

## SIMON FRASER UNIVERSITY

## MEMORANDUM

**To:** Senate  
**From:** Senate Committee  
on Academic Planning  
**Subject:** Master of Aquaculture Program **Date:** November 16, 1989  
SCAP 89-6

Action undertaken by the Senate Committee on Academic Planning at its meeting of April 5, 1989, and the Senate Graduate Studies Committee at its meeting of April 3, 1989 gives rise to the following motion:

**Motion:**

"that Senate approve and recommend approval to the Board of Governors, as set forth in S. 90-8 the proposal for a Master in Aquaculture Program including

|             |   |   |
|-------------|---|---|
| New Courses | ECON 663-4                              | The Economics and   |
|             |   | Management of Aquaculture                                       |
|             | * BUS <sup>543-4</sup> <del>542-4</del> | <del>Introductory graduate</del><br>Aquaculture Marketing       |
|             | MRM 615-3                               | Management of Aquaculture<br>Resources                          |
|             | BISC 630-5                              | Introduction to Aquaculture<br>Systems                          |
|             | BISC 632-5                              | Salmonid Fish Diseases and<br>Their Control                     |
|             | BISC 631-5                              | Growth, Reproduction and<br>Nutrition in Aquaculture<br>Systems |
|             | BISC 633- <del>6</del>                  | Current Topics in<br>Aquaculture                                |
|             | BISC 635-0                              | Practicum and Research<br>Paper"                                |

\* Bus 542 replaced by Bus 543-4 as approved by Senate 8/1/90  
Paper S.90-15

S I M O N F R A S E R U N I V E R S I T Y

MEMORANDUM

DEAN OF GRADUATE STUDIES

TO: Prof. L. Salter, FROM: Bruce Clayman  
Acting VP, Academic

SUBJECT: Aquaculture DATE: 10 November 1989

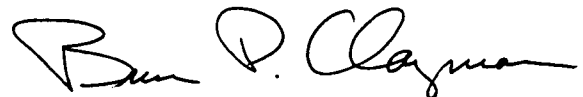
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The proposal to establish a Master in Aquaculture program in the Department of Biological Sciences was approved by the SGSC and then by SCAP some time ago. In each case the approvals were contingent on some minor additions to the proposal. The proposal is now complete and, I understand, on the next Senate agenda.

I have received two additional items (enclosed) relevant to Senate's consideration of this proposal:

- The written response of the proposers (report by Dr. L. Druehl, dated 10 November 1989) to the specific criticisms and comments of the external assessors of the program. This report reproduces the arguments originally made orally to the Assessment Committee. All the significant points raised by the assessors have been addressed, either by changes to the proposal or by presentation of the reasons that changes are not necessary at this time.
- The response of the department to the comments of the external reviewers of the Department. The review occurred after the approval by the Assessment Committee of the Aquaculture proposal. The reviewers had raised some concerns regarding the place of professional programs (such as Aquaculture) in the Department. The enclosed memorandum (October 19, 1989 to Dr. C.H.W. Jones from Dr. L.M. Srivastava) addresses this point and reinforces the commitment of the department to the mounting of the program, contingent on the provision of additional funding.

I am confident that the proposal to establish a Master in Aquaculture program is sound and has the support of the Department and so recommend it to Senate for approval.



c.c. C.H.W. Jones  
L.M. Srivastava  
L. Druehl  
N. Hunter

ln010sal

Response to Referees' Comments on the Simon Fraser University  
Master in Aquaculture Proposal.

Four outside referees have commented on the proposed Master in Aquaculture program (Dr. W. Pennell, then Director of Research, B.C. Salmon Farmers Association; Dr. R.E. Foreman, then Associate Professor, University of British Columbia; M.J.E. Fralick, Manager, Aquaculture Industry Management, B.C. Ministry Agriculture and Fisheries; Dr. C.A. Simenstad, Wetland Ecosystem Team, University of Washington).

All four felt that there was a need for this program and that the program was appropriate to industry. There were individual points of concern. These points are discussed below.

-- The majority of referees expressed concern over the thesis evaluation (Pennell, Fralick, Simenstad). In response to this, we have given added emphasis to the thesis (pp. 9-10).

- 1) The preparation period has been projected from one to two semesters.
- 2) There will be at least two knowledgeable professionals supervising the thesis preparation.
- 3) The thesis will be defended as described in Sections 1.9, 1.10, and 1.11 of the Graduate Regulations.

-- Concern was expressed regarding course offerings:

- 1) Pennell did not agree with some of the fourth semester elective offerings (he did not specify which courses). We agree that a greater suite of advanced course electives would be desirable and we expect some new offerings will be proposed by new faculty. However, at this time we believe we have a sound program and that the introduction of new elective fourth semester courses would be premature.
- 2) Foreman touched upon the concerns of Pennell and promoted an aquaculture engineering course and an advanced (elective) disease/pest course. We considered the engineering option earlier along with various environmental courses (see 4 below), concluding they would make the program too ungainly. The disease/pest course elective is an interesting possibility; one that Professor L. Albright may respond to should there be student demand.

- 3) Fralick felt that the electives Economics 863 and 864 (relating to fisheries economics) were inappropriate. We have responded to this by suggesting an appropriate course will be put forth by that faculty member responsible for the economic portion of the program (p. 11). Similarly, we have suggested a new business elective (p. 11). Either of these courses could provide training in seafarm management as suggested by Fralick.
- 4) Simenstad expressed ecological concerns, desiring to see more training on environmental impact, and ecosystem definition. We agree with his concerns. However, our program is geared to management from industries' point of view. We feel that our managers should be good environmental citizens but we should not expect them to be competent in how to assess impact, etc. If our program was geared to government managers Dr. Simenstad's comments would be more appropriate. Students wishing to emphasize the ecological approach may do so through any of a number of MRM offerings (p. 10).

-- Foreman correctly called attention to the possibility of admission requirements eliminating some of the clientele for whom the program is intended. We have attempted to overcome this problem by giving the Director and instructors some discretion in accepting students (pp. 8 and 10). Essentially, the perceived problem relates to a non-biology major's status in the program. This student will emphasize, for example, economics in the final semester and do an economics thesis. It is our belief that training appropriate to the Masters level can be achieved by this person in the first and second semester biology courses. Similarly, the first and second semester business, economics and resource management courses will be appropriate to biology majors. This is the basic tenet of an interdisciplinary program. We are attempting to achieve a well-rounded degree with focus on an advanced area.

-- All reviewers believed there would be sufficient demand for this program (10-15 students per year). Since Simon Fraser initiated discussion on this program in 1985, I have received numerous inquiries about such a program. Some of these students may have gone elsewhere, however. Fralick and Pennell suggested some students may not be successful in finding local employment, but both suggested international opportunities. We have always considered that a significant portion of our students may be from overseas and that they are training for opportunities in their home nation.

LD/eh

*Louis Ornell*  
10 November 1989

# SIMON FRASER UNIVERSITY

## MEMORANDUM

OCT 20 1989

DEAN OF GRADUATE  
STUDIES OFFICE

To... Dr. C. H. W. Jones .....  
..... Dean of Science.....  
Subject... **M. AQUACULTURE**.....

From... L. M. Srivastava.....  
Chair.....  
..... Biological Sciences.....  
Date... October 19, 1989.....

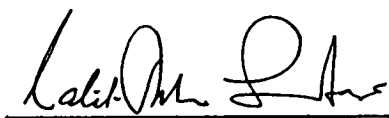
You will recall that the External Review Report had raised some concerns regarding the place of professional programs in an academic department such as ours, and specifically the addition of a new Master's program in Aquaculture. At its meeting yesterday, the Department discussed these aspects of the Report and passed the following two motions:

"The Department goes on record as accepting in principle the idea of new professional programs."

"We wish to endorse the Department's earlier decision to proceed with the M. Aquaculture proposal. In keeping with the External Review Committee Report, the M. Aquaculture proposal will only be developed if new funding and resources are made available."

I should advise you that the Department is aware of the potential threats such as dilution of, or diversion of, resources from the academic programs (External Review Report #3.3). Accordingly, the Department wishes to re-emphasize that M. Aquaculture will be developed only if new funds and resources, as outlined in the Program Budget and underscored by the External Review are provided. The proposal is timely and there is need for this program in B.C. and Canada, and we hope that the University will take this opportunity to seek special funding for this program from the government.

On a different note, I am distressed at the manner in which the proposal on M. Aquaculture has been handled. The proposal left our Department and the Faculty of Science nearly two years ago and except for the time when comments by the External Reviewers and the Senate Committee were received, the proposal has languished for what appears to be poor coordination and communication. It was with some relief therefore that we heard via the grapevine that the proposal was going to the November meeting of Senate, only to be told by Dean Clayman and yourself that that was not to be and the Proposal still needed some work. As far as we know the comments of the External Reviewers were addressed and incorporated, if not, reasons were given, and the Revised Proposal was accepted by the Senate Committee. We have no objection to doing whatever still needs to be done but we do expect clear directions. I look forward to receiving these directions from yourself or Dean Clayman.



LMS/ms

cc L. Salter  
B. Clayman  
L. Druehl  
R. Brooke

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Proposal for

**MASTER IN AQUACULTURE**

Submitted by

Simon Fraser University

for

**FUNDS FOR EXCELLENCE IN EDUCATION FUNDING**

February 1987

As amended December 3, 1987  
File: D9

Amended July 11, 1988

Amended December 8, 1988

Approved by Faculty of Science  
March 16, 1987

5.

EXECUTIVE SUMMARY

We propose the establishment of a Master's Program in Aquaculture at Simon Fraser University to complement our Institute for Aquaculture Research. We do so for 3 reasons: 1. Culture of fin fish, shell fish and other invertebrates, and seaweeds including phytoplankton is increasing world wide. This industry, just beginning in British Columbia, will consolidate and increase over the foreseeable future. 2. Associated with this increase is the need for increased research and training in disease and parasite control, nutrition, growth and reproduction of fisheries\* stock, resource management, fisheries economics and markets, food processing and packaging, etc. 3. At Simon Fraser University we have a relatively large group of people in the Departments of Biological Sciences, Natural Resource Management, Economics, and Business with interest in basic and applied aspects of aquaculture to serve as the nucleus for the proposed Institute and Master's Program. We have a successful track record in mounting and operating interdisciplinary, professionally oriented programs which liaise with industry and are driven by industry needs.

Integral to the Proposal is a 4 semester (16 months) Master's Program in Aquaculture with sufficient options to train people in either the biological or managerial aspects of aquaculture. This professional, multidisciplinary program builds on the technical program offered at Malaspina College and includes a graduate level Coop option.

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\*'Fisheries' is used here as a generic term to include fin fish, shell fish, seaweeds, and phytoplankton.

TABLE OF CONTENTS

|   | Page |
|---|------|
| Title Page  | i    |
| Executive Summary   | ii   |
| Table of Contents   | iii  |
| Proposal for a Master's Program in Aquaculture  | 1    |
| I. General Information  | 2    |
| II. Program Description and Related Matters   | 3    |
| 1. Objectives   | 3    |
| 2. Relationship of proposed degree program to the<br>role and mission of the university | 6    |
| 3. Curriculum   | 6    |
| - Admission   | 6    |
| - Required Courses  | 8    |
| 4. Formal consultation with professional<br>organizations                               | 12   |
| 5. Formal consultation with non-university agencies                                     | 13   |
| III. Need for Program   | 14   |
| 1. Cultural, societal or professional needs   | 14   |
| 2. Enrolment  | 15   |
| 3. Types of jobs  | 16   |
| 4. Annual employer demand   | 16   |
| 5. Current candidates for appropriate openings  | 17   |
| 6. Student placement patterns in professional<br>programs                               | 17   |
| IV. Present and Projected Resources   | 18   |
| 1. Present faculty  | 18   |
| 2. Present undergraduate and graduate offerings   | 18   |
| 3. Present facilities   | 18   |
| 4. New resource requirements  | 19   |
| V. Evaluation   | 22   |
| Part III-The Advisory Council and Technology Transfer                                   | 24   |
| Appendices I-III  | 25   |



PROPOSAL FOR A MASTER'S PROGRAM IN AQUACULTURE

I. General Information

1. Title - Masters Program in Aquaculture
2. Credential to be awarded to graduates - Master of Aquaculture (M.Aq.)
3. Department of Biological Sciences  
Simon Fraser University, Burnaby, B. C., V5A 1S6
4. Date of Senate approval
5. Schedule for implementation - September 1989.

## II. PROGRAM DESCRIPTION AND RELATED MATTERS

### 1. Objectives

In recent years, world aquacultural operations have increased dramatically due to advances in science and technology, population growth, and declines in catch of traditional fisheries. Between 1975 and 1980 aquaculture increased by 42% and contributed approximately 10% to the world fishery. North America is relatively new to this endeavour and produces only 1.61% of the total world aquacultural products. Canada only produces 0.05% of the total, well behind such countries as Norway, Korea, Japan and China.

In British Columbia there is a great deal of interest and need for training in aquaculture. Many farms culturing salmon, herring, sablefish, trout, abalone, oyster, mussels, seaweeds such as Laminaria (Kombu) and Porphyra (nori) have sprung up along the B.C. coast and aquacultural farmers have become concerned about questions of disease, nutrition, growth and reproduction. Malaspina College has a two year program which provides basic technical and trade training in aquaculture, but there is a need for more specialized training addressing disease and nutrition, growth and reproduction, as well as the more novel biotechnological applications to aquaculture. Engineering science is required for design of systems for water conditioning, development of specialized containments, thermal installations, oxygen enrichment, etc.

Research and instructional needs in aquaculture are in six recognized areas: 1. to culture organisms there is a need to crowd them; this practice leads to three major problems that have to be addressed for any species -- disease, stress and parasitic infections. 2. Nutritional studies are necessary

for all cultivated species. Whereas some of this information is available from other countries, there is need to have this information for species important to British Columbia. Even for species that are well studied, nutritional information for different stages of life cycle and in different environments is required. Also, there may be other species, potentially important to aquaculture in B.C. for which there is no information. 3. More information is needed in the area of genetic manipulation. Many species have been domesticated but the selection and hybridization of superior production traits still needs to be investigated. Genetic manipulations are also needed to produce unisex and sterile populations. 4. Physiological studies, involving energetics, manipulation of growth hormone, etc., can enhance aquacultural operations and production. For example, the smolt developmental stage in salmonid fishes, seawater adaptability, sexual maturation for brood stock production are not well understood especially under conditions of aquaculture. 5. Economic assessment and innovative marketing research are essential to a stable, competitive B.C. aquaculture industry. 6. Finally, resource management will assist in integrating aquaculture into other coastal uses and provide a vehicle for environmental impact assessment.

We propose the development of a Master of Aquaculture and associated research program at Simon Fraser University. Malaspina and Capilano Colleges are already operating a vocational program in aquacultural techniques and the University of British Columbia has proposed a B.Sc. program in Aquacultural Sciences. The 4 semester program at Simon Fraser University would complement the colleges' programmes and build upon our present undergraduate and graduate instructional and research strengths in the aquatic sciences. Our proposed program would provide a multidisciplinary program aimed at the above biological

problems as well as related training in managerial aspects including resource management, fisheries economics and marketing as they pertain to the aquaculture industry.

Aspects of aquaculture are presently taught at Simon Fraser University at the undergraduate and graduate levels in two different but related units: the Department of Biological Sciences and the School of Natural Resources Management. In addition, the Department of Economics and Faculty of Business offer courses in Fisheries Economics, and Marketing. The Institute of Fisheries Analysis provides a forum for inter-Faculty information exchange. These units have active researchers in many areas of aquaculture production and marketing. The Department of Biological Sciences has experts in kelp biology, invertebrate zoology, fish diseases, fish physiology, fish ecology and environmental toxicology. The School of Natural Resources Management, the Department of Economics and the Institute of Fisheries Analysis address many other areas associated with aquaculture such as resource development and management, ecology, economics, marketing, hydrology, law, planning, quantitative analysis, policy, sociology, and project evaluation.

We propose the addition of six graduate courses to our already existing undergraduate and graduate courses in marine biology, resource management, fisheries economics and business. The new courses will have a strong applied bias and field experience. They will utilize existing faculty at Simon Fraser University as well as experts from other B.C. institutions, Malaspina College, government laboratories and abroad as guest lecturers or on short term contract. This approach allows for flexibility in program offering and cost effectiveness with the changing needs of this new industry.

2. Relationship of proposed degree to the role and mission of the university.

At Simon Fraser University we have a relatively large group of people in the Departments of Biological Sciences, Natural Resource Management, Economics and Business who share interests in basic and applied aspects of aquaculture and can serve as the nucleus for the proposed program. We have a successful track record in mounting and operating interdisciplinary, professionally oriented programs which liaise with industry and are driven by industry needs. Simon Fraser University already has two professional graduate degrees (Master of Pest Management and Master of Resource Management) as well as a professional diploma in Environmental Toxicology. An additional professional degree in the area of biotechnology is also being planned. Many aspects of these other programs will overlap or complement an aquacultural program.

3. Curriculum

The Master of Aquaculture program will take four semesters (16 months) and require a minimum of 36 semester hours credit. The Department of Biological Sciences will be the home department for this program. It is designed as an overview into aquaculture for government officials concerned with aquatic resource management and the aquaculture industry, aquaculture financial officers, administrators, managers, and aquaculture farm operators. All students will have to take the required courses as a common core. Subsequently, depending on the students' interests and background, they can take electives that emphasize biological aspects, economics, marketing, resource management, etc.

Admission

The Graduate Program Committee in Biological Sciences will be responsible for recommending admission, reviewing the students' progress and arranging for

the supervision and examination of all students enrolled in the Master of Aquaculture program. For students specializing in the economic, marketing or resource management aspects of aquaculture, the Graduate Program Committee in Biological Sciences will seek advice on these matters from the Director, Master of Aquaculture program, and members from appropriate departments which are part of the Institute for Aquaculture Training and Research.

The minimum admission requirement for entry into the programme is a Bachelor's degree with a cumulative GPA of 3.0 from a recognized university or the equivalent. Students with extensive experience in the aquaculture industry may be given special consideration. Submitted evidence of this experience, usually in the form of references from qualified referees, of the student's ability to undertake advanced work in aquaculture will be considered.

Applicants with deficiencies in prerequisite courses will normally be required to do qualifying work.

Before entering the program students should have completed the following courses or their equivalents. These prerequisites may be waived under special circumstances on recommendation from the Director, Master of Aquaculture Program, to the Department Graduate Studies Committee.

- BISC 303 (3) Microbiology
- BISC 306 (3) Invertebrate Biology
- BISC 326 (3) Nonvascular Plants
- BISC 400 (3) Evolution
- BISC 416 (3) Fish Biology
- BISC 424 (3) Marine Biology and Oceanography

REQUIRED COURSES (36 credits) (\*New courses. The details of new courses are given in Appendix I).

Semester 1 (13 credits)

- \*BISC <sup>630</sup>~~631~~ (5) Introduction to Aquaculture Systems (lectures, demonstrations and site visits). This course will review major cultivated organisms and is divided into three parts:
- (i) Fish Culture
- (ii) Invertebrate Culture
- (iii) Algal Culture
- \*BISC <sup>632</sup>~~632~~ (5) Salmonid Fish Diseases and Their Control
- MRM <sup>615</sup>~~615~~ (3) Management of Aquaculture Resources.



Semester 2 (14 credits)

- \*BISC <sup>631</sup>~~6X3~~ (5) Growth, Reproduction and Nutrition in Cultured Fish.  
Invertebrates and Algae (lectures, demonstrations and site visits)
- \*BISC <sup>633</sup>~~6X1~~ (1) Current topics in Aquaculture I (student and professional presentations). This course emphasizes topics covered in BISC 6X1, 6X2 and 6X3.
- \*ECON <sup>663</sup>~~6XX~~ (4) The Economics and Management of Aquaculture
- \*BUS <sup>542</sup>~~6XX~~ (4) Aquaculture Marketing

Semester 3

- \*BISC <sup>635</sup>~~6AA~~ (0) Practicum and research paper.  
Candidates must have at least 6 weeks hands-on experience at a commercial aquaculture operation appropriate to the student's particular interest. As an extension of this practical experience, the student is required to prepare a research review on a topic selected in consultation with a faculty advisor. During the preparation of the research review, the candidate will have the assistance of a major advisor and one other knowledgeable graduate committee member. This review will be written as a research paper which will be defended as described in Section 1.9, 1.10, and 1.11 of the Graduate Regulations. The defense will occur no earlier than in the 4th semester of the program.

Semester 4 (at least 9 credits of electives and enrolment in BISC 6AA)

Courses should be chosen from the following or after consultation with a faculty advisor, depending on student's interest, background and future employment expectations.

ELECTIVE COURSES (9 credits)

Biological Aspects

- BISC 805 (3) Endocrinology
- BISC 814 (3) Aquatic Ecology
- BISC 815 (3) Plant Physiology
- BISC 832 (3) Marine Microbiology
- BISC 834 (4) Marine Plant Ecology
- BISC 843 (3) Population Processes
- BISC 859 (3) Special Topics - Fish Physiology

Resource Management

- MRM 611 (5) Population and Community Ecology
- MRM 612 (5) Management Models of Biological Resources
- MRM 613 (5) Current Topics in Fisheries Management

Regional Resource Planning for Aquaculture

- MRM 621 (5) Economics of Natural Resources
- MRM 642 (5) Regional Planning I
- MRM 644 (5) Public Policy Analysis and Administration
- MRM 646 (5) Environmental and Social Impact Assessment
- MRM 662 (5) Coastal Zone Management

Economics

ECON 863 (4) Fisheries Economics

ECON 864 (4) Studies in Economic Fisheries Management

An advanced course in Aquaculture Economics, requiring ECON 6XX as a prerequisite, will be proposed by the faculty member designated to support the Master of Aquaculture program.

Marketing

An advanced course in Aquaculture Marketing, requiring BUS 6XX as a prerequisite, will be proposed by the faculty member designated to support the Master of Aquaculture program.

4. Formal consultation with professional organizations

B.C. Salmon Farmers' Association - B. Nellis

B.C. Oyster Growers' Association - P. McLelland

Western Trout Growers' Association - B. Leiman

Mariculture Association of B.C. - R. Baden

Washington State Natural Resources, Dept. Aquaculture - T. Munford

5. Formal consultation with non-university agencies

Mr. J. Fralick, Aquaculture Coordinator, Ministry of Agriculture and Fisheries

Dr. J. Spence, Aquaculture Consultant, Ministry of Agriculture and Fisheries

Mr. J. Baxter, Department of Education

Dr. W. Pennell, Aquaculture and Fisheries, Malaspina College

Dr. W. Gibson, Capilano College

Mr. M.R. Gordon, Aquaculture Program Leader, B.C. Research Council

Dr. R. Foreman, Arts, Science and Technology Centre

Dr. R. Waaland, University of Washington

Dr. T. Watson, President, Tidal Rush Marine Farms Ltd.

Mr. N.B. Hope, President, Pacific Aquafoods Ltd.

### III. NEED FOR PROGRAM

#### 1. Cultural, societal or professional needs

In addition to the objectives set out earlier, the proposed program will provide training for research and development, and an advisory role to the aquaculture industry in coastal, at times remote, communities and native Indian band aquaculture operations. Graduates of the program would also be in a better position to review and deal with the complexities of resource-use conflicts associated with the industry. The program provides a step toward developing the industry and its management to a level comparable with other resource-based industries.

The program will meet professional needs by providing an advanced degree coordinated with and complementing other programs at the college level. It will provide specialized training and exposure to current research in aquaculture. It will promote interest and effort at higher academic levels and encourage university involvement in the industry in terms of research and teaching. The proposed aquaculture program will also provide training for those in research centres at a level appropriate for dealing with the complexities of this field, provide specific expertise which can be transferred by graduates to aquacultural sites, permit those in related disciplines to shift their focus to aquaculture, provide students with current expertise in science and technology related to aquaculture, and provide a more focused and coordinated effort in training to form a comprehensive approach to meeting the educational needs of the industry. Finally, coincident with the apparent rapid expansion of this industry, there is a need to provide educational opportunities for advanced students to ensure maximum utilization of its potential and to promote the exchange of ideas and knowledge.

## 2. Enrolment

(a) There is good indication of considerable student interest in an aquaculture program. In addition to direct contact of faculty members by students enquiring about aquaculture, Simon Fraser University receives letters of enquiry from potential students each year. Although approximately 30% of inquiry letters to the Department of Biological Sciences do not specify a particular area of interest, many indicate an interest in marine biology and aquaculture. Such aquaculture-oriented letters may average 10 per year at this time. For example, in the past year, 25 inquiry letters showed an interest in marine biology and 9 letters specifically asked about an aquaculture program (Graduate Studies files).

(b) Based on the level of interest shown at the present time, enrolment of approximately 10 new students can be expected each year. An additional 10% of the total enrolment might be formed by transfer students.

(c) In support of these enrolment estimates for this type of program, reference can be made to the increasing awareness of the general public to the development and opportunities in the aquaculture industry, the orientation toward resource-based industries in the province and along the coast, and to levels of interest and enrolment in other professional programs at this university. With reference to this last point, the Master of Pest Management program at SFU is a successful program with more than 100 graduates. The program has enrolled 40 to 50 students at any one time and receives between 8 and 12 new enrolments each year.

(d) At the present time, a program in aquaculture would require a minimum enrolment of 8 to 10 students with a limit in the program of 20.

### 3. Types of jobs

Graduates from this program would be employed in private industry, government and educational institutions. Positions in private industry would include those in research and development, sales, industry-government liaison, and resource advisory capacity. Graduates would also be employed in consulting firms as aquaculture specialists. The program would be a natural step toward a position as a government specialist in Canada or as a specialist or advisor in developing countries. Educational institutes would also provide employment opportunities in terms of the development of aquaculture programs or activities or participation in related teaching. In universities, graduates may proceed to higher degrees or may be employed as assistants in aquacultural research.

### 4. Annual employer demand

With the continued growth of the aquaculture industry in Canada, the demand for graduates of this program will clearly increase. One index of this lies in the current and the expected employment figures provided by a consulting firm in 1984 (Science Council of B.C., Envirocon Study). Estimates for the aquaculture industry in B.C. at that time were 450 full-time and 320 part-time currently employed with a projection to 10 years of 950 full-time and 650 part-time. Similarly, at the national level, information from the World Aquaculture Society indicates that in Canada in 1986 there were approximately 1000 licensed operations and 4000 hobby fish farms. The existence of these and the current growth of the industry indicates sustained and increasing demand for graduates with higher training. Moreover, even at the present time every issue of the World Aquaculture Society Newsletter lists employment opportunities with many requiring advanced degrees in aquaculture. Based on the current status of the

industry, its projected growth and existing opportunities, the demand for graduates will be high both provincially and nationally.

5. Current candidates for appropriate openings

At the present time this program is not available in B.C. at (a) Simon Fraser University or (b) other universities. Although graduates with advanced degrees in marine biology and fisheries might be considered for openings in the employment market they would lack the specialized training and interdisciplinary experience of graduates from the proposed program.

6. Student placement patterns in professional programs

Records of placement of graduates of the Master of Pest Management Program at Simon Fraser University indicate that of 84 graduates for whom this information is available, 6% found employment in teaching, 21% in industry and approximately 73% in a professional capacity (based on records of 84 graduates as of 1986).



## IV. PRESENT AND PROJECTED RESOURCES

1. Present faculty with expertise in marine biology and aquaculture - Appendix II.
2. Present undergraduate and graduate offerings in Biological Sciences - Appendix III.
3. Present facilities

**ON CAMPUS**

- 1 Flow-through refrigerated seawater system (capacity 10,000 gal).
- 1 Aquarium room - seawater and dechlorinated fresh water. Temperature maintained at 10-14°C, area 18' x 38' (research and restricted instruction).
- 1 Aquarium room - dechlorinated fresh water. Ambient temperatures, area 18' x 38' (research).
- 1 Teaching laboratory - serviced with seawater. Capacity 18 students. Microscopes and dissecting scopes available (teaching).
- 1 Teaching/Research Vessel - HM Albion - a 34' ship suitable for a variety of exercises.
- 4 Inflatable boats (12-14') with motors and safety gear.

**OFF CAMPUS**

Vancouver Public Aquarium - available for general tours and specific demonstrations on larval fish development and other aspects of animal husbandry important to mariculture.

Pacific Biological Station, Nanaimo - available for a variety of demonstrations important to mariculture.

Ramfield Marine Station - available for short and long term instruction in a variety of areas important to mariculture.

4. New Resource Requirements

This program will be offered providing adequate new resources are allocated to cover the following cost areas on a continuing basis:

- i) FACILITY - See budget.
  
- ii) SUPPORT PERSONNEL - A skilled person familiar with local aquaculture operations, able to organize field trips and oversee the aquaria.
  
- iii) SPACE - 1/2 lab/semester in Fall and Spring, similar to one of the present labs. Office space for faculty and space for graduate students.
  
- iv) CAPITAL COST -
  
- v) FIELD TRIPS -
  
- vi) MATERIALS AND SUPPLIES -
  
- vii) DIRECTOR AND OFFICE -
  
- viii) LIBRARY RESOURCES are being determined; if found inadequate, some costs will be incurred in acquiring these resources.

Budget

The main features of the budget are indicated below:

|                           | <u>Year 1</u>            | <u>Year 2</u>    | <u>Year 3</u>    | <u>Year 4</u>    |
|---------------------------|--------------------------|------------------|------------------|------------------|
| 1) Faculty <sup>a)</sup>  | 87,500.00                | 150,000.00       | 237,500.00       | 250,000.00       |
| 2) Support Personnel      | 17,500.00                | 30,000.00        | 30,000.00        | 30,000.00        |
| 3) Equipment              | 60,000.00                | --               | --               | --               |
| 4) Field Trips            | 20,000.00                | 30,000.00        | 30,000.00        | 30,000.00        |
| 5) Materials and Supplies | 14,000.00                | 24,000.00        | 24,000.00        | 24,000.00        |
| 6) Director & Office      | <u>12,833.00</u>         | <u>22,000.00</u> | <u>22,000.00</u> | <u>22,000.00</u> |
|                           | 211,833.00               | 256,000.00       | 343,500.00       | 356,000.00       |
|                           | TOTAL FOR FIRST 3 YEARS: |                  | \$811,333.00     | continuing       |

a) Faculty: The final faculty complement will include:

- i) The equivalent of two faculty positions in the Faculty of Science in the areas of Fish Disease and Nutrition. Two to four short term (4-12 months) faculty will be hired each year to provide instruction in those areas where the university currently lacks expertise or alternatively to replace those of our faculty who are heavily involved in the program. The total cost of this is assumed to be equivalent to two full-time faculty.
- ii) Three faculty positions in the Faculties of Arts, Applied Sciences, and Business Administration in the areas of Fisheries Economics, Resource Management, Marketing and Business Administration. Until such time as full-time appointments are made, short-term appointments will be utilized.

Some of the people currently being considered for short-term appointments are listed below:

Aquacultural Economics:

Dr. Trond BJORNDAL, Norway School of Economics and Business Administration, Bergen Norway (see attached course outline)

Dr. Jean Claude Michaud, Universite Quebec Rimouski, Marine Resource Management, Rimouski, Quebec

Both will be at SFU for their sabbaticals and will be teaching Aquacultural Economics.

Fish Diseases

Dr. T.P. Evelyn, Dept. of Fisheries and Oceans, Pacific Biological Station,  
Nanaimo, B. C. - SFU Adjunct Professor

Dr. R. Roberts, Head, School of Aquaculture, Stirling University, Stirling  
Scotland

Fish Nutrition

Dr. D. Higgs, Dept. of Fisheries and Oceans, West Vancouver Lab, West Vancouver

Fish Reproduction

Dr. E.M. Donaldson, Dept. of Fisheries and Oceans, West Vancouver Lab., West  
Vancouver

Revised and updated April 30, 1987

V. EVALUATION

1. Through the offices of the Department of Fisheries and Agriculture and the Universities Council of British Columbia we have communicated our proposed program to other British Columbia universities and to British Columbia colleges and interested government agencies. Evaluations of our program by these two agencies were thus independently derived.

2. A preliminary evaluation of a postgraduate program in aquaculture was solicited from the following:

Mr. R. Baden, Mariculture Association of B.C. President and mussel/oyster grower.

Dr. R. Foreman, Director, Arts, Sciences and Technology Centre, and algae aquaculturalist.

Mr. B. Hope, President, Pacific Aqua Foods Ltd.

Mr. B. Leaman, West Trout Growers.

Mr. T. May, B.C. Salmon Growers' Association, Executive and salmon grower.

Mr. P. McLelland, B.C. Oyster Growers Association, Executive.

Dr. T. Mumford, Nori expert, Washington State Department of Natural Resources.

Dr. R. Waaland, Professor, University Washington, active in seaweed aquaculture.

Thus far we have received responses from Drs. R. Foreman, R. Waaland and R. Baden (attached).

3. Our proposed program will be scrutinized at various University levels for quality. Further, we intend to maintain very close liaison with Malaspina College and the Department of Fisheries and Agriculture during all stages of design and implementation.
  
4. We will confer with an advisory committee, consisting of industrialists, government representatives and educators on a semi-annual basis. It is our intention that the committee will provide client feedback and long-term evaluation for our program.

Part III

THE ADVISORY COUNCIL AND TECHNOLOGY TRANSFER

## SIMON FRASER UNIVERSITY

OFFICE OF THE DEAN  
FACULTY OF ARTS

TO: Walter Wattamaniuk ✓  
Secretary SCAP

FROM: Sheila Roberts  
Secretary, Faculty  
of Arts Graduate  
Studies Committee

RE: New Course

DATE: October 11, 1989

The Faculty of Arts Graduate Studies Committee at its meeting of 11 October 1989, approved the enclosed new course ECON 663-4: The Economics and Management of Aquaculture, for inclusion in the Aquaculture Program. This course will be included in the Economics Graduate Course Listing, but will not count towards a Graduate Degree in Economics.

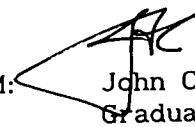
*Sheila Roberts*

/kcp  
encl.

c: J. Chant  
Economics Department

SIMON FRASER UNIVERSITY  
MEMORANDUM

TO: Chairman, Graduate Studies Committee  
Faculty of Arts

FROM:  John Chant, Chairman  
Graduate Program  
Economics

RE: Econ 663

DATE: June 26, 1989

Economics 663, The Economics and Management of Aquaculture has been designed to provide an economics component for the Master of Aquaculture Program. Although the course will not be offered by permanent faculty of the Department of Economics, arrangements will be made to obtain fully qualified instructors that have indicated willingness to offer the course. The course will not carry credit for the M.A. and Ph.D. degrees in the Department of Economics.



New Graduate Course Proposal Form

CALENDAR INFORMATION:

Department: Economics Course Number: 663  
 Title: The Economics and Management of Aquaculture  
 Description: Introduction to the economic theory and management techniques  
relating to Aquaculture.  
 Credit Hours: 4 Vector: 3-1-0 Prerequisite(s) if any: \_\_\_\_\_

ENROLLMENT AND SCHEDULING:

Estimated Enrollment: 10 When will the course first be offered: 90-2  
 How often will the course be offered: once a year

JUSTIFICATION:

Part of Master of Aquaculture core program.

RESOURCES:

There is currently no faculty on  
 Which Faculty member will normally teach the course: permanent staff competent to teach this  
course.  
 What are the budgetary implications of mounting the course: \_\_\_\_\_  
Provision will have to be made to staff this course.

Are there sufficient Library resources (append details): Library resources being determined.

- Appended: a) Outline of the Course See attached letter to S. Thomas.  
 b) An indication of the competence of the Faculty member to give the course.  
 c) Library resources

Approved: Departmental Graduate Studies Committee: \_\_\_\_\_ Date: \_\_\_\_\_  
 Faculty Graduate Studies Committee: [Signature] Date: Oct. 11/89  
 Faculty: \_\_\_\_\_ Date: \_\_\_\_\_  
 Senate Graduate Studies Committee: [Signature] Date: \_\_\_\_\_  
 Senate: \_\_\_\_\_ Date: \_\_\_\_\_

## COURSE DESCRIPTION

### THE ECONOMICS AND MANAGEMENT OF AQUACULTURE

#### ECONOMICS 643

The course introduces the student to economic theory and management techniques relating to aquaculture. Extensive applications to real world aquaculture are made, with an emphasis on salmon farming. The course consists of three parts.

In part one the aquaculture production process is analysed. Markets for salmon and marketing of farmed salmon are surveyed. The rationale for regulation of aquaculture is studied. Finally, the industrial structure of different salmon farming industries is compared and explained.

In part two management techniques relevant to fish farms are analysed. These include investment analysis, production planning, cash-flow budgeting and cost analysis, with application to hatcheries as well as grow-out farms.

The third part of the course deals with optimal harvesting (bioeconomic analysis) in aquaculture. Relevant theory is covered, and the student is introduced to personal computer models for optimal harvesting.

Lectures            Topic and Readings

Part I:    The Production process and salmon aquaculture

Introduction

The production process in aquaculture

Regulations of aquaculture

Readings:    Allen et al, Ch. 1; Shang, Chapters 1 and 2

The industrial structure of the Norwegian salmon  
aquaculture industry

Salmon aquaculture in other countries (with emphasis on  
B.C. and Chile)

Markets and market outlook for salmon

Readings: Bjørndal, Chapters 1, 2 and 6;

Bjørndal and Schwindt; Ruckes; Lin and Hermann;

Lindberg; Shaw and Muir, Chapters 2 and 8.

Case study:    Investment in salmon aquaculture in Norway,  
B.C., and Chile (class discussion)

Conjoint analysis of salmon markets

Guest lecture by Dr. J. Anderson, University of Rhode  
Island

Readings:    Anderson and Brooks; Anderson (1987)

Part II:    Management models

Investment in a salmon hatchery:    Production planning  
and financial analysis (Norwegian data).

Investment in a salmon farm:    Production planning and  
financial analysis (Norwegian and/or B.C. data).

Application of a financial planning model to investments  
in salmon farm (Personal Computer model).

Reading:    Bjørndal, Ch. 3

Midterm

Cost of production in salmon aquaculture.

Application of cost of production model (PC-model)

Readings:    Bjørndal, Ch. 3; Salvanes; Shaw and Muir,  
Chapter 5

Case study:    Use of PC models

Part III: Bioeconomic analysis

Optimal harvesting: Discrete time model (undergraduates only)

Reading: Bjørndal, Ch. 5

Optimal harvesting: Continuous time analysis

Reading: Bjørndal, Ch. 4

Optimal harvesting: Advanced analysis, including uncertainty (graduate students only)

Reading: Arnason; Lillestol

Ocean ranching

Reading: Anderson (1985), Anderson (1985a), Shaw and Muir Chapter 4, Stokes

Case study: Optimal harvesting

Field trip

Term paper presentations

## References

- P.G. Allen, L.W. Botsford and W.E. Johnston (1984) Bioeconomics of Aquaculture Amsterdam: Elsevier.
- J.L. Anderson (1985) "Private Aquaculture and Commercial Fisheries: Bioeconomics of Salmon Ranching" Journal of Environmental Economics and Management 12: 353-370
- J.L. Anderson (1985a) "Market Interactions Between Aquaculture and the Common Property Commercial Fishery" Marine Resource Economics 2: 1-24
- J.L. Anderson (1987) "Strategic Design and Marketing of Aquacultured Salmon" Paper presented at the symposium on markets for seafood and aquacultural products (Charleston, SC, August 19-21, 1987)
- J.L. Anderson and P. Brooks (1986) "Conjoint Analysis of the New England Salmon Market". Prepared for Fisheries and Oceans Canada, Vancouver, B.C.
- R. Arnason (1987) "Optimal Feeding Schedule and Harvesting Time in Aquaculture" Unpublished mimeo
- T. Bjørndal (1988) Economics of Aquaculture (selected chapters in translation)
- T. Bjørndal and R. Schwindt (1987) "Norwegian Direct Investment in the British Columbia Salmon Aquaculture Industry: A Case Study" Discussion Paper No. 1/1987, Institute of Fisheries Economics, Norwegian School of Economics and Business Administration
- J. Hillestol (1986) "On the Problem of Optimal Timing of Slaughtering in Fish Farming" Modeling, Identification and Control 7: 199-207.
- B. - H. Lin and M. Herrmann (1987) "An Economic Analysis of Atlantic Salmon Markets" Paper presented at the symposium on markets for seafood and aquaculture products (Charleston, SC, August 19-21, 1987)
- J. Lindbergh (1987) "The Economic Potential for the Commercial Production of Atlantic and Pacific Salmon in Chile" Paper presented at the Fundacion Chile conference on salmon aquaculture (Santiago, March 17-19, 1987)
- E. Ruckes (1987) "World Production and Salmon Markets: An Overview" Paper presented at the Fundacion Chile conference on salmon aquaculture (Santiago, March 17-19, 1987)
- K. Salvanes (1987) "The Structure of the Norwegian Fish Farming Industry: An Empirical Analysis of Economics of Scale" Discussion paper No. 3/1987, Institute of Fisheries Economics, Norwegian School of Economics and Business Administration
- Y.C. Shang (1981) Aquaculture Economics: Basic Concepts and Methods of Analysis. Boulder: Westview Press
- S.A. Shaw and J.F. Muir (1987) Salmon: Economics and Marketing London: Croom Helm
- R.L. Stokes (1982) "The Economics of Salmon Ranching" Land Economics 58: 464-477

New Graduate Course Proposal Form

CALENDAR INFORMATION:

Department: Business Administration Course Number: 542  
5XX  
Title: Aquaculture Marketing  
Description: The marketing of aquaculture products and related services to business  
and other non-consumer sector buyers  
Credit Hours: 4 Vector: 4-0-0 Prerequisite(s) if any:

ENROLLMENT AND SCHEDULING:

Estimated Enrollment: 10 When will the course first be offered: subject to funding  
How often will the course be offered: 1/year

JUSTIFICATION:

Part of Master of Aquaculture Core Program

RESOURCES:

Which Faculty member will normally teach the course: Lindsay Meredith  
What are the budgetary implications of mounting the course: course will be fully funded  
by Aquaculture Program

Are there sufficient Library resources (append details): yes

Appended: (a) Outline of the Course  
(b) An indication of the competence of the Faculty member to give the course.  
c) Library resources

Approved: Departmental Graduate Studies Committee: \_\_\_\_\_ Date: \_\_\_\_\_  
Faculty Graduate Studies Committee: [Signature] Date: Mar 20/89  
Faculty: Lindsay Meredith Date: Mar 20/89  
Senate Graduate Studies Committee: [Signature] Date: 12 Oct/89  
Senate: \_\_\_\_\_ Date: 37.

## ***Economics***

ECON 863 (4) Fisheries Economics  
ECON 864 (4) Studies in Economic Fisheries Management

An advanced course in Aquaculture Economics, requiring ECON 6XX as a prerequisite, will be proposed by the faculty member designated to support the Master of Aquaculture program.

## ***Marketing***

A graduate course in Aquaculture Marketing, 5XX, is proposed to support the Master of Aquaculture program.

This course is being proposed as an introductory graduate level course in Marketing. In addition to satisfying the Marketing requirements of Aquaculture, we see it as being an ideal course for those students entering the Master of Business Administration program who need an introductory marketing course prior to taking the specialized marketing courses in the program.

As well, subject to available space (we could not reasonably handle more than 30 students in a graduate course of this type), and prior to approval of the instructor, we would make such a course available to any student on campus who needs an introductory graduate level course in Marketing.

## AQUACULTURE MARKETING

### Master of Aquaculture

This course deals with the marketing of aquaculture products and related services to business and other non-consumer sector buyers. The student will be expected to apply the essential theoretics of business sector marketing specifically to the problems of selling aquaculture output. The course will introduce the concepts of demand estimation; marketing mix principles (product, price, distribution and promotion); market control mechanisms and; the development of marketing plans. Students will be expected to complete a major demand estimation project for an aquaculture product or service.

### RATIONALE

The marketing component of the aquaculture program is proposed for two reasons:

1. Many graduates of the proposed Master of Aquaculture program are expected to enter the aquaculture industry directly or to work with aquaculture related organizations. Personnel working in either of the aforementioned capacities will be expected to possess not only an understanding of the physical sciences role in aquaculture but also to have a basic understanding of the management sciences which are applicable. The aquaculture and marketing course is expected to provide students with a functional background which will at the very least: enable them to recognize marketing related problems in aquaculture; determine the need for help if necessary and; evaluate the effectiveness of suggested solutions to their problems.

While this course is not intended to produce marketing specialists, it will be more than sufficient to create an educated group of marketing services consumers who are capable of evaluating the work of marketing consultants.

2. Among those aquaculture graduates who continue their education or work in research areas the marketing course should prove useful in applying for research funds. Specifically, many government and other granting agencies now request that market feasibility studies accompany applications for physical sciences funding. The training provided in this course should be sufficient to enable aquaculture graduates to carry out this task without having to spend "front-end" money to purchase such services.



**COURSE OUTLINE - AQUACULTURE MARKETING**

1. INTRODUCTION TO AQUACULTURE MARKETING
  - Macroenvironment
  - Aquaculture Marketing Systems & Constraints
2. ORGANIZATIONAL BUYING BEHAVIOUR
  - Buyer Behaviour
  - Buyer/Seller Interaction
3. AQUACULTURE MARKET SEGMENTATION
  - Primary Product Segmentation Strategies
  - Resource Markets - The Problem of Segmenting for Secondary Outputs
4. DEMAND ESTIMATION
  - Market Definition
  - Direct & Indirect Substitutes
  - Complementary Products
5. PRODUCT
  - Product Monitoring Procedures
  - New Product Introduction
6. PRICE
  - Pricing Strategies
  - Pricing Procedures
7. DISTRIBUTION
  - Channel Management & Design
  - Logistics
8. PROMOTION
  - Advertising & Promotion
  - Personal Selling
9. SALES FORECASTING
  - Forecasting Techniques
10. MARKET PLANNING & STRATEGY
  - Marketing Plans
  - Strategic Decision Making
11. MARKET CONTROL SYSTEMS
  - Market Monitoring Procedures
  - Customer Profile Systems

12. INTERNATIONAL AQUACULTURE MARKETING

- International Marketing
- Cultural Constraints
- Joint-venturing

RECOMENDED TEXTS:

1. (A) Industrial Marketing, Analysis Planning & Control, Robert R. Reeder, Edward G. Brierly & Betty H. Reeder, Prentice Hall, 1986.

OR

- (B) Industrial Marketing Management, Michael D. Hull & Thomas W. Spoh, Dryden Press, 2nd Ed., 1984.

2. Marketing in Fisheries & Aquaculture, Ian Chaston, Fishing News Books Ltd., England, 1983.

# SIMON FRASER UNIVERSITY

## MEMORANDUM

To..... *R. Peterman*  
..... *M.R.M.*  
Subject.....

From..... *Marian McGinn*  
..... Registrar's Office  
Date..... *March 10, 1989*

The proposed Master's Program in Aquaculture was referred back to the Senate Graduate Studies Committee because it wasn't 100% clear that the new courses associated with the proposal had all been approved by their respective faculties and had been considered on their own merits (as opposed to being part of the package).

Would you please ensure that all courses have been approved by the various committees and sign in the appropriate places on the course proposal forms.

I would appreciate receiving these proposals back by Thursday, March 16, 1989, as they are to be on the Agenda of the Senate Graduate Studies Committee for the meeting on April 3, 1989.

Thanks!

*Marion*

*ph 3/88*

*17 March '89*

*Marion,*

*This course proposal was examined on its own merits by the Faculty of Applied Sciences Graduate Studies Comm. on 24 June 1988. That Committee approved it as indicated by Dave Goodman's signature. The Master's Program in Aquaculture proposal was not discussed at that meeting. Thank you for taking care of this.*

*Randall M. Peterman*

*H2.*

CALENDAR INFORMATION:

Department: Natural Resources Management Program Course Number: MRM <sup>615</sup>~~612~~

Title: Management of Aquaculture Resources

Description: Environmental, political, and social issues related to siting and operation of aquaculture facilities. Topics drawn from coastal zone management, regional planning public policy analysis; environmental and social impact assessment; resource law and ecology.

Credit Hours: 3 Vector: 3-0-0 Prerequisite(s) if any: none

ENROLLMENT AND SCHEDULING:

Estimated Enrollment: 12-15 When will the course first be offered: 88-1

How often will the course be offered: Once per year

JUSTIFICATION:

The topics covered in this course are an essential component of the core program. Aquaculturalists must be made aware of the broad issues that are raised by their facilities.

RESOURCES:

New faculty with contributed lectures by Drs. Day, M'Gonigle, and Peterman

Which Faculty member will normally teach the course: \_\_\_\_\_

What are the budgetary implications of mounting the course: Cost of new faculty

Are there sufficient Library resources (append details): See attached letter

- Appended: a) Outline of the Course
- b) An indication of the competence of the Faculty member to give the course.
- c) Library resources

Approved: Departmental Graduate Studies Committee: Randall M. Peterman Date: 27 Nov 1987

Faculty Graduate Studies Committee: [Signature] Date: Jan 24/88

Faculty: \_\_\_\_\_ Date: \_\_\_\_\_

Senate Graduate Studies Committee: BPCC Date: 12 Oct/89

Senate: \_\_\_\_\_ Date: 43.

Resource Management of Aquaculture

MRM <sup>615</sup>~~617~~

This course will focus on broad issues that emerge from aquaculture facilities, including environmental, political, and social problems. Topics will be drawn from the fields of coastal zone management, regional planning, public policy analysis, environmental and social impact assessment, resource law, and ecology.

- A. Environmental issues
  - 1. Site feasibility
  - 2. Shoreline land use conflicts
  - 3. Water quality
  - 4. Aesthetics
  
- B. Political issues
  - 1. Regulations -multiple government agencies with conflicting requirements
  - 2. Legal jurisdictions
  - 3. Competitive use of resources such as egg supply (who gets priority when eggs are limited, public or private facilities?)
  - 4. Roles of government vs. private agencies in:
    - a. Basic research
    - b. Selective breeding of brood stock
    - c. Supply of feed
    - d. Extension services
    - e. Research on processing and transportation of product
  
- C. Social issues
  - 1. Impacts on communities and interest groups
  
- D. Ecological problems
  - 1. Intensive aquaculture (control over entire life span of organism)
  - 2. Extensive aquaculture (control over only part of life span)
  - 3. Interactions between species when target species is released from rearing facility
    - a. Predator numerical responses
    - b. Density-dependent marine growth and survival
    - c. Spread of disease and parasites
    - d. Confounding of measures of success
  - 4. Responses to relaxation of natural selection
  
- E. Experimental design of facilities and operating procedures
  - 1. To evaluate improvements
  - 2. To avoid confounding of results
  - 3. To identify time-treatment interactions
  - 4. Statistical power

Note: Some sections of this course will be expanded and others contracted, depending on the specific area of expertise of the new faculty member who will be responsible for this course. It may also be necessary to offer another course in order to cover the material in adequate depth.

## PRESENT FACULTY WITH EXPERTISE IN MARINE BIOLOGY AND AQUACULTURE

|                 |   |
|-----------------|---|
| L.J. Albright   | Marine Microbiology, Fish and shellfish diseases                        |
| L.M. Dill       | Behavioural Ecology of Fishes   |
| L.D. Druehl     | Marine phycology, Ecology, Mariculture                                  |
| P.V. Fankboner  | Marine Invertebrate Biology, Invertebrate Nutrition                     |
| G.H. Geen       | Marine and Freshwater Ecology, Plankton Ecology Salmonid Biology        |
| E.B. Hartwick   | Marine Invertebrate Ecology, Cephalopod Biology                         |
| B.A. McKeown    | Fish Physiology, Endocrinology, Aquaculture Research                    |
| M.J. Smith      | Molecular Biology, Developmental and Cell Biology of Marine Echinoderms |
| L.M. Srivastava | Cell Biology, Physiology and Biochemistry of Kelp                       |
| R.C. Ydenberg   | Behavioural Ecology, Predation in Marine Environment                    |

Adjunct Professors

|               |                             |
|---------------|-----------------------------|
| T.P.T. Evelyn | Fish Diseases and Pathology |
| Z. Kabata     | Fish Parasitology           |
| L. Margolis   | Fish Parasites and Diseases |

Associate Members

|               |  |
|---------------|--|
| R.M. Peterman | Fish population dynamics and modelling |
|---------------|--|

## PRESENT UNDERGRADUATE AND GRADUATE OFFERINGS

Undergraduate

- BISC 306-3 Invertebrate Biology**  
An introduction to the selected invertebrate phyla with emphasis on functional morphology, diversity and ecology. Normally, a compulsory weekend field trip to a marine station is required with this offering. (3-0-3)
- BISC 326-3 Biology of Non-vascular Plants**  
A survey of form, function and phenetics. (2-0-3)
- BISC 403-3 Microbial Ecology**  
A study of the interaction of bacteria, algae and fungi with their physical, chemical and biological environment. Occasional field trips may be required as part of the course.  
Prerequisite: BISC 303 (2-0-4)
- BISC 408-3 Parasitic Associations**  
The biological, ecological and genetic aspects of biotic associations including commensalism, mutualism and parasitism; aspects of host-parasitic interactions and the concept of disease; adaptive modifications and parasite evolution. (2-0-3)
- BISC 414-3 Limnology**  
Biological, chemical and physical features of lakes and other inland waters. Particular attention will be directed to an examination of lakes in Western Canada and the impact of human activities on them. Local field trips form part of the laboratory work. (2-0-4)
- BISC 421-3 Biotechnology**  
Laboratory with accompanying lectures to give practical experience in the application of industrial microbiology and the new recombinant DNA technology. (2-0-4)
- BISC 424-3 Marine Biology and Oceanography**  
Contemporary topics in marine biology, including descriptive oceanography, with emphasis on the ecology of planktonic and benthic organisms. Field trips are normally a requirement of this course. (2-0-4)
- BISC 445-3 Environmental Physiology of Animals**  
A discussion of the physiological mechanisms and adaptations which permit animals to live in diverse environments. The course will adopt a comparative approach to physiology. (3-1-0)

- BISC 455-3 Endocrinology**  
A study of endocrine organs and their role in integrating physiological functions in animals. (3-1-0)
- BISC 490-5 Research Design**
- BISC 491-5 Research Technique**
- BISC 492-5 Research Reporting**
- BISC 498-3 Undergraduate Research**  
Students who wish to take this course must have completed their 6th semester in Biology. A student will be permitted to enrol in this course only if he/she obtains the prior written agreement of a professor to act as research adviser.
- BISC 471-02 Biology of Seaweeds**  
The contemporary biology of seaweeds is reviewed. Emphasis is on the comparative adaptability of seaweeds inhabiting different environments. Students may be required to complete a research project.
- BISC 472 Marine Invertebrate Ecology**  
Ecology of marine shallow water organisms at the population, community and ecosystem level. Theoretical and applied aspects of marine benthic ecology. (2-0-4)
- BISC 473 Fish Biology**  
An introduction to the biology of fishes with an emphasis on classification, evolution, anatomy, physiology and ecology. (3-0-4)

### Marine Science Courses

- NOTE:** These courses are generally offered at the Bamfield Marine Station, Vancouver Island, during the summer. See page 125 for further information.
- MASC 400-6 Directed Studies**  
A course of directed studies under the supervision of a member of faculty. The study will involve a research project approved by the supervisor in the field of interest of the student, and will be designed to take maximum advantage of the laboratory and/or field opportunities offered by the Bamfield Marine Station.
- MASC 401-6 Special Topics in Marine Biology**  
Offered, as opportunities arise, by visiting scientists who are working at the Bamfield Marine Station. It is expected that the course will generally be of a specialized nature and be at a level appropriate to senior undergraduate students.  
Prerequisite: Will vary and will be announced in advance of the course offerings.



- MASC 402-3 Special Topics in Marine Biology**  
Offered, as opportunities arise, by visiting scientists who are working at the Bamfield Marine Station and are prepared to offer a course extending over a 3-week period. Course will be of a specialized nature.  
Prerequisite: Will vary and will be announced in advance of the course offering.
- MASC 410-6 Marine Invertebrate Zoology**  
A survey of the marine phyla, with emphasis on the benthic fauna in the vicinity of the Bamfield Marine Station. The course includes lectures, laboratory periods, field collection, identification, and observation. Emphasis is placed on the study of living specimens in the laboratory and in the field.
- MASC 411-6 Comparative Embryology of Marine Invertebrates**  
A comprehensive study of development of marine invertebrates available at the Bamfield Marine Station including all major phyla and most of the minor phyla. Lectures will cover gametogenesis, fertilization, regeneration, cell lineage, mosaic and regulated development, larval development and metamorphosis of the different groups. Laboratory work will include methods and techniques of obtaining and handling gametes, preparation and maintenance of larval cultures and observation of development up to metamorphosis if possible. Some selected and clearly defined classical experiments will be performed. Efforts will also be made to study various pelagic larvae.  
Prerequisite: BISC 306 or 316.
- MASC 412-6 Biology of Fishes**  
Classification, physiology, ecology, behavior and zoogeography of fishes with particular emphasis on those in the marine environment of the British Columbia coast. Local collections from a variety of habitats will be used for experimental studies.  
Prerequisite: BISC 316
- MASC 413-3 Biology of Marine Molluscs**  
An advanced course of selected topics emphasizing functional morphology, ecology and evolution of this diverse phylum. Field trips will be undertaken to survey the representative molluscs of the Bamfield region. Students will be expected to complete an independent field or laboratory study of selected molluscs.
- MASC 420-6 Marine Phycology**  
A survey of the marine algae with emphasis on the benthic forms in the vicinity of the Bamfield Marine Station. The course includes lectures, laboratory periods, field collection, identification, and observation. Emphasis is placed on the study of living specimens in the laboratory and in the field.

- MASC 430-6 Marine Ecology**  
An analytical approach to biotic associations in the marine environment. Opportunities will be provided for study of the intertidal realm in exposed and protected areas and of beaches and estuaries in the vicinity of the Bamfield Marine Station; plankton studies and investigations of the subtidal and benthic environments by diving and dredging are envisaged.  
Prerequisite: BISC 306 or 326.
- MASC 435-6 Introduction to Biological Oceanography**  
An introduction to the biology of the oceans, with supporting coverage of relevant physics and chemistry. Emphasis will be placed on plankton biology, community structure and life histories, and influencing environmental factors. Collections will be made from sheltered inlets, through Barkley Sound to offshore waters. The course will involve both field and laboratory studies of plankton organisms.  
Prerequisites: BISC 306 or 326. Students may not receive credit for both MASC 435 and BISC 424.
- MASC 440-3 Biology of Marine Birds**  
The interrelationship of birds and the marine environment. Lectures will emphasize the systematics and ecological relationships, behaviour, life histories, movements and conservation of marine birds. Census techniques and methods of studying marine birds in the field will be stressed during field trips in the Barkley Sound region. Seabird identification, classification, morphology, plumages and molt will be examined in the laboratory.
- MASC 445-3 Biology of Marine Mammals**  
A survey course covering systematics and distribution of marine mammals, their sensory capabilities and physiology, with special emphasis on the Cetacea. The course includes lectures, laboratory periods and numerous field trips in the Barkley Sound region. The course will involve an independent field study.
- MASC 446-3 Comparative Ethology**  
A comparative study of marine animals (vertebrate and invertebrate) emphasizing behavioural description, underlying physiological mechanisms, the biological significance of behaviour and behavioural evolution. The course will include independent laboratory and field studies.

### Graduate Courses

- BISC 814-3 Aquatic Ecology**  
Current problems in the ecology of marine and freshwater environments. Topics will be selected from recent developments in physiological ecology, energetics, population ecology and community studies.

**BISC 832-3 Marine Microbiology**

The relationship of marine microbes to the biological, chemical and physical parameters of the oceanic environment.

**BISC 834-4 Marine Plant Ecology**

Lectures and student projects on the relationships of marine plants to their physical and biological environments. Benthic algae will be stressed.

## SIMON FRASER UNIVERSITY

MEMORANDUM

TO: L.M. Srivastava, Chairman      FROM: Sharon Thomas,  
Dept. of Biological Sciences      Head, Collections  
Management Office

SUBJECT: MASTER'S PROGRAM IN      DATE: October 8, 1987  
AQUACULTURE

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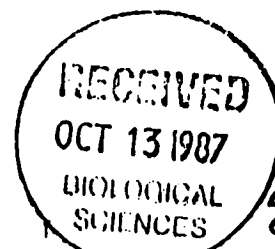
The Library will be able to support the proposed new MASTER'S PROGRAM IN AQUACULTURE without enormous expense because of the existing collections in Biological Sciences, Economics and Business Administration. These collections were built during the last twenty-two years and were themselves supplemented by additional materials acquired to support the Institute of Fisheries Analysis and the Natural Resources Management Program.

Normal acquisitions in this area were supplemented between 1982 and 1985 by a SSHRC grant for the purchase of library materials in Fisheries Resource Management. This grant enabled us to acquire a significant body of material emphasizing the social sciences aspects of fisheries management. Funds were used to purchase backfiles for relevant journals, documents from the FAO and current monographs which had not been previously owned by the Library.

Approval plans currently in place ensure full coverage for the following areas relating specifically to this program:

Marine Ecology, including  
Salt water ecology  
Fresh water ecology  
Estuarine ecology

...2



Aquatic Biology, including  
Salt water biology  
Fresh water biology  
Plankton  
Aquatic flora  
Aquatic fauna

Less comprehensive coverage, consisting of a forms notification service from which desired titles are selected and ordered is presently in operation for:

Fishes and Fish Culture, including  
Hatcheries and fisheries  
Shellfish culture

Diseases of Fish

Coverage for these areas should probably be upgraded at an estimated average annual cost of \$1,500.

Nevertheless, the existing collection is strong enough to provide basic support for the proposed new courses. In fact, titles cited in the proposed course descriptions are, without exception, either in the collection or already on order. The current topic courses will undoubtedly require additional and undetermined future additions.

Although the Library's journal collection has not been augmented lavishly during the past few years, we do have significant holdings in journals for the relevant disciplines as well as good runs of the following titles:

American Fisheries Society. Transactions.

Aquaculture

Aquaculture and Fisheries Management

Aquatic Toxicology

Bulletin Stastique des Peche Maritimes

In addition, the Library owns a complete set of the major abstracting journal:

Aquatic Sciences and Fisheries Abstracts

Nevertheless, it is certain that here, as elsewhere, new journals will be desired and I have recently received requests for:

Diseases of Aquatic organisms

Fish Physiology and Bio-Chemistry

I believe the annual cost of acquiring and binding the necessary new journals will be approximately \$500.

In summary, the proposed MASTER'S PROGRAM IN AQUACULTURE will probably add the following annual costs to the Library's present obligations:

|                |            |
|----------------|------------|
| Books -----    | \$ 1,500   |
| Journals ----- | <u>500</u> |
|                | \$ 2,000   |

ST

53.

66

To: L. M. Srivastava, Chairman,  
Dept. of Biological Sciences

From: Sharon Thomas, Head  
Collections Management Office

Subject: Library Resources in Biotechnology and Aquaculture

Date: February 5, 1987

Thanks for sending me copies of these two proposals. Now that I have them in hand it shouldn't take too long to evaluate the Library's ability to support them.

*Sharon Thomas*

RECEIVED  
FEB-6 1987  
BIOLOGICAL  
SCIENCES

54.

CALENDAR INFORMATION:

Department: Biological Sciences Course Number: BISC <sup>630</sup>~~631~~

Title: INTRODUCTION TO AQUACULTURE SYSTEMS

Description: An introduction to aquaculture and review of the major cultivated groups - fish, invertebrates and algae

Credit Hours: 5 Vector: 3-0-4 Prerequisite(s) if any:

ENROLLMENT AND SCHEDULING:

Estimated Enrollment: 12-15 When will the course first be offered: 87-3

How often will the course be offered: Once per year

JUSTIFICATION:

An indispensable course for aquaculture as an introduction to species cultured and the theoretical basis for techniques and procedures.

RESOURCES:

Which Faculty member will normally teach the course: McKeown, Hartwick and Druehl

What are the budgetary implications of mounting the course: Replacement teaching time, special lectures and seminars as well as site visits.

Are there sufficient Library resources (append details): Library resources are being determined. See attached letter to S. Thomas, Library.

- Appended:
- a) Outline of the Course
  - b) An indication of the competence of the Faculty member to give the course.
  - c) Library resources

Approved: Departmental Graduate Studies Committee: D. V. C. Brooks Date: 17 February 1987

Faculty Graduate Studies Committee: P. W. Perin Date: 16 March 1987

Faculty: CHW Jones Date: 16 March 1987

Senate Graduate Studies Committee: B. P. C. Date: 12 Oct/81

Senate: \_\_\_\_\_ Date: \_\_\_\_\_



## Lectures.

- 1-3 Review of world-wide aquaculture production and methods, limnology, and coastal oceanography.
- 4-8 Overview of aquaculture strategies, risks (biological, physical, chemical), management, planning, techniques, products and terminology.
- 9-24 **Fish culture**  
 Species amenable to culture and specific requirements (biological, physical).  
 Water quality.  
 Environmental factors - temperature, salinity, photoperiod, oxygen, flow, etc.  
 Growth - feeding rates, requirements, techniques, strategies.  
 Breeding - genetics, selective breeding, hybridization, brood stock management, fertilization, triploidy, egg incubations, data collection and assessment, harvesting, handling, marketing.
- 25-32 **Invertebrate culture**  
 Species cultured and specific requirements (biological and physical).  
 Growth and maturation - nutritional requirements and techniques (sowing, racks, rafts, long line, etc.)  
 Breeding, fertilization, development and larval stages for seeding.
- 33-39 **Algal culture.**  
 Species cultured and specific requirements (biological and physical).  
 Growth (seed, germlings, grow out sporophytes)  
 Culture techniques for various life cycle stages.

## Demonstrations and site visits.

There will be an extensive field component for practical experience and appreciation of actual methods and problems. There will also be regular visits to local hatcheries, fish farms, oyster leases and laboratories.

## Course books

- Barduck, J.E., J.H. Ryther and W.O. McLarney. 1972. Aquaculture. John Wiley & Sons, Inc., New York.
- Brown, E.E. and J.B. Gratzek. 1980. Fish Farming Handbook. Avi Publ. Co. Inc., Westport, Conn.
- Imai, T. 1977. Aquaculture in Shallow Seas. Prem Printing Press, Lucknow, India.
- Kafuku, T. and H. Ikenoue. 1983. Developments in Aquaculture and Fisheries Science. Elsevier Scientific Publ. Co., Amsterdam.
- McLarney, W. 1984. The Freshwater Aquaculture Book. Hartley & Marks Publ., Wash.
- McVey, J.P. 1983. CRC Handbook of Mariculture. CRC Press, Inc., Florida.
- Muir, J.F. and R.J. Roberts. 1982. Recent Advances in Aquaculture. Croom Helm Publ., London.
- Pillay, T.V.R. and W.A. Dill. 1979. Fishing News Books Ltd., Farnham, Surrey, England.
- Watson, A.S. 1979. Aquaculture and Algal Culture. Noyes Data Corp., Park Ridge, New Jersey.

**CALENDAR INFORMATION:**

**Department:** Biological Sciences **Course Number:** BISC 632  
 632  
 632

**Title:** Salmonid Fish Diseases and Their Control

**Description:** Pathophysiology and systematic pathology of salmonids, various viral, bacterial, fungal, protozoan, metazoan and phytoplankton diseases of salmonids - isolation and detection.

**Credit Hours:** 5 **Vector:** 3-0-4 **Prerequisite(s) if any:**

**ENROLLMENT AND SCHEDULING:**

**Estimated Enrollment:** 12-15 **When will the course first be offered:** 87-3

**How often will the course be offered:** Once per year

**JUSTIFICATION:**

One of the major problems with domesticated salmonids is diseases. In aquacultural situations these problems are multiplied. This course is thus necessary to give students the theoretical background on salmonid diseases and also the techniques for isolation and detection.

**RESOURCES:**

**Which Faculty member will normally teach the course:** Dr. L. Albright

**What are the budgetary implications of mounting the course:** There will be costs associated with materials and supplies, fish and replacement salary for the faculty who would normally be teaching other courses.

**Are there sufficient Library resources (append details):** Library resources are being determined. See attached letter to S. Thomas, Library.

**Appended:** a) Outline of the Course  
 b) An indication of the competence of the Faculty member to give the course.  
 c) Library resources

**Approved:** Departmental Graduate Studies Committee: Don A.C. Brooke Date: 17 February 1987

Faculty Graduate Studies Committee: P.W. Peirson Date: 16 March 1987

Faculty: G.H.W. Jones Date: 16 March 1987

Senate Graduate Studies Committee: B.P. Clay Date: 12 Oct/87

Senate: \_\_\_\_\_ Date: \_\_\_\_\_

## SALMONID FISH DISEASES AND THEIR CONTROL

L.J. Albright  
 Dept. of Biological Sciences  
 Simon Fraser University  
 Burnaby, B.C. V5A 2T6  
 (604) 291-3193

| Lecture | Topic   |
|---------|---|
| 1       | Introduction: Fish-Environment-Pathogen                         |
| 2       | The Aquatic Environment   |
| 3       | Salmonid Anatomy and Physiology                                 |
| 4       | Salmonid Anatomy and Physiology                                 |
| 5       | Pathophysiology and Systematic Pathology of salmonids           |
| 6       | Pathophysiology and Systematic Pathology of Salmonids           |
| 7       | Humoral Immunity Mechanisms of Salmonids                        |
| 8       | Cellular Immunity Mechanisms of salmonids                       |
| 9       | The Normal Microflora of Salmonids                              |
| 10      | The Concept of Disease  |
| 11      | Pathogenic Properties of Bacteria                               |
| 12      | Pathogenic Properties of Viruses, Fungi and Protozoa            |
| 13      | Bacterial Diseases of Salmonids                                 |
| 14      | Bacterial Diseases of Salmonids                                 |
| 15      | Fungal Diseases of Salmonids                                    |
| 16      | Viral Diseases of Salmonids                                     |
| 17      | Protozoan and Helminth Diseases of Salmonids                    |
| 18      | Phytoplankton - salmonid interactions within cultured fish pens |
| 19      | General Control Methods of Salmonid Pathogens                   |
| 20      | Unique Aspects of Diseases of Cultured Salmonids                |
| 21      | Salmonid Vaccines in Theory and Practice                        |

- 22 Regulations Pertaining to Salmonid Disease Control
- 23 Procedures and Equipment for Disease Testing at Source
- 24 Salmonid Disease Prevention and Control
- 25 Integrated Management of Farmed Salmonid Diseases

## Laboratory

## Topic

- 1 Salmonid Anatomy and Physiology
- 2 Anatomy and Physiology of the Salmonid Egg
- 3 The Normal Salmonid Microflora and Microfauna
- 4 Physical and Behavioural Signals of Disease in the Living Salmonid
- 5 Salmonid Tissue and Organ Examination for Disease
- 6 The Isolation and Identification of *Renibacterium salmoninarum* (Bacterial Kidney Disease) from infected Salmon.
- 7 The Isolation and Identification of *Vibrio anguillarum* (Vibriosis Disease) from diseased salmon.
- 8 The Isolation and Identification of *Aeromonas salmonicida* (Furunculosis Disease) from Diseased Trout
- 9 The Isolation and Identification of Infectious Hematopoietic Necrosis (IHN) virus from Diseased Salmon
- 10 The Identification of Protozoan and Metazoan Parasites of Cultured Salmon
- 11 Injection, Oral and Infiltration Methods for Immunizing Salmon
- 12 Chemotherapy of Diseased Salmon
- 13 Stress in Relation to Salmonid Disease Control

60.

## Course Texts

- Anderson, D.P. 1974. Fish Immunology. T.F.H. Publications. Neptune City, N.J.
- Amos, K.H. 1965. Procedures for the Detection and Identification of Certain Fish Pathogens. 3rd. ed., Fish Health Sec., Amer. Fish. Soc., Corvallis, OR.
- de Kinkelin, P. 1934. Symposium on Fish Vaccination. O.I.E., Paris.
- Herwig, N., L. Garibaldi and R.E. Wolke. 1979. Handbook of Drugs and Chemicals Used in the Treatment of Fish Diseases. Thomas, Springfield.
- Kinne, O. 1993. Diseases of Marine Animals. Vol. II. Introduction. Bivalvia to Scaphopoda. B.A.H., Hamburg.
- Kinne, O. 1994. Diseases of Marine Animals. Vol. IV. Part 1. Introduction. Pisces. B.A.H., Hamburg.
- Mawdesley-Thomas, L.E. 1972. Diseases of Fish. Academic, N.Y.
- Meyer, P.F., J.W. Warren and T.G. Carey. 1983. A Guide to Integrated Fish Health Management in the Great Lakes Basin. Great Lakes Fisheries Commission. Spec. Pub. 83-2. Ann Arbor, MI.
- Pickering, A.D. 1981. Stress and Fish. Academic. Toronto.
- Post, G.W. 1983. Textbook of Fish Health. T.F.H. Publications, Neptune City, N.J.
- Roberts, R.J. 1978. Fish Pathology. Bailliere Tindall, London.
- Roberts, R.J. 1985. Grundlagen der Fischpathologie. Paul Parey, Berlin.
- Wedermyer, G.A., F.P. Meyer and L. Smith. 1976. Environmental Stress and Fish Diseases. T.F.H. Publications, Neptune City, N.J.

CALENDAR INFORMATION:

Department: Biological Sciences Course Number: BISC <sup>631</sup>~~649~~

Title: Growth, Reproduction and Nutrition in Aquaculture Systems

Description: Growth, reproduction and nutrition for the major groups cultivated.

Credit Hours: 5 Vector: 4-2-0 Prerequisite(s) if any:

ENROLLMENT AND SCHEDULING:

Estimated Enrollment: 12-15 When will the course first be offered: 88-1

How often will the course be offered: Once per year

JUSTIFICATION:

A major area of concern for aquacultural operations and one which can improve biological yields.

RESOURCES:

Which Faculty member will normally teach the course: New faculty

What are the budgetary implications of mounting the course: Cost of new faculty

Are there sufficient Library resources (append details): Library resources are being determined. See attached letter to S. Thomas, Library.

- Appended:
- a) Outline of the Course
  - b) An indication of the competence of the Faculty member to give the course.
  - c) Library resources

Approved: Departmental Graduate Studies Committee: D.M.C. Brooks Date: 17 February 1987

Faculty Graduate Studies Committee: P.W. Perand Date: 16 March 1987

Faculty: C.H.W. Jones Date: 16 March 1987

Senate Graduate Studies Committee: B.P. Clay Date: 12 Oct/87

Senate: \_\_\_\_\_ Date: \_\_\_\_\_

62.

## Lectures

## 1-15 Growth

Feeding behavior.  
 Feeding strategy - trophic diversity, food acquisition, food exploitation.  
 Digestion.  
 Metabolism and energy conversion.  
 Physiological energetics - energy relations, metabolism, excretion, growth.  
 Hormonal enhancement of growth.  
 Environmental factors and growth.  
 Growth rates and models.

## 16-30 Reproduction

Reproductive physiology.  
 Environmental influences.  
 Hormonal control of sexual maturation, ovulation and spermiation.  
 Hormonal sex control.  
 Triploidy.  
 Gamete preservation.

## 31-45 Nutrition

Proteins.  
 Carbohydrates.  
 Lipids.  
 Vitamins.  
 Minerals.  
 Diet formulations.  
 Changes in nutrition with life stages.

## 46-52 Genetics

Breeding.  
 Sex control.  
 Hybridization.  
 Recombinant DNA studies.

## Course Books

- Hoar, W.S., D.J. Randall and J.R. Brett. 1979. Fish Physiology - Bioenergetics and growth. Vol. VIII. Acad. Press, New York.
- Hoar, W.S., D.J. Randall and E.M. Donaldson. 1982. Fish Physiology - Reproduction. Vol. IX. Acad. Press, New York.
- Kafuku, T. and H. Ikenoue. 1983. Developments in Aquaculture and Fisheries Science. Elsevier Scientific Publ. Co., Amsterdam.
- McLarney, W. 1984. The Freshwater Aquaculture Book. Hartley & Marks Publ., Wash.
- McVey, J.P. 1983. CRC Handbook of Mariculture. CRC Press, Inc. Florida.
- Muir, J.F. and R.J. Roberts. 1982. Recent Advances in Aquaculture. Croom Helm Publ., London.
- Pillay, T.V.R. and W.A. Dill. 1979. Advances in Aquaculture. Fishing News Book Ltd., Farnham, Surrey, England.

63



CALENDAR INFORMATION:

Department: Biological Sciences Course Number: BISC <sup>633</sup> 611

Title: Current Topics in Aquaculture

Description: A seminar series on aquacultural topics related to BISC 6X1, 6X2 and 6X3.

Credit Hours: 1 Vector: 1-0-0 Prerequisite(s) if any: BISC 6X1  
BISC 6X2

ENROLLMENT AND SCHEDULING:

Estimated Enrollment: 12-15 When will the course first be offered: 88-1

How often will the course be offered: Once per year

JUSTIFICATION:

To emphasize current research developments and aquacultural problems in a seminar forum.

RESOURCES:

Which Faculty member will normally teach the course: Any faculty member in aquacultural program as organizer.

What are the budgetary implications of mounting the course: Teaching relief time for organizer and invited speakers.

Are there sufficient Library resources (append details): Library resources are being determined. See attached letter to S. Thomas, Library.

- Appended:
- a) Outline of the Course
  - b) An indication of the competence of the Faculty member to give the course.
  - c) Library resources

Approved: Departmental Graduate Studies Committee: D.W.C. Ponder Date: 17 February 1987

Faculty Graduate Studies Committee: P.W. Ponder Date: 16 March '89

Faculty: G.H. Jones Date: 17 March 1987

Senate Graduate Studies Committee: B.P. Clark Date: 12 Oct/89

Senate: \_\_\_\_\_ Date: \_\_\_\_\_

64.

**CALENDAR INFORMATION:**

Department: Biological Sciences Course Number: BISC ~~634~~ 635

Title: Practicum and Research Paper

Description: Six weeks experience at a commercial aquaculture operation according to student's interests as well as a research paper.

Credit Hours: 0 Vector: NA Prerequisite(s) if any: Acceptance into program

**ENROLLMENT AND SCHEDULING:**

Estimated Enrollment: 12-15 When will the course first be offered: 88-2

How often will the course be offered: Once per year

**JUSTIFICATION:**

Students will gain experience and expertise in a specialized area of their particular interest. It is in the summer semester because a greater variety of procedures are being carried out at this time by aquacultural operations.

**RESOURCES:**

Which Faculty member will normally teach the course: Any faculty in the aquaculture program as advisor.

What are the budgetary implications of mounting the course: Replacement time for faculty advisor and minor travel expenses.

Are there sufficient Library resources (append details): Library resources are being determined. See attached letter to S. Thomas, Library.

- Appended: a) Outline of the Course
- b) An indication of the competence of the Faculty member to give the course.
- c) Library resources

Approved: Departmental Graduate Studies Committee: Don C. Bonke Date: 17 February 1987

Faculty Graduate Studies Committee: P.W. Peter Date: 16 March 89

Faculty: G.W. Jones Date: 17 March 1987

Senate Graduate Studies Committee: B.P. Clay Date: 12 Oct/89

Senate: \_\_\_\_\_ Date: \_\_\_\_\_ 65.

# SIMON FRASER UNIVERSITY

OFFICE OF THE DEAN  
OF GRADUATE STUDIES



BURNABY, BRITISH COLUMBIA  
CANADA V5A 1S6  
Telephone: (604) 291-4255

16 May 1988

Dr. Bill Pennell  
Director of Research  
B.C. Salmon Farmers Association  
2459A Bellevue Avenue  
West Vancouver, B.C.  
V7V 1E1

Dear Dr. Pennell:

I am in receipt of your letter which was sent via Fax machine to me on 13 May 1988 which outlines your review of the proposed Master of Aquaculture graduate program at Simon Fraser University. I would like to thank you for the time taken to review this proposal and for your valuable comments and recommendations.

The Assessment Committee for New Graduate Courses will be discussing this issue soon. Thank you again for your contribution.

Sincerely,

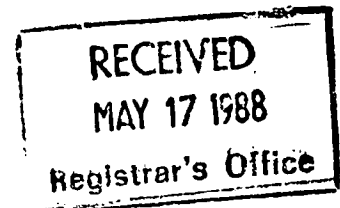
A handwritten signature in cursive script that reads "B.P. Clayman".

B.P. Clayman  
Dean of Graduate Studies

BPC:pm

LMA16PEN

c.c. M. McGinn  
Dr. L. Srivastava  
N. Hunter



66.



2459A Bellevue Avenue, West Vancouver, B.C. V7V 1E1  
Telephone (604) 922-4325 • Fax (604) 922-6875

0588-050

May 13, 1988

Dr. B.P. Clayman  
Dean of Graduate Studies  
Office of the Dean of Graduate Studies  
Simon Fraser University  
Burnaby, B.C.  
V5A 1S6

Dear Dr. Clayman,

I have read with interest the proposal for a Master of Aquaculture Program at Simon Fraser and have several comments to make. I have discussed this program at some length on several occasions during the past two years with Professors Druehl and McKeown and I am familiar with its origins and goals. I will direct my remarks to your specific questions:

1. In terms of rigour and academic quality, the program looks sound. The approach of bringing in experts from local organizations and from abroad definitely strengthens the program which is centered in an area where many specialized skills are needed, more than will be found in any one department or, in fact, university. The Masters Degree differs from traditional programs in the lack of a research thesis (in the sense of original field or laboratory research) but this is a modern trend and will suit the target group, most of whom will not become researchers. Evaluation of the thesis could be strengthened however.
2. I believe that the proposal's estimate of 10 - 15 students is realistic.

0588-050  
SFU

Page 2  
May 13/88

3. Future demand for the graduates is difficult to estimate, but there should be a need for such people in the middle levels of large companies in B.C. (for example, R&D coordinators, marketing people, and general operations managers). There may be some retraining of people already in these company positions and in corresponding government positions. Overseas students could make up a significant proportion of future enrollment; post-graduate degrees are in high demand in many developing countries and CIDA, ICOD and IDRC frequently support overseas students in such programs as a component of these development projects.

In terms of the curriculum, I would like to make further comment. IN Semester 4 there are a number of course options which do not fit well within the proposed direction of the program. These include fragments from the Resource Management Program, (Fisheries Economics, Fisheries Management, Population Biology, etc.) While, in special cases, a student might take certain courses in these areas, they really do not belong in the curriculum, and there are other areas where effort might be better spent, for example, more depth in culture techniques and strategies, general financial farm management, engineering and field experience.

This is not an inexpensive program considering the relatively small number of expected students. It will be important to coordinate these offerings with those of other institutions; course transferability of credits between UBC graduates and BSC Diploma Holders from Malaspina College would be attractive. The latter option has been discussed informally with favourable outcome.

Yours sincerely,



William Pennell, Ph.D  
Director of Research

# SIMON FRASER UNIVERSITY

OFFICE OF THE DEAN  
OF GRADUATE STUDIES



BURNABY, BRITISH COLUMBIA  
CANADA V5A 1S6  
Telephone: (604) 291-4255

09 May 1988

Dr. Ronald E. Foreman  
Associate Professor  
Department of Botany  
3529-6270 University Boulevard  
Vancouver, B.C.  
V6T 2B1

Dear Dr. Foreman:

I am in receipt of your letter of May 3, 1988 which outlines your review of the proposed Master of Aquaculture graduate program at Simon Fraser University. I would like to thank you for the time taken to review this proposal and for your valuable comments and recommendations.

The Assessment Committee for New Graduate Courses will be discussing this issue soon. Thank you again for your contribution.

Sincerely,

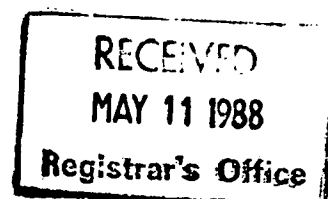
A handwritten signature in cursive script, appearing to read "B.P. Clayman".

B.P. Clayman  
Dean of Graduate Studies

BPC:pm

LMA9FOR

c.c. M. McGinn  
Dr. L. Srivastava  
N. Hunter



C.C. M. M'Ginn

THE UNIVERSITY OF BRITISH COLUMBIA

MAY - 1988  
MAY - 1988  
DEPARTMENT OF GRADUATE STUDIES  
STUDIES OFFICE



Department of Botany  
13529 - 6270 University Boulevard  
Vancouver, B.C. Canada V6T 2B1

Telephone (604) 228-2133

3 May 1988

Dean B. P. Clayman  
Dean of Graduate Studies  
Simon Fraser University  
Burnaby, B. C.  
V5A 1S6

Dear Dean Clayman,

**Re: Review of the proposed Masters of Aquaculture graduate program.**

As you requested I have reviewed the documents provided and would like to offer the following comments and recommendations.

**Students**

There is a general inconsistency in the documentation. In section 3, curriculum (page 8), it states "It is designed as an overview into aquaculture for administrators and managers as well as aquaculture farm operators" (emphasis mine). However, the admission requirements (page 10) would effectively eliminate most of these individuals and, indeed, the remainder of the document appears to favor biological science students interested in an M.Sc. in aquaculture. As these are the most likely students for the program I suggest the curriculum needs to be reconsidered.

**Recommendations**

1. Strengthen (restate) the goals and objectives of the program so as to permit future evaluation of program strengths and weaknesses. Clear objectives will also encourage individual course instructors to provide a focus bridging the academic and industry requirements.
2. Reconsider / redefine the target group of students for the program and clarify the options available for students with biological science background as well as administrators, managers and farm operators.
3. Assuming the program is not only for biology-oriented students, restructure the curriculum so as to encourage students with biological backgrounds to specialize on one aspect (type) of aquaculture (i.e. salmonids), and acquire a better management and engineering background. Non-biological students should have a curriculum designed to provide a better biological background. Perhaps two streams need to be recognized?

4. The curriculum is weak in several areas: aquaculture engineering, aquaculture project management, and diseases and parasites of non-salmonid organisms. Consideration should be given to strengthen these areas. In addition, in my opinion, there is insufficient emphasis on economic aspects.

#### Comments:

In my opinion, a basic deficiency in the proposed program is that it doesn't go far enough in defining its objectives vis-a-vis the two most likely groups of students: biologists interested in an M.Sc. and non-biologists with an interest in aquaculture. The two groups have widely different backgrounds and curriculum needs, but these can be dealt with by course options if the program objectives (goals) are well defined.

One of the major difficulties in obtaining an economically viable aquaculture operation is the interface between biology, and cost-effective production and marketing. Individuals trained in the biological sciences find it difficult to deal with the necessity of bottom-line management practices; while managers and engineers find it difficult to deal with imperfectly understood organisms and the independent variables common in biological systems. Thus, to be successful the company must not only be able to grow the organism, it must also successfully manage and market the product. Most importantly, it must make a profit. As a result, economics, cost-effectiveness, engineering and project management are often of equal or greater importance to success than actually growing the organism.

One or more aquaculture engineering courses should be included in the curriculum to deal with: aquaculture production operations, functional specifications for performance and reliability; systems analysis; systems design; inter-relationships between the characteristics of the species and the facilities, equipment and environment with the view of developing and maintaining a comprehensive production system; and basic engineering aspects.

Equally important is the course on aquaculture business management which should include consideration of scheduling, cost analysis, projections, and problems of bottom-line management. I note that product quality control and its importance to the economics of aquaculture is not included as a topic in any of the course outlines documented.

One area which I believe to be especially important concerns disease, parasites, epiphytes, etc. As the industry develops this area will acquire increasing importance due to a) additional stress on the organisms which will result from demands for higher and higher production, and b) the need to minimize risks to the investors. I suggest that the proposed program would be strengthened considerably by increasing the emphasis and course opportunities



in this area. In the final analysis the attraction of the program to non-biologists will be aquaculture problem-oriented, while biologists will find many employment opportunities in "pest" control. I believe I am correct in saying that scientists in this area, at other aquaculture centres, are in great demand by the industry; probably because they are most likely to deal with the unanticipated, or poorly known, problems that threaten a company or the industry at large. Given the proposed course on salmonid fishes a faculty position in the area of invertebrate and marine plant diseases and parasites should be considered. In addition, the importance of protozoans as salmonid parasites may need to be reviewed.

By streaming the students into two groups, individuals with a strong biological background could focus on a speciality area of aquaculture (i.e. shellfish) and be required to take a full course load of management, marketing and engineering courses to provide good balance. Students with courses or experience in the latter could be required to take a full biological program to provide them with better balance and skills. Having students of both types in the program at once would be highly desirable, and result in a dynamic and interesting academic program. I believe such a program would be highly successful.

In answer to some of the specific questions raised in your covering letter:

1. The faculty are generally well qualified for this program and I believe both academic quality and rigour will be more than satisfactory given a strong mandate. The most difficult aspect will be achieving a satisfactory emphasis, and balance, between academic goals and industrial needs. It might be advantageous to encourage qualified members of the industry to instruct in the program from time to time and, perhaps, to participate directly in the current topics course. This would result in increased creditability, better industry relationships and facilitate arrangements for the practicum. I note that the list of present faculty on page 29 only includes biologists and, for the most part, they have limited actual experience in aquaculture. Faculty from business and management should be included.
2. The student estimates presented appear reasonable and the program should grow with time as the industry matures.
3. Demand for graduates from the program should also be good, especially if the program objectives are met. There is a deficit of suitably experienced individuals associated with the industry at this time, and long-term success of the industry will depend on increasing availability of human talent.
4. UBC offers a broad range of aquaculture courses, and has recently restructured it's program offerings in aquaculture at the undergraduate level. However, to my knowledge, it has not taken the graduate program route proposed for SFU. Thus, UBC B.Sc. graduates are likely candidates for this interdisciplinary SFU masters program.

In conclusion, the proposed degree and program are timely and needed by industry. I believe the program will be quite successful.

Yours sincerely,

*Ronald E. Foreman*  
Ronald E. Foreman  
Associate Professor

# SIMON FRASER UNIVERSITY

OFFICE OF THE DEAN  
OF GRADUATE STUDIES



BURNABY, BRITISH COLUMBIA  
CANADA V5A 1S6  
Telephone: (604) 291-4255

10 May 1988

Mr. J.E. Fralick, Manager  
Aquaculture Industry Development  
Province of British Columbia  
Ministry of Agriculture & Fisheries  
Victoria, B.C.  
V8W 2Z7

Dear Mr. Fralick:

I am in receipt of your letter of May 4, 1988 which outlines your review of the proposed Master of Aquaculture graduate program at Simon Fraser University. I would like to thank you for the time taken to review this proposal and for your valuable comments and recommendations.

The Assessment Committee for New Graduate Courses will be discussing this issue soon. Thank you again for your contribution.

Sincerely,

A handwritten signature in cursive script, reading "B.P. Clayman".

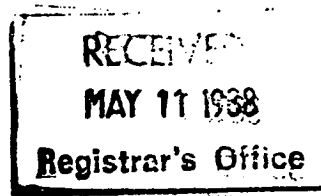
B.P. Clayman  
Dean of Graduate

Studies

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c.c. M. McGinn  
Dr. L. Srivastava  
N. Hunter





MAY - 1988  
DEAN OF GRADUATE  
STUDIES OFFICE

May 4, 1988

Dr. B.P. Clayman  
Dean of Graduate Studies  
Simon Fraser University  
Burnaby, British Columbia  
V5A 1S6

Dear Dr. Clayman:

**New Master's in Aquaculture Program**

Thank you for the opportunity to comment on the New Master's in Aquaculture Program which Simon Fraser University is proposing to offer. I am extremely encouraged by the development of such a program which is specific to aquaculture. Current programs at all of our British Columbia universities can provide reasonable graduate education in aquaculture but it is of great value to have a specific program of study.

Please find the following comments in response to the questions you posed in your letter of April 7, 1988.

Question 1: I believe that the academic rigor is comparable to other master's programs with three exceptions.

First, it would be advisable to have two faculty and an outside professional pass on the research paper and its defence. This will assist in providing a broader perspective for the research and lend greater professionalism from the perspective of those outside the academic community.

Second, although I feel that the program requirements for the first three semesters are excellent, I am uncertain about the requirements of the fourth semester. In some ways this semester seems like an attempt to add existing courses to a new program in order to extend its length. Alternatively, if the intent of this semester is to give the student more time to develop the research paper and also to provide a semester of in-depth special projects through senior graduate courses then it is an excellent approach because the student will be able to follow-up on interesting aspects of aquaculture which are disclosed through the preceding practicum.

May 4, 1988

Third, I feel that the Economics courses 863 and 864 will be inappropriate to the type of program that is being proposed. Both of these courses appear to be concerned with fisheries economics rather than farm production economics. These two aspects of the discipline are very different and the aquaculture academic or practitioner should have a sound knowledge of the economics of aquaculture production. I strongly recommend that new courses be developed for the program in the area of farm business management.

Question 2: I would anticipate between 8 and 12 students will apply to the program each year.

Question 3: I doubt that more than half this number of graduates could be assimilated into the B.C. industry each year unless they had previous on-farm experience. Employment for many of the graduates may be in the international marketplace.

Hopefully, my comments have been of assistance to you and I am prepared to discuss any element further at your request.

Yours very truly,



J.E. Fralick, Manager  
Aquaculture Industry Development  
Aquaculture and Commercial Fisheries Branch

# SIMON FRASER UNIVERSITY

OFFICE OF THE DEAN  
OF GRADUATE STUDIES



BURNABY, BRITISH COLUMBIA  
CANADA V5A 1S6  
Telephone: (604) 291-4255

11 May 1988

Dr. Charles A. Simenstad  
Wetland Ecosystem Team  
Fisheries Research Institute WH-10  
University of Washington  
Seattle, Washington  
U.S.A. 98195

Dear Dr. Simenstad:

I am in receipt of your letter of 30 April 1988 which outlines your review of the proposed Master of Aquaculture graduate program at Simon Fraser University. I would like to thank you for the time taken to review this proposal and for your valuable comments and recommendations.

The Assessment Committee for New Graduate Courses will be discussing this issue soon. Thank you again for your contribution.

Sincerely,

A handwritten signature in cursive script, appearing to read "B.P. Clayman".

B.P. Clayman  
Dean of Graduate Studies

BPC:pm

LMA11SIM

c.c. M. McGinn  
Dr. L. Srivastava  
N. Hunter



MAY 1 1988  
DEAN OF GRADUATE  
STUDIES OFFICE

WETLAND ECOSYSTEM TEAM  
Fisheries Research Institute WH-10  
University of Washington  
Seattle, Washington 98195  
(206) 543-7185

10 April 1988

Dr. B. P. Clayman, Dean of Graduate Studies  
SIMON FRASER UNIVERSITY  
Burnaby, British Columbia V5A 1S6  
CANADA

Dear Dean Clayman:

It is with interest that I reviewed the proposed Master of Aquaculture graduate program at Simon Fraser. I have addressed your explicit questions and have extended my comments along several specific issues which you will hopefully find constructive.

Firstly, I should state several caveats to this review. As a research marine biologist, my perspective on a graduate degree in aquaculture is based upon the problems I perceive or am consulted on in terms of the potential ecological problems associated with serious mariculture projects. In addition, these pertain predominantly to mariculture, rather than freshwater aquaculture. Thus, these comments apply to disciplines and training which graduate students destined for mariculture industry and management agency positions would have under their belts in order to design, operate, and regulate such activities such that environmental conflicts are mitigated. I am afraid I cannot provide much review on aspects of economics, processing and packaging, i.e., the managerial end of the industry.

In that context, the first comment I might note is that increasing requirements for research, monitoring and guidelines for assessing the environmental impacts of aquaculture would, in my opinion, be added as a basic reason (p. ii) to establish both the Institute for Aquaculture Research and the Masters Program in Aquaculture. Graduates should not, as they are now, be pumped out of the educational systems with the simple perspective that aquaculture can operate on common public resources (at least in most of the mariculture situations) without some consideration for environmental affects. Similarly, it is implied (p. iii) that the Advisory Council to the Institute will be focused on private sector "clients"; although government representatives are mentioned (p. 27) as members of this council, those agencies which regulate water quality, fish health, and other aspects of environmental quality (where many of your graduates will end up) should be represented explicitly and equally. It is for this reason that many of the following comments are oriented toward establishing a solid educational and research understanding of the biological processes, habitats, and communities which interface with aquaculture activities.

I am returning the copy of the proposal as I have made marginal (literally and figuratively) on it, which might be of interest.

My responses to your explicit questions are as follows:

## 1. Academic quality and rigor; comparison with other programs

It is stated that the Masters of Aquaculture program is "designed as an overview into aquaculture for administrators and managers as well as aquaculture farm operators" (p. 8). This seems to imply predominantly industry positions; are the scientifically-educated resource agency managers who will increasingly deal with aquaculture included in this? If not, it should be considered that this is likely to be a major source of employment for your graduates.

From the course descriptions, it appears that many of the prerequisites for the curriculum (p.10-13) are survey courses; if this is the case, I would suggest that more depth be recommended on several topics. Specifically, both plant (BISC 347) and animal physiology (BISC 305) should be considered, as should more depth in marine and estuarine oceanography and ecology. In the latter case, I could not find specific courses which extend BISC 424; are there courses which address in more detail components of marine biology and oceanography such as water chemistry and water quality, primary production and nutrient cycles, circulation and sedimentation processes, predator-prey or food web cycles, etc? If not, I suggest that you consider the importance of this basic understanding of how "aquaculture environments" work.

In this respect, even our college (College of Ocean and Fishery Sciences) does not have a course in its curriculum which introduces estuarine and shallow coastal habitats and processes, and neither did I find such a course description in your catalog. This is, in my opinion, a major gap in our curricula when applied to the needs of students entering careers such as aquaculture and resource management. Unless it happens to be the speciality of the professor, classic oceanography and marine biology courses are characteristically dominated by "blue water" or "rocky intertidal" principles, respectively, and these are not, in most cases, transferable to much of our coastal and estuarine ecosystems. This might be a good opportunity for your Biological Sciences Department to develop such a course if it is deemed important to the new program, as I am sure that it would benefit the all marine resources and management programs. The University of California at Davis used to have an aquaculture program which provided a good, basic background to the ecological, biogeochemical, hydrological, etc. processes influencing the culture of estuarine and marine organisms; you might also solicit their review of your program proposal.

Since there will be no thesis per se, the practicum and research paper (BISC 6AA) will be one of the more critical determinants of a student's practical expertise. As described, this is derived primarily through experience at a commercial aquaculture operation. This seems like a limited view of the potential spectrum of positions which your students might fulfill. Wouldn't other "hands-on" experience be just as appropriate, e.g., participation on an (non-industry) aquaculture research project or involvement in resource agency regulation of an aquaculture activity? I would recommend increasing the scope of BISC 6AA accordingly, or at least leave it to the discretion of the student's advisory committee. One advantage of this flexibility is that students employed as research assistants or interns on non-industry aquaculture projects could utilize their work experiences for the research topic.

One of the strongest recommendations I can make for this program is the inclusion of the appropriate Natural Resource Management (MRM) courses, whose descriptions I find particularly germane to the program's objectives. From my viewpoint, courses like MRM 646 (Environmental and Social Impact Assessment) are going to be extremely important to

students in this program; as such, I would tend to make this course and others like it required. For the same reasons, the Resource Management of Aquaculture (MRM 6XX) course is a logical and important expansion of this program.

## 2. Estimate of the number of students likely to seek admission

From the standpoint of recent or pending graduates at the Bachelors level, I would predict that perhaps ten students might annually apply to the Masters Program in Aquaculture. The emphasis on "students with extensive experience in the aquaculture industry" (p. 9), however, brings up an additional enrollment element, that of aquaculturists who wish to return to school (potentially after an extended absence) to upgrade their training and education. Although you haven't made this component of the industry a target, I would think that there would be a reasonable number of active aquaculturists who for one reason or another (e.g., expansion of scale or species) might wish to devote several years to gain further, state of the science education. Since this is basically a non-thesis program (other than BISC 6AA), it would be attractive to a returning or part-time graduate. To wit, you might wish to promote the program in that context. This could add potentially three to five additional applicants per annum.

Relative to student enrollment, you might also wish to evaluate the potential funding for students entering the program. In addition to the standard teaching assistant support, it would be wise to have commitments from industry and other sources (NRC) for funding support of students in this program. Correspondingly, it might also be worthwhile to survey the funding sources for an indication of the number of students which might be supportable on aquaculture research projects.

## 3. Estimate future demand for graduates

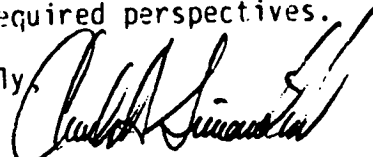
Although there is considerably more caution being exercised in promotion of aquaculture on this side of the border, my experience is that employment opportunities are at least as high as you have described for Canada. As pressure increases for limited sites and markets, the industry will likely be seeking better educated and experienced technical staff, and the resource management agencies will undoubtedly require specifically-trained individuals in order to better handle the complex issues involved in aquaculture management and regulation.

My impression is that there are at least ten to twenty positions available within this region of the US alone which could be easily filled by the graduates of such a program.

In summary, I would endorse the program for An Institute for Aquaculture Research and Master in Aquaculture as needed, timely, and well-conceived. My priority recommendations would be to: (1) bolster the curriculum with requirements for more basic marine biology, oceanography, and estuarine ecology; (2) design the program to encourage former graduates to return from industry and resource management agencies to "upgrade" their education relative to this rapidly-evolving biotechnology; and, (3) ensure that students receive a thorough understanding of the multitude of management issues involved with aquaculture.

I hope this review provides you with the required perspectives.

Sincerely,



Charles A. Simenstad  
Marine Biologist

79