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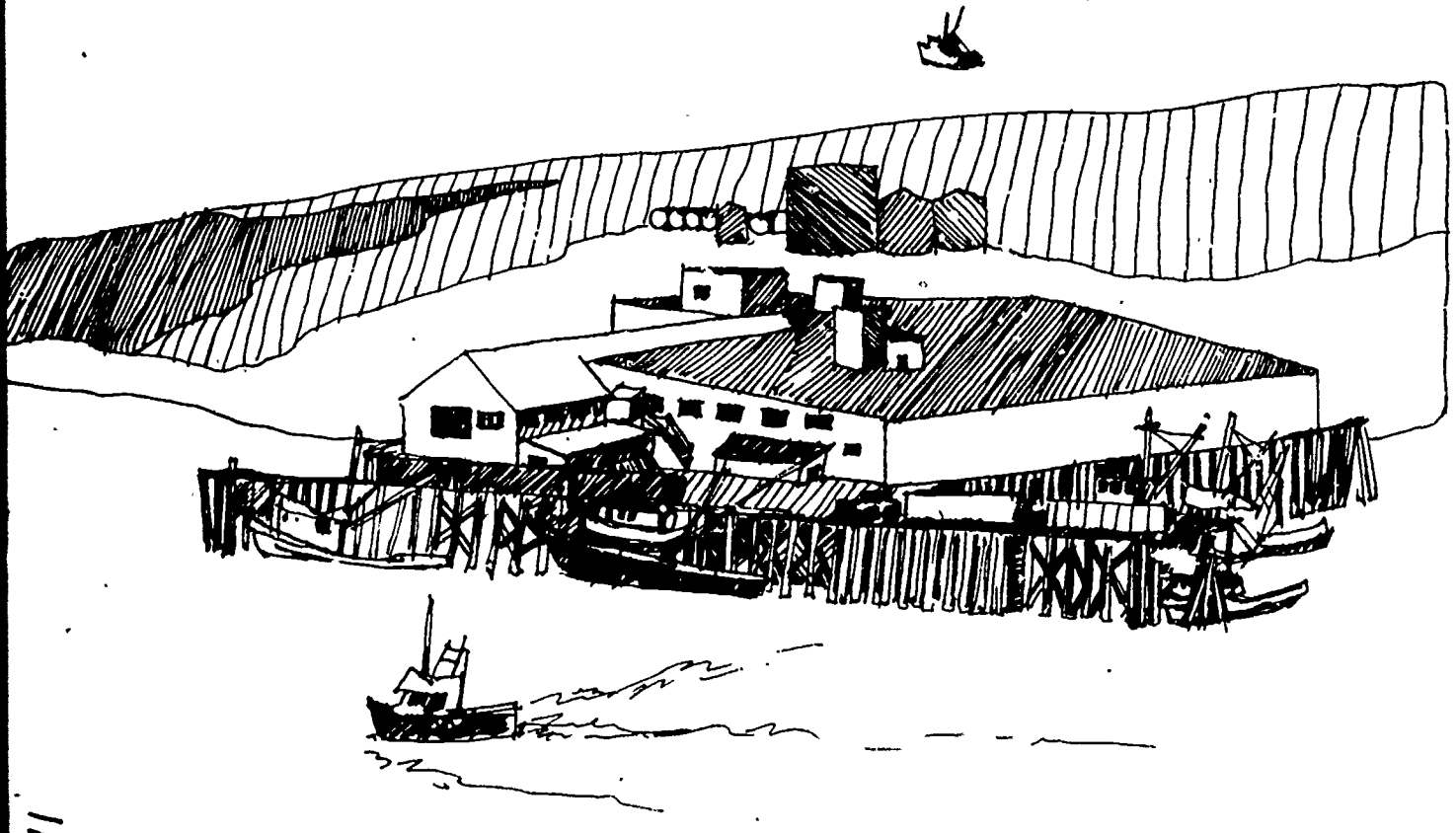
ABSTRACT

This program is designed to involve students in the economy of their community. It combines an interdisciplinary educational program with practical field and laboratory experience. This program provides opportunities in the area of aquaculture, controlled cultivation of marketable species and the total ecological corrections necessary to maintain a viable fisheries in the Shumagin areas. It involves all seventh through tenth grade students on a continuous basis. Included are units and topics in water quality, general biology, fisheries techniques, aquatic plant and insect studies, biological and physical oceanography and limnology, pathology, and aquaculture technology. Program philosophy and goals are stated. Planned course statements are given for fish husbandry, general biology, water resources, and fisheries science. Each statement includes the following: course description, goals, content outline, examples of learning activities, methods of evaluation, and learning materials. (AJ)

AQUACULTURE

A COURSE OF STUDY FOR

Sand Point Secondary School



SAND POINT SECONDARY SCHOOL

AQUACULTURE PROGRAM

INTRODUCTION

The Sand Point High School Aquaculture Program is designed to involve Native students in the economy of their community. The program, initially funded in 1975 by the Johnson O'Malley Program, is unique because 1) it is a first of its kind offered through a public secondary education system in Alaska, and 2) it combines an inter-disciplinary educational program with practical field and laboratory experience. A student built incubation and pond rearing system for salmon will be the project's prime mover.

The aquaculture program will compliment the development of a complete marine science program in the new expanded high school at Sand Point in the 1976 fiscal year. The program represents a positive step in designing relevant economic and cultural experiences for high school students based on the needs and interests of the region in which they live.

The program will provide educational opportunities in the areas of aquaculture, controlled cultivation of marketable species, and the total ecological corrections necessary to maintain a viable fisheries in the Shumagin area. The program is worked into a science program of individualized studies. It involves all seventh through tenth grade students on a continuous basis and eleventh and twelfth grade students incidentally.

The program will include units and topics in water quality, general biology, fisheries biology, ecology, hydrography, fisheries techniques, aquatic plant and insect studies, biological and physical oceanography and limnology, pathology, and aquaculture technology.

Besides involving the students in fish biology and ecology, the program has an added attraction of improving fish stocks in a local stream. The students will be provided with an opportunity to develop a demonstration fish rearing facility. The Netarts gravel and Heath vertical incubators have been selected as production models, but other incubator systems will be available for instructional purposes. The gravel incubators and other hatchery materials will be prefabricated at the high school and assembled in the field. This fall the students will spend much of their time

spawning and seeding the incubators, and for the remainder of the year, continue to take an active part in the actual hatchery operation.

The students will take their own pink and silver salmon eggs. The pink salmon will emerge from the incubators in the spring and migrate to sea with as little human handling as possible and with no supplemental feeding. The silver salmon will be retained primarily for instructional purposes. The students will be responsible for feeding and care of eggs, fry, fingerlings, and young salmon, hatchery techniques, water quality diagnosis, and culture and examination of diseased fish. The facility will give the students a total experience in salmon farming and ecology.

Besides maintenance and operation of the hatchery, other field study and individual laboratory instruction will characterize the program. Classroom activities will include films and printed material from government agencies. Various biological, geological, oceanographical, and limnological sampling equipment will be available. Classroom demonstrations, data collection, and field excursions will be emphasized. The students will also be responsible for a salt water aquarium.

Within walking distance from school are ponds, streams, and estuarine habitats for fish and shellfish studies. A twenty-eight foot dory and skiffs will be available for marine sampling.

The students will make an annual field trip to various aquaculture facilities throughout the state of Alaska to gain field experience in estuarine pen rearing, lake and stream stocking, heated water hatcheries, and moder aquaculture research techniques.

STATEMENT OF PHILOSOPHY

The aquaculture curriculum consists of those courses and activities designed to meet the individual student's educational needs related to marine science. Emphasis is placed on the process of scientific inquiry by students so that they can discover and interpret scientific knowledge, develop desirable attitudes, interests, and appreciation related to aquaculture, and recognize that these behaviors can be applied to the solution of current and future problems in the fisheries industry.

Inquiry is stimulated through various means, using the field experience as a focal point for

learning. There should be provisions for both small-group and individual instruction. Opportunities should be provided for students to apply methods and knowledge of aquaculture to inquiry into the solution of problems of the community's fisheries economy.

PROGRAM GOALS

1. The student will be able to demonstrate a knowledge of fisheries and fish stock upon which the community depends economically.

2. The student will understand the life cycles of commercially important fish, emphasizing salmon and their ecology.

3. The student will understand the life cycles of commercially important shellfish, emphasizing shrimp and crab and their ecology.

4. The student will be able to utilize conventional language, instruments, and operations of aquaculture.

5. The student will understand the significance of management to the conservation of fish stocks.

6. The student will be able to demonstrate the knowledge and the skills required for entrance in college level courses in fisheries.

7. The student will be able to demonstrate a knowledge of career opportunities in the fisheries industry.

8. The student will be able to develop the knowledge and the skills to perform satisfactorily the requirements for entry level employment in the fisheries industry.

Planned Course Statements for Aquaculture

1.	Course Title:	FISH HUSBANDRY				
2.	Credit Awarded:	1/4	1/2	3/4	1	(circle one)
3.	Grade Level First Offered:	9	10	11	12	(circle one)
4.	Required Area of Study:	Science				
5.	Prerequisite(s):	Science — Grades 7, 8, 9 and 10				
6.	Elective or Required Offering:	Elective				

COURSE DESCRIPTION

In this course, the students will be responsible for taking their own salmon eggs, seeding incubators, feeding and caring of fry and fingerlings. Students will study cause, effect, and treatment of various diseases and parasites of fish.

Community resources will be utilized extensively with considerable emphasis being placed on practical field experiences in fish farming and ecology. Furthermore, students will make visual observations of ecological conditions of streams such as discharge, pollution, temperature, depth of ice, etc.

COURSE GOALS

1. The student will be able to understand the purpose and function of artificial fish culture, *e.g.*, mitigation, rehabilitation, and enhancement.	Purpose & Function
2. The student will be able to demonstrate a knowledge of the history of fish culture.	History of Fish Culture
3. The student will demonstrate a knowledge of basic icthyology.	Icthyology
4. The student will demonstrate a knowledge of the external and internal anatomy of salmonids.	
5. The student will be able to classify salmonids.	

6. The student will be able to identify distinguishing characteristics of salmonids.	
7. The student will be able to demonstrate a knowledge of the life histories of salmonids.	
8. The student will be able to demonstrate a knowledge of the reproductive anatomy of females, *e.g.*, structure of ovaries.	Reproductive Anatomy of Females
9. The student will be able to distinguish the difference between egg sizes and fecundity from fish to fish and species to species.	Fecundity & Egg Size
10. The student will be able to define spermatogenesis and oogenesis.	Salmonid Sperm & Egg
11. The student will be able to demonstrate a knowledge of the structure of egg and sperm.	
12. The student will be able to demonstrate an understanding of the mechanisms of fish fertilization.	Fertilization
13. The student will be able to demonstrate an understanding of the factors affecting the success of fish fertilization.	
14. The student will be able to demonstrate a knowledge of spawning techniques of salmon and trout.	Spawning Techniques
15. The student will be able to demonstrate an understanding of the implications of the developmental stages of fish embryo and the factors affecting their development.	Embryology
16. The student will be able to demonstrate a knowledge of the use and construction of incubation equipment, *e.g.*, trough, vertical flow, and gravel incubators.	Incubation Equipment & Methods
17. The student will be able to care for salmonid eggs during incubation, i.e., recognize developmental stages; remove dead or infertile eggs; chemically treat eggs to combat fungus; clear debris and silt; and maintain water.	Care of Salmonid Eggs

18. The student will be able to understand the reasons for egg enumeration.	Egg Enumeration
19. The student will be able to demonstrate a knowledge of the techniques of egg enumeration.	
20. The student will be able to determine when eggs can be shipped successfully.	Egg Transportation
21. The student will be able to demonstrate a knowledge of shipping techniques and procedures.	
22. The student will be able to care for adult salmon and trout.	Care of Adult Salmonids
23. The student will be able to demonstrate a knowledge of trapping techniques for adult salmon and trout.	
24. The student will be able to understand the factors affecting salmonid maturation and spawning.	
25. The student will be able to demonstrate a knowledge of the use and methods of gamete storage and preservation.	Gamete Storage
26. The student will be able to demonstrate an understanding of basic genetics, *e.g.*, selective breeding and hybridization.	Genetics
27. The student will be able to care for fry and fingerlings, *i.e.*, knowledge of rearing units, physical defects, methods of transferring, etc.	Care of Fry & Fingerlings
28. The student will be able to demonstrate a knowledge of the types of units used in salmonid rearing, *e.g.*, non-circulating and circulating ponds or pools.	Types of Holding Units
29. The student will be able to determine the carrying capacities or stocking rates of rearing units.	Carrying Capacities
30. The student will be able to demonstrate an understanding of factors affecting carrying capacities of rearing units.	
31. The student will be able to demonstrate a knowledge of feeding methods, *i.e.*. amount of food to feed, feeding frequency, food particle size, etc.	Feeding Methods

32. The student will be able to demonstrate an understanding for the reasons for grading fish.	Fish Grading
33. The student will be able to demonstrate a knowledge of grading methods.	
34. The student will be able to grade fish.	
35. The student will be able to estimate or calculate the number of fish in a rearing unit.	Fish Enumeration
36. The student will be able to weigh fish.	
37. The student will be able to demonstrate a knowledge of the methods of transporting and planting fish.	Fish Transportation
38. The student will be able to keep accurate hatchery records.	Hatchery Records
39. The student will be able to demonstrate a knowledge of the nutritional requirements of fish.	Nutrition
40. The student will be able to demonstrate a knowledge of the types of fish feeders.	
41. The student will be able to use an automatic fish feeder.	
42. The student will be able to demonstrate a knowledge of the sources of fish food.	
43. The student will be able to demonstrate an understanding of how fish assimilate food.	
44. The student will be able to demonstrate an understanding of how fish metabolize food in order to obtain energy.	Metabolism & Food Energy
45 The student will be able to demonstrate a knowledge of the factors affecting fish metabolism.	
46. The student will be able to demonstrate a knowledge of food classifications, *e.g.*, carbohydrates, lipids, proteins, vitamins, and minerals.	Food Groups

47. The student will be able to recognize fish feed ingredients, *e.g.*, fresh meats, dry meals, fish products, etc.	Fish Feed Ingredients
48. The student will be able to select nutritionally sound diets for fish.	Diets & Feeds
49. The student will be able to demonstrate a knowledge of practical rations for salmonids.	Practical Rations for Salmonids
50. The student will be able to demonstrate a knowledge of salmonid diseases.	Salmonid Diseases
51. The student will be able to identify sources of salmonid diseases.	
52. The student will be able to demonstrate a knowledge of the techniques for preventing and treating diseases of salmonids.	
53. The student will be able to determine the probable cause of death for diseased salmonids.	Autopsy & Diagnostic Techniques
54. The student will be able to identify protozoan parasites of salmonids.	Protozoan Parasites
55. The student will be able to demonstrate a knowledge of viral diseases of salmonids.	Viral Diseases
56. The student will be able to demonstrate a knowledge of bacterial diseases of salmonids.	Bacterial Diseases
57. The student will be able to simulate controlled marketing of their products (live, frozen, canned, etc.) and report the comparative costs and return of each method.	Economics

COURSE CONTENT OUTLINE

1. Purpose and Functions
   - 1.1 Mitigation
   - 1.2 Rehabilitation
   - 1.3 Enhancement

2. History of Fish Culture
   - 2.1 World fish culture
   - 2.2. Fish culture in U.S.

3. Review of Icthyology
   - 3.1 External anatomy of salmonids
   - 3.2 Internal anatomy of salmonids
   - 3.3 Classification
   - 3.4 Distinguishing characteristics
   - 3.5 Life histories (emphasis on silver and pink salmon)

4. Reproductive Anatomy of Females
   - 4.1 Structure of ovaries

5. Fecundity and Egg Size

6. Development and Structure of Salmonid Sperm and Eggs
   - 6.1 Spermatogenesis
   - 6.2 Oogenesis
   - 6.3 Structure of sperm
   - 6.4 Structure of egg

7. Fertilization
   - 7.1 Processes
   - 7.2 Factors affecting success

8. Spawning Techniques
   - 8.1 General
   - 8.2 Trout spawning techniques
   - 8.3 Salmon spawning techniques

9. Embryology
   - 9.1 Developmental Stages
   - 9.2 Factors affecting development

10. Incubation Equipment and Methods
   - 10.1 General
   - 10.2 Incubation in troughs
   - 10.3 Vertical flow-through incubators
   - 10.4 Gravel incubators

11. Care and Handling of Salmonid Eggs During Incubation
   - 11.1 Review of developmental stages
   - 11.2 Removal of dead or infertile eggs
   - 11.3 Chemical treatments to combat fungus
   - 11.4 Silt and debris
   - 11.5 Water failure

12. Egg Enumeration
   - 12.1 General
   - 12.2 Enumeration techniques
     - 12.2.1 Sampling
     - 12.2.2 Counting all eggs

13. Egg Transportation and Shipment
   - 13.1 Situations requiring egg shipments
   - 13.2 Stages when eggs can be shipped
   - 13.3 Shipping procedures

14. Holding and Care of Adult Salmon and Brood Trout

- 14.1 Introduction
- 14.2 Trapping and holding adult salmon and anadromous trout
- 14.3 Holding and care of brood trout
- 14.4 Factors affecting salmonid maturation and spawning

15. Gamete Storage and Preservation

- 15.1 Short term storage
- 15.2 Cryogenic preservation

16. Genetics, Selective Breeding, and Hybridization

- 16.1 Introduction
- 16.2 Selective breeding
  - 16.2.1 Intentional selection
  - 16.2.2 Dangers
- 16.3 Hybridization
  - 16.3.1 Uses
  - 16.3.2 Types
  - 16.3.3 Fertility
  - 16.3.4 Crosses

17. Care and Handling of Fry

- 17.1 General incubation procedures
- 17.2 Precautions
- 17.3 Fry disorders
- 17.4 Transition from sack-fry to feeding fry
- 17.5 Holding units
- 17.6 Methods for transferring fry to starting tanks

18. Types of Holding Units Used in Salmonid Rearing

- 18.1 Non-circulating pools or ponds
  - 18.1.1 Raceways
  - 18.1.2 Large ponds of irregular shape

18.2 Circulating pools

18.2.1 Circular pools

18.2.2 Foster-Lucas ponds

18.2.3 Burrows rectangular recirculating raceways

18.2.4 Circulating pools

19. Determining Carrying Capacities or Stocking Rates of Rearing Units

19.1 Factors to consider

19.1.1 General

19.1.2 Principle

19.2 Methods for calculating or estimating pond loading

20. Feeding Methods

20.1 Amount of food to feed

20.2 Food particle size

20.3 Feeding frequency

20.4 Presenting food to fish

21. Grading

21.1 Reasons for grading

21.2 Types of grading devices

21.3 Usefulness of grading

22. Weighing and Enumerating Fish

23. Transporting and Planting Fish

23.1 Introduction

23.2 Providing adequate oxygen

23.3 Metabolis wastes

23.4 Methods

24. Hatchery Records

- 24.1 Fundamental types of information needed
- 24.2 Examples of hatchery record systems

25. Nutrition

- 25.1 Types of feeders
- 25.2 Sources of food
- 25.3 Assimilation of food

26. Metabolism and Food Energy

- 26.1 Major types of metabolism
- 26.2 Factors affecting metabolism
- 26.3 Energy – general
- 26.4 Energy – food

27. Carbohydrates, Lipids, Proteins, Vitamins, Minerals

28. Fish Feed Ingredients

- 28.1 Fresh meats
- 28.2 Dry meals
- 28.3 Fish products
- 28.4 Supplements and special purpose ingredients

29. Diets and Feeds

- 29.1 Types of diet mixtures
- 29.2 Examples of practical feeds
- 29.3 Gross nutritional composition

30. Practical rations for Salmonids

- 30.1 Open formula feeds
- 30.2 Commercial closed feeds

31. Introduction to Salmonid Diseases
    - 31.1 The study of disease
    - 31.2 The kinds of diseases fish suffer
    - 31.3 The sources of fish diseases
    - 31.4 The prevention of fish diseases
    - 31.5 The identification of sick fish
    - 31.6 The treatment of diseased fish

32. Autopsy and Diagnostic Techniques
    - 32.1 Collecting specimens
    - 32.2 Techniques

33. Protozoan Parasites of Salmonids

34. Viral Diseases of Salmonids

35. Bacterial Diseases of Salmonids

36. Miscellaneous Parasites of Salmonids

37. Economic Evaluation of Proposed Projects
    - 37.1 Costs
    - 37.2 Receipts
    - 37.3 Benefit to cost ratios

EXAMPLES OF LEARNING ACTIVITIES

1. Laboratory experiments
2. Field trips
3. Individual and group projects

4. Taking of salmon eggs
5. Feeding and caring of fry and fingerlings
6. Construction of incubators
7. Use of audio-visual media
8. Water quality diagnosis
9. Compiling notebook
10. Classroom discussions
11. Reading on assigned topics
12. Group and individual evaluation
13. Interviews
14. Lecture and demonstrations
15. Accumulation and organization of data
16. Guest speakers
17. Research
18. Written and oral tests
19. Water safety instruction
20. Boat handling

METHODS OF EVALUATION

The student's grade will be determined by the teacher based on: 1) the student's performance of and participation in classroom, laboratory, and field activites; 2) written assignments and tests; and 3) individual and group projects.

TEXTBOOK(S) AND/OR LEARNING MATERIALS PRESCRIBED

Handouts, laboratory exercises, diagrams, wall charts, slides, articles from periodicals, and selected reference texts will be provided to students. In addition, an audio-visual documentary of the students' recent trip to fish culture programs in western Washington and films will be available for student viewing.

1. Course Title: GENERAL BIOLOGY

2. Credit Awarded: 1/4 1/2 3/4 1 (circle one)

3. Grade Level First Offered: 7 8 9 10 11 12 (circle one)

4. Required Area of Study: Science

5. Prerequisite(s):

6. Elective or Required Offering: Required

COURSE DESCRIPTION

An introduction to the principles of biology and ecology as they apply to both plants and animals. The course will cover the nature of life, fundamental principles of chemistry, growth and reproduction, genetics, plants and animals, and biology of man. The interactions between organisms in biological communities, and the environmental factors in communities will also be studied.

Field trips will be made to varied environments in the area to study organisms in their natural associations, and specimens will be collected for laboratory study. The students will also maintain a salt water aquarium.

COURSE GOALS

1. The student will be able to distinguish the difference between living and nonliving things.	The Living Condition
2. The student will demonstrate an understanding of the fundamental characteristics of organisms.	
3. The student will demonstrate a knowledge of environmental factors that influence organisms and how organisms adapt to their environment.	
4. The student will demonstrate an understanding of matter, elements, atoms and molecules, isotopes, compounds, enzymes, solutions, and suspensions.	The Chemistry of Life

5. The student will demonstrate an understanding of energy and energy changes.	
6. The student will be able to demonstrate a knowledge of the relationship between elements, compounds, and organisms.	
7. The student will demonstrate a knowledge of the functions of carbohydrates, lipids, and proteins in living systems.	
8. The student will be able to name the parts of a cell.	The Structure of Life
9. The student will demonstrate a knowledge of the processes and functions of cells and how they contribute to the organization of living things.	
10. The student will demonstrate an understanding of homeostasis, permeability, and diffusion, *e.g.*, osmosis and plasmolysis.	The Cell and Its Environment
11. The student will demonstrate an understanding of photosynthesis.	Energy of Living Things
12. The student will demonstrate an understanding of respiration.	
13. The student will demonstrate a knowledge of DNA and RNA and their relationship to protein synthesis.	Nucleic Acids and Protein Synthesis
14. The student will be able to distinguish the difference between sexual and asexual reproduction.	Cell Growth and Reproduction
15. The student will demonstrate a knowledge of mitosis and meiosis.	
16. The student will demonstrate a knowledge of spermatogenisis and oogenisis.	
17. The student will demonstrate an understanding of such terms as allele, heterozygous, homozygous, phenotype, hybrid, etc.	Heredity
18. The student will be able to demonstrate a knowledge of the principles of dominance and recessiveness, the law of segregation, and the law of independent assortment.	
19. The student will be able to demonstrate an understanding of various genetic crosses.	

20. The student will demonstrate a knowledge of genes, chromosomes, and gene action.	Genetic Material
21. The student will demonstrate a knowledge of mutations.	
22. The student will be able to demonstrate a knowledge of the inheritance of genetic characters.	Genes in Human Populations
23. The student will demonstrate an understanding of selection, hybridization, and inbreeding.	Applied Genetics
24. The student will be able to demonstrate a knowledge of the geological time table of life.	Organic Variation
25. The student will demonstrate a knowledge of natural selection and survival of the fittest.	
26. The student will demonstrate a knowledge of the mechanisms of evolution.	
27. The student will demonstrate a knowledge of taxonomy.	The Diversity of Life
28. The student will demonstrate an understanding of how scientific names are written.	
29. The student will demonstrate a knowledge of viruses, *e.g.*, chemical composition, properties, identification, economic importance, viral diseases, etc.	Viruses
30. The student will demonstrate a knowledge of bacteria, *e.g.*, forms, structure, identification, motility, bacterial diseases, etc.	Bacteria
31. The student will demonstrate a knowledge of protozoans, *e.g.*, parts, locomotion, reproduction, pathology, etc.	Protozoans
32. The student will demonstrate a knowledge of fungi, *e.g.*, classes, identification, characteristics, reproductive structures, diseases, etc.	Fungi
33 The student will demonstrate a knowledge of algae, *e.g.*, characteristics, reproduction, classification, economic importance, etc.	Algae

34. The student will demonstrate a knowledge of mosses and ferns, *e.g.*, development, structure, life cycles, etc.	Mosses and Ferns
35. The student will demonstrate a knowledge of seeds, seed plants, and roots, *e.g.*, function of organs, classification, identification, tissue structure, etc.	Seeds and Roots
36. The student will demonstrate a knowledge of leaves and stems, *e.g.*, structure, growth, types, function, etc.	Leaves and Stems
37. The student will demonstrate a knowledge of plant growth and behavior, *e.g.*, effects of environment, dormancy, tropism, etc.	Plant Growth and Behavior
38. The student will demonstrate a knowledge of plant reproduction, *e.g.*, processes, parts, etc.	Plant Reproduction
39. The student will demonstrate a knowledge of metazoans, *e.g.*, structure, classification, identification, etc.	Metazoans
40. The student will demonstrate a knowledge of sponges and coelenterates, *e.g.*, characteristics, development, symmetry, etc.	Sponges and Coelenterates
41. The student will demonstrate a knowledge of molluscs and echinoderms, *e.g.*, identification, classification, water vascular system, structure, etc.	Molluscs and Echinoderms
42. The student will demonstrate a knowledge of Arthropods, *e.g.*, characteristics, classification, economic importance, etc.	Animals with Jointed Legs
43. The student will demonstrate a knowledge of insects, *e.g.*, identification, classification, diversity, metamorphosis, economic importance, etc.	Insects
44. The student will demonstrate a knowledge of vertebrates, *e.g.*, characteristics, classes, specialized organ systems, etc.	Introduction to Vertebrates
45. The student will demonstrate a knowledge of vertebrate embryology.	Vertebrate Embryology
46 The student will demonstrate a knowledge of fishes, *e.g.*, characteristics, classification, organ systems, etc.	Fishes
47. The student will demonstrate a knowledge of amphibians, *e.g.*, identification, classification, metamorphosis, behavior, etc.	Amphibians

48. The student will demonstrate a knowledge of reptiles and birds, *e.g.*, characteristics, reproduction, classification, etc.	Reptiles and Birds
49. The student will demonstrate a knowledge of mammals, *e.g.*, characteristics, classification, structural advantages, organ systems, etc.	Mammals
50. The student will demonstrate an understanding of the history of man.	History of Man
51. The student will demonstrate a knowledge of the anatomy and physiology of the organ systems of man, *e.g.*, digestive system, excretory system, circulatory system, etc.	Physiology of Man
52. The student will be able to define such terms as ecosystem, niche, biome, etc.	Introduction to Ecology
53. The student will be able to understand the interrelationships of organisms, *e.g.*, predation, commensalism, parasitism, symbiosis, etc.	
54. The student will be able to understand the interrelationship of organisms with their environment.	
55. The student will be able to demonstrate a knowledge of the water cycle, carbon-oxygen cycle, and nitrogen cycle.	
56. The student will demonstrate an understanding of the balance of nature.	
57. The student will demonstrate a knowledge of factors causing periodic changes in the environment.	Environmental Changes
58. The student will demonstrate a knowledge of modes of living and zones of life.	Modes of Living and Zones of Life
59. The student will demonstrate a knowledge of barriers to distribution.	
60. The student will demonstrate an understanding of energy relationships of living things (productivity), *e.g.*, food web, food pyramid.	Energy Relationships and Productivity
61. The student will demonstrate a knowledge of animal behavior and the effects of external stimuli on animal activity.	

COURSE CONTENT OUTLINE

1. Life and Its Origin
   - 1.1 Characteristics of the living condition
   - 1.2 The chemistry of life
     - 1.21 Matter
     - 1.22 Energy and energy changes
     - 1.23 Elements
     - 1.24 Atoms and molecules
     - 1.25 Isotopes
     - 1.26 Solutions and suspensions
     - 1.27 Elements, compounds, and organisms
     - 1.28 Carbohydrates, lipids, proteins
     - 1.29 Enzymes
   - 1.3 The structure of life
     - 1.31 Cell composition
     - 1.32 Contribution to the organization and growth of living things
   - 1.4 The cell and its environment
     - 1.41 Homeostasis
     - 1.42 Permeability
     - 1.43 Diffusion
       - 1.431 Osmosis
       - 1.432 Plasmolysis
   - 1.5 Energy of living things
     - 1.51 Photosynthesis
     - 1.52 Respiration
   - 1.6 Nucleic acids and protein synthesis
     - 1.61 DNA
     - 1.62 RNA
     - 1.63 Synthesis of proteins
   - 1.7 Cell growth and reproduction
     - 1.71 Sexual reproduction
     - 1.72 Asexual reproduction
     - 1.73 Mitosis
     - 1.74 Meiosis
     - 1.75 Spermatogenisis
     - 1.76 Oogenisis

2. The Stream of Life
   - 2.1 Heredity
     - 2.11 Genetic terms
       - 2.111 Heterozygous, phenotype, hybrid, etc.
     - 2.12 Principle of dominance and recessiveness
     - 2.13 Law of segregation
     - 2.14 Crosses
     - 2.15 Law of independent assortment
   - 2.2 Genetic Material
     - 2.21 Chromosomes
     - 2.22 Genes
     - 2.23 Mutations
   - 2.3 Genes in human populations
     - 2.31 Inheritance of genetic characters
   - 2.4 Applied genetics
     - 2.41 Selection
     - 2.42 Hybridization
   - 2.5 Organic variation
     - 2.51 Timetable of life
     - 2.52 Natural selection
     - 2.53 Survival of the fittest
     - 2.54 Mechanisms of evolution
   - 2.6 The diversity of life
     - 2.61 Scientific classification

3. Primitive Forms of life
   - 3.1 Viruses
   - 3.2 Bacteria
   - 3.3 Protozoans
   - 3.4 Fungi
   - 3.5 Algae

4. The Plant Kingdom
   - 4.1 Mosses and ferns
   - 4.2 Seeds and roots
   - 4.3 Leaf and stems
   - 4.4 Flowers and fruit
   - 4.5 Plant growth and behavior
   - 4.6 Plant reproduction

5. Invertebrate Animals
   - 5.1 Metazoans
   - 5.2 Sponges and coelenterates
   - 5.3 Echinoderms and molluscs
   - 5.4 Animals with jointed legs
   - 5.5 Insects

6. Vertebrate Animals
   - 6.1 Introduction to vertebrates
     - 6.11 Characteristics
     - 6.12 Classes
     - 6.13 Specialized systems
     - 6.14 Behavior
   - 6.2 Embryology – patterns of development of embryo
   - 6.3 Fishes
   - 6.4 Amphibians
   - 6.5 Reptiles and birds
   - 6.6 Mammals

7. Biology of Man
   - 7.1 History
   - 7.2 Physiology
     - 7.21 Bones and muscle
     - 7.22 Blood flow and circulation
     - 7.23 Exchange of gases and transport of oxygen and carbon dioxide
       - 7.231 Emphasis on gill apparatus of fish
     - 7.24 Nutrition and the digestive system
     - 7.25 Transport and excretion
     - 7.26 Hormones and the endocrine system
       - 7.261 Chemical regulation
       - 7.262 Cellular activity, particularly growth
     - 7.27 The nervous system
     - 7.28 Reproduction, including morphogenisis, autotomy, parthenogenisis, and regeneration

8. Ecology
   - 8.1 Introduction to ecology
     - 8.11 The biosphere, niches, communities, populations, biomes, etc.
     - 8.12 Interrelationships of organisms
       - 8.121 Symbiosis, commensalism, mutualism, predation, parasitism, epiphytism, and saprophytism

8.13 Interrelationships of organisms with their environment
8.14 The water cycle
8.15 The carbon-oxygen cycle
8.16 The nitrogen cycle
8.17 Biological balance

8.2 Periodic changes in environment

8.3 Modes of living and zones of life
8.31 Barriers to distribution

8.4 Energy relationships and productivity
8.41 Food web, food pyramid

8.5 Animal behavior and the effects of external stimuli on animal activity

EXAMPLES OF LEARNING EXPERIENCES

1. Maintaining salt water aquarium
2. Field trips
3. Laboratory exercises
4. Use of audio-visual media
5. Individual and group projects
6. Sampling equipment
7. Classroom discussions
8. Interviews
9. Guest speakers
10. Reading on assigned topics
11. Lecture and demonstrations
12. Group and individual evaluation
13. Data collection
14. Compiling notebook
15. Written and oral tests
16. Water safety instruction
17. Boat handling

METHODS OF EVALUATION

The students will be evaluated and graded by the instructor based on: 1) attitude and willingness to learn, 2) performance of classroom, laboratory, and field exercises, and 3) written and oral tests and assignments.

TEXTBOOK(S) AND/OR LEARNING MATERIALS PRESCRIBED

Texts, manuals, handouts, magazines, wall charts, slides, posters, models, and other suggested references will be available to the students. Films and filmstrips will also be shown when deemed desirable.

1. Course Title:	WATER RESOURCES						
2. Credit Awarded:	1/4		1/2		3/4	1	(circle one)
3. Grade Level First Offered:	7	8	9	10	11	12	(circle one)
4. Required Area of Study:	Science						
5. Prerequisite(s):	Science — Grade 7						
6. Elective or Required Offering:	Required						

COURSE DESCRIPTION

This course will include the study of the origin and extent of oceans, geology of the sea bottom, parameters of water quality, physical and chemical characteristics of water, and its movement in waves, tides, and currents, and water pollution.

The students will determine stream flow measurements and impoundment exchange rates. Special emphasis will be placed on stream and lake surveying (morphometric and physical parameters). A quantitative and qualitative study of plankton will be made. Biological aspects will be discussed to a lesser degree.

COURSE GOALS

1. The student will demonstrate an understanding of the use and value of water.	Use and Value of Water
2. The student will demonstrate an understanding of the use of water by fish.	
3. The student will demonstrate a knowledge of the water requirements for maintaining aquatic life.	
4. The student will demonstrate a knowledge of aquatic life resources.	Aquatic Life Resources
5. The student will be able to demonstrate a knowledge of the metric system.	The Metric System

6. The student will be able to recognize the practical applications of oceanographic studies.	Introduction to Oceanography
7. The student will be able to demonstrate a knowledge of the oceans, *e.g.*, Pacific, Atlantic, Indian, etc.	Land and Sea
8. The student will be able to demonstrate an understanding of sea level and changes in sea level.	
9. The student will be able to demonstrate a knowledge of the ocean depths, *e.g.*, features, major basins, formation, etc.	
10. The student will demonstrate a knowledge of the features of the continental margin, *e.g.*, continental shelf, continental slope, continental rise.	
11. The student will demonstrate an understanding of the coastal ocean, *e.g.*, features, importance to man, etc.	
12. The student will be able to demonstrate a knowledge of ocean rises.	Deep Ocean Floor
13. The student will be able to demonstrate a knowledge of ocean basins.	
14. The student will be able to demonstrate a knowledge of abyssal plains.	
15. The student will be able to demonstrate a knowledge of submarine volcanoes.	
16. The student will be able to demonstrate a knowledge of island arcs and trenches.	
17. The student will be able to demonstrate a knowledge of coral reefs.	
18. The student will demonstrate an understanding of the origin of the oceans and atmosphere, *e.g.*, crustal structure, sea floor spreading, fracture zones, volcanic ridges, magnetic stripes.	
19. The student will demonstrate an understanding of the origin of life on earth.	

20. The student will demonstrate a knowledge of the origin and classification of sediments.	Sediments
21. The student will be able to demonstrate an understanding of the transport and accumulation of sediments.	
22. The student will demonstrate an understanding of the distribution of sediments.	
23. The student will demonstrate a knowledge of the properties of pure water.	Physical Properties of Sea Water
24. The student will be able to demonstrate a knowledge of measured properties of sea water, *e.g.*, pressure, dissolved solids, settleable solids, etc.	
25. The student will be able to determine sea water temperatures, depth, salinity, and turbidity.	
26. The student will demonstrate a knowledge of computed properties of sea water, *e.g.*, specific volume, surface tension, specific heat, etc.	
27. The student will demonstrate a knowledge of transmission properties of sea water, *e.g.*, sound, fate of incipient solar radiation.	
28. The student will demonstrate a knowledge of waves, *e.g.*, surface waves, destructive waves, stationary waves, internal waves, etc.	Water Movements
29. The student will demonstrate a knowledge of tides, *e.g.*, tide-producing forces, astronomical tides, meteorological tides, tidal bore.	
30. The student will demonstrate a knowledge of currents *e.g.*, large scale, density currents, effects of Coriolis Force, tidal currents, etc.	
31. The student will demonstrate a knowledge of the molecular structure and composition of sea water.	Chemical Properties of Sea Water
32. The student will be able to determine alkalinity, water hardness, and pH.	
33. The student will be able to demonstrate a knowledge of dissolved solids, dissolved gases, nutrients, oxidation and reduction.	

34. The student will demonstrate an understanding of sea ice, *e.g.*, formation, ice drift, ice deformation.	Sea Ice
35. The student will be able to demonstrate a knowledge of air-sea interactions, *e.g.*, heat exchange, evaporation and condensation, hurricanes and typhoons, etc.	Air-Sea Interactions
36. The student will be able to demonstrate an understanding of the types of estuaries.	Estuaries
37. The student will demonstrate a knowledge of the origin and development of estuaries.	
38. The student will demonstrate an understanding of biological productivity in estuaries.	
39. The student will demonstrate a knowledge of types of estuarine circulation.	
40. The student will demonstrate a knowledge of the coastal ocean, *e.g.*, currents, storm surges, tidal effects, etc.	The Coastal Ocean
41. The student will demonstrate an understanding of shorelines and shoreline processes, *e.g.*, beaches, deltas, coastlines.	Shoreline and Shoreline Processes
42. The student will be able to collect and identify plankton.	Plankton
43. The student will demonstrate an understanding of methods of plankton flotation.	
44. The student will demonstrate a knowledge of plankton distribution.	
45. The student will demonstrate a knowledge of productivity of plankton.	
46. The student will demonstrate a knowledge of color and bioluminescense of plankton.	
47. The student will demonstrate a knowledge of the benthos, *e.g.*, rocky beaches, reef communities, etc.	The Benthos

48. The student will demonstrate a knowledge of the origin and classification of lakes and ponds.	Lakes and Ponds
49. The student will demonstrate a knowledge of morphology and morphometry.	
50. The student will be able to determine the area and volume of a lake or pond.	
51. The student will be able to determine the exchange rate of a lake or pond.	
52. The student will demonstrate a knowledge of the physical parameters of lakes and ponds.	
53. The student will demonstrate a knowledge of the optical properties of lakes and ponds.	
54. The student will demonstrate a knowledge of hydromechanics.	
55. The student will demonstrate a knowledge of the chemical parameters of lakes and ponds.	
56. The student will be able to determine stream flow measurements, *e.g.*, velocity, volume, etc.	Flowing Waters
57. The student will demonstrate a knowledge of the classification of streams according to the source of water, temperature, and elevation.	
58. The student will demonstrate a knowledge of ecological classification.	Biological Limnology
59. The student will be able to recognize modes of living, *e.g.*, seston, neuston, nekton, etc.	
60. The student will be able to demonstrate a knowledge of trophic classification, *e.g.*, producers, consumers.	
61. The student will demonstrate an understanding of population control, *i.e.*, law of the minimum.	

62. The student will demonstrate an understanding of the benthos, *e.g.*, profundal zone, littoral zone, periphyton, psamnion, etc.

63. The student will demonstrate a knowledge of trophic dynamics.

64. The student will be able to identify types of water pollution. — Water Pollution

65. The student will demonstrate a knowledge of causes and effects of water pollution.

66. The student will demonstrate a knowledge of the control of water pollution.

COURSE CONTENT OUTLINE

1. Use and Value of Water
   - 1.1 Use of water by fish
   - 1.2 Requirements for maintaining aquatic life

2. Value of Aquatic Life Resources

3. Review of the Metric System

4. Introduction to Oceanography
   - 4.1 Applications

5. Land and Sea
   - 5.1 The oceans
   - 5.2 Sea level
   - 5.3 Ocean depths
   - 5.4 Continental margin
   - 5.5 Coastal ocean

6. Deep Ocean Floor
   - 6.1 Ocean rises
   - 6.2 Ocean basins
   - 6.3 Abyssal plains
   - 6.4 Submarine volcanoes
   - 6.5 Island arcs and trenches
   - 6.6 Coral reefs

7. History of Ocean and Atmosphere
   - 7.1 Crustal structure
   - 7.2 Sea-floor spreading
   - 7.3 Fracture zones and volcanic ridges
   - 7.4 Magnetic stripes
   - 7.5 Origin of ocean and atmosphere
   - 7.6 Origin of life on earth

8. Sediments
   - 8.1 Origin and classification
   - 8.2 Transport and accumulation
   - 8.3 Distribution

9. Physical Properties of Sea Water
   - 9.1 Properties of pure water
   - 9.2 Measured properties
     - 9.21 Temperature
     - 9.22 Salinity
     - 9.23 Pressure
     - 9.24 Depth
     - 9.25 Dissolved solids
     - 9.26 Settleable solids
     - 9.27 Turbidity
   - 9.3 Computed properties
     - 9.31 Specific volume
     - 9.32 Surface tension
     - 9.33 Specific heat
     - 9.34 Viscosity
     - 9.35 Density
     - 9.36 Sound velocity
   - 9.4 Transmission properties
     - 9.41 Sound
     - 9.42 Fate of incipient solar radiation
       - 9.421 Distribution of radiation
       - 9.422 Distribution of heat
       - 9.423 Energy content
       - 9.424 Annual temperature cycle
       - 9.425 Types of stratification

10. Water Movements
    - 10.1 Waves
        - 10.11 Surface waves
        - 10.12 Destructive waves
        - 10.13 Stationary waves
        - 10.14 Internal waves
        - 10.15 Shallow water waves
        - 10.16 Ideal waves
        - 10.17 Breakers and surf waves
        - 10.18 Wind generated waves
        - 10.19 Distribution
    - 10.2 Tides
        - 10.21 Tide-producing forces
        - 10.22 Astronomical tides
        - 10.23 Meterological tides
        - 10.24 Tidal bore
    - 10.3 Currents
        - 10.31 Large scale
        - 10.32 Density currents
        - 10.33 Effects of Coriolis Force
        - 10.34 Tidal currents
        - 10.35 Contour currents
        - 10.36 Long shore currents
        - 10.37 Counter currents

11. Chemical Properties of Sea Water
    - 11.1 Molecular structure and composition
    - 11.2 Salinity
    - 11.3 Dissolved solids
    - 11.4 Dissolved gases
    - 11.5 Nutrients
    - 11.6 Oxidation and reduction
    - 11.7 Alkalinity
    - 11.8 Water hardness
    - 11.9 Hydrogen ion concentration

12. Sea Ice
    - 12.1 Formation
    - 12.2 Ice drift
    - 12.3 Ice deformation

13. Air-Sea Interaction
    - 13.1 Heat exchange
    - 13.2 Evaporation and condensation
    - 13.3 Hurricanes and typhoons
    - 13.4 Exchange of chemical particles
    - 13.5 Formation of winds
    - 13.6 Exchange of electrical energy

14. Estuaries
    - 14.1 Types and examples
    - 14.2 Origin and development
    - 14.3 Biological productivity
    - 14.4 Estuarine circulation

15. The Coastal Ocean
    - 15.1 Temperature and salinity
    - 15.2 Coastal currents
    - 15.3 Storm surges
    - 15.4 Tide effects on river discharge
    - 15.5 Ocean effects on land climate

16. Shoreline and Shoreline Processes
    - 16.1 Coastlines
    - 16.2 Deltas
    - 16.3 Beaches

17. Plankton
    - 17.1 Composition
    - 17.2 Flotation in water
    - 17.3 Spatial distribution
    - 17.4 Temporal distribution
    - 17.5 Productivity
    - 17.6 Color and bioluminescence

18. The Benthos
    - 18.1 Rocky beaches
    - 18.2 Reef communities
    - 18.3 Deep ocean benthos
    - 18.4 Benthos of coastal sediment

19. Lakes and Ponds
    - 19.1 Origin and classification
    - 19.2 Morphometry and morphology
        - 19.21 Nomenclature and definitions
        - 19.22 Shoreline surveys
        - 19.23 Exchange rate of lakes and impoundments
    - 19.3 Physical parameters
    - 19.4 Optical Properties
    - 19.5 Hydromechanics
    - 19.6 Chemical parameters

20. Flowing Waters
    - 20.1 Stream flow measurements
        - 20.11 Velocity
        - 20.12 Volume
    - 20.2 Stream types based on source, temperature, and elevation

21. Biological Limnology
    - 21.1 Ecological classification
    - 21.2 Mode of living
        - 21.21 Seston
        - 21.22 Neuston
        - 21.23 Nekton, etc.
    - 21.3 Trophic classification
        - 21.31 Producers
        - 21.32 Consumers
    - 21.4 Population control
        - 21.41 Law of the Minimum
    - 21.5 The benthos
        - 21.51 Profundal zone
        - 21.52 Littoral zone
        - 21.53 Periphyton
        - 21.54 Psammon
    - 21.6 Trophic dynamics

22. Water Pollution
    - 22.1 Cause
    - 22.2 Effect
    - 22.3 Control

EXAMPLES OF LEARNING EXPERIENCES

1. Field trips
2. Laboratory experiments
3. Use of audio-visual media
4. Individual and group projects
5. Water quality diagnosis
6. Sampling equipment
7. Classroom discussions
8. Interviews
9. Guest speakers
10. Morphometry
11. Hydromechanics
12. Reading on assigned topics
13. Group and individual evaluation
14. Lecture and demonstrations
15. Accumulation and organization of data
16. Compiling notebook
17. Research
18. Written and oral tests
19. Water safety instruction
20. Boat handling

METHODS OF EVALUATION

Grades are arrived at by the instructors evaluation of 1) attitude, participation, and performance of classroom, laboratory, and field exercises, 2) individual and group projects and 3) written and oral tests and assignments.

TEXTBOOK(S) AND/OR LEARNING MATERIALS PRESCRIBED

Handouts, texts, wall charts, sampling equipment, slides, posters, magazines, and other suggested references will be provided to students. Films and filmstrips will also be shown when deemed desirable.

1. Course Title: FISHERIES SCIENCE

2. Credit Awarded: 1/4 1/2 3/4 1 (circle one)

3. Grade Level First Offered: 7 8 9 10 11 12 (circle one)

4. Required Area of Study: Science

5. Prerequisite(s): Science — Grades 7 and 8

6. Elective or Required Offering: Required

COURSE DESCRIPTION

Lectures, laboratory work, and field trips are designed to acquaint the students with the life histories, and identification of commercially important fish and shellfish. Related topics include age and growth, management techniques with an emphasis on life history relationships, habitat improvement including fertilization, poisoning, biological controls, and chemical rehabilitation.

The students will also study creel census techniques and population estimates, including marking and tagging and the use of anesthetics. Fishways, net mending techniques, and commercial fishing methods will be reviewed.

Aquatic plants, insects, and plankton will be collected for laboratory study.

COURSE GOALS

1. The student will demonstrate a knowledge of basic ichthyology.	Ichthyology
2. The student will be able to identify the internal and external anatomy of salmonids.	
3. The student will be able to classify salmonids.	
4. The student will be able to recognize distinguishing characteristics of salmonids.	

5. The student will demonstrate a knowledge of life histories of salmonids, *e.g.*, embryology, life history stages.

6. The student will be able to identify the anatomy of halibut.

7. The student will be able to classify halibut.

8. The student will be able to recognize the distinguishing characteristics of halibut.

9. The student will demonstrate a knowledge of life histories of halibut, *e.g.*, embryology, life history stages.

10. The student will be able to identify the anatomy of crabs.

11. The student will be able to classify crabs.

12. The student will be able to recognize the distinguishing characteristics of crab.

13. The student will demonstrate a knowledge of life histories of crab, *e.g.*, embryology, life history stages.

14. The student will be able to identify the anatomy of shrimp.

15. The student will be able to classify shrimp.

16. The student will be able to recognize the distinguishing characteristics of shrimp.

17. The student will demonstrate a knowledge of the life history of shrimp, *e.g.*, embryology, life history stages.

18. The student will be able to identify the eight major orders of aquatic insects.

Natural Foods and Food Habits

19. The student will demonstrate a knowledge of the economic importance of aquatic insects.

20. The student will be able to collect and identify plankton.

21. The student will be able to quantify plankton samples.

22. The student will demonstrate a knowledge of the distribution of plankton.

23. The student will demonstrate a knowledge of age and growth with special emphasis on salmon.

24. The student will demonstrate a knowledge of the methods for determining age and growth.

25. The student will be able to age salmonids by reading scale samples.

26. The student will demonstrate an understanding of back calculations for determining growth.

27. The student will demonstrate a knowledge of methods for determining growth and condition.

28. The student will demonstrate a knowledge of the purposes for fishing regulations.

Management Techniques

29. The student will demonstrate a knowledge of management techniques, *e.g.*, design of fishing gear to permit escape of smaller fish, closure of nursery grounds, removal of competing and predator species, etc.

30. The student will demonstrate a knowledge of the general effectiveness of fishing regulations.

31. The student will demonstrate a knowledge of the relationship of life histories to management *e.g.*, degree of movement, developmental migrants, resident species, zones inhabited, etc.

Relation of Life History to Management

32. The student will demonstrate a knowledge of zones of life, *e.g.*, marine, anadromous, freshwater.

33. The student will demonstrate a knowledge of classification by manner of reproduction.

34. The student will demonstrate a knowledge of stream and lake management *e.g.*, effects of competition on survival and growth, stocking programs, species, etc.	Stream and Lake Management
35. The student will demonstrate a knowledge of the efficiency of stream and lake management techniques.	
36. The student will be able to demonstrate a knowledge of factors to consider before recommendation of a stream improvement program.	Habitat Protection and Stream Improvement
37. The student will demonstrate a knowledge of the effects of habitat improvement.	
38. The student will demonstrate a knowledge of habitat protection and improvement techniques, *e.g.*, removal of obstructions, dams, deflectors, covers, spawning channels, etc.	
39. The student will demonstrate a knowledge of common mistakes made when undertaking a habitat improvement program.	
40. The student will demonstrate a knowledge of the basic methods used in habitat protection and improvement of lakes.	Habitat Protection and Lake Improvement
41. The student will demonstrate a knowledge of fertilization of lakes *e.g.*, types of fertilizers, methods of application, costs, major obstacles, etc.	
42. The student will demonstrate a knowledge of the methods used controlling undesirable species, *e.g.*, poisoning, netting, biological control, liberalized fishing laws.	Control of Undesirable Species
43. The student will be able to identify and classify aquatic plants.	Aquatic Plant Control
44. The student will demonstrate a knowledge of the economic importance of aquatic plants,	
45. The student will demonstrate a knowledge of chemical control of aquatic plants, *e.g.*, types of chemicals, methods of application, advantages and disadvantages, costs, etc.	
46. The student will demonstrate a knowledge of the reasons for creel censuses.	Creel Census

47. The student will demonstrate a knowledge of the types of creel censuses, *e.g.*, general census, complete census, stratified-sample census.	
48. The student will demonstrate a knowledge of marking and tagging, *e.g.*, development, information derived from marking, techniques, materials, methods of attachment and recovery, etc.	**Marking and Tagging**
49. The student will demonstrate a knowledge of anesthetics, *e.g.*, types, uses, methods.	**Anesthetics**
50. The student will demonstrate a knowledge of the basics for population enumeration.	**Population Enumeration**
51. The student will demonstrate a knowledge of the methods of population enumeration.	
52. The student will be able to estimate the population of fish in a section of a local stream.	
53. The student will demonstrate a knowledge of biomass estimates.	
54. The student will demonstrate a knowledge of fishways, *e.g.*, fishways at dams, fish screens, permanent fish traps, etc.	**Introduction to Fishways**
55. The student will be able to hang and repair a net.	**Net Mending**
56. The student will demonstrate a knowledge of commercial fisheries techniques, *e.g.*, seines, nets or trawls, rakes and tongs, lines, traps, etc.	**Commercial Fisheries**

COURSE CONTENT OUTLINE

1. Ichthyology
   - 1.1. Salmonids
     - 1.11 External anatomy
     - 1.12 Internal anatomy
     - 1.13 Classification
     - 1.14 Distinguishing characteristics
     - 1.15 Life histories
       - 1.151 Embryology
       - 1.152 Life history stages

1.2 Halibut
- 1.21 Anatomy
- 1.22 Classification
- 1.23 Distinguishing characteristics
- 1.24 Life history
  - 1.241 Embryology
  - 1.242 Life history stages

1.3 Tanner and King Crab
- 1.31 Anatomy
- 1.32 Classification
- 1.33 Distinguishing characteristics
- 1.34 Life histories
  - 1.341 Embryology
  - 1.342 Life history stages

1.4 Shrimp
- 1.41 Anatomy
- 1.42 Classification
- 1.43 Distinguishing characteristics
- 1.44 Life history
  - 1.441 Embryology
  - 1.442 Life history

2. Natural Foods and Food Habits

2.1 Aquatic insects
- 2.11 Diptera
- 2.12 Odonata
- 2.13 Hemiptera
- 2.14 Ephemeroptera
- 2.15 Neuroptera
- 2.16 Plecoptera
- 2.17 Coleoptera
- 2.18 Trichoptera

2.2 Plankton-review
- 2.21 Composition
  - 2.211 Qualitative
  - 2.212 Quantitative
- 2.22 Distribution

3. Age and Growth

3.1 General

3.2 Methods

- 3.21 Scales
- 3.22 Otoliths
- 3.23 Bones
- 3.24 Back calculations (growth)
- 3.25 Method for determining growth and condition

4. Management Techniques
   - 4.1 Purpose of fishing regulations
   - 4.2 Design of fishing to permit escape of smaller fish
   - 4.3 Closure of nursery grounds
   - 4.4 Protection of spawning grounds
   - 4.5 Removal of competing and predator species
   - 4.6 Stocking of barren or depleted waters
   - 4.7 Restriction to certain seasons
   - 4.8 Protection based on sex and condition
   - 4.9 Regulation concerning sale
   - 4.10 How regulations can effect a species
   - 4.11 General effectiveness

5. Relation of Life History to Management
   - 5.1 Degree of movement
   - 5.2 Resident species
   - 5.3 Developmental migrants
   - 5.4 Annual migrants
   - 5.5 Zones inhabited and classification
     - 5.51 Marine
     - 5.52 Dromous
     - 5.53 Freshwater
   - 5.6 Classification by manner of reproduction

6. Stream and Lake Management
   - 6.1 Species
   - 6.2 Effects of competition on survival and growth
   - 6.3 Survival of stocking program
   - 6.4 Formulating a stocking program
   - 6.5 Efficiency

7. Habitat Protection and Improvement of Streams
   - 7.1 Factors to consider
     - 7.11 Conditions to be determined before recommendation of a stream improvement program

7.2 Measurement of effects of habitat improvement
7.3 Cost of habitat improvement
7.4 Removal of obstructions
7.5 Deflectors
7.6 Spawning channels
7.7 Dams
7.8 Covers
7.9 Common mistakes

8. Habitat Protection and Improvement of Lakes
8.1 Methods
8.2 Fertilization
8.21 Fertilizer and its relation to the food chain
8.22 Types of fertilizers
8.23 Methods of application
8.24 Disadvantages of large scale fertilization programs
8.25 Costs
8.26 Major obstacles
8.27 Knowledge of bottom characteristics

9. Control of Undesirable Species
9.1 Poisoning
9.11 Types
9.12 Methods of Application
9.2 Netting
9.3 Biological control
9.31 General
9.32 Types
9.4 Water level control
9.5 Liberalized fishing regulations

10. Aquatic Plant Control
10.1 Aquatic plants
10.11 Identification
10.12 Classification
10.13 Economic importance
10.2 Chemical control
10.21 Types
10.22 Methods of application
10.23 Advantages and disadvantages
10.24 Costs

11. Introduction to Creel Census
    - 11.1 General
    - 11.2 General census
    - 11.3 Complete census
    - 11.4 Stratified-sample census

12. Marking and Tagging
    - 12.1 Development of marking
    - 12.2 Information derived from marking
    - 12.3 Marking techniques
    - 12.4 Materials
    - 12.5 Choice of tag for specific experiment
    - 12.6 Methods of attachment
    - 12.7 Methods of recovery

13. Anesthetics
    - 13.1 Types
    - 13.2 Uses
    - 13.3 Methods

14. Population Enumeration
    - 14.1 General
    - 14.2 Methods
        - 14.21 Direct
            - 14.211 Total tally
            - 14.212 Area density
            - 14.213 Density contour
        - 14.22 Indirect
            - 14.221 Mark-recapture
            - 14.222 Peterson method
            - 14.223 Schnable method
            - 14.224 Delury method
    - 14.3 Biomass estimates
        - 14.31 General
        - 14.32 Methods

15. Introduction to Fishways
    - 15.1 Fishways at natural obstructions
    - 15.2 Fishways at dams
    - 15.3 Fish screens
    - 15.4 Permanent fish traps

16. Basic Net Mending Techniques
    - 16.1 Hanging net
    - 16.2 Building net

17. Commercial Fisheries
    - 17.1 Seines
    - 17.2 Nets or trawls
    - 17.3 Weirs
    - 17.4 Traps
    - 17.5 Lines
    - 17.6 Spears
    - 17.7 Rakes and tongs

EXAMPLES OF LEARNING EXPERIENCES

1. Field trips
2. Laboratory exercises
3. Individual and group projects
4. Use of audio-visual media
5. Sampling equipment
6. Classroom discussion
7. Interviews
8. Guest speakers
9. Reading on assigned topics
10. Group and individual evaluation
11. Lecture and demonstrations
12. Accumulation and organization of data
13. Compiling notebook
14. Research
15. Written and oral tests
16. Water safety instruction
17. Boat handling

METHODS OF EVALUATION

The students will be graded by the teacher based on 1) attitude, participation, and performance of classroom, laboratory, and field exercises, 2) individual and group projects, and 3) written and oral tests and assignments.

TEXTBOOK(S) AND/OR LEARNING MATERIALS PRESCRIBED

Handouts, magazines, texts, sampling equipment, wall charts, slides, posters, and other suggested references will be provided to students. Films and filmstrips will also be shown when deemed irable.

AQUACULTURE A Course of Study for
Sand Point Secondary School

1975 — 1976

Jay Hammond, Governor
Dr. Marshall L. Lind
Commissioner of Education

Office of Public Information and Publications
Alaska Department of Education
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