proportion of them rated ecology, ichthyology-systematic zoology, fishery management, and biostatistics-population dynamics as the most valuable subject. They also had stronger negative opinions; a larger proportion of them listed advanced zoology, chemistry, physics, economics, and humanities-liberal arts as the least valuable subject (although a slightly larger proportion of the intermediate age group rejected humanities-liberal arts).

COMPARISON OF OPINIONS FROM PFB AND FISH CULTURISTS

Few members of PFB were concerned with any kind of aquaculture; therefore a similar questionnaire was submitted to people in the western United States who were on a mailing list (December 1968) for the Northwest Fish Culturists Conference. The number of respondents was much smaller, perhaps because a considerable proportion of the fish hatchery superintendents lacked college degrees, but usable answers were obtained from 16 fish cultural supervisors and 19 fish cultural researchers. The first group included 7 without a baccalaureate degree, 9 with, and none with a higher degree. Of the second group all had baccalaureate degrees, 5 had master, and 7 doctorate degrees; 15 were employed by government laboratories.

A larger proportion of the fish cultural supervisors than of the PFB members rated physiology, oceanography-limnology, aquacultural sciences, and hydraulic engineering as the most useful courses. They found basic mathematics very useful but not higher mathematics or biostatistics-population dynamics, but many wanted to add courses in the latter. They listed English composition and public speaking as the most valuable course about as often as the PFB members did. Above all they wished they could have added more courses in the aquacultural sciences.

The fish cultural researchers valued subjects much differently from either the total PFB members or the PFB researchers. A larger proportion of them listed physiology, advanced biology, chemistry, advanced chemistry, physics, and the aquacultural sciences as their most valuable subject, and botany, sociology, and economics as their least valuable. Fewer of them than of the other two groups rated biostatistics-population dynamics as their most valuable subject but many wished they had taken more. Above all they wished they had taken more physiology, advanced chemistry, and aquacultural sciences.

COMPARISON OF OPINIONS FROM PFB AND STUDENTS

The questionnaire circulated to the PFB was also given to undergraduate and graduate seminar groups in the College of Fisheries of the University of Washington. Replies were received from 20 undergraduate and 28 graduate students.

There was a notable diversity of opinion among the undergraduates. A relatively large proportion listed the following subjects as the most valuable course and a similarly large proportion rated them as their least valuable: research methods, advanced chemistry, physics, fisheries-fishery biology, fishery management, and biostatistics-population dynamics. Because of this diversity, no critical comparison of their opinions with those of PFB members is possible; but they seemed to value zoology and communication courses much less than PFB members and aquacultural sciences more than PFB members.

The graduate students were much closer to PFB members in opinions and differed largely from them in only a few subject areas. A larger proportion of them rated physiology, biostatistics-population dynamics, and aquacultural sciences as the most valuable course, whereas fewer of them included chemistry and communications as the most valuable course. They differed especially with regard to communications; they had no understanding of its importance.

SUMMARY AND CONCLUSIONS

1. No single curriculum is ideal for training in fishery science. The field has become much too broad and includes too many specialties that each require a high level of training. The specialization is expected at graduate level, of course, but is desirable even at undergraduate level if students can anticipate either the graduate work or the type of job they will enter.

A corollary of the above conclusion is that a person with a terminal baccalaureate degree should not be a dropout from a research-oriented, two-degree or three-degree program. A majority of the jobs in fishery science has been held and probably will continue to be held by people with only a baccalaureate degree. Some of these jobs will be major administrative, decision-making jobs with rewards equal to those that will be open to holders of a doctorate degree.

2. A biology or zoology undergraduate major may be good preparation for graduate work in fisheries, but it is relatively poor preparation for a job. Advanced biology courses in general are much less useful than courses in English composition, public speaking, fishery science and management, and the quantitative sciences.

3. Student and faculty opinions about curricula are probably not the best guides. Both differ substantially from the opinions of a majority of the nonteaching professionals in the field, especially in their evaluation of subjects that develop the ability to deal with people.

4. Courses in the social sciences, humanities, and liberal arts have not been as useful as people now want them to be. With a few exceptions these subjects were characteristically among those listed as the least useful. The exceptions are important as indication of needed improvements because they include courses in resource economics and administration—both public and business. These are courses that are relevant to real problems, and it would appear that many social sciences-humanities-liberal arts courses have not been relevant hitherto.

5. The high value of general courses in science, both basic and applied, and the mixed value of advanced courses indicate the importance of teaching the general courses especially well.

6. There are advantages in a fishery education that is interrupted by periods of work. The student can form definite opinions about specialties that he needs for the job that he has or wants. In addition almost everyone can benefit from refresher courses that cover new developments.

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