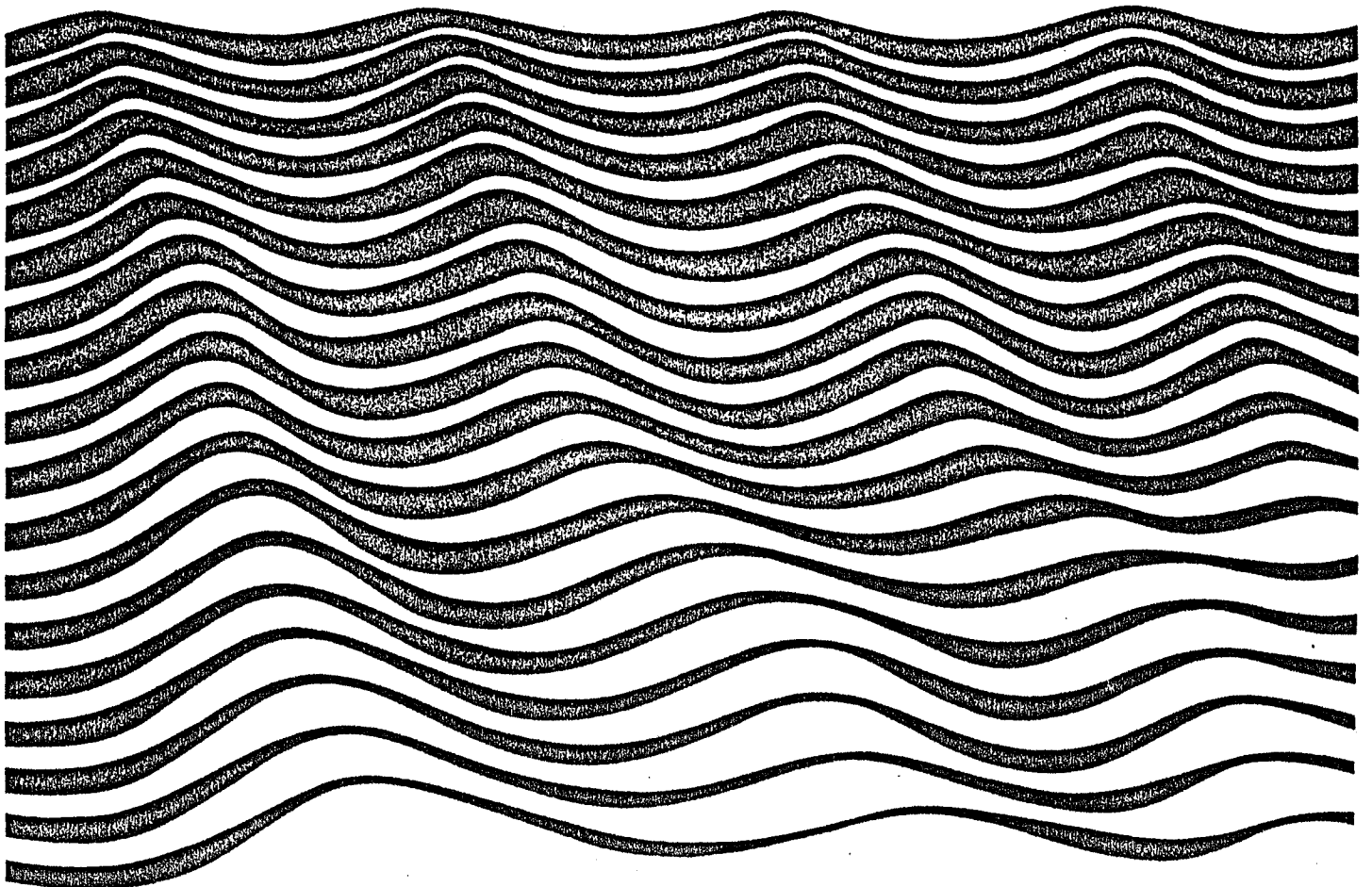


# Unesco reports in marine science

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## Year 2000 challenges for marine science training and education worldwide



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# Training and Education in Marine Science: the Views of 130 Members of ICLARM's Network of Tropical Fisheries Scientists\*

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## Abstract

A questionnaire on the teaching and training of marine science for the year 2000 and beyond was sent to the 732 members of ICLARM's Network of Tropical Fisheries Scientists. There were 130 responses, which were analyzed using X<sup>2</sup> tests for differences between geographical regions. Significant regional differences occurred with reference to the following areas: that mariculture, resource assessment and management, computer applications, and environmental impact and monitoring, will be important occupational areas towards the year 2000; that none of the present areas in marine science education will decline in importance; that computers and ecological modelling will complement the new areas of emphasis; that teaching methods will eventually change and be more applicable to each country's natural resource endowment; and that the NTFS presently plays an important role in marine science education and research.

## Introduction

As a contribution toward the "UNESCO Workshop on Teaching and Training in Marine Sciences for the Year 2000 and beyond", the authors distributed questionnaires prepared by the staff of the UNESCO Marine Science Division to the 732 members of ICLARM's Network of Tropical Fisheries Scientists (NTFS). The questionnaire had been slightly expanded through the addition of a question pertaining to the role of the NTFS (see Appendix I). This contribution presents the results of a statistical analysis of the 130 responses received up to March 1988, by regions, defined in Table 1.

Table 1. Basic statistics of survey of NTFS numbers, as used in this contribution.

Item	Asia-Pacific	Africa and West Asia	Area Latin America and Caribbean	Europe, USA and Canada	Total
Number of countries	28	27	26	13	94
Number of NTFS members	370	129	83	150	732
Number of respondents	57	19	15	39	130
% response	15	15	18	26	18

\*ICLARM Contribution No. 469.

The reasons for creating the NTFS were that "fisheries scientists in the tropics tend to work in far greater isolation than those in temperate regions and the lines of communication, such as they are, often run north-south instead of equatorially. The result is that scientists in adjacent countries or even in the same country can quite often be unaware that they are working on parallel tasks. Scientists of the Indo-Pacific and of the Atlantic seas have similar problems and similar fisheries but minimal contacts, particularly if they do not rank high in seniority [...]. The principal vehicle for communication in the Network [is] a newsletter [called "Fishbyte", now in its fifth year] for exchanges of informal notes, news and views on stock assessment and management" (Munro and Pauly 1982).

Membership of the NTFS is now 732; Table 1 gives a regional breakdown. Funding for the NTFS activities comes from ICLARM, the FAO/DANIDA (Danish International Development Agency) Training Course in Tropical Fish Stock Assessment, the FAO regular program and NORAD (Norwegian Agency for International Development) (through the R/V Fridtjof Nansen Project).

## Materials and Methods

The modified UNESCO questionnaire was mailed to members of the NTFS during November 1987, with a cover letter requesting answers to be returned no later than the end of December 1987. However, answers were received well into 1988 and the cutoff date was extended to 31 March 1988; altogether 130 answers were considered, of which 90% consisted of filled questionnaires, and the rest of informal letters. Some questionnaires were completed by groups, but these were treated as individual answers.

Since the questionnaires were open-ended, the responses received were divided into subsets (see Table 2 where the number to the left refers to the original number of each question). This increased the number of "questions" from 7 to 14. All responses provided by respondents were included in the tabulation. Thus, the least frequency per response is 1. This implies that for any question with  $n$  number of alternative responses, one respondent may have from 1 to  $n$  responses. Thus, the total number of responses per region may exceed the number of respondents. For example, Question #1 has 11 possible responses. For the Asia-Pacific region, which includes a total of 57 respondents, this implies an expected total of 627 responses (see Table 2).

Table 2. Summary of responses to UNESCO questionnaire (questions 1-6) with  $X^2$  for significance of regional differences computed as explained in the text (see also Table 3); \* refers to  $P < 0.9$ ; \*\* to  $P < 0.95$  and \*\*\*  $P < 0.99$ .

	Asia-Pacific	Africa and West Asia	Respondents Latin America and Caribbean	Europe, USA and Canada	Total	Computed $X^2$
<b>1A. WHAT NEW OCCUPATIONAL AREAS THAT REQUIRE EXCLUSIVE OR ACTUAL EXPERTISE SEEM TO BE INCREASINGLY IMPORTANT TOWARDS 2000?</b>						
a. Mariculture/Marine Aquaculture (genetics, disease, ocean ranching, coastal aquaculture)	20	10	8	18	56	25.82***
b. Marine Engineering/Electronics	6	1	1	2	10	
c. Resource assessment and management/coastal management	27	6	4	8	45	8.02**
d. Mineral deposits/energy sources	7	2	2	2	13	
e. Social sciences (economics, politics)/Marine policy	4	1	2	14	21	
f. Computer applications such as acoustics, GIS, remote sensing, automated monitoring)	8	3	2	12	25	8.70**
g. Environmental impact and monitoring	12	3	3	18	36	9.68**
h. Mathematics and statistics	1	2	1		4	
i. Resource bioeconomics	1	1		2	4	
j. Ecology/ecosystem approach	9	4	4	4	21	2.57
k. Gear technology		1	1		2	

Continued

Table 2. Continued

	Asia-Pacific	Africa and West Asia	Respondents Latin America and Caribbean	Europe, USA and Canada	Total	Computed $X^2$
<b>1B. WHAT AREAS WILL SIGNIFICANTLY DECREASE IN IMPORTANCE?</b>						
a. None	5	2	5	8	20	6.76*
b. Descriptive marine biology (taxonomy)	8	3	1	2	14	2.69
c. Descriptive ecology (biochemistry)	4	1	3	3	11	3.01
d. Research vessel surveys	1	1		1	3	
e. Physical oceanography	6		1	3	10	
f. Fishing gear technology				1	1	
g. Baseline data gathering	2				2	
h. Classical population dynamics	1	1		1	3	
<b>2. WHAT KEY KNOWLEDGE AND SKILLS WILL BE REQUIRED AT THAT TIME?</b>						
a. Computer applications	19	3	8	18	48	7.12*
b. Basic sciences (physics, mathematics, chemistry, biology)	8	1	3	4	16	2.01
c. Social sciences (economics, politics)	5		1	3	9	
d. Cost-effective research	1			1	2	
e. Technical skills and extension work	4	1	4	3	12	6.24
f. Environmental conservation and management	3	1		2	6	
g. Improved assessment/monitoring skills	9	4	1	1	15	6.12
h. Ecological approach/modelling	17		1	10	28	9.68**
i. Applied science	4	1		2	7	
j. Genetics				1	1	
k. Aquaculture engineering				1	1	
<b>3A. WILL TEACHING METHODS USED TO IMPART KNOWLEDGE AND SKILLS CHANGE?</b>						
a. Yes; (have to be changed)	27	10	13	22	72	7.5*
b. No	7	2	2	3	14	0.62
c. No idea	1				1	
<b>HOW:</b>						
a. Shift from theoretical to applied (on-the-job training)	16	4	4	14	38	1.54
b. Post-educational training	5	1		4	10	
c. Computer-based and audio-visual methods	22	4	6	10	42	3.33
d. Re-education	2				2	
<b>3B. HOW CAN DEVELOPMENTS IN TECHNOLOGY IMPROVE THE METHODS TO ACQUIRE KNOWLEDGE AND SKILLS FOR THOSE HAVING FINISHED THEIR FORMAL EDUCATION?</b>						
a. Ability to teach specialized marine science	4	1		5	10	2.89
b. Post-educational training	3			2	5	
c. Computer-based, audio-visual teaching methods	7	2		5	14	2.12
d. Application of techniques	2	1	1	5	9	
e. Multidisciplinary approach	3	1		3	7	
f. More effective information dissemination	4				4	
g. Upgrade teaching skills	4				4	

Continued

Table 2. Continued

	Asia-Pacific	Africa and West Asia	Respondents Latin America and Caribbean	Europe, USA and Canada	Total	Computed $X^2$
<b>3C. WHAT IS THE ROLE OF DISTANCE LEARNING AND COMPUTER-BASED EDUCATION?</b>						
a. None/not effective	1			1	2	
b. Complementary (used as tools only)	14	2	3	11	30	2.41
c. Very important	2	3	2	4	11	3.74
<b>3D. HOW CAN METHODS BE ADAPTED TO DEAL WITH ENORMOUS GROWTH IN INFORMATION AND SPECIALIZATION?</b>						
a. Specialization (smaller groups)	1	1		1	3	
b. Use of computers	6	2	4	2	14	5.24
c. Training of personnel	5			1	6	
d. Workshops/seminars/networks	4	2			6	
e. Standardize methods	3		1		4	
<b>4A. WHAT ARE THE MAIN OBSTACLES TO APPLY SUCH INSTRUCTIONAL METHODS, PARTICULARLY IN COUNTRIES DEVELOPING THEIR MARINE SCIENCE CAPABILITIES AND WHAT IS NEEDED TO OVERCOME THEM?</b>						
a. Funds (equipment, training, technical capability)	39	10	8	21	78	3.01
b. Lack of appropriate primary education	3	1	1	3	8	
c. Politics, traditional/cultural barriers (e.g., language)	12	1	5	12	30	5.72
d. Lack of qualified teaching staff	13	5	6	16	40	4.4
e. Technology, e.g., computer literacy		1			1	
<b>4B. HOW TO OVERCOME THESE BARRIERS?</b>						
a. Government to government approach	2	2			4	
b. Symposia	3	2	2	1	8	
c. "Open-mindedness"	3	1	1	1	6	
d. Scientists from developed countries to act as "experts"			2		2	
<b>5A. WHAT WILL AND SHOULD BE THE MAIN DIFFERENCES IN EDUCATIONAL REQUIREMENTS IN MARINE SCIENCE BETWEEN REGIONS AND COUNTRIES?</b>						
a. Education should be dovetailed to suit the country's resource endowment and potential	24	14	8	15	61	7.36*
b. Export of professionals from developed to developing countries rather than offer scholarships to developing countries	2	1		1	4	
c. Export of personnel from developing to developed countries						
d. Shift to practical approach (technical and management)	5	2	2	1	10	2.43
e. None	4	1		3	8	
f. Export of scientists from developed to developed countries		1			1	
g. Difference in national objectives	3		1		4	
h. Developed countries to rely on technology				1	1	

Continued

Table 2. Continued

	Asia-Pacific	Africa and West Asia	Respondents Latin America and Caribbean	Europe, USA and Canada	Total	Computed X <sup>2</sup>
<b>5B. TAKING INTO ACCOUNT CERTAIN NEGATIVE IMPACTS OF NATIONAL DEVELOPMENT STRATEGY OF THE 70S AND 80S, WHAT EXPERIENCES FROM COUNTRIES WITH A LONG TRADITION IN MARINE SCIENCE TEACHING AND TRAINING ARE AND WILL BE RELEVANT FOR COUNTRIES DEVELOPING SUCH CAPABILITIES AND VICE VERSA?</b>						
a. No value for those just starting	1				1	
b. Gap between LDC and OECD to widen				2	2	
c. Degradation experience	3			1	4	
d. Export of skilled personnel from developed countries	2			1	3	
<b>6. HOW CAN MARINE SCIENCE TEACHING AND TRAINING BE MADE MORE EFFECTIVE IN ACHIEVING THE PERCEIVED GOALS FOR THE STATE OF THE ENVIRONMENT AND THE MANGEMENT OF MARINE RESOURCES FOR YEAR 2000 AND BEYOND?</b>						
a. Improve local training capacity/ manpower planning	9	6	3	6	24	2.71
b. Improve undergraduate level teaching e.g., by periodic review of curricula	11	3	1	5	20	1.75
c. Regional/global research centers to permit more contact among scientists	10	2	2	3	17	2.1
d. Training of decisionmakers	4	1		7	12	5.75
e. Link-up with economic goals	4	1	2	2	9	
f. Interdisciplinary approach	2			1	3	
<b>7. ROLE OF THE NTFS</b>						
a. Education and research	3	3	3	9	18	6.84*
b. Information dissemination with regard software case studies, translations, critical reviews of papers, scientific publications	8	3	3	3	17	1.8
c. *publication of journal/newsletter	5	2		3	10	
d. Extension work	2	1			3	
e. Submit position papers Roster of personnel/profile of	9		2	10	21	6.35*
f. researches	3	1	1	2	7	
g. Curator of data center	2				2	
h. Assistance in securing funds Assisting interns in participating	6	1	3	1	11	4.89
i. in training programs/workshops Establishing geographical units/	7	2	5	3	17	6.55*
j. meetings	11	7	2	6	26	4.32
k. Expand scope, e.g., to aquaculture; network of marine scientists	1			1	2	
<b>8. NON-RESPONSE</b>						
a. Irrelevant study				2	2	
b. Already received a copy	1				1	
c. Passed to another	1				1	
d. No experience in marine science	3			1	4	
e. Late; busy	1			1	2	

Inferences based on simple frequency analysis are not affected by this because the importance of a particular response is evaluated on the basis of absolute and not of relative frequencies and because the regional totals and the number of responses per category can be treated as independent.

The chi-square test was applied to learn whether regional differences in attitude, stage of economic development, etc., influence response.

The chi-square value provides an estimate of the significance of any differences between the observed and expected frequencies, the expected frequency being a function of the row and column totals. Since the resulting row and column totals do not represent the actual number of responses, no valid generalization about a particular question can be made using this test. This inconsistency was remedied here by applying the chi-square to every response with 10 or more occurrences, and not to the whole response block (all responses pertaining to one question).

For example, for Question #1, 20 out of the 57 respondents from the Asia-Pacific region perceived mariculture/marine aquaculture to be an increasingly important occupational area requiring expertise towards the year 2000. This implies that the remaining 37 of the respondents did not consider mariculture as important. The chi-square table used would then have 4 columns, representing the 4 regions and 2 rows, representing either an affirmative or negative response. (See Table 3 for an illustration of this example). The same procedure was applied to all responses listed in Table 2 for which 10 or more responses were available.

Table 3. Illustration of arrangement of responses and computation of  $\chi^2$  values for a given question (here: No. 1a, significance of aquaculture). The i refers to rows (i.e., response) and the j to the column (i.e., region).

Item	Asia-Pacific	Africa and West Asia	Area Latin America and Caribbean	Europe, USA and Canada	Total
Observed values = $O_{ij}$					
Total number of respondents	57	19	15	39	130
Important	20	10	8	18	56
Not important	37	9	7	21	74
Expected values = $E_{ij}$					
Important	24.55	8.18	6.46	16.80	
Not important	21.06	5.12	3.98	11.95	
$(O_{ij} - E_{ij})^2$					
Important	0.84	0.4	0.37	0.09	
Not important	12.06	2.93	2.28	6.85	

$$\chi^2 = \sum_j \sum_i \frac{(O_{ij} - E_{ij})^2}{E_{ij}}$$

## Results and Discussion

The NTFS members considered marine aquaculture, resource assessment and management (including coastal zone management), computer applications (Geographical Information Systems or GIS), remote sensing, automated monitoring, acoustics, environmental impact and monitoring, and ecology/ecosystem approach to be increasingly important as new areas requiring expertise by the year 2000 (Table 2). Some members believed that the areas of descriptive marine biology including taxonomy and ecology will decline in significance, but the dominant view is that none of the areas now important in marine science education will wane - at least up to year 2000.

As a complement to the new areas of emphasis, the NTFS members felt that skills in computer applications, ecological modelling, the basic sciences including mathematics, physics and chemistry, improved technical extension work and monitoring should be upgraded.

An overwhelming affirmation of the eventuality of change in the methods used to impart knowledge and skills, if not an actual and urgent need for it, was expressed by the NTFS members. Changes should occur by employing computer-based and audiovisual methods and shifting, as one respondent put it, "from theoretical to practical training".

"Distance learning" and computer-based education were judged important but most of the respondents considered these more as tools and complements to existing educational methods rather than as major methods. This "tool/complement" nature is again highlighted by the respondents' perceived importance of computers (as against training of personnel through workshops, etc.) in handling the enormous growth in information and specialization.

NTFS members pointed to the scarcity of funds as the greatest obstacle to the application of improved instructional methods. Scarcity of funds affects recruitment of trained personnel, improvement of technical capability, and purchase of equipment. The absence of qualified teaching staff figured prominently as an obstacle although it was also mentioned as a consequence of scarce funding. To a lesser extent, political and cultural barriers were also regarded as obstacles to efficient implementation of modern instructional methods.

To overcome these barriers, some respondents suggested bilateral and/or multilateral agreements between governments, the holding of symposia (e.g., to foster "open-mindedness"), and "transfer of technology" from developed to developing countries.

The majority of respondents believe that marine science education should be tailored to suit the country's resource endowment.

In order to upgrade teaching and training, the NTFS members believe the following should be achieved: improve local training capacity/manpower planning; improve undergraduate level teaching; establish regional/global research centers to permit more contact among scientists; and train decisionmakers.

The responses to Question #7 highlight the achievement of the NTFS in the field of education and research, specifically in information dissemination. However, NTFS members perceive the need to create more impact in the field of marine science education by: preparing/submitted position papers; establishing geographical groupings and organizing regular meetings; and, assisting members in securing funds for training and workshops.

Table 2 shows the results of the chi-square tests. The following statements relevant to marine science education were observed to be associated with significant regional differences:

a) that mariculture, resource assessment and management, computer applications, and environmental impact and monitoring will become increasingly important occupational areas by the year 2000;

b) that none of the present areas in marine science education will decline in importance;

c) that use of computers and ecological modelling will complement the new areas of emphasis;

d) that teaching methods will or have to change;

e) that education should be adapted to suit a country's resource endowment, thus leading to the differences of the educational requirements among countries;

f) that the NTFS contributes usefully to education and research, but that it also should assist with preparation/submission of position papers, and provide assistance for interns to participate in training workshops.

The method of analysis we used here, however, does not straightforwardly allow for identification of possible causes for these regional differences.

Overall, the responses received correspond to the general recommendations in ACMRR (1981), Chia (1984), Chua (1987) and Agüero and Costello (1987) and with the results of UNESCO/ROSTEA (1988).

We intend to refine our analysis in a future contribution, by matching the responses we received with specific characteristics of the respondents (e.g., their educational levels and type and number of publications), such as to be able to identify causes for the observed regional differences. Such detailed analysis may yield insights concerning improvements capable of implementation, e.g., through the NTFS or as part of some activity on Training, Education and Mutual Assistance in the Marine Sciences (TEMA) (UNESCO 1984).

## Acknowledgements

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## Appendix I: Modified UNESCO Questionnaire, as Sent to NTFs Members

- |  |   |
|--|---|
| <p>1. What new occupational areas that require exclusive or partial expertise in marine science can be foreseen as developing towards the year 2000? What areas will significantly decrease in importance?</p> <p>2. What key knowledge and skills will be required at that time and how will these differ from today's?</p> <p>3. What will the university teaching methods used to impart the knowledge and skill change? If so, how? How can developments in technology improve the methods to acquire knowledge and skills for those having finished their formal education?</p> <p>What will be the roles for distance learning and computer-based instruction?</p> <p>How can methods be adapted to deal with the enormous growth in information and specialization?</p> <p>4. What are and will be the main obstacles to applying such instructional methods, particularly in countries</p> | <p>developing their marine science capabilities, and what is needed to overcome them?</p> <p>5. What will and should be the main differences in educational requirements in marine science between regions and countries? What will this mean for national teaching and training programs?</p> <p>Taking into account certain negative impacts of the international development strategy of the 70's and 80's, what experiences from countries with a long tradition in marine science teaching and training are and will be relevant for countries developing such capabilities and vice versa?</p> <p>6. How can marine science teaching and training be made more effective in achieving the perceived goals for the state of the environment and the management of marine resources for the year 2000 and beyond?</p> <p>7. What role could the Network of Tropical Fisheries Scientists of ICLARM play in tackling the issues raised in points (1) to (6)?</p> |
|--|---|