Energy

GEOTHERMAL

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DIRECT USE OF LOW TEMPERATURE GEOTHERMAL WATER BY AQUAFARMS INTERNATIONAL, INC. FOR FRESHWATER AQUACULTURE (PRAWNS AND ASSOCIATED SPECIES)

An Operations and Maintenance Manual

By
R. Broughton
M. Price
V. Price
Dov Grajcer

April 1984

MASTER

Work Performed Under Contract No. AC03-79ET27047

Aquafarms International, Inc.
Mecca, California

Technical Information Center
Office of Scientific and Technical Information
United States Department of Energy

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DIRECT USE OF LOW TEMPERATURE GEOTHERMAL WATER BY AQUAFARMS INTERNATIONAL, INC. FOR FRESHWATER AQUACULTURE (PRAWNS AND ASSOCIATED SPECIES).

AN OPERATIONS AND MAINTENANCE MANUAL

By
R. Broughton
M. Price
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Dov Grajcer, Ph.D.

April 1984

Prepared By
Aquafarms International, Inc.

For the
U.S. Department of Energy
San Francisco Operations Office

Under Contract No. DE-AC03-79ET27047

ABSTRACT

In connection with an ongoing commercial aquaculture project in the Coachella Valley, California; Aquafarms International Inc. conducted a twelve month prawn growout demonstration project. This project began in August, 1979 and involved the use of low temperature (85°F) geothermal waters to raise freshwater prawns, Macrobrachium rosenbergii (deMan), in earthen ponds. The following publication is an operations and maintenance guide which may by useful for those interested in conducting similar enterprises.

The demonstration project was part of the United States Department of Energy's "Direct Utilization of Geothermal Energy Field Experiment Program" (Contract Number 03-79-ET-27047, PON ET-78-N-03-2047).

KEYWORDS:

Geothermal
Direct use
Low temperature
Freshwater prawn
Growout
Ponds
Operations and maintenance

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Information gathered for this manual was obtained partially from current publications from various state cooperative extension services, trade bulletins and technical society newsletters. Along these lines, we thank Mr. Verl Stevens, Editor, American Fisheries Society Fish Culture Newsletter, for his permission to incorporate some of his original illustrations. Special thanks also go to Lou Patras for assistance with manuscript preparations.

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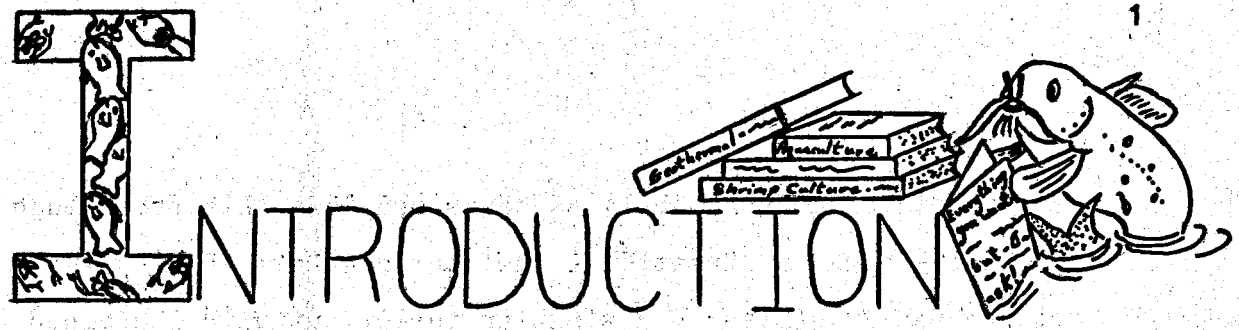

INTRODUCTION

I.0 Aquaculture, what is it?

Aquaculture is the husbandry of aquatic organisms.[1,*] It is that branch of agriculture that deals with an empounded or defined water space. These ponds and facilities correspond roughly with soil farmers fields and pastures. The crops grown might be either animals or plants with the end products being aimed at the food, recreation or ornamental markets. These culture techniques can be extensive or intensive. Extensive culture designates the cultivation of large areas of water by methods involving the smallest possible use of labor, tools, etc.. Intensive pertains to a method of farming whereby much capital and labor are expended upon making a small area highly productive. One system might combine both methods; an extensive culture for early growth, with an intensive completion phase to ready the product for market.

Presently, aquaculture is a supplementary source of aquatic products. The bulk of these goods come from the fishing industry. In 1975, world aquaculture production amounted to 10 percent of the total world fish catch.[2] In the United States fish and shellfish consumption has increased but traditional fisheries resources are approaching near maximum yield levels.[3] U.S. aquaculture supplies a small percentage of the fisheries products consumed.

* Bibliography located at the end of each section.

As theoretical and pragmatic advances are made this percentage can be increased. Educational institutions have treated aquaculture and fisheries as a singular topic, but with increased knowledge and development both subjects have come into their own. They are now viewed as separate, comparable fields.

I.1 History of aquaculture

In some parts of the world, aquaculture is almost as old as agriculture. Carp were cultured as long ago as 2698 B.C. in China. There they were grown in ponds on silkworm farms.[4] A treatise called Fish Breeding dated 475 B.C. told of captive carp.[5] During the Tang Dynasty (A.D. 618-904) the Chinese asserted that a body of water is a three dimensional growing space. This philosophy infers that if a pond is treated as a field and only one kind of crop is planted, it is likely to result in wasted space. A fertile pond will produce a number of different fish food organisms. Fish, selective in their diet, could be matched to these different food sources so that all dimensions of the pond were utilized. Their polyculture of several species of carp (Figure I-1) is based on this ancient concept.[1] Kwai Sin Chak Shik written is A.D. 1234, describes how carp fry were transported in bamboo baskets.[4]

Aquaculture also developed in the West. Evidence in a tomb frieze of 2500 B.C. suggests that Tilapia may have been cultivated in Egypt. The ancient Greeks and Romans fattened fish in ponds. The Romans cultivated oysters.[1]

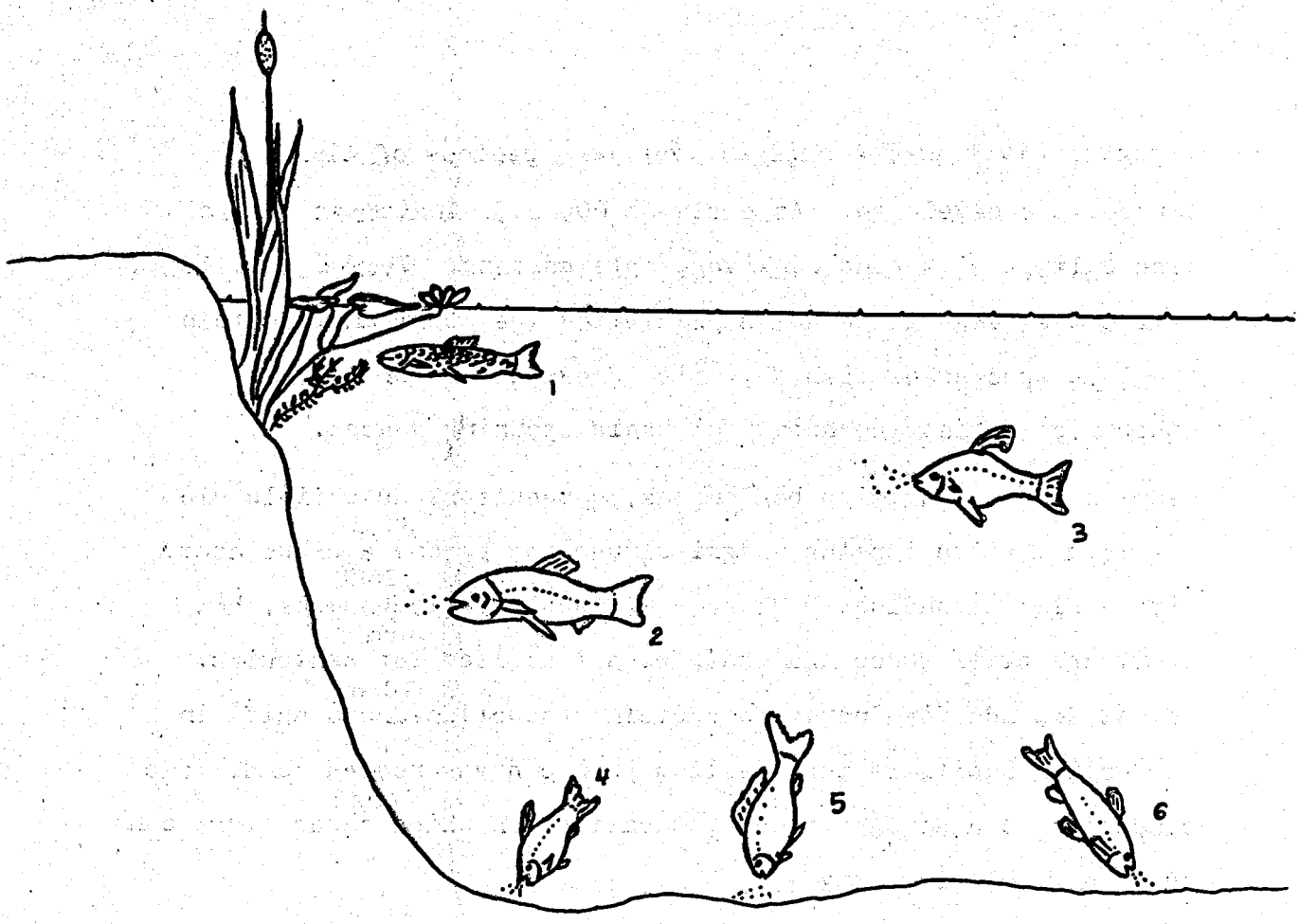

Figure I-1. Ancient Chinese carp polyculture. The habitat and feeding niches of the principle carp species are represented. (1) Grass carp (Ctenopharyngodon idellus) feeding on vegetation. (2) Big head (Aristichtys nobilis) feeding on zooplankton in midwater. (3) Silver carp (Hypophthalmichtys molitrix) feeding on phytoplankton in midwater. (4) Mud carp (Cirrhinus molitorella) feeding on benthic animals and detritus. (5) Common carp (Cyprinus carpio) feeding on benthic animals and detritus. (6) Black carp (Mylopharyngodon piceus) feeding on mollusks.[1]

Wherever civilization existed over long periods of time aquaculture developed. As early as 600 B.C. India was combining fish culture with pond bank vegetable gardens. By 246 B.C. legislation was established which prohibited the killing of certain inedible species of fish. It also provided protection for other fish during the height of their spawning season.[4]

Despite these promising beginnings, aquaculture as a field did not maintain its impetus. Agriculture has become agribusiness, with a high technology backdrop. Aquaculture techniques, however, are still those that have been practiced for centuries. Recent demands for increased protein production and a shift in the eating habits of the American public have created conditions conducive to a strong fiscal foundation, on which aquaculture can build a viable industry.

I.2 Status of this manual

Aquafarms International Incorporated (AII) was formed in 1975 as a commercial aquaculture endeavor. Located in the Coachella Valley, the companys' original emphasis was the development of a viable freshwater prawn (Macrobrachium rosenbergii) farm. Other aquaculture aspects were initiated by AII after the initial prawn research, development and pilot plant stage was completed. A total capability team was formed which encompasses fields of biology, water chemistry, geophysics, nutrition, marketing and business management.

This team conducted, under contract, a prawn grow-out demonstration project using low temperature, geothermal water in earthen ponds (D.O.E. contract number 03-79-ET-27047). During this time, in order to more fully utilize the temperature and downstream water resources, a number of other aquatic species were experimentally grown. After completion of the D.O.E. involvement, AII continued to add species to its research and commercial lines, thus enabling them to act as consultants to a number of public and private aquaculture projects. As this Operations and Maintenance Manual was compiled, information was included which can be used for in-house operation of the AII grow-out facility as well as serving as a preliminary guide and growing manual applicable to a range of facility sizes.

Selected Bibliography

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4. Chakroff, M.. 1976. Freshwater Fish Pond Culture and Management. Peace Corps Program and Training Journal. Manual Series Number 1B. ACTION, Washington, D.C..

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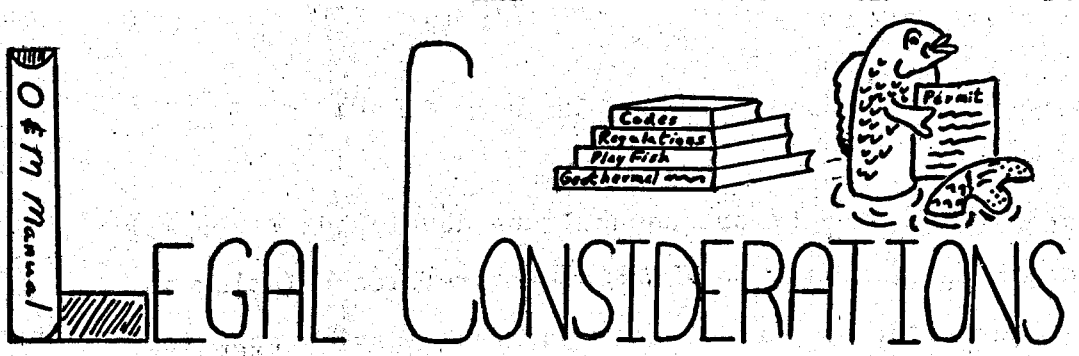


LEGAL CONSIDERATIONS

1.0 What are they?

Many county, state and federal agencies must be delt with during the planning, construction and operational phases of an aquaculture project. Their cooperation involves regulation through issuance of permits, licenses or certifications.

Public regulations are many and varied, ranging from environmental assessments and impact statements to special permits. Some regulations govern specific activities (e.g., construction, well digging, water course modification, and installation of sanitary facilities) regardless of location. Other regulations govern activities within specific geographic areas (e.g., conservation districts, shoreline setback and management areas, near-shore waters, geothermal overlay zones).

1.1 Associated problems

An initial problem faced by the prospective aquaculturist is determining the number of permits, project reports, and public hearings that could be required for securing government approvals. The next problem is to assess the amount of time and expenditure needed to meet agency requirements.

1.2 Regulatory statutes

Another difficulty centers on the uncertainties of the many laws and regulations relevent to aquaculture. Many of these

laws were adopted before aquaculture developed into a well recognized activity. Some of their statutes relating to land and water use are broadly phrased, leaving room for administrative judgement on their applicability to aquaculture use.[1]

1.3 Agencies and activities

The following list shows activities in aquaculture for which permits or approval may be required and the agencies involved.

ACTIVITY	AGENCY OR ORGANIZATION
Structures in coastal zone waters	U.S. Dept. of Transportation; Harbors Division, U.S. Coast Guard; Coastal Zone Management Commission, State of California; City and County Planning Boards
Shoreline setback variance	Coastal Zone Management Commission; City and County Planning Boards
Land use	
Designation of type of use, zone classification	County Planning Board
Use permits	County Planning, Building and Safety; Dept. of Health
Conservation	U S. Bureau of Land Management; State Dept. of Natural Resources
Leasing State Lands	Dept. of Natural Resources; Land Management Division, State of California
Leasing Federal Lands	U.S. Bureau of Land Management; U.S. Forest Service
Water Use and Well Drilling (Special permits are required for development and operation of geothermal wells.)	Counties; Division of Oil and Gas, State of California, The Resources Agency

Water Course Modification	U.S Corps of Engineers; California Dept. of Fish and Game; Counties
Discharge Permits	U.S. Corps of Engineers; U.S. Environmental Protection Agency; Water Resources Control Board, State of California
Importation of Animal Life	U.S. Department of Agriculture; California Dept. of Fish and Game
Inland Waters, Privately Owned (Commercial Fish License or Pond Operator License)	California Dept. of Fish and Game

1.4 Effects on Aquaculture

Both California and federal law have defined aquaculture as agriculture. As such, the emphasis of many regulations and constraints has been shifted. This shift, however, does not mean prospective aquaculturists can be lax in their preparations for dealing with regulatory agencies. Incomplete, inaccurate or inadequate information can be costly to both the project and the regulatory agency. Time lost on reapplication, turndowns or submission of forms to incorrect agencies are all costly in both time and money spent. Prospective aquaculturists should insure that their information is complete and factual, as well as insuring theat the agency contacted is mandated to perform the desired function.

1.5 Special contact agencies

Direct use of low temperature geothermal water for aquaculture requires special coordination with two state agencies. The planning, drilling, operation and closure of geothermal wells must be permitted by the Division of Oil and Gas, Department

of Conservation, the Resources Agency of California. There are several district offices; each office is responsible for a different geographic area of the state.

The Division of Oil and Gas has produced two publications of special interest. Specifically citing geothermal resource law is publication number PRC02 - California Laws for Conservation of Geothermal Reources, April 1981. Publication number two, PR7S - Drilling and Operating Geothermal Wells in California, is a general information manual covering the requirements for development of geothermal wells. Both publications are available through the regional offices or through the Sacramento Headquarters (1416 Ninth St., Room 1316-35, Sacramento, California 95814).

The following forms are a sample of those required by the Division of Oil and Gas for the planning, development and production phases of a geothermal well.

RESOURCES AGENCY OF CALIFORNIA
DEPARTMENT OF CONSERVATION
DIVISION OF OIL AND GAS

Notice of Intention to Drill a Geothermal Resources Well

(SUBMIT IN DUPLICATE)

Operator		Well Designation				
Field		County	Sec.	T.	R.	B.&M.
Name *(Person submitting report – print or type)*		Street Address				
Title *(Agent or officer of company)*	City		State		Zip Code	

Signature _____ Date _____ Telephone Number _____

The appropriate drilling fee, an indemnity or cash bond, a complete drilling program, and a parcel map showing the operator's surface rights, mineral rights, and the location of the proposed well must accompany this notice.

Location of well: _____ meters _____ *(Direction)* along section/property line, and _____ meters _____ *(Direction)* at right angles to said line from the _____ corner of section/property _____ *(Cross out one)* or _____.

Elevation of prepared site above/below sea level: _____ meters. *(Cross out one)*

Is the surface location or intended productive interval within 100 feet of property boundary? *yes* ☐ *no* ☐

If well is to be directionally drilled, show proposed coordinates (from surface location) at total depth:

_____ meters _____ *(Direction)* and _____ meters _____ *(Direction)*.

PROPOSED CASING PROGRAM

All depth measurements taken from top of _____ *(Derrick Floor, Rotary Table, or Kelly Bushing)* that is _____ meters above ground.

SIZE OF CASING CM API	WEIGHT (Kg)	GRADE AND TYPE	NEW OR USED	TOP OF CASING (m)	SIZE OF HOLE (cm)	VOLUME OF CEMENT (m^3)	CEMENTING DEPTHS	CALCULATED FILL BEHIND CASING

Intended zone(s) of completion: _____ *(Name, depth, and expected pressure)*. Estimated total depth: _____ meters.

ENVIRONMENTAL INFORMATION

(SEE REVERSE SIDE)

If a governmental agency has prepared an environmental document, please submit a copy of the document with this notice *or* supply the following information:

Government Agency: _____ Contact Person: _____

Address: _____ Phone: ( ) _____

Document title: _____ S.C.H. No.: _____

Submitted in compliance with Section 3724, Division 3, Chapter 4, Public Resources Code.

OGG105 4-79-DWRR-2M

ENVIRONMENTAL INFORMATION

The California Environmental Quality Act (CEQA) applies to the project described in the information on the front of the notice if the project could have a significant impact on the environment. To approve a project subject to CEQA, the Division of Oil and Gas must consider the need for either a Notice of Exemption, a negative declaration, or a final environmental impact report. If none of these documents exists or if an operator is seeking approval for a project involving six (6) or fewer exploratory wells (including temperature observation wells), the operator shall contact the Division of Oil and Gas CEQA Unit as soon as possible. The phone number is (916) 445-9686. The address is 1416 Ninth Street, Room 1316-35, Sacramento, California 98514.

FOR DIVISION USE ONLY

API WELL NO. _____

MAP	MAP BOOK	CARDS	FEE	BOND	FORMS		GEP #	EXEMPT ☐	NEG. DEC. ☐	E.I.R. ☐
					OGG114	OGG121	(14 SP)	CLASS____	SCH. NO.____	

RESOURCES AGENCY OF CALIFORNIA
DEPARTMENT OF CONSERVATION
DIVISION OF OIL AND GAS

A.P.I. No. _____

WELL LOG AND CORE RECORD - GEOTHERMAL

Operator		Well name and number				
Field		County	Sec.	T.	R.	B.&M.

FORMATIONS PENETRATED BY WELL

Depth in meters to:		Thickness (meters)	Drilled or cored	Recovery	Description
Top of formation	Bottom of formation				

In compliance with Section 3735 , Chapter 4 , Division 3 of the Public Resources Code, the information given herewith is complete and correct so far as can be determined from all available records.

Name		Title	
Address		City	Zip Code
Telephone Number	Signature		Date

File this record in duplicate with the appropriate geothermal district office.

OGG101 (5-77-GSR1-1M)

Form OGG100 (1/80)

RESOURCES AGENCY OF CALIFORNIA
DEPARTMENT OF CONSERVATION
DIVISION OF OIL AND GAS

14

A.P.I. No.

WELL SUMMARY REPORT - GEOTHERMAL

Operator	Well name and number				
Field	County	Sec.	T.	R.	B.&M.
Location (property or section corner, or street center lines)		Elevation of ground (meters above sea level)			

Commenced drilling (date)	Total depth (meters)	Plugged depth (meters)	Depth measurements taken from top of: ☐ Derrick floor ☐ Rotary table ☐ Kelly bushing
Completed drilling (date)	Geologic formation and age at total depth		Which is meters above ground.
Commenced producing (date)			Geologic marker(s) / Depth (meters)
Junk			

DATE	STATIC TEST (Shut-in well head)		PRODUCTION TEST DATA								
			Total mass flow data					Separator data			
	Temp °C	Press. bars	kg/hr	Temp °C	Press. bars	Enthalpy	Orifice	Water kg/hr	Steam kg/hr	Press. bars	Temp °C

CASING RECORD (present hole)

Size of casing (A.P.I.)	Top of casing (m)	Depth of shoe (m)	Weight of casing (kg)	New or second hand	Seamless or lapweld	Grade of casing	Size of hole drilled (cm)	Volume of cement (m^3)	Depth of cementing if through perforations (m)

PERFORATED CASING (size, top, bottom, perforated intervals, size and spacing of perforation and method)

Was analysis of effluent made? Yes ☐ No ☐	Electric log depths	Temperature depths

In compliance with Section 3735 , Chapter 4 , Division 3 of the Public Resources Code, the information given herewith is a complete and correct record of the present condition of the well and all work done thereon, so far as can be determined from all available records.

Name	Title	
Address	City	Zip Code
Telephone Number	Signature	Date

File this report in duplicate with the appropriate geothermal district office.

Form OGG103 (3/80)

RESOURCES AGENCY OF CALIFORNIA
DEPARTMENT OF CONSERVATION
DIVISION OF OIL AND GAS

A.P.I. No. _____

WELL HISTORY - GEOTHERMAL

Operator	Well name and number				
Field	County	Sec.	T.	R.	B.&M.

It is of the greatest importance to have a complete history of the well. Use this form to report a full account of all important operations during the drilling and testing of the well or during redrilling, permanently altering casing, plugging, or abandonment, with the dates thereof. Be sure to include such items as hole size (in cm), formation test details, volumes of cement used (in m^3), top and bottom of plugs (in m), perforation details, sidetracked junk, bailing tests, shooting and initial production data (in kg/hr), and zone temperature (in °C).

DATE	HISTORY

In compliance with Section 3735, Chapter 4, Division 3 of the Public Resources Code, the information given herewith is a complete and correct record of the well and all work done thereon, so far as can be determined from all available records.

Name	Title	
Address	City	Zip Code
Telephone Number	Signature	Date

File this report in duplicate with the appropriate geothermal district office.

Form OGG107 (1/80)

RESOURCES AGENCY OF CALIFORNIA
DEPARTMENT OF CONSERVATION
DIVISION OF OIL AND GAS

API No._____

REWORK/SUPPLEMENTARY NOTICE
GEOTHERMAL WELL

Submitted in compliance with Section 3724, Division 3, Chapter 4, Public Resources Code

Operator		Well Designation				
Field or GRA		County	Sec.	T.	R.	B.&M.
Name *(Person submitting report – print or type)*		Street Address				
Title *(Agent or officer of company)*	City		State		Zip Code	

Signature_____ Date_____ Telephone Number_____

The present condition of the well is as follows:

1. Total depth: _____ meters.
2. Complete casing record, including plugs:

3. Last produced: _____, 19____ _____
(Production in kg/hr. or gal. /min.)

The proposed work is as follows:

File this report in duplicate with the appropriate geothermal district office.

Form OGG108 (1/80)

RESOURCES AGENCY OF CALIFORNIA
DEPARTMENT OF CONSERVATION
DIVISION OF OIL AND GAS

API No._____

NOTICE OF INTENTION TO ABANDON GEOTHERMAL WELL

Submitted in Compliance with Section 3724, Division 3, Chapter 4, Public Resources Code

Operator		Well Designation				
Field/GRA		County	Sec.	T.	R.	B. & M.
Name (*Person submitting report – print or type*)		Street Address				
Title (*Agent or officer of company*)	City		State		Zip Code	

Signature:_____ Date:_____ Telephone Number:_____

The present condition of the well is as follows:

1. Total depth:_____ meters
2. Base of freshwater aquifer:_____ meters
3. Last produced:_____, 19___
   _____
   (*Production in kg/hr., gal./min.*)
4. Results of initial production test: (includes fluid analysis)
   _____ (Kg/hr., gal./min.) rate
   _____ (Bars, psi) pressure
5. Bottom hole temperature:_____ ° C
6. Maximum temperature:_____ ° C, depth:_____ (*meters*)
7. Stratigraphic markers and depths (in meters):

8. Formation and age at total depth:_____

Complete casing record, including plugs:

To fulfill the abandonment requirements of the division, the following work is proposed:

File this report in <u>duplicate</u> with the appropriate geothermal district office.

STATE OF CALIFORNIA
DEPARTMENT OF CONSERVATION
DIVISION OF OIL AND GAS
1416 NINTH STREET, ROOM 1316, SACRAMENTO 95814

DESIGNATION OF AGENT FOR INDIVIDUAL OR PARTNERSHIP

In compliance with Section 3721, Division 3, Public Resources Code, notice is hereby given and..... (I, we)

hereby certify that..... (I, we) _____

of _____, State of _____, have appointed, authorized and

empowered _____

whose address is _____, (Postal Address) (City) (Zip Code)

State of California, as _____ (my, our) agent for the State of California* _____

upon whom all orders, notices and processes under the provisions of said act may be served.

This notice revokes all former appointments made for said purpose.

IN WITNESS WHEREOF _____ (I, we) have signed this certificate this _____ day of _____ 19____

_____
(Name and Title)

_____
(Signature)

Witness:

_____
(Signature)

Agents acceptance:

Accepted..... _____
(Signature)

Sec. 3721. Every owner or operator of any well shall designate an agent, giving his post office address, who resides in this State, upon whom may be served all orders, notices, and processes of the supervisor, a board, or any court of law. Every person so appointing an agent shall, within five days after the termination of any such agency, notify the supervisor, in writing, of such termination, and unless operations are discontinued, shall appoint a new agent.

NOTE: An operator may appoint himself as agent.

* Should the owner or operator filing this form choose to appoint more than one agent, the phrase, "the State of California," should be deleted and the exact area for which the agent is to be appointed should be inserted. A separate form must be filed for each agent.

STATE OF CALIFORNIA
DEPARTMENT OF CONSERVATION
DIVISION OF OIL AND GAS
1416 NINTH STREET, ROOM 1316, SACRAMENTO 95814

DESIGNATION OF AGENT FOR CORPORATION

In compliance with Section 3721, Division 3, Public Resources Code, notice is hereby given and we hereby certify that _____

a corporation organized and existing under and by virtue of the laws of the _____

of _____ by resolution of its board of directors, has appointed, authorized and empowered _____

whose address is _____ (Postal Address) _____ (City) _____ (Zip Code)

State of California, as its agent for the State of California* _____

upon whom all orders, notices and processes under the provisions of said act may be served.

This notice revokes all former appointments made for said purpose.

IN WITNESS WHEREOF the corporation has caused this certificate to be signed by its President and attested by its Secretary this _____ day of _____ 19____.

_____, President
(Name)

_____
(Signature of President)

Attest:

_____
(Signature of Secretary)

CORPORATE SEAL

Sec. 3721. Every owner or operator of any well shall designate an agent, giving his post office address, who resides in this State, upon whom may be served all orders, notices, and processes of the supervisor, a board, or any court of law. Every person so appointing an agent shall, within five days after the termination of any such agency, notify the supervisor, in writing, of such termination, and unless operations are discontinued, shall appoint a new agent.

* Should the owner or operator filing this form choose to appoint more than one agent, the phrase, "the State of California," should be deleted and the exact area for which the agent is to be appointed should be inserted. A separate form must be filed for each agent.

STATE OF CALIFORNIA BOND NO. .....

INDIVIDUAL GEOTHERMAL RESOURCES WELL INDEMNITY BOND

(SEE INSTRUCTIONS ON REVERSE SIDE FOR APPLICABLE AMOUNT)

Know All Men by These Presents:

WE

That I,

as principal, and a corporation

organized and existing under and by virtue of the laws of the STATE OF
and authorized to transact surety business in the STATE OF CALIFORNIA, as surety, are held and firmly bound unto the STATE OF CALIFORNIA in the sum of ..... THOUSAND AND NO/100 DOLLARS ($....,000.00) lawful money of the United States of America, to be paid to the said State of California, for which payment, well and truly to be made, we bind ourselves, our heirs, executors and successors, jointly and severally, firmly by these presents.

THE CONDITION OF THE ABOVE OBLIGATION IS SUCH THAT,

WHEREAS, said principal is about to acquire ownership or operation, drill, redrill, deepen, maintain, or abandon a

.....-temperature geothermal resources well designated as....., Sec. .....,
(high or low)

T. ..... R..... , ... B. & M., and is required to file this bond in connection therewith in accordance with Sections 3723.5 and 3725 to 3729, inclusive, of Chapter 4 of Division 3 of the Public Resources Code of the State of California.

NOW, THEREFORE, if said .....,

the above bounden principal, shall well and truly comply with all the provisions of Chapter 4 (commencing with Section 3700) of Division 3 of the Public Resources Code and shall obey all lawful orders of the State Oil and Gas Supervisor, or his district deputy or deputies, if not appealed as provided in that chapter, or upon affirmance thereof by the Geothermal Resources Board, if appealed thereto, and shall pay all charges, costs, and expenses incurred by the supervisor or his district deputy or deputies in respect of such well or the property of said principal, or assessed against such well or the property of such principal, in pursuance of the provisions of said chapter, then this obligation shall be void; otherwise, it shall remain in full force and effect.

IN WITNESS WHEREOF, the seal and signature of the said principal is hereto affixed and the corporate seal and name of the said surety is hereto affixed and attested by its duly authorized at

California, this day of , 19 .

[Principal] .....

By .....

(SEAL OF PRINCIPAL)

[Surety] .....

By .....

Office of surety to which correspondence relating to this bond should be addressed:

.....

.....

(SEAL OF SURETY)

The premium charged for this bond is $ ..... per annum.

NOTARIZATION OF THE SURETY:

STATE OF CALIFORNIA
COUNTY OF } *ss.*

On this ..... day of ....., in the year 19 .....,

before me, ...
A Notary Public in and for said County and State, personally appeared

.....
known to me to be the person whose name is subscribed to the within instrument

as the of

, and acknowledged to me that he subscribed the name

of thereto and his own name as .....

.....

.....
Notary Public in and for said County and State

INSTRUCTIONS

1. *The surety on the bond may be any surety company licensed in California.*
2. *The signature of the surety must be notarized.*
3. *If the principal is a corporation, the corporate seal must be affixed.*
4. *If the principals are partners, their individual names shall appear in the body of the bond, with the recital that they are partners composing a firm, and naming said firm.*
5. *The name of the principal as well as the designation and number of the well on the bond must agree exactly with that shown on the notice of intention to acquire ownership or operation, drill, redrill, deepen, permanently alter the casing, or abandon.*
6. *A bond containing a cancellation clause at the option of the surety is not acceptable.*
7. *Low-temperature well is a well from which fluid produced has a temperature that is no more than the boiling point at the altitude of occurrence.*
8. *Applicable amount:*

Coverage for high-temperature well.....$25,000

Coverage for low-temperature well:

less than 2,000 feet total depth.....$ 2,000
at least 2,000 feet but less than 5,000 feet total depth.....$10,000
at least 5,000 feet but less than 10,000 feet total depth.....$15,000
at least 10,000 feet or greater total depth.....$25,000

If a well is deepened to a depth requiring higher bond coverage, either a rider specifying supplemental coverage or a new bond is required.

NOTE: In lieu of an individual indemnity bond, a person may, with the written approval of the Supervisor, file a cash bond or securities in the appropriate amount as prescribed in Section 3728.5, Division 3 of the Public Resources Code.

A supply of this form may be obtained from the Division of Oil and Gas.

STATE OF CALIFORNIA BOND NO..... 22

BLANKET GEOTHERMAL RESOURCES WELL CASH BOND

$100,000 CASH OR $120,000 SECURITIES

Know All Men by These Presents:

WE

That I,

as principal, present a total cash deposit of ONE HUNDRED THOUSAND AND NO/100 DOLLARS ($100,000.00) in the form of:

Cashiers Check No....., in the amount of $....., and/or
Certified Check No....., in the amount of $....., and/or
Certificate of Deposit No. ....., in the amount of $....., and/or
Passbook Account No. ....., in the amount of $.....
accompanied by a properly executed assignment form: or

a total deposit of ONE HUNDRED TWENTY THOUSAND AND NO/100 DOLLARS ($120,000.00) in the form of bearer bonds listed by number on the reverse side of this form, issued by the:

United States Government in the amount of $....., and/or
State of California in the amount of $.....;

all made payable solely to the State Division of Oil and Gas.

THE CONDITION OF THE ABOVE OBLIGATION IS SUCH THAT,

WHEREAS, said principal is about to acquire ownership or operation, drill, redrill, deepen, maintain, or abandon geothermal resources wells in CALIFORNIA and is required to file this bond in connection therewith in accordance with Section 3728.5, of Chapter 4 of Division 3 of the Public Resources Code of the State of California.

NOW, THEREFORE, if said.....,

the above bounden principal, shall well and truly comply with all the provisions of Chapter 4 (commencing with Section 3700) of Division 3 of the Public Resources Code and shall obey all lawful orders of the State Oil and Gas Supervisor, or his district deputy or deputies, if not appealed as provided in that chapter, or upon affirmance thereof by the Geothermal Resources Board, if appealed thereto, and shall pay all charges, costs, and expenses incurred by the supervisor or his district deputy or deputies in respect of such wells or the properties of said principal, or assessed against such wells or the properties of such principal, in pursuance of the provisions of said chapter, then this obligation shall be void; otherwise, it shall remain in full force and effect.

If the principal fails to comply with all of the provisions of Chapter 4 (commencing with Section 3700), Division 3 of the Public Resources Code and to obey all lawful orders of the State Oil and Gas Supervisor or his deputies, then the supervisor may draw upon this bond to pay all costs and expenses incurred by the supervisor or his deputy in respect to such wells or properties.

This bond shall be subject to all conditions set forth in Sections 3723.5 and 3725 to 3729, inclusive, P.R.C.
IN WITNESS WHEREOF, the seal and signature of the said principal is hereto affixed.

at California, this day of , 19

This is to certify under penalty of perjury that the above cash deposit and/or bearer bond is free of all liens including tax liens by the U. S. Revenue Service of the State of California Franchise Tax Board, Board of Equalization or Department of Employment.

(SEAL OF PRINCIPAL)

[Principal].....

By.....

APPROVED BY....., State Oil and Gas Supervisor

By....., Deputy

DATE....., 19.....

OGG160D (11/81/DWRR/2C)

(SEE OVER)

NOTARIZATION OF THE PRINCIPAL:

STATE OF CALIFORNIA
COUNTY OF } SS.

On this..... day of..... , in the year 19.....,

before me, ...
a Notary Public in and for said County and State, personally appeared

.....
known to me to be the person whose name is subscribed to the within

instrument as the of

, and acknowledged to me that he subscribed the name

of thereto and his own name as .....

.....

.....
Notary Public in and for said County and State

INSTRUCTIONS

1. *If the principal is a corporation, the corporate seal must be affixed.*
2. *Each principal must file a separate bond. A bond with more than one principal is not acceptable.*
3. *If the principals are partners, their individual names shall appear in the body of the bond, with the recital that they are partners composing a firm, and naming said firm.*
4. *The name of the principal on the bond must agree exactly with that shown on the notice of intention to acquire ownership or operation, drill, redrill, deepen, permanently alter the casing, or abandon.*
5. *The signature of the principal must be notarized.*
6. *Savings account passbooks must be accompanied by an assignment form acknowledging assignment of the account to the State Division of Oil and Gas.*

BEARER BONDS

United States Government bonds

Bond No.	*Amount*
	$

Total $ _____

State of California bonds

Bond No.	*Amount*
	$

Total $ _____

Conditions for acceptance of Bearer Bonds:

Original Bearer Bonds will be held by the State Treasurer. Coupons will remain attached to the Bonds until released. Coupons will not be cashed at maturity and remitted to the principal.

A supply of this form may be obtained from the Division of Oil and Gas.

STATE OF CALIFORNIA BOND NO. .....

INDIVIDUAL GEOTHERMAL RESOURCES WELL CASH BOND

(SEE INSTRUCTIONS ON REVERSE SIDE FOR APPLICABLE AMOUNT)

Know All Men by These Presents:

WE

That I,

as principal, present a total cash deposit of ..... THOUSAND AND NO/100 DOLLARS ($.....,000.00) in the form of:

Cashiers Check No. ..... , in the amount of $ ..... , and/or
Certified Check No. ..... , in the amount of $ ..... , and/or
Certificate of Deposit No. ..... , in the amount of $ ..... , and/or
Passbook Account No. ..... , in the amount of $ .....
accompanied by a properly executed assignment form; or

a total deposit of .....THOUSAND .....HUNDRED AND NO/100 DOLLARS ($....., ...00.00) in the form of bearer bonds listed by number on the reverse side of this form, issued by the:

United States Government in the amount of $ ..... , and/or
State of California in the amount of $ ..... ;

all made payable solely to the State Division of Oil and Gas.

THE CONDITION OF THE ABOVE OBLIGATION IS SUCH THAT,

WHEREAS, said principal is about to acquire ownership or operation, drill, redrill, deepen, maintain, or abandon a

.....-temperature geothermal resources well designated as.....Sec..... ,
(high or low)

T. ..... , R. ..... , ...B. & M., and is required to file this bond in connection therewith in accordance with Section 3728.5, of Chapter 4 of Division 3 of the Public Resources Code of the State of California.

NOW, THEREFORE, if said ..... ,

the above bounden principal, shall well and truly comply with all the provisions of Chapter 4 (commencing with Section 3700) of Division 3 of the Public Resources Code and shall obey all lawful orders of the State Oil and Gas Supervisor, or his district deputy or deputies, if not appealed as provided in that chapter, or upon affirmance thereof by the Geothermal Resources Board, if appealed thereto, and shall pay all charges, costs, and expenses incurred by the supervisor or his district deputy or deputies in respect of such well or the property of said principal, or assessed against such well or the property of such principal, in pursuance of the provisions of said chapter, then this obligation shall be void; otherwise, it shall remain in full force and effect.

If the principal fails to comply with all of the provisions of Chapter 4 (commencing with Section 3700), Division 3 of the Public Resources Code and to obey all lawful orders of the State Oil and Gas Supervisor or his deputies, then the supervisor may draw upon this bond to pay all costs and expenses incurred by the supervisor or his deputy in respect to such well or property.

This bond shall be subject to all conditions set forth in Sections 3723.5 and 3725 to 3729, inclusive, P.R.C.
IN WITNESS WHEREOF, the seal and signature of the said principal is hereto affixed.

at Califomia, this day of , 19

This is to certify under penalty of perjury that the above cash deposit and/or bearer bond is free of all liens including tax liens by the U.S. Revenue Service or the State of California Franchise Tax Board, Board of Equalization or Department of Employment.

[Principal] .....

By .....

APPROVED BY ....., State Oil and Gas Supervisor

By ..... , Deputy

DATE ..... , 19 .....

(SEAL OF PRINCIPAL)

NOTARIZATION OF THE PRINCIPAL:

STATE OF CALIFORNIA
COUNTY OF } ss.

On this .....day of ....., in the year 19 .....,

before me, ...
a Notary Public in and for said County and State, personally appeared

.....

known to me to be the person whose name is subscribed to the within instrument

as the of

, and acknowledged to me that he subscribed the name

of thereto and his own name as .....

.....

.....
Notary Public in and for said County and State

INSTRUCTIONS

1. *If the principal is a corporation, the corporate seal must be affixed.*

2. *If the principals are partners, their individual names shall appear in the body of the bond, with the recital that they are partners composing a firm, and naming said firm.*

3. *The name of the principal as well as the designation and number of the well on the bond must agree exactly with that shown on the notice of intention to acquire ownership or operation, drill, redrill, deepen, permanently alter the casing, or abandon.*

4. *The signature of the principal must be notarized.*

5. *Savings account passbooks must be accompanied by an assignment form acknowledging assignment of the account to the State Division of Oil and Gas.*

6. *Low-temperature well is a well from which fluid produced has a temperature that is no more than the boiling point at the altitude of occurrence.*

7. *Applicable amounts:*

	CASH OR SURETY BOND	*UNITED STATES OR STATE OF CALIF. BOND*
Coverage for high-temperature well	*$25,000*	*$30,000*
Coverage for low-temperature well:		
less than 2,000 feet total depth	*$ 2,000*	*$ 2,400*
at least 2,000 feet but less than 5,000 feet total depth	*$10,000*	*$12,000*
at least 5,000 feet but less than 10,000 feet total depth	*$15,000*	*$18,000*
at least 10,000 feet or greater total depth	*$25,000*	*$30,000*

If a well is deepened to a depth requiring higher bond coverage, either a rider specifying supplemental coverage or a new bond is required.

Conditions for acceptance of Bearer Bonds:

Original Bearer Bonds will be held by the State Treasurer. Coupons will remain attached to the Bonds until released. Coupons will not be cashed at maturity and remitted to the principal.

A supply of this form may be obtained from the Division of Oil and Gas.

STATE OF CALIFORNIA BOND NO. .....

$100,000 BLANKET GEOTHERMAL RESOURCES WELL INDEMNITY BOND

Know All Men by These Presents:

WE

That I,

as principal, and a corporation

organized and existing under and by virtue of the laws of the STATE OF..... and authorized to transact surety business in the STATE OF CALIFORNIA, as surety, are held and firmly bound unto the STATE OF CALIFORNIA in the sum of ONE HUNDRED THOUSAND AND NO/100 DOLLARS($100,000.00) lawful money of the United States of America, to be paid to the said State of California, for which payment, well and truly to be made, we bind ourselves, our heirs, executors and successors, jointly and severally, firmly by these presents.

THE CONDITION OF THE ABOVE OBLIGATION IS SUCH THAT,

WHEREAS, said principal is about to acquire ownership or operation, drill, redrill, deepen, maintain, or abandon geothermal resources wells in CALIFORNIA and is required to file this bond in connection therewith in accordance with Sections 3723.5 and 3725 to 3729, inclusive, of Chapter 4 of Division 3 of the Public Resources Code of the State of California.

NOW, THEREFORE, if said .....,

the above bounden principal, shall well and truly comply with all the provisions of Chapter 4 (commencing with Section 3700) of Division 3 of the Public Resources Code and shall obey all lawful orders of the State Oil and Gas Supervisor, or his district deputy or deputies, if not appealed as provided in that chapter, or upon affirmance thereof by the Geothermal Resources Board, if appealed thereto, and shall pay all charges, costs, and expenses incurred by the supervisor or his district deputy or deputies in respect of such wells or the properties of said principal, or assessed against such wells or the properties of such principal, in pursuance of the provisions of said chapter, then this obligation shall be void; otherwise, it shall remain in full force and effect.

IN WITNESS WHEREOF, the seal and signature of the said principal is hereto affixed and the corporate seal and name of the said surety is hereto affixed and attested by its duly authorized at

California, this day of 19

[Principal] .....

By .....

(SEAL OF PRINCIPAL)

[Surety] .....

By .....

Office of surety to which correspondence relating to this bond should be addressed:

.....

.....

(SEAL OF SURETY)

The premium charged for this bond is $ .....per annum.

NOTARIZATION OF THE SURETY:

STATE OF CALIFORNIA
COUNTY OF } ss.

On this .....day of ....., in the year 19 .....,

before me, ...
a Notary Public in and for said County and State, personally appeared

.....
known to me to be the person whose name is subscribed to the within instrument

as the of

, and acknowledged to me that he subscribed the name

of thereto and his own name as .....

.....

.....
Notary Public in and for said County and State

INSTRUCTIONS

1. *The surety on the bond may be any surety company licensed in California.*
2. *The signature of the surety must be notarized.*
3. *If the principal is a corporation the corporate seal must be affixed.*
4. *Each principal must file a separate bond. A bond with more than one principal is not acceptable.*
5. *If the principals are partners, their individual names shall appear in the body of the bond, with the recital that they are partners composing a firm, and naming said firm.*
6. *The name of the principal on the bond must agree exactly with that shown on the notice of intention to acquire ownership or operation, drill, redrill, deepen, permanently alter the casing, or abandon.*
7. *A bond containing a cancellation clause at the option of the surety is not acceptable.*

NOTE: In lieu of a blanket indemnity bond, a person may, with the written approval of the Supervisor, file a cash bond or securities in the appropriate amount, as prescribed in Section 3728.5, Division 3 of the Public Resources Code.

A supply of this form may be obtained from the Division of Oil and Gas.

The Department of Fish and Game is the other organization with which all potential and practicing aquaculturists must deal. This is the agency mandated by the state of California to certify and regulate aquaculture.

A brochure, Aquaculture in Inland Waters of California (Inland Fisheries, Informational Leaflet Number 8), outlines licensing fees, registration proceedures and prohibited species and is available through the headquarters (Department of Fish and Game, the Resources Agency, State of California, 1416 Ninth St., Sacramento, California 95814). This publication also lists specific sections of California law dealing with aquaculture and its regulation.

The following form is a sample of the application required by the Department of Fish and Game for the registration of each location.

NOTE: A separate application form must be completed for each location registered.

Registration no._____
Date issued_____
Issued by_____
Office_____

State of California
The Resources Agency
DEPARTMENT OF FISH AND GAME

APPLICATION FOR AQUACULTURE REGISTRATION
Pursuant to Sections 15000-15803 of the Fish and Game Code

Name of business:_____ Phone no.( )_____

Owner's name(s):_____

Mailing address:_____
Street or P. O. Box City Zip code

Address of facility:_____
(or plant) Street City Zip code

Species to be maintained (use only approved names):_____

_____

_____

Location of facility to be registered: County:_____

FOR FRESHWATER AQUACULTURE, FILL OUT THE FOLLOWING SECTION

Nearest town_____ Road or highway_____

Township_____ Range_____ Section_____

Name and describe fully the source from which water is obtained, and the location and type of diversion_____

_____

Attach a sketch showing arrangement of ponds and points at which inlet and outlet are screened. (SEE REVERSE SIDE)

FOR SALTWATER AQUACULTURE, FILL OUT THE FOLLOWING SECTION

Our cultivation areas are located as follows: (Please indicate whether State-leased or private)

Bay or area	Lot numbers or descriptions

General description of kind of work or business engaged in (please check ALL appropriate boxes)

_____research and development _____private consumption/use _____fishout ponds

_____rearing product for sale _____commercial _____noncommercial (no sales)

_____other_____

FG 750 (10/82)

INSTRUCTIONS FOR PREPARING MAPS FOR FRESHWATER AQUACULTURE

1. Give location number of point of diversion.
2. Show the location of the spring or stream, and give name.
3. Show the point of diversion (i.e., the point at which water is to be taken from the stream or spring).
4. Show location of the main ditch or pipeline and points where screened.
5. Indicate clearly the proposed place of use of the water. For ponds, show the number and location of each. (See sketch below.)

(EXAMPLE)

Township 25N Range 1W Section 6

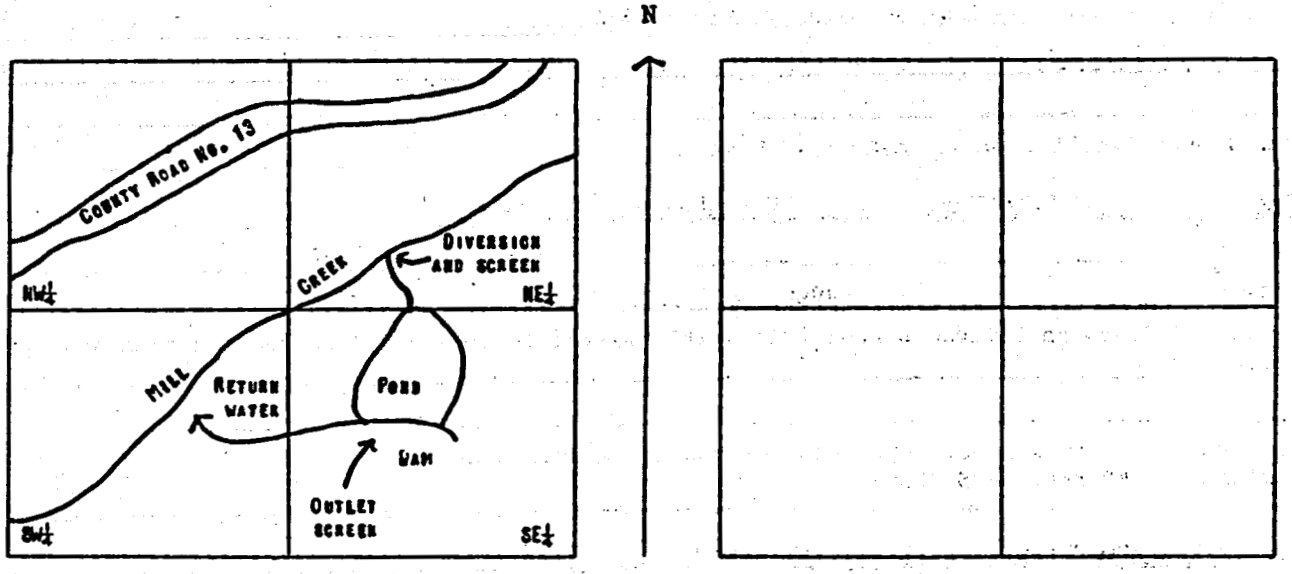
_____ 1/4 _____ 1/4

_____ Base and meridian

Township ____ Range ____ Section ____

_____ 1/4 _____ 1/4

_____ Base and meridian



Section 6 NW¼

I have read the Fish and Game Commission regulations governing registered aquaculturists and Sections 15000 through 15803 of the Fish and Game Code, and will operate in conformity with them.

Signed _____ Title (if a company) _____ Date _____

NOTE: There is a $50.00 registration fee for each company registering their facilities, regardless of the number of locations. On receipt of $50.00 and completed registration applications, and if all applicable provisions of the Fish and Game Code and the Fish and Game Commission regulations have been complied with, certificate of registration will be issued.

Inspected by _____ Approved by _____

Date _____ Date _____

The department has 30 days from date of receipt in which to make its recommendations.

T.H.P. No._____

Notification No._____ Received_____

STATE OF CALIFORNIA

RESOURCES AGENCY
DEPARTMENT OF FISH AND GAME
NOTIFICATION OF REMOVAL OF MATERIALS AND/OR ALTERATION OF LAKE, RIVER, OR STREAMBED BOTTOM, OR MARGIN

A. APPLICANT Pursuant to Sections 1601–1606 of the California Fish and Game Code

I, _____ (Name of Applicant) of _____ (Mailing Address)

Representing _____ (Name of Agency, Company, etc.)

Hereby notify the California Department of Fish and Game of operations to be carried out by me, or the organization I represent, from _____ (Date) to _____ (Date)

_____ (Name of Stream, River, or Lake) of _____ County, tributary to _____ in the _____ (NE, NW, SE, or SW) ¼,

Section _____ Township _____ Range _____ U.S.G.S. Map _____,

Co. Assessor's Parcel No. _____ Property Owner _____,

whose address is _____

_____ (Name of Person to Be Contacted at Site During Operations) _____ is responsible for operations at the site.

He can be reached at _____ (Mailing Address) _____ (Telephone)

B. Description of operation 1. The nature of said operations will be as follows:
Check all squares which apply.

- ☐ Soil, sand, gravel, and/or boulder removal or displacement
- ☐ Water diversion or impoundment
- ☐ Mining—other than aggregate removal
- ☐ Road or bridge construction
- ☐ Levee or channel construction
- ☐ Logging
- ☐ Temporary, recreational or irrigation dam
- ☐ Other—Describe below

2. Type of material removed, displaced or added ☐ Soil ☐ Sand ☐ Gravel ☐ Boulders
Volume_____

3. Equipment to be used in the described site_____

4. Use of water (i.e., domestic, irrigation, gravel, washing, etc.)_____ Quantity_____

5. Describe type and density of vegetation to be affected, and estimate area involved.

_____

6. What actions are proposed to protect fish and wildlife resources and/or mitigate for project impacts?_____

_____

7. Please attach and send to the Department any available project environmental documents.

8. Briefly describe proposed construction methods. Diagram or sketch below the location of your operation to clearly indicate the stream or other water and access from named public road. Indicate locked gates with an "X". Show existing features with a solid line (————) and proposed features with a broken line (- - - - - -). Show compass direction. Attach larger scale map if necessary.

NO CARBON NEEDED
FG2023 (REV. 3-80)

_____ (Signature of Applicant) Date

QUAD ⓘ◇ OSP

1.6 Special considerations

A. Special permits are required for geothermal well development.

B. Annual bonds and permits required for operation of geothermal wells.

C. Special permits are required for closure of geothermal wells.

D. Annual licensing and special permits required for importation of and growing of warmwater aquaculture species.

SELECTED BIBLIOGRAPHY

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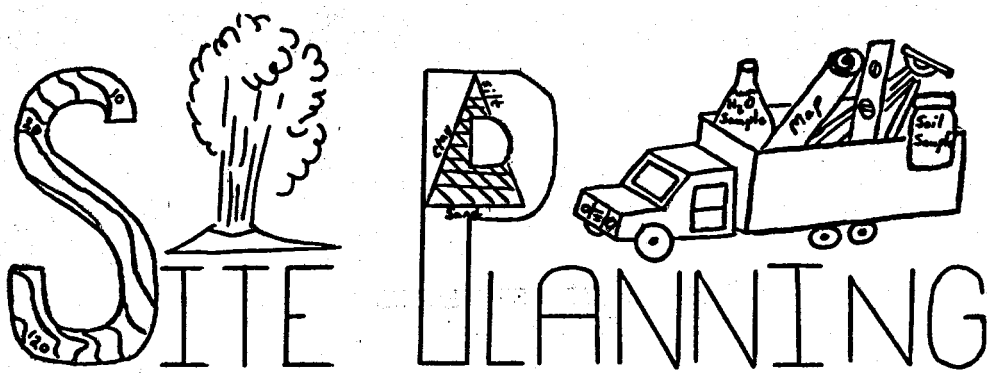
National Research Council. 1978.
Aquaculture in the United States, Constraints and Opportunities. National Academy of Sciences, Washington, D.C.



2.0 Site Selection

Site selection is the first and most critical factor in prawn farming and other forms of aquaculture. The selection involves the location of suitable land. Although large quantities of land may be for sale, leased or owned, few meet all the criteria for an aquaculture site. A grow-out facility needs sufficient water availability, appropriate water temperatures, good water quality, complete protection against floodwaters, as well as good accessibility and drainage.

Soils should be those with good water holding ability. However, ponds should never be located on lands where pesticide or herbicides have regularly been applied to crops.[1] Residues of both pesticides and herbicides in soils can be tested for by qualified laboratories.

Climatic conditions such as mean annual rainfall and temperature, as well as minimum and maximum temperatures and rainfall, should be checked. Weather charts containing this information are available from the National Weather Service, National Oceanic and Atmospheric Administration (Figure2-1). Other climatic data such as prevailing wind direction, seasonal occurence of tornadoes or hurricanes needs to be obtained.

CLIMATOLOGICAL SUMMARY FOR INDIO U. S. DATE GARDEN, RIVERSIDE COUNTY

Elevation 20' Latitude 33 43 Longitude 116 14

1931-1960

TEMPERATURE (degrees F)

	No. Yrs.	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual	
Highest	30	94	96	103	109	117	120	122	121	122	113	99	96	122	
Mean Daily Maximum	30	70.4	74.0	80.3	87.5	94.0	101.5	107.2	105.4	102.4	92.2	80.7	72.5	89.0	
Mean Daily	30	54.1	58.1	64.5	72.3	79.1	86.4	92.1	90.6	86.1	75.5	62.9	55.8	73.1	
Mean Daily Minimum	30	37.8	42.2	48.7	57.0	64.2	71.3	76.9	75.8	69.7	58.7	45.1	39.0	57.2	
Lowest	30	13	20	28	33	38	52	59	57	46	37	23	20	13	

PRECIPITATION

Greatest Monthly	30	2.06	1.72	1.51	.54	.26	.09	1.87	2.38	8.96	1.55	2.04	3.42	8.96	(9/39)
Mean Monthly	30	.50	.42	.25	.10	.01	.01	.12	.33	.43	.23	.30	.68	3.38	
Least Monthly	30	0	0	0	0	0	0	0	0	0	0	0	0	0	
Greatest Daily	30	1.85	1.25	1.33	.45	.26	.09	1.70	2.20	6.45	1.13	1.03	2.36	6.45	(9/39)
No. Days (.01) inch	30	2	2	2	1	*	*	*	1	1	1	2	3	15	

Snowfall	30	T	0	0	0	0	0	0	0	0	0	0	T	T
Relative Humidity*	14	49	41	36	33	30	27	32	34	33	35	41	47	36
Clear #	33	19	17	20	22	25	26	23	22	24	24	21	18	260
Partly Cloudy #	33	6	6	6	5	4	3	5	6	4	4	5	6	60
Clouay #	33	6	5	5	3	3	1	3	3	2	3	4	7	45

* Thermal Airport

\# From earlier records

Figure 2-1. Weather data chart. Temperatures, rainfall (precipitation), and other climatic data are shown as monthly averages (maximum, mean or average, and minimum) for periods up to 33 years. This chart was provided by the National Weather Service, Coachella Valley office (Mr. Carl Garczynski).

Flood maps, available from the U.S. Geological Survey or the Federal Emergency Management Agency, show historic flood heights and dates against topographic contour lines for localized areas. Potential flooding sites are also indicated. These maps are a valuable resource tool when evaluating sites.

Water availability is, of course, of primary importance in site selection. Without a sufficient supply, the projected development is impractical. Water needs are discussed in the chapter on pond construction (section 3.5). When adequate water sources are available, water quality is the next item of concern. Water quality has been covered extensively in the chapter on pond management. However, particular attention should be paid to the section on bioassays. In general water quality encompasses water temperature, contaminants, beneficial nutrients, salinity, and alkalinity.

After sufficient water sources are located and their quality ascertained, the physical and chemical characteristics of the soil are the next items to be investigated. Soil survey maps are available through either the U.S. Geological Survey or the U.S. Department of Agriculture and its Soil Conservation Service.[2] These maps are aerial photographs with general soil type areas outlined and indexed. These soil surveys also contain descriptive text which includes; soil descriptions, use and management information, morphology and soil classification data. In some areas the Soil Conservation Service also offers planning help and laboratory testing services. Site specific information must

still be taken, as soil conditions may vary greatly within these areas.

Physical characteristics of soils include soil size (texture) and arrangement (structure) of individual soil particles. Soil texture describes the mixture of different sizes of mineral particles. Mineral particles are grouped by size into four classes; gravel and stones, sand, silt, and clay. The sizes of these particles are as follows:

Particle Class	Particle Size (inches)
Clay	0 to 0.00008
Silt	0.00008 to 0.002
Sand	0.002 to 0.080
Gravel/Stones	0.080 and larger

Soil texture classes have been further defined to describe relative amounts of sand, silt and clay. When the percentage of each particle size in a soil is known, these data can be plotted on a soil texture triangle (Figure 2-2). The result is a textural name corresponding to its location on the triangle. With experience, the texture of a soil can be felt and determined fairly accurately by rubbing moist soil between thumb and forefinger. How it ribbons or is pushed out in a thin strip; how it hangs together; how sticky smooth or gritty it is will give a rapid on-site idea of soil characteristics.[3] However, a more accurate analysis should be conducted.

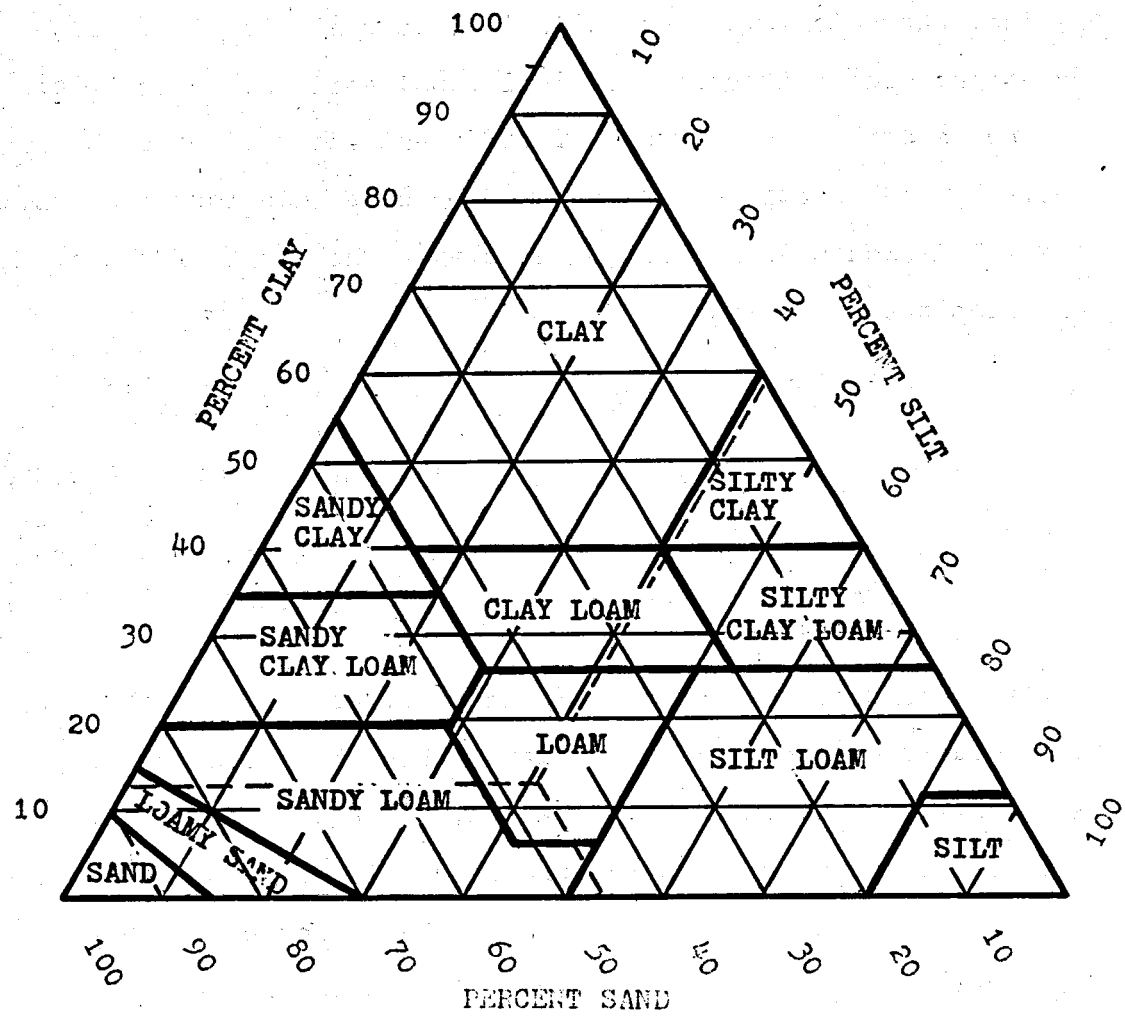


Figure 2-2. Soil textural triangle. When data points for percentage of sand, silt and clay are plotted the resulting cross point lies within a defined soil texture class. For example, a soil with 35% sand, 35% clay and 30% silt would be a clay loam.

Soil structure is the arrangement of combined particles of clay, sand and silt. These aggregates are held together by either clay or organic matter. The structure of the soil is the size and form of these aggregates. Granular, massive, platy, and prismatic or blocky are the terms used to define soil structure. Structure is important as it helps determine soil porosity, the ability of water to pass through the soil. A percolation test can be conducted at the site to determine the ability of the soil to hold water. A hole is dug in the soil, water is added to a measured depth and the decrease in water depth over time is noted. This figure will give an indication of the water holding capacity of the soil. This is important information, as liners or other barrier systems may need to be considered if the soil is very permeable (see Pond Construction 3.2).

Chemical characteristics of the soil include alkalinity, salinity and nutrients. These are important because they may affect pond waters through leaching. The salinity and alkalinity may also affect cement or chemical additives used to seal ponds.

Numerous soil samples must be taken in order to be representative of the site. Samples should not be taken from small, unusual spots; old fence rows, roadbeds, fertilizer bands, and small wet spots should all be avoided. A map of the area should be made and sample sites noted. Individual samples should be uniform in size and depth; placed in a clean plastic bucket and well mixed. The sample itself should contain about one pint of this mixture and be placed in a plastic lined soil bag, which

has been labled. These samples can then be sent to a soil testing laboratory for analyses.

2.1 Site Plan

After the site has been selected, a topographic map of the area should be obtained. This map, which shows land elevations, boundaries and contours, is a necessity in drafting a master plan for development. A master plan will show pond sizes and locations, electrical facilities, wells,windbreaks, roads, drainare systems, and buildings. It is possible to design the master plan so development may be carried out in organized phases, sections or series.

A consulting engineer may be of help in establishing a master plan, as topographic or other geographic features may affest the feasibility of the proposed design. Once completed, the master plan can be used by contractors to either bid on or lay out the facility. An additional portion of the master plan can include a fiscal analysis, which outlines cost breakdowns for various phases and items of the development.

2.2 Special considerations

A. It is necessary to locate a site in a geothermally active area.

B. The proposed site must conform to other physical parameters: appropriate climate, topography, and soil porosity.

C. The site must have sufficient quantities of geothermal water to allow culture of the desired species.

D. The quality of the geothermal water must allow culture of the target species. It must not contain detrimental constituents and must be of sufficient temperature for optimizing growth.

E. The use of warm, geothermal waters in correctly designed facilities can mitigate extreme climatic effects. Therefore, facilities could be located close to available markets, allowing more geographical freedom if all other criteria are met.

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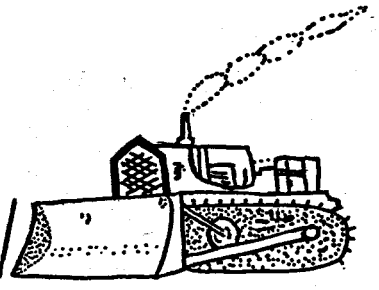
POND CONSTRUCTION



3.0 Before construction

Pond construction should be preceded by thorough planning. The same principles are followed whether the pond is a single back-yard pond or part of a large commercial operation. Site planning has chosen the general area and has established parameters with which a professional can develop the best plan for the specific location. These parameters should be noted so that operation and maintenance personnel can refer to them when necessary for the day-to-day running of the facility.

First considerations are topographic and climatic. The information gathered during the site planning and development phase must now be carefully integrated so each pond can be individually designed. Pond size, shape and orientation are dependant on species needs, land contour, fiscal considerations, prevailing wind direction and strength, availability of water, mean annual temperatures (and their variation), equipment availability, soil type and permeability, agricultural history, possibility of flooding, and future expansion plans.

Species needs are of prime importance. Behavioral characteristics determine the conditions required for fast growth and good survival. Prawns prefer crevices and irregularities, a water depth that absorbs harmful light rays, a water temperature of 85°F,

a varied food source and a moderate water exchange rate. Each warm water fish species has specific requirements. Unlike bottom dwelling prawns, pond substrate is less important to midwater or topwater fish. Temperature needs vary, for example, Tilapia barely tolerate, or begin to die, at temperatures of 60°F; however, largemouth bass will grow at that temperature.[1] At AII a management plan has been developed which utilizes species needs as a prerequisite for pond design and location. Land contours should be established during the topographic study phase (see Site Planning and Development). This data must now be incorporated to design a pond that involves moving the least amount of dirt the shortest distance, to obtain the desired effect. Before building a pond it is wise to seek professional advice, such as that which can be obtained from the Soil Conservation Service.

3.1 Pond types

Dugout and levee are the two general types of ponds. The former is excavated so that the bottom lies below the surrounding ground surface. In levee ponds, soil within the pond area is pushed to all sides to form dams or banks. For the first pond of a series, four banks must be constructed. Additional adjacent ponds can minimize costs and conserve space because only three banks need to be constructed for each adjoining pond. These less expensive levee ponds are generally preferable and may be drained without pumping.

Because the dams and levees are "walls" of the ponds, this

network is the essence of the aquaculture facility. These structures should be made of compacted nonporous materials.[1] The site that is being developed into ponds ideally will be clay but more likely will be a mixture of soil types. Where this is the case, as it is at AII, each pond will reflect its soil texture class. The amount of clay in the soil and the particle size distribution determine the water holding capacity. Fine textured soils hold more water than coarse textured soils.[2] The slope of the pond bank will vary from 4:1 to 2:1. Sandy soils require a more gentle slope than a composite soil and a clay substrate can withstand the steeper slope.

3.2 Sealing the pond

Whatever type of soil underlies a pond, proper construction of the walls is the most important element to prevent leakage. Compaction of the soil is important for dams, levees, and throughout the pond. A sheepsfoot roller or the wheels of a heavy tractor can be used to compress the soil.

If the soil being moved is porous, the leaky ponds may be repaired with various sealants. The use of sealants entails considerable expense, so it is best to locate ponds over soil which is known to retain water. One frequently used method is to bring in clay from another part of the property that is being developed or from a local source. Bentonite clay may be purchased. It has the ability to absorb large amounts of water and expands eight to twenty times its original volume. It is applied to a dry pond

bottom at a rate of one to three pounds per square yard. A laboratory soil analysis should be made to determine the precise rate of application. The bentonite is spread evenly, mixed with the soil, moistened, and compacted.

Ponds constructed on fine-grained soils might be sealed with a chemical additive such as soluble salts. Sodium chloride and sodium polyphosphates are the most common. The sealant is first mixed with the soil and then compacted. The application of any chemical may adversely effect the environment so before applications are used consult your Water Quality Resources Board and the Environmental Protection Agency.

Another popular method for sealing ponds is lining them with a flexible membrane. This membrane might be made of polyethylene, vinyl, or butyl rubber. Stones must be removed or ponds must be cushioned with a layer of fine material. Liners are laid in overlapping strips with cemented or taped seams. The lining is anchored by burying the edges in a trench. To protect against punctures, approximately ten inches of fine soil should be used to cover the membrane.

A durable, though costly, solution is cement. After placing bags of cement around the ponds, the cement is tilled into the soil and water is used to facilitate compaction. The local Soil Conservation Service can advise you as to the amount of cement needed and any particulars that would aid in application in your area. Gunite is sometimed used and must be applied profession-

ally. Plastering or pouring cement into forms is also possible.

Regardless of what type of pond sealant system is contemplated, it should be remembered that the agricultural history of the site can influence its eventual success. If it is suspected that the land has been exposed to herbicides or insecticides, soil samples should be checked for residues. Certain chemicals are hazardous to prawns and fish and their presence would omit the soil from direct use as pond bank or fill.

3.3 Pond banks, levees and shape

Whether the ponds are used lined or unlined, the levees must be sturdy enough to withstand the pressure of the water in the pond. To allow for the machinery used in pond management, the top of the bank should be ten to twelve feet wide.[3] The corners of the levees need to be broad enough for the turning of pick-up trucks and tractors, a minimum turning radius of 16 feet. Those to be negotiated by transport trucks should have a minimum turning radius of 40 feet.

Topographic features of the land govern the shape and size of ponds. The preferred shape is rectangular, even though rectangular ponds may be more expensive to build. As a means of minimizing the effects of wave action on levees, ponds should be built perpendicular to the prevailing wind direction.[4] Pond bottoms are gently sloped from inflow to outflow ends. This slope aids in draining as well as in harvesting. Some farmers prefer to incorporate a "harvest basin" at the deep end of the pond (Fig. 3-1). Refer to Table 3-1 when making decisions pertaining to

size and depth.

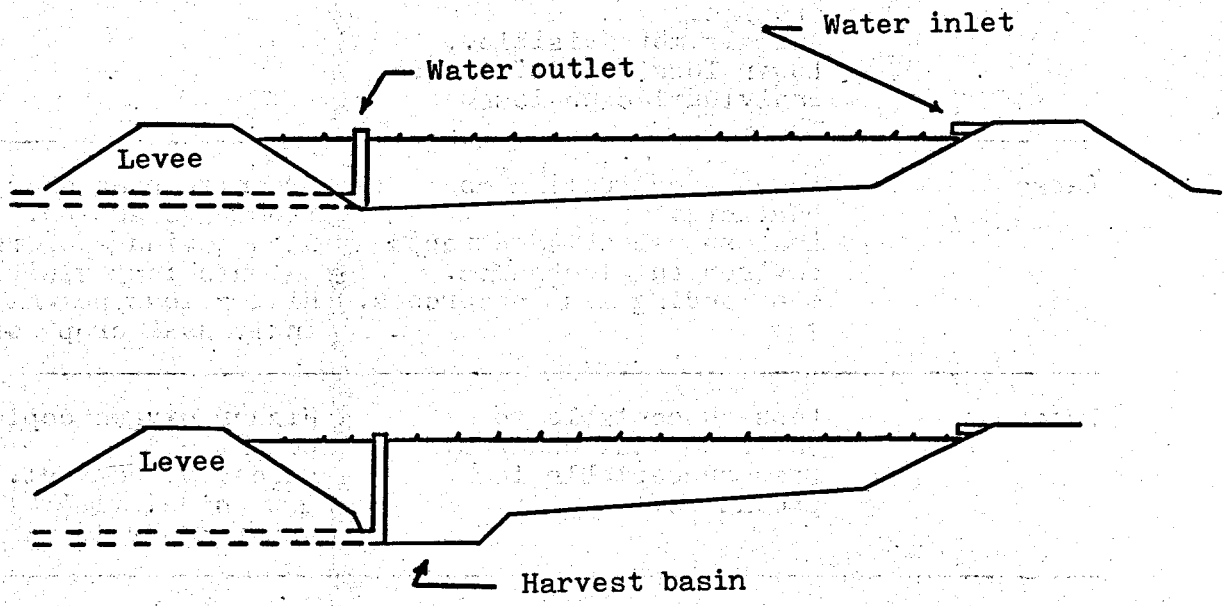


Figure 3-1. Production pond contours, with and without a harvest basin.

Table 3-1. Considerations to be weighed when deciding pond size and depth.[5]

Size	Advantages	Disadvantages
Small (one acre or less)	Faster, easier, cheaper to harvest. Rapid drainage and refill. Less subject to wind caused erosion. Animals more visible. Lower loss potential for individual crop loss.	High cost/acre to build. More subject to rapid environmental changes.
Large	Lower construction cost per acre. Less susceptable to rapid environmental changes. Overfeeding less hazardous.	Prone to bank erosion from wave action. Slow drainage or refilling. Animals less visible. Higher loss potential for individual crop loss.
Deep	Less susceptable to environmental changes. Less susceptable to predation.	Higher oxygen depletion potential. Harder to harvest. Low animal visibility. Water tends to stratify.
Shallow	High oxygen exchange per unit volume. Ease of harvest. Higher animal visibility. Water does not stratify.	More susceptable to environmental change. More susceptable to predation.

3.4 Equipment needs

Pond building equipment should be leased or purchased. A bulldozer or earthmover is generally used in dry areas for levee construction. In wet areas a dragline can construct either levee or dugout type ponds. A backhoe is used for pipe and monk installation or for small dugout areas. Large pieces of equipment might not be practical for a fish farm to purchase, but a backhoe and/or tractor operational and maintenance efficiency.

3.5 Water delivery and drainage systems

While ponds are being designed and constructed, water delivery, drainage and diversion should be addressed. The prospective pond builder should consider the conditions prevailing during the hottest and/or driest part of the year, when evaporation is greatest amd and oxygen depletion in the pond is most likely.[2] Those culturists depending on direct-use geothermal should calculate the volume of water needed to maintain the ponds through the coldest weather. A chart similar to the weather chart (Figure 2-1) may be obtained from your local National Oceanic and Atmospheric Administration or by contacting the National Weather Records Center in Asheville, North Carolina. The need for water diversion or flood control cannot be ignored. If your site has been determined to be flood prone (see Site Planning and Development), measures should be taken at the initial stages of construction to mitigate the potential effects. This program should be incorporated into any future site expansion plans. Flood control drains can be incorporated into pond water delivery and drainage systems.

Pond water delivery and drainage systems should be integral considerations in the pond design and layout phase. Topographic conditions need to be evaluated and utilized to facilitate the delivery and especially the draining of water. Proper facility design and layout can minimize the amount of piping required. Tandem pond construction allows sets of ponds to share inlet and drain systems (Figure 3-2).

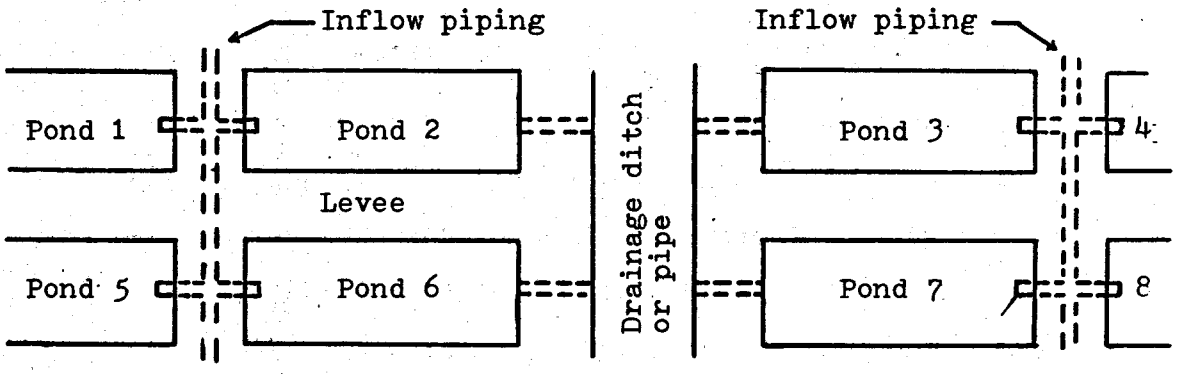
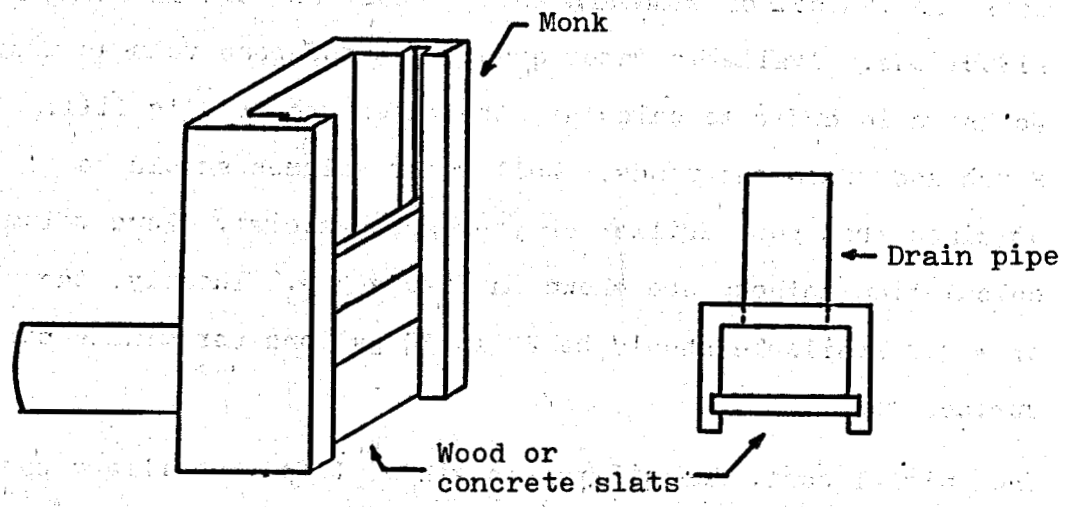


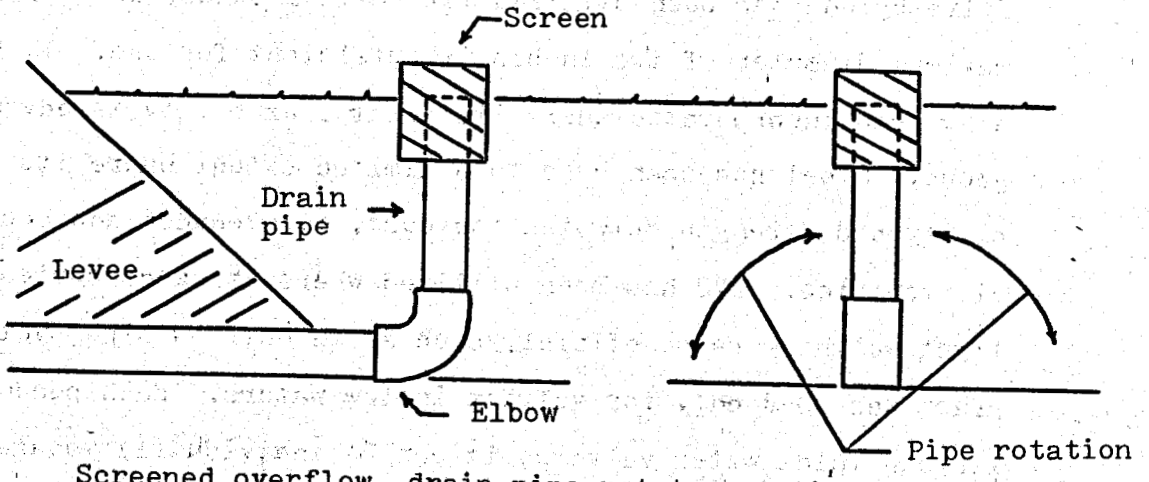
Figure 3-2. Typical pond water distribution and drainage system. Ponds 1,2,5 and 6 share inflow piping, as do ponds 3,4,7 and 8. Ponds 2,3,6 and 7 share drainage facilities, either ditches or pipes.

Pumping is sometimes a necessity for water delivery. For long term usage it is both uneconomic and undependable. When draining ponds, pumping is expensive and totally undesirable. Drainage is usually accomplished through use of agricultural drop boxes (sluice boxes, monks) or rotating pipes (Figure 3-3). Either can be screened as needed and as appropriate to animal size.

Figure 3-3. Screened overflow and monk type drains.



Monks, sluice or agricultural drop boxes can can be constructed of wood, concrete, or concrete blocks. Increasing or decreasing the width or number of slats allows the water level to be adjusted.



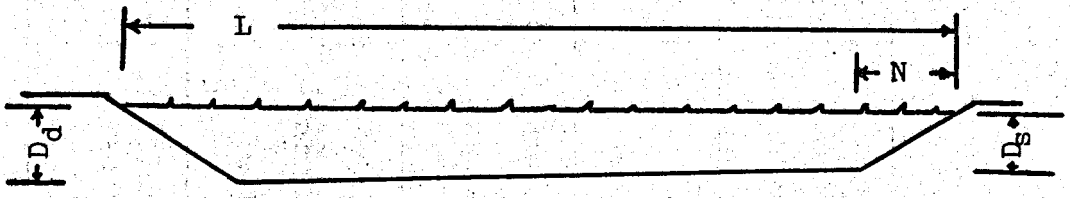
Screened overflow, drain pipe rotates at pipe elbow to raise or lower water levels. Screen size is variable.

Planning the water delivery system must take into account both the typical or standard water needs, as well as emergency situations. Available water quantities and pond volumes must be known in order to calculate the rates required to fill, flush and drain the ponds. Well water volumes should be obtained from your driller or your geophysicist. Pond volume calculation methods are shown in Figure 3-4. Ideally, the supply of water available should be 20 to 50 gallons per minute per surface acre.

The initial cost, durability (length of life), auxiliary parts, availability, and ease of installation should all bear on your decision as to the type of pipe used. Table 3-2 gives a comparison of some of these factors.

AII has utilized a combination of pipe types and auxiliary parts. Aluminum has been used for temporary, above-ground systems. Polyethylene has been utilized for smaller ponds, where its maximum diameter of two inches is sufficient for use. It has also been incorporated where its great flexibility is advantageous. Steel has been used to a limited extent where its durability and strength outweigh its cost, maintenance and coupling difficulties. PVC has been utilized where its accessories and light weight were beneficial, such as in outflow pipe systems. Brass was used pnly for valving inflow waters. Each pond has its own inlet water valve so it can be individually managed.

Figure 3-4. Pond volume calculation method and example. Remember to keep all units the same.*



L = length of water
W = width of water
D_s = depth of water, shallow end
D_d = depth of water, deep end

N = horizontal distance, edge of water to base of sloped bank

or

= (slope)(D_s) therefore

Slope = N/D_s

$$\text{Total Pond Volume} = (L-N)(W-N)D_s + \left[(L-N)(W-N)(D_d-D_s)\right]/2$$

Example

A pond is 36 feet wide, 75 feet long, 36 inches deep at one end, 48 inches deep at the other and has a slope of 3:1.

L = 75 feet
W = 36 feet
D_s = 36 inches = 3 feet
D_d = 48 inches = 4 feet

N = 3·3 = 9

$$\text{Total Pond Volume} = (75-9)(36-9)3 + \left[(75-9)(36-9)(4-3)\right]/2$$

$$= 66 \cdot 27 \cdot 3 + (66 \cdot 27 \cdot 1)/2$$

$$= 5346 + 891$$

$$= 6237 \text{ cubic feet}$$

or since 43,560 cubic feet = 1 acre foot

6237/34560 = 0.14 acre feet

* See the appendix for conversion tables.

Table 3-2. Comparative data for five types of available piping.

Pipe	Fittings/ Joints	Cost * (per foot)	Problems	Advantages
Steel	Welded or threaded	$2.45 up schedule 40	Scaling, corrosion in saline waters. High weight per foot.	High strength. Long life.
Aluminum	Slip/tension or clamped	$0.60 up	Low strength. Corrosion in alkaline waters.	Light weight
PVC	Glued, threaded, some pressure clamp fittings available	$0.70 up	Moderate strength. Becomes brittle with continued exposure to sunlight.	Light weight. Does not corrode.
Polyethylene	Slip/tension or clamped	$0.50 for 2 inch dia.	Limited fittings available. Available only in long rolls. Moderate to low strength.	Semi-flexible. Light weight.
Concrete	Mortared or slip fitted.	$1.75 for 5 inch dia.	Very heavy per foot. Limited to large sizes. Brittle.	Long life. High strength.

* Costs are those available at time of publication and may vary depending on location and available supplies.

3.6 Special considerations

A. It is necessary to design and lay out the pond(s) depth, size, shape, and orientation to minimize negative environmental effects on the geothermal water in the ponds.

B. Consideration should be given to installation of a dual inlet piping system. This would allow mixing of geothermal and other, cooler water sources at the inlet end of a pond. This would be one method to obtain optimum temperatures and water flow rates.

C. Careful selection of piping must be done to avoid scaling and corrosion which can be factors in using lower quality geothermal water.

D. Consideration should be given to construction of downstream or cascade systems. These systems allow maximum use of both water and temperature through sequential use of geothermal water. Water travels from one pond to the next in a series; each pond is cooler than the one preceeding.

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4.0 Targeting species

To make the best choice of a species to culture, one must assess what species needs the farm site can accomodate. For example, no matter how much one wishes to grow rainbow trout, geothermal waters in the Coachella Valley must be greatly modified to serve the animals' needs. A warmwater species would be a more natural choice. When the list has been reduced to the best biological choices, a fiscal assessment must be undertaken. As in all other farming, or any other business, ultimate choices are based more on potential economic returns than on personal whims.

Sucessful culture is facilitated by learning as much as possible about the animal(s). Some brief background information is given at the end of this chapter. A.I.I. has experimentaly grown many of these species in geothermal waters. However, this portion of the research was not conducted under the contracted D.O.E. agreement. As these experiments were privately financed, some results and information are proprietary. The species listed are some examples of potential culture species. These species are those in which interest is most often expressed. The following should be a starting point for your information search. After familiarizing yourself with life histories, state of the art grow-out techniques need to be investigated.

Examine this information as to its applicability to the situation you wish to create. Farming methods and social mores vary from place to place. Some techniques which are valid in a rainy climate may not apply to the desert and some practices that are encouraged by other governments might be prohibited by the F.D.A..

Biological information must be correlated with economic considerations for an accurate picture. The length of growth period from stocking to harvest will be influenced by how well the optimum temperature for growth can be maintained. An animal's water quality needs help determine how many to stock per acre. The type of enclosure tolerated by the animal could determine the type and size of pond and hence the cost of pond construction and harvesting method chosen. Nutritional requirements and preferences help answer; what kind of food, what quantity, and what kind of feed distribution. All this (and more) will help the prospective aquaculturist choose or target the "best" species for the situation.

4.1 Securing the stock

To hatch or not to hatch, that is the question.....

Once one has chosen the species most compatible with pond area parameters and management goals, the initial stock must be obtained. Either the small animals can be purchased or brood stock aquired, for fingerling production. Some growers prefer to rear their own fingerlings/post larvae. The proceedures re-

quire considerable experience and specialized facilities. Hatching areas and nursery ponds must be carefully monitored. Environmental and feed requirements differ for newly hatched animals than suceeding stages. Early life stages are highly susceptable to both chemical and physical fluctuations in their environment. Brood must be selected, held in appropriate enclosures and fed specialized diets to ensure top breeding condition. After spawning the percentage of sucessfully hatched eggs is enhanced with use of specialized containers and water quality equipment. Fresh water prawn larvae require a salty environment and are very sensitive to both chemical and physical fluctuations in water quality. Both fry and larvae demand frequent nutritious feedings but nutritional criteria can change daily. Fingerlings and post larvae thrive in well attended areas. The selections and care of brood as well as detailed hatchery proceedures is an area all to itself and beyond the scope and purpose of this guide.

The beginning grower and the more experienced farmer may find it expedient to buy the fingerlings/postlarvae. Costs vary and are dependant on species, individual sizes, quantity, and seasonal availability. Stock should be purchased from a reputable grower. In some cases, these suppliers will treat and deliver the stock to the pond for an additional charge. Since a beginning culturist might not be aware of proper treatment and handling proceedures, or not be equipped to transport quantities of live animals, this service could be politic.

4.2 Stocking the pond

Several items must be considered prior to stocking your pond. For maximum production, feeding or good quality ration is essential (see chapter 6). With supplementary feeding contemplated, higher stocking densities can be contemplated than those occuring under unsupplemented or "wild" conditions. The following stocking densities have been used in the two culture situations:

Culture species	Culture system	
	Extensive	Wild
Freshwater prawn (*Macrobrachium rosenbergii*) [1]	1 per square foot	------*
Catfish (*Ictalurus punctatus*)[2]	2,000 to 4,000 per surface acre	100 to 200 per surface acre
Tilapia[3]	3,500 to 7,500 per surface acre	------*
Largemouth bass (*Micropterus salmoides*)[2]	variable	50 per surface acre

The next item to be considered is the proper time to stock grow out ponds. When stocking fish, their size will be one of the variables to weigh. Larger fingerlings or juveniles can be stocked in the fall. However, fall stocked fish in large ponds often fail to feed in the winter, if temperatures are exceptionally low, and die of malnutrition. In general, spring stocking of fish removes one more chance of failure due to lack of knowledge

* These animals are not indigenous to the United States, therefore, natural population figures are not applicable.

of winter effects on fish.[4]

When stocking fingerlings/postlarvae, remember that acclimatizing them to new water is essential. Abrupt changes in temperature, alkalinity (pH), or dissolved oxygen are deadly to fish and shrimp. Thus, acclimatization is best done slowly, by adding water from the pond to the hauling container. Water should be added slowly enough so the temperature does not change by more than one degree every 10 minutes, nor does the pH change more than one unit per hour.

The larger the stocking size, the faster the animal will reach edible, marketable size in the grow-out ponds. A good rule is to stock the largest animals you can afford. However, the size of the animals desired at the end of the season can also determine the number of animals stocked.

4.3 Species compatible to direct use geothermal aquaculture

Direct use of low temperature geothermal waters for aquaculture has many advantages. These warm water sources mitigate the majority of effects of climatic variation, when utilized in a well planned facility. This allows the culture of warm water species and optimizes growth potential throughout the year. A number of warm water species are suitable for culture under these conditions. The following sections contain information on the most commonly cultured species.

4.4 Freshwater prawns, Macrobrachium rosenbergii (deMan)

In nature these adult prawns seem to choose freshwater but larval development occurs in the more saline portions of river estuaries. An egg carrying or "berried" female travels toward the brackish water. When the ripe eggs hatch, the larvae swim through the water, feeding mostly on zooplankton. Although molting is frequent, it takes from one month to six weeks for the larvae to mature and metamorphose into a postlarvae. It is at this post-larval or "P.L." stage that young prawns are frequently introduced into ponds for culture. These P.L.s are produced in hatcheries, not collected from rivers. In the hatchery the best in nature is mimicked; food is plentiful, predators are excluded, and summer is eternal. Water can be warmed by heat exchangers, either geo-thermal, gas or electric.

In nature these young prawns begin migrating upstream, towards freshwater. Within nine months to one year, some females will return, berried, to the estuary to begin a new cycle.

How prawns grow

Freshwater prawns are classified as belonging to the class of arthropods known as Crustacea. "Crusta" refers to the crust or shell of the animal. As crustaceans are invertebrates (animals without backbones) this outer shell or exoskeleton must be removed before the animal can grow. This shedding process is referred to as molting. The shed exoskeleton is known as a molt. When the prawn molts, there is a fully developed, soft shell underneath.

This shell is filled with body fluids until it reaches a "size" larger than the carapace which was shed.

After a short time, this new exoskeleton hardens and the most visible portion of the growth process is complete. This process is repeated frequently in very young prawns. Larval prawns molt almost daily, postlarvae every second or third day, larger juveniles several times per month, and adults monthly or bimonthly. Adult female prawns molt as a preliminary to mating as well as for growth.

A farmer will see these exoskeletons in her/his pond from time to time. The unknowing observer might assume that these prawns have "died" or that the shells should be removed. Neither is true, the animals have simply molted and will eat the chitinous carapace.

As these prawns are subtropical or tropical in origin, optimum water temperature for growth is from 82°F to 86°F. Stress or mortality occurs at temperatures of approximately 61°F or below.[5]

Physical characteristics

Macrobrachium belong the the class Crustacea. They are also recognized as decapod crustacea by the possession of 10 (5 pair) walking legs. The claws are modifications of the first two pairs of legs. The larger pair of claws, the second pair of legs, is used to capture food, for defense, and are more developed in males than in females. The small, first pair of claws manipulates food and act as cleaning tools. The head or cephalothorax has two pairs of antennules and one pair of antennae, mouth parts,

the paired legs, rostrum and eyes. The gills lie between the body wall and the carapace, just above the walking legs. Gills are constructed so that the water passes over them and the blood through them. The blood extracts oxygen from the water and releases carbon dioxide into it. After the gas exchange is made, the oxygenated blood is carried by the arteries to all parts of the body. The gills, therefore, serve as the breathing mechanism of the shrimp.

The abdomen has 5 pairs of appendages called swimmerettes. These swimmerettes can act for either slow forward or backward motion. They also carry eggs in the female and the first pair serve as copulatory organs in the male. The tail is fan like and it serves as a powerful swimming appendage; shrimp swim backward when alarmed. The details of the appendages of crustaceans are complex and their scope beyond discussion here. However, figure 4-1 is a stylized drawing, showing general body form, appendages and placement.

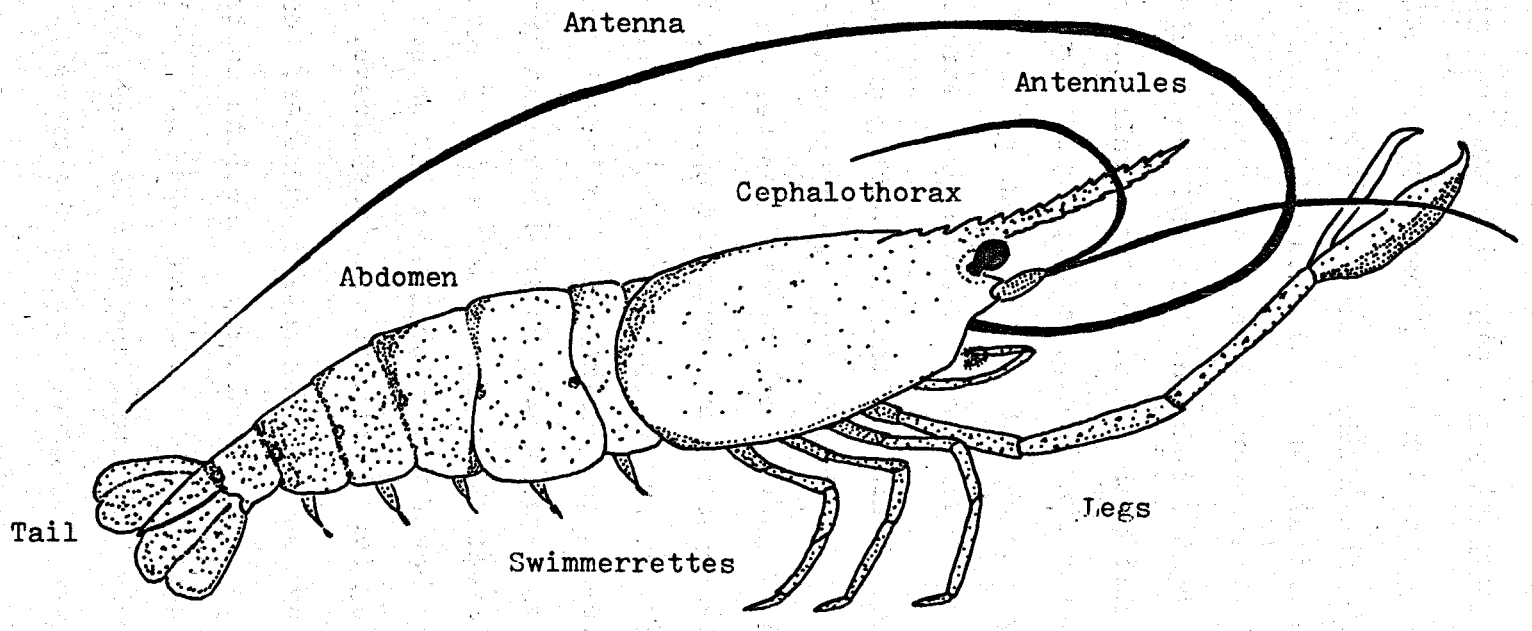

Figure 4-1. Stylized drawing of a freshwater prawn, showing general body form, appendages and placement.

4.5 Crawfish (Pacifasticus leniusculus and Procambarus clarki)

Both the red swamp crayfish (Procambarus clarki) and the signal crayfish (Pacifasticus leniusculus) are members of the class Crustacea. Both animals are omniverous and are most active at night. Like all decapod crustaceans, they possess an exoskeleton covering cephalothorax, abdomen, tail and the 5 pairs of legs. Like freshwater shrimp the first pair is small and helps manipulate food. A second function of this pair of legs is to act as a cleaning tool. The second pair of legs are modified into massive claws, used for defense, feeding and mating.

The breeding season begins in the late Spring extending into Fall. During this time the male deposits a sperm packet into an external receptacle on the female.[6] The female attaches her eggs to the swimmerettes after passing them over the sperm for fertilization. The female carries her eggs approximately 15 days, until they hatch. Unlike freshwater shrimp, all the larval stages have occurred within the egg. Newly hatched crayfish are fully formed, with a miniature adult like shape. These newly hatched crayfish cling to their mother for 5 to as long as 27 days.[7] They are capable of fending for themselves when they leave.

The red swamp crayfish is an extensive burrower, leading to potential problems in pond culture. Some pond culture for signal crayfish occurs in California; however, traditionally wild caught animals constitute the bulk of these animals brought to market. The largest market for crawfish is in

the Southern United States. Red swamp crawfish constitute the majority of this market. Variable market prices have made profitability irregular. Crawfish farming is often a secondary crop.

4.6 Fish

The following section covers fish. Unlike shrimp and crayfish which are invertebrates, fish are vertebrates (animals with backbones). Figure 4-2 shows a stylized fish with body parts indicated. Although body shapes may vary widely, all fish have skin which may or may not be covered by scales. These scales occur in a variety of shapes, sizes, textures, and thicknesses. Fish mouths also appear in a variety of shapes, sizes and positions on the head. The predatory fishes usually have large or hinged mouths, an example is the largemouth bass. Herbivors have mouths and teeth suitable for grazing vegetable matter.

Although most fish possess a well defined eye and ear like organ (the otolith) the major sensory organ is the lateral line.[8] The fish uses this set of small sensory organs to detect prey, avoid obstacles in turbid water, detect depth, and help maintain its balance.

The lateral line is usually visible running along the body of the fish, at a position slightly above the middle. This organ extends from the rear of the gill area to the end of the caudal peduncle. The gills are covered by a bony or fleshy flap (the operculum). Water taken in at the mouth immediately passes over the gills and out through the gill openings at the back of the head. No water reaches the stomach as the gullet is closed so tightly no water can enter. When food touches the gullet, however, the muscles relax and it is passed down the esophagus and into the stomach.

Minimal quantities of water are swallowed as the gullet closes very tightly around the food.[9] Like those of a shrimp, the gills of a fish extract oxygen from the water and pass it on to the blood circulating through them. The blood then carries the oxygen throughout the body, while having released carbon dioxide back into the water through the gills.

Forward motion or swimming is accomplished by flexing the caudal peduncle and therefore the caudal fin. Backward motion is achieved by using the pectoral fins. Stabilization requires use of caudal, pectoral, and the other fins. Variability is wide in the matter of fin shape and size.

The following is a list of terms and definitions which are frequently used when disucssing fish anatomy:

Adipose fin - a small fleshy fin which lacks rays, is located between the dorsal and caudal fins of some fish. This fin and another specialized "whisker like" structure called barbels are found on catfish.

Anal fin - usually located right behind the anal vent.

Anal vent - also called the anus. In most fishes the openings of the urogenital ducts are at the surface, behind the anus.

Caudal fin - the rayed part of the tail.

Caudal peduncle - the fleshy part of the tail.

Dorsal fin - runs along the top of the fish. May be single or

double.

Eye - lidless, most often the eyes are lateral with partially independant fields of vision and movement.

Gills - covered by a flap called the operculum. Water is taken in through the mouth passed through the gills which remove the oxygen and nutirents from the water. The water is then passed outside of the body of the fish through the gill slits.

Lateral line - an area of sensitivity that helps the fish feel pressure and temperature changes in the water around it.

Length, standard - measurement most commonly used by aquaculturists when calculating growth - size data.

Length, total or fork - actual total length of fish body, or length to end of fork in tail.

Mouth - used for food and water (see gills) intake.

Pectoral fins - paired fins used for balance and locomotion, located behind the gills.

Pelvic fins - paired fins used for balance and locomotion, located on the ventral surface. Also called the ventral fins.

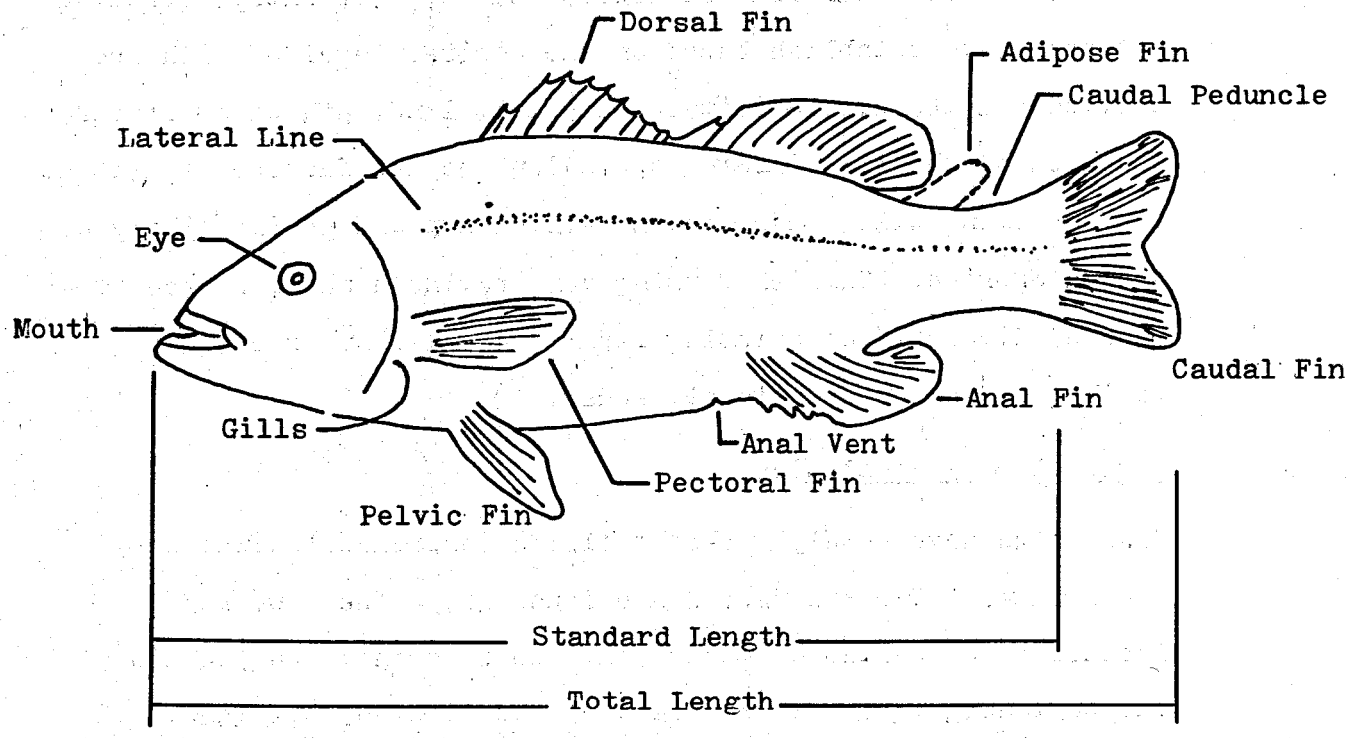

Figure 4-2. Stylized fish drawing, indicating positions and names of anatomical parts. After Needham and Needham, A Guide to the Study of Freshwater Biology.

4.7 Channel catfish (Ictalurus punctatus)

Channel catfish (Ictalurus punctatus) are members of the catfish family, Ictaluridae. This fish is one of the most extensively cultured species in the United States, with more than 60,000 acres of water in production. The U.S. Department of Agriculture states, " a fish farmer must decide what type of catfish farming enterprise to establish based on the desired level of fish production and the availability of capital, land, and water resources. The size of the fish farming operation and the farmers commitment to management will determine the efficiency and profitability of the enterprise. Catfish farming may provide a major source of income, diversify an existing farming operation, or satisfy family food and recreational needs".[10]

Physical characteristics

These fish have deeply forked tails; 4 long barbels (whiskers) are located under the jaw, 2 are found above the jaw, and 1 located at each side of the mouth. Sharp spines are located at the beginning edges of the pectoral and first dorsal fins. The body does not have scales and the heads are broad and flat. These fish are omniverous and are mostly nocturnal. Catfish usually spawn in the spring, as water temperatures increase. Peak spawning occurs when water temperature is 78°F to 82°F. Wooden boxes, milk cans, kegs, tile, hollow logs, and other containers are used for spawning sites. A female will gradually lay her entire egg supply to be fertilized, then guarded by the male.

The male fans the eggs during guarding to remove silt and to oxygenate them. These eggs hatch in 6 to 10 days.

Catfish will grow from fingerlings to slightly more than one pound in about 200 days, when stocked in production ponds. The number and size stocked, per surface acre, determines the eventual harvest size. Large fingerlings (10 inches long) stocked at 1,200 per surface acre will average two pounds. Medium size fingerlings (4 to 6 inches) stocked at 1,500 per surface acre will reach slightly more than one pound. These same fingerlings will reach less than one pound when stocked at 2,000 per acre. These growth figures are dependent on optimum water temperature and food being available during the grow-out period.

4.8 Other catfish species commonly cultured

Blue catfish (*Ictalurus furcatus*)

The second most frequently used culture species is the blue catfish. It is reported that this fish grows more slowly than the channel catfish, but its growth is more uniform. One advantage is that when "dressed out" blue catfish yield a slightly higher percentage of more usable product. Some culturists prefer blue catfish as they can be readily trained to surface feed and their temperament makes them easier to seine. However, a higher feed conversion ratio and a longer time to maturity are some of this species disadvantages.[3]

White catfish (*Ictalurus catus*)

These fish do not grow as rapidly or as large as channel catfish. Their maximum length ranges from 10 to 18 inches. They seldom exceed three pounds in weight and because they have a rather large head, the usable proportion of this fish is smaller.[11]

Brown bullhead (*Ictalurus nebulosus*) and black bullhead (*I. melas*)

The smallest Ictalurids commonly used as food items are the bullheads.[3] These are more usually a fisheries product than a cultured species. The black bullhead, however, has aquired a recognized place as a stocked farm-pond species.[11] These hardy catfish have large heads and their total body weight seldom exceeds 2 to 3 pounds. Profitable culture could be difficult as the market is small and prices paid for these products are usually low.[3]

4.9 Largemouth bass (Micropterus salmoides)

Largemouth bass are members of the sunfish family, Centrarchidae. These fish are among the most popular game fish in the United States and can be found in almost every state. Spawning takes place in April or May when water temperatures are in the mid 60's. The male bass cleans out a nest approximately 20 inches in diameter and 6 inches deep. When the nest is completed a female is induced to spawn, laying several hundred eggs at one time. These eggs are fertilized by the male and adhere to the bottom of the nest. The male guards the nest until the eggs hatch, from 5 to 10 days, depending on water temperature. Bass fry remain near the nest until they absorb the yolk sack, then travel in schools until they reach approximately one inch.

The food of the young bass is small crustaceans and insect larvae, such as amphipods and midge larvae. Larger fish are also predators, and eat insects, frogs, crayfish, and other fish. Providing this live food is the principle obstacle to bass culture.

Largemouth bass may grow to 5 inches the first year, 10 inches the second, 14 inches the third, and 16 inches the fourth. Spawning occurs after the second or third year.[11]

4.10 Other Centrarchids

Bluegill (Lepomis macrochirus), Redear sunfish (Lepomis microlophus) and Green sunfish (Lepomis cyanellus)

These fish are grown primarily for the stocking of private ponds. They are popular panfishes and a favorite of sport fishermen.[11] There is little, if any, market for these fish outside of the arena of sportfishing and some states forbid the sale of Centrarchids as food.[3]

4.11 Tilapia

Tilapia are members of the sunfish family, Centrarchidae. They are thought to be the fish which was caught by Saint Peter and fed to the multitudes.[3] These fish are found extensively in tropical and sub-tropical waters of the world, and are a major culture species outside the United States. These fish are more or less herbivorous.

Three species of tilapia are allowed to be cultured by the California Department of Fish and Game. Tilapia zilli is a partially prohibited species and may be possessed only in San Bernardino, Los Angeles, Orange, San Diego, Imperial and Riverside counties. Tilapia mossambica and T. honorum as well as T. zilli may only be stocked in waters approved by the California Department of Fish and Game.

Growth of tilapia, like catfish, varies with stocking density, spawning frequency and food supply. It has been reported that fish of slightly less than two pounds have been grown in one year. A more realistic rate of growth would be to expect fish of one-quarter pound after one year.

Adult male T. zilli dig out a nest in pond bottoms. The female deposits the eggs, which the male then fertilizes. Both sexes then brood the eggs until they hatch, and remain to protect the fry until they can swim off by themselves.

Female T. mossambica lay their eggs in a nest on the pond bottom, them pick them up in their mouths. The male discharges sperm in-

to the nest and this is also picked up by the female. Fertilization, therefore, takes place in the females mouth and the eggs hatch in 3 to 5 days. The larvae remain in the mouth until the yolk sack is absorbed. These larvae remain near the mother for about 15 days and will retreat back into her mouth if threatened. This species is known as a mouth brooder because of this process. The chief purpose of this technique seems to be protection, as fertilized eggs separated from a female will hatch successfully.

Tilapia have been the subject of much experimentation on the effects of species cross breeding. These experiments are attempting to create faster growing fish. The increased growth rate could be the result of hybrid vigor (heterosis) or monosex culture.

4.12 The minnow family - Carp (Cyprinus carpio)

Carp (Cyprinus carpio) are members of the minnow family, Cyprinidae. Records of carp culture go back as far as ancient China. This is the fish which was fattened by the Greeks and the Romans.[3] It was introduced from Germany into the United States in 1876. The carp spread across this country, where it prefers warm waters with an abundance of organic matter.

Spawning occurs in shallow water in the spring and summer. It takes place both in the early morning and during the night. The female may be seen splashing as she broadcasts her eggs. The eggs are adhesive and stick to plants and debris.[11] After fertilization either the adults ot the eggs can be removed. Another option is to allow the eggs to hatch and to remove the small fish. Leaving the eggs with the adults might result in some losses as the adults may eat a portion of the eggs. In some countries there is little or no attempt to spawn in captivity. Eggs, fry, or various sized fish are collected from rivers and transferred to ponds for grow-out. Conversely, other nations have an extensive artificial breeding program. There are a number of diverse strains available. The best known are mirror, line and leather carp. These fish are partially scaled and exhibit heterosis. In Europe, "scaleless" varieties are considered a superior food product and command a higher price in the market place. Even these varieties have many intermuscular bones which the American consumer finds objectionable.[3] Some work has been done to breed

carp for reduced number of intermuscular bones.[12]

Yields of pond cultured carp vary from area to area. Reported figures are as low as 25 pounds per acre for natural growth in ponds (in Europe) to as high as 4,000,000 pounds per acre for animals reared in closed recirculating systems (in Japan).[3] Fifteen hundred pounds per acre is a frequntly cited harvest figure for intensive culture in ponds with supplementary feed (in Europe, India, Israel, Nigeria, U S.A., and Yugoslavia).[3]

Although carp are easy to culture they are difficult to market in the United States. It is considered by Americans to be too fatty and bony. Aquaculturists that use open water sources sometimes find this fish has invaded the culture facility. This "trash" fish must be destroyed or it will compete with target species for food. In Europe or other parts of the world where protein is in short supply and carp is established in ethnic tradition, the market is more receptive. There carp are marketed fresh, frozen, canned or even as a salted, dried snack.[13]

4.13 Other minnows

There are three types of minnows commonly permitted for culture by the California Department of Fish and Game. Fathead minnows (Pimphales promelas), red shiners (Notropis lutrensis) and golden shiners (Notemigonus crysoleucas) are all utilized as either a bait source or as supplemental live feed. These minnows belong to the family Cyprinidae.

The fathead minnow feeds on supplemental feed, microscopic algae and other plankton. Breeding males develop numerous horn like projections, tubercles, on the head. A pad develops on his back immediately behind the head. This pad is used in preparing the nest site and for carrying eggs. Nests are located on the underside of floating objects. A female releases a few eggs at a time; these are fertilized by the male. The male then picks up the eggs and places them in the nest. Males of this species grow faster and larger than females.[14]

Golden shiners are omniverous and will eat any plant or animal life small enough. They will also readily accept artificial food. A protozoan parasite, Ilistophora ovariae, has plagued the industry in recent years. Severity of this infection is increased with increased age of the female. Careful selection and management of broodstock are required. The male fertilizes the female internally. Fertilized eggs are then broadcast randomly. These adhesive eggs stick to available surfaces and hatch in four to eight days (at 75°F to 80°F).[14] The adults give neither protection nor care to eggs or fry. The female grows larger and faster than the male.

Red shiners are omniverous, but readily accept artificial feed. Like the fathead, the male developes tubercles on the head and also the body during breeding season. The male is larger and more brightly colored than the female. The red fins, orange-red belly, and violet dorsal areas become even more brightly colored during breeding season.[11] These fish deposit their fertilized eggs on submerged water plants.

4.14 Special considerations

A. The utilization of geothermal waters for aquaculture necessitate careful matching of species requirements with available water quality, temperature, and quantity.

B. The use of geothermal water in cascade or downstream systems necessitates matching species temperature requirements with progressively cooler pond temperatures.

C. If post larvae or fry are available, stocking can be carried out on a year round basis.

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5.0 Definition

Pond management involves the day to day operation of the site. General pond and facility maintenance, feeding, water quality monitoring, standing crop assessment, and harvesting are all involved in this broad topic. Although pond management sounds simple, easy and uncomplicated, it is extremely complex. The viability of the project is dependant on the proficiency of the pond management personnel.

5.1 The pond manager

A good pond manager is not only capable of keeping an operation running smoothly, from day to day, but is always aware of poten tial problems and able to handle them when they do occur. This means a pond manager must be aware of what is occurring both in and around the ponds at all times. The pond manager must be sensitive to the culture species' behavior, determining when the animals are stressed.

5.2 Pond maintenance

General pond maintenance deals with establishment and perpetuation of a beneficial pond environment. This is necessary to achieve optimum conditions for maximum growth potential. One of the methods used to insure a beneficial pond environment is the establishment and upkeep of windbreaks. These natural barriers,

"help control soil blowing, reduce the drying effects of wind on soil and plants...".[1] Local or regional offices of the U.S. Soil Conservation Service should be consulted regarding the initial planning, selection and developmental phases of windbreaks. This government service has the personnel, facilities and experience necessary.

Maintenance specifics

Pond maintenance involves sustaining desired pond levels and water flow rates, cleaning and repair of inflow and outflow screens, and the control of undesirable plant and animal influences (see chapters 7 and 8). The following lists contain items which are done on a daily, weekly, monthly or on an "as needed" basis:

Daily

Check and adjust pond flows to maintain desired levels.

Check each pond for stressed animals or mortalities, determine cause(s) and correct, record mortalities.

Run daily weather, water quality checks (see water quality section of this chapter).

Note changes in pond color.

Clean outlet screens, replace if necessary.

Feed, watch consumption and modify feeding rate based on weather, seasonal variation or "slack period".

Calibrate water quality monitoring equipment.

Record migratory waterfowl.

Weekly

Check nets for holes, repair when necessary.

Collect pond population subsamples, calculate data for necessary

feed weights.

Check feed quantities remaining, order when necessary.

Monthly

Tabulate and plot climatic data; ambient air temperature and rainfall data.

Tabulate and plot water quality information; pond temperatures and dissolved oxygen.

Plot population growth data.

As needed

Make underwater visual checks on pond condition and animals.

Arrange temporary water tramsfer.

Increase water flows, bounce for aeration.

Add, remove or replace screens.

Remove unwanted vegetation on roads and pond banks.

Plant grass.

Harvest animals.

Clean and repair nets.

Speak to visitors.

Try new harvest methods.

Record ponds harvested, condition and weight of animals.

Exchange pumps.

Order feed.

Change feed size as appropriate.

Plant, fertilize, and maintain windbreaks.

As wells are dug, record ground strata information, temperature data, and take samples.

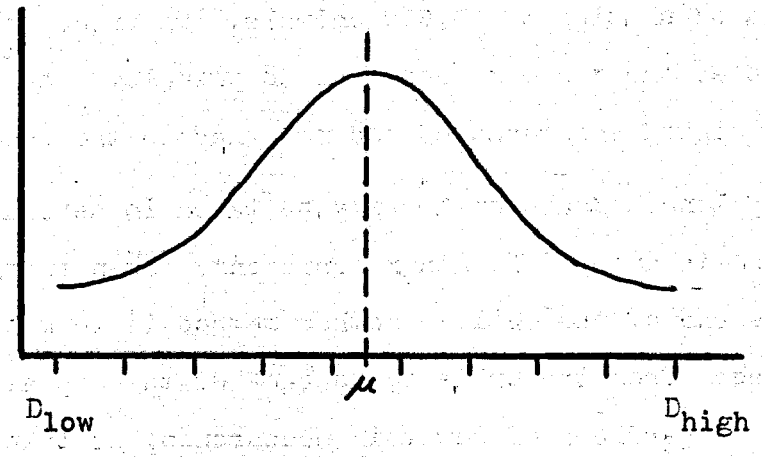


Figure 5-1. Normal distribution curve for population lengths or weight; μ indicates the mean or average of the entire population. N is the number of individuals at each length or weight and D is the length or weight value for each size class.

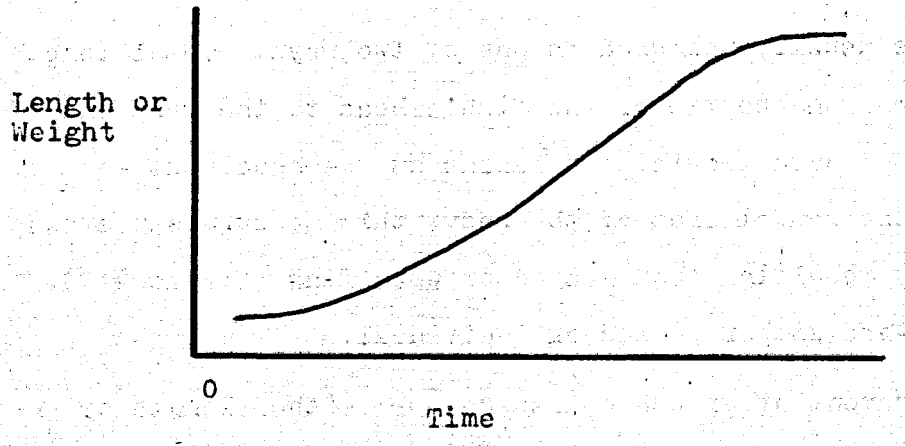


Figure 5-2. Pond population growth curve. Weights or lengths are averages per unit time, weeks or biweekly.

Subsampling example

As a simplified example we will use a pond of one-quarter acre, with a population of 10,000 animals. The pond manager has collected the minimum sample of 58 animals. Each animal has been weighed and measured and returned to the pond.

Shrimp length measurements may be taken in several ways. The easiest is a total length measurement, taken from the eye orbit to the end of the tail. Another method is to measure only the carapace, from the orbit to the back of the cephalothorax. (Figure 5-3). Regardless of how this measurement is taken, always use the same type of measurements throughout the grow-out phase. Weight measurements may be taken individually or as a pooled sample and divided by the number of animals in the sample to obtain an average weight.

Fish are usually measured in one of two ways. Total length is the distance from the tip of the fish's head to the very end of the tail. Standard length also begins at the head, but ends at the end of the caudal area of the body; this measurement avoids inaccuracy resulting from frayed or worn fins (Figure 4-2). Fish weights are either pooled or individual.

Establishment of growth charts can use either length or weight data. However, the data used to plot are averages. Feeding rates, however, are based solely on average weight data.

$$\text{Average weight} = \frac{\text{Pooled weight}}{\text{Number of animals in pooled sample}}$$

$$\text{or} = \frac{\text{Total of individual weights}}{\text{Total number of indiviauals}}$$

$$\text{Feed needed} = \text{Average weight} \times \text{Number of animals in pond} \times 0.03$$

Example: Pooled sample weight = 2.9 pounds

Sample number of animals = 58

$$\text{Average weight} = \frac{2.9}{58} = 0.05 \text{ pounds per animal}$$

Feed needed = 0.05pounds/animal x 10,000 animals x 0.03

= 500 x 0.03

= 15 pounds of feed

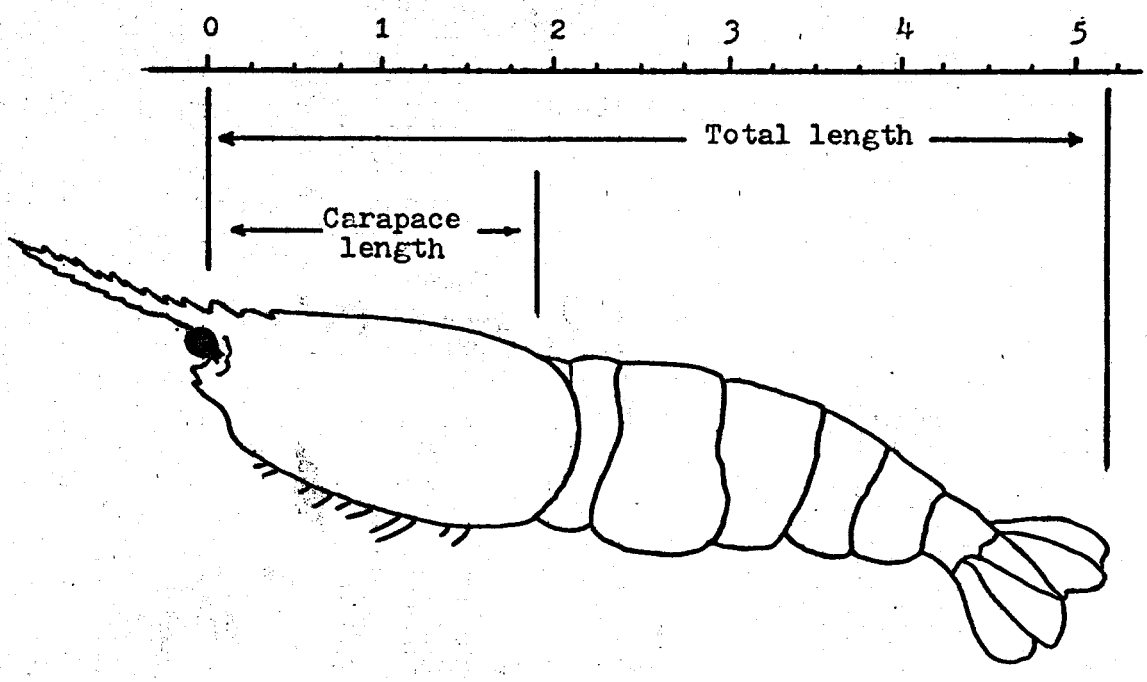


Figure 5-3. Shrimp measuring diagram. This tool shows points of measurement for both total length and carapace length. It can be used to actually measure shrimp. The shrimp shown is 5.19 inches long, total length, or 1.86 inches long, carapace length. For simplicity, it is preferable to use the nearest quarter inch, but always round consistently. Rounding would make total length equal 5.25 inches and carapace length would be 2.0 inches.

5.3 Feeding the ponds

Feeding your ponds is one of the daily routines of pond management. Feeding the ponds is the actual proceedure involved with distributing a specific quantity of ration (feed) to the animals in each pond. Information on types of feed and nutritive data are to be found in the chapter on feed and nutrition. The following section is devoted to information necessary to feed correctly.

The population of a pond always contains a few slow growing animals and a similar number of rapid or fast growers. The majority of animals, however, approach a mean or moderate growth rate. This "normal population size distribution" is demonstrated by the belled curve in figure 5-1. In order to determine the amount of feed necessary per pond, per day, frequent small samples (subsamples) of animals must be taken.

Subsampling is usually conducted on a weekly or biweekly basis, using available harvest methods to catch a representative group of animals. These animals are weighed and measured, then the averages are calculated for both. These numbers represent an average size for the pond population and are used to calculate the quantity of feed required (see example).

When plotted against time on a graph, these data give a visual record of pond production (standing crop) or growth under your specific conditions (Figure 5-2). Careful handling of the animals is necessary to allow them to be returned to the ponds with the least amount of stress possible.

The number of animals to be sampled varies with the total number of animals in the pond. To be statistically accurate; to provide a 95% probability that the sample includes representatives of all size ranges found in the pond, the following minimum sample sizes are necessary:

Total Population (Number of Animals)	Minimum Sample Size
50	34
100	44
250	52
500	55
1,000	57
1,500	57
2,000	58
4,000	58
10,000	58
100,000 or larger	58

Culture animals will grow differently under varying conditions of water quality, availability of natural food, temperature, genetic background, and the feeding regime. For this reason, it is necessary to establish a feeding chart for your specific situation.

5.4 Quantity to be fed

The accepted rate of feeding, within the aquaculture industry, is from 3 percent to 5 percent of the total body weight per pond per day. However, the pond manager must continually watch for variations in the feeding habits of her/his animals. Leftover feed indicates that a lower rate should be used. Certain other rules can be followed:

1. Do not feed in the rain.
2. Cut feeding rate by 1/2 when water temperatures exceed 90°F.
3. Feed with caution or stop feeding when more than 4 consecutive days of overcast have occurred. Feeding may resume after the first day of sunshine.
4. Evening is the preferred time to feed. If desired, split feeding between late evening and early morning.
5. Feed in waters less than 3 feet deep. Deep water contains less oxygen and animals don't feed as well.
6. At least 25 percent of the pond area should be covered when feeding.
7. Animals feed less in cool water, regulate the amount of feed with temperature. Always check for under or over feeding.
8. If aniamls go off feed, determine the cause immediately and correct. Do not resume feeding until adverse conditions have been corrected.
9. Do not feed at least 24 hours before harvesting the animals.

5.5 Where to feed

Presentation of feed near individual animals and in the particle size, shape and texture acceptable to the species being fed is important. Small animals may not travel far to accept food, therefore the ration should be made available over a wide area. Large animals may travel longer distances, but the size and the number of feeding sites should allow all animals to eat. Particle density needs to be considered as some culture species surface feed, while others are bottom feeders. Fish and shrimp are creatures of habit and should be fed at the same time every day. Time to feed is determined by the peak activity periods for each species (usually early morning or late evening).

The frequency of feeding varies inversely with animal size. Small animals need to be fed several times per day, but the total amount fed should not exceed the desired percentage per day. Frequency of feeding is decreased as the animals increase in size.

5.6 How to feed

Recently automated feeding devices have gained wide acceptance. These devices vary from hopper-blowers pulled and powered by a tractor; to stationary units which combine a feed storage tank with an electronically driven auger and rotating disc, which scatters the feed at scheduled times.

Automated feeders are time and labor saving devices. However, they cannot determine if the animals are feeding, and will continue to add feed to a pond, regardless. This may result in an

oxygen depletion due to breakdown of the feed and a subsequent loss of animals. Unfortunately unattended feeding is both risky and unwise.

Many farmers prefer to feed manually. This method maintains a constant check on the condition of both pond and aniamls. Other farmers use a combination of methods, including self feeders. These devices hold a supply of feed and drop it into the water only after a trigger device is "bumped" by the culture animal.

5.7 Water quality

Water quality is a nebulous term which encompasses a wide range of information and criteria. Its importance in pond management cannot be stressed enough. However, water quality is an equally important consideration in the planning phase. Although the quantity of water available may be sufficient for the projected development; the quality of water may make the entire project unfeasible.

In order to determine the water quality, water samples from the proposed site should be subjected to both a chemical analyses and a bioassay. These tests should be conducted by a reputable facility. A bioassay requires placing known numbers of the desired culture species in sample water and discerning the stress reactions which occur. The bioassay is, in fact, the most critical test to be performed. Regardless of how favorable the chemical results, the bioassay is the test which determines the viability of the project. The bioassay should, therefore, be conducted only by qualified personnel, who are familiar with the habits and characteristics of the target species.

To the pond manager, water quality consists of all the physical and chemical factors which affect water and control its ability to sustain life. The physical characteristics include such items as color, density, temperature, and turbidity. The chemical factors include alkalinity (pH), salinity, total hardness, dissolved oxygen (D.O.), other dissolved gases, ammonia, nitrogen, hydrogen sulfide, sulphates and phosphates. Chemical factors including trace element and heavy metal concentrations, as well as radiochemistry are also important; especially when dealing with potential direct use of deep source point geothermal waters. In particulat, both the radiochemistry and heavy metal analyses are critical from a health standpoint. Consult with local or regional public health officials for further information regarding allowable limits.

5.8 Water quality definitions

The following is a list of definitions and information on water quality terms and their importance in pond management:[1]

WATER

1. Is the universal solvent.
2. Essential to <u>all life</u>, plant and animal.
3. Made of hydrogen and oxygen associated chemically in several ways - mainly as H_2O.
4. Does not exist in pure state under natural conditions.
5. Relatively stable both chemically and physically.

WATER DENSITY

1. Density is the weight per unit volume of a substance.
2. Density of water at 4°C (39.5 F) is 1.000.
3. Water colder than 4°C is less dense.
4. Water warmer than 4°C is less dense.
5. Temperature, pressure, dissolved substances change density.

WATER CURRENTS

1. Classed as horizontal, vertical, returning and density currents.
2. Extremely important in aeration, distribution of plant nutrients, etc.

WATER TEMPERATURE RELATIONS

1. Has the highest specific heat (amount of heat required to raise temperature of 1g. of a substance 1°C) of any commonly known substance.
2. Changes temperature more slowly than surrounding air or soil.
3. Changes in temperature affect density of water (Figure 5-4).

WATER STRATIFICATION

1. In static waters differences in water temperature cause a layering effect.

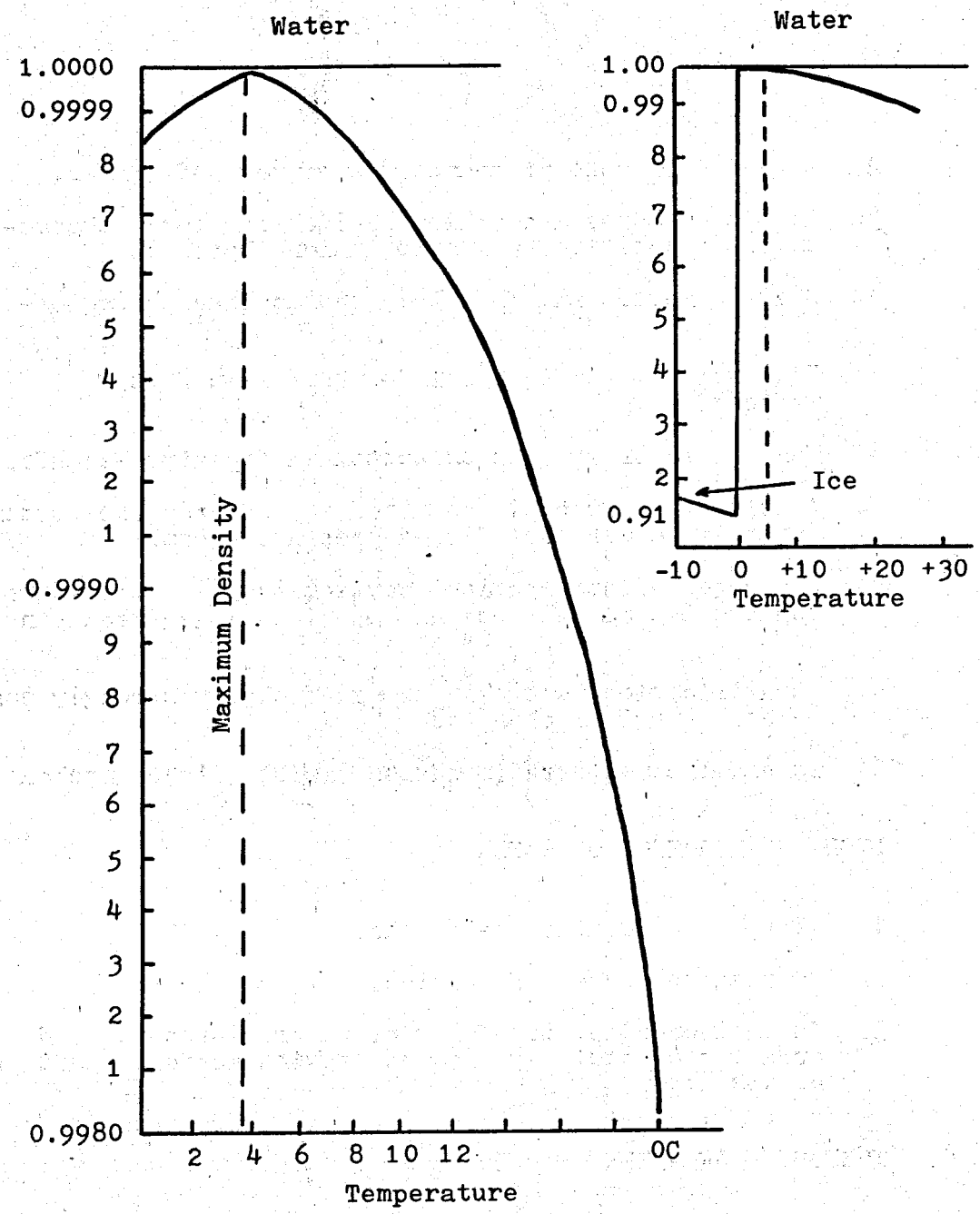


Figure 5-4. Water density and specific gravity as related to water temperature.

2. Layering is most pronounced in summer and winter.

3. Layers or zones are called epilimnion (top), thermocline (transition) and hypolimnion (bottom).

4. Shallow waters may show only thermocline characteristics.

5. Cool water tends to remain on bottom in hot weather.

6. Warmest water will be on bottom in freezing weather.

7. Considerable force is required to displace the bottom layer if temperature differences are great.

8. Prolonged stratification, particularly in rich waters, renders bottom water unsuitable for oxygen-requiring life.

9. Stratification is broken up naturally by strongly contrasting weather changes.

10. In small ponds stratification can be altered mechanically.

LIGHT PENETRATION OF WATER

1. Affects temperature relations.

2. Relates to oxygen production.

3. Is influenced by turbidity of water, intensity and duration of sunlight, amount of wind action, plant growth, etc.

TURBIDITY OF WATER

1. Caused by suspended materials of various kinds.

2. Can greatly affect light penetration.

3. An important influence in heat exchange.

4. Affects the kind and amount of plant life in a pond.

5. Excessive turbidity can have detrimental effects on productivity.

ALKALINITY OF WATER

1. Is expressed as calcium carbonate ($CaCO_3$) equivalent or pH.
2. Caused mainly by presences of carbonates (CO_3^-), bicarbonates ($HCO_3^=$), hydroxides (OH^-), phosphates ($PO_4^=$) and organic substances.
3. Carbonates, bicarbonates, and hydroxides are most universally present.
4. Because of chemical interrelationships only two of the three will be present in measurable amounts at a time.
5. Total alkalinity of a particular water expresses the amount of these substances present.
6. Best fish production is associated with a total alkalinity of 100-120ppm, other factors being equal.
7. Total alkalinity and methyl orange alkalinity mean the same thing.
8. Total alkalinity is determined by titrating a sample of water with standardized acid to the color change of methyl orange.

PH OF WATER

1. An expression of the H^+ and OH^- ions present.
2. pH values always fall between 0 and 14 on the pH scale.
3. Values on the scale express the acidity or alkalinity of a solution in terms of the number of H^+ ions present.
4. At pH 7.0, H^+ and OH^- are equal and the solution is neutral.
5. Below pH 7.0, lower values denote increasing acidity while above pH 7.0, values indicate less H^+ ions in comparison to OH^- ions.
6. Each one unit change in pH value represents a ten-fold change in the H^+ ion concentration.

7. Both fish and aquatic life are affected by pH conditions (Figure 5-5).

8. pH values for a given body of water reflect complex interaction between various types of plants, amount of photosynthesis taking place, basic chemical composition of the water supply and respiration of the life present.

9. pH of a body of water can be changed chemically but becomes progressively more difficult as the amount of water involved increases.

10. Optimum range of pH for fish culture is fairly narrow, from 6.5 to 8.5.

BUFFER AFFECT IN WATER

1. Stabilizes chemical changes.

2. Example is reaction between carbon dioxide and calcium carbonate. When carbon dioxide is produced it reacts with calcium carbonate to form calcium bicarbonate which is neutral in reaction. Had not the reaction between CO_2 and $CaCO_3$ taken place, CO_2 accumulation would have resulted in an increase in the H^+ ions which would have lowered pH to a more acid level. This reaction is reversible when carbon dioxide is being withdrawn by actively growing green plants and removal of calcium carbonate by precipitation retards development of highly alkaline conditions. Thus, pH changes are buffered by calcium salts.

3. Buffer effects are the result of ionization and reaction of buffer salts, formed by weak acids.

4. Water supplies having plentiful amounts of buffer salts are generally easier to manage since drastic changes in water qualtiy are buffered by these substances.

5. Not all effects of buffer materials are desirable as they may decrease effect of herbicide treatments.

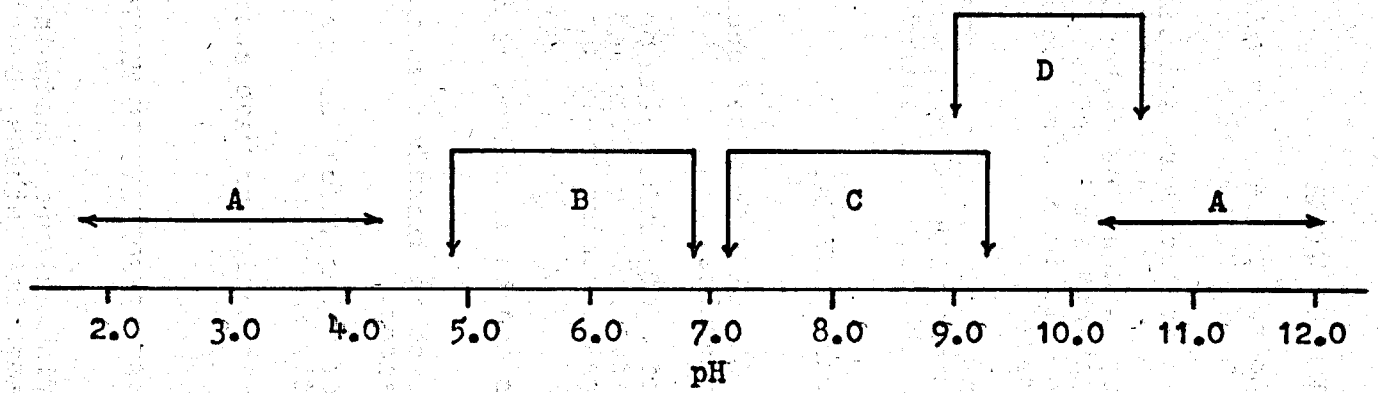
Figure 5-5. Relationships of pH of pond waters and their suitability for fish culture.

A - Water toxic to pond fishes

B - Fish grow very slowly; little reproduction. Very low production

C - Desirable range for fish culture

D - Low production



TOTAL HARDNESS OF WATER

1. Refers to the presence in water of elements calcium, magnesium, iron, and aluminum.

2. Divided into temporary and permanent hardness.

3. Temporary hardness or carbonate hardness occurs when these elements are combine with carbonates. When boiled these solutions loose CO_2 into air and carbonate is precipitated.

4. Permanent hardness is that where elements listed above are combined with the radicals of inorganic acids. Usually, chlorides and sulfates are involved.

GAS RELATIONSHIPS OF WATER

1. Gas can dissolve in water occupying the space between water molecules.

2. A condition of equilibrium or balance tends to become established under a given set of conditions with some of the gas entering the water and an equal amount leaving.

3. More gas can be dissolved at low than at high temperatures.

4. An increase in dissolved solids decreases the solubility of gases.

5. Amount of water vapor the gas contains affects its solubility in water.

6. Surface agitation or wave action increases the rate of change.

DISSOLVED GASES IMPORTANT IN WATER

1. From a fish culture standpoint, oxygen, carbon dioxide, ammonia, methane, hydrogen sulfide, nitrogen, sulfur dioxide, and carbon monoxide are considered the most important.

2. Amount present is expressed in parts per million(ppm), or parts of the gas per million parts water on a weight basis.

OXYGEN

1. Main sources are plant photosynthesis and diffusion from the atmosphere.
2. The diffusion process is slow and occurs only at the water surface.
3. Conditions for diffusion can be improved by mechanical means.
4. Photosynthesis is the most important source of oxygen for static waters.
5. Oxygen level fluctuates over a 24 hour period in relation to light conditions. Lowest levels occur prior to sunrise.
6. Plant and animal respiration are sources of loss.
7. Chemical oxygen demand can be a factor in low oxygen levels, particularly in bottom waters.
8. Extremely high levels of concentration are associated with "gas bubble" disease.
9. When the combined oxygen consumed exceeds the amounts entering the water for any appreciable length of time, levels may drop into the deficient zone.
10. Amounts of CO_2 and ammonia present influence the amount causing mortality to fish.
11. Bacterial action probably represents the greatest influence in oxygen removal under pond conditions.

CARBON DIOXIDE IN WATER

1. May be harmful if dissolved amount is more than 10ppm.
2. Reserve amounts are present as bicarbonates, carbonates, and inorganic forms.
3. Is essential for plant growth and is limiting factor to plant growth in soft, acid waters.

4. Sources include diffusion from atmosphere, inflowing ground water, decomposition of organic matter, and respiration of living organisms. Decomposition of organic matter is probably the most important source in ponds.

5. Losses of CO_2 are caused by photosynthesis, precipitation of carbonates, diffusion into the atmosphere, and chemical combination.

AMMONIA IN WATER

1. Is seldom present in appreciable amounts, if conditions are favorable for green plant growth.

2. Under normal conditions is rapidly converted by bacteria.

3. A level of one ppm is an indication of pollution and 2 to 3 ppm is cause for concern.

4. Toxicity is graeter when oxygen levels are low.

5. High levels can be reduced by flushing, dilution, plant uptake, and by aeration.

6. Sources are metabolic wastes, feed residues, decaying plants, inflowing water and nitrogen fixing plants.

BORON IN WATER

1. Found in higher concentrations in deep source point geothermal water.

2. Can inhibit plant and animal growth at higher levels.

3. Regulates metabolism of carbohydrates in plants.

CALCIUM IN WATER

1. Found in combination with carbonates, bicarbonates, sulfates, chlorides, nitrates or hydroxides.

2. Is the major element in water hardness.

3. Its salts generally have low solubility.

4. Is important as a component of the buffer system, as a micro-nutrient for plants and a mineral required by animals.

5. High levels reduce availability of phosphates and iron. It also effects the action of several herbicides.

CHLORIDES IN WATER

1. Amounts normally found are not an influencing factor, up to 1,000 to 1,200ppm.

2. Chlorides and sulfates are major salts in ground waters where a noticeable brine content is present.

HYDROGEN SULFIDE IN WATER

1. A poisonous gas, highly soluble in water.

2. Is produced when organic matter decays in the absence of oxygen.

3. A level of more than 0.3ppm is cause for concern.

HYDROXIDES IN WATER

1. Are involved in water alkalinity (high pH).

2. Result when plants extract bound CO_2 from carbonates of calcium, sodium and magnesium.

3. Are the active toxicant in lime sterilization.

4. Begin to affect fish life directly at a pH of 10 to 11.

IRON IN WATER

1. Common in ground water as soluble ferrous Fe^{++} or ferrous salt.

2. Oxidizes to ferric Fe^{+++} when water is aerated.

3. Ferric form is relatively insoluble and precipitates.

4. Iron influences availability of phosphates and mechanically clogs gills of fishes held in water carrying noticeable amounts of the ferric form.

5. More than 0.3ppm can be cause for concern.

MAGNESIUM IN WATER

1. Has similar role as calcium and is frequently associated with it in rock formations.

2. Its salts are more soluble than calcium salts.

3. Contributes to total hardness of water.

4. Is less desirable than calcium being a factor in high alkaline pH development. It is less a factor than sodium.

5. It is an essential micro-nutrient for green aquatic plant growth.

MANGANESE IN WATER

1. Generally associated with iron.

2. Has a chemical oxygen demand as monovalent Mn^{+}.

3. Has proven to be toxic to some fish under certain conditions.

NITROGEN IN WATER

1. As nitrogen gas N_2 is both inert and nontoxic.

2. Has caused gas bubble disease when present in large amounts in ground waters.

3. Is unavailable to plants, except for a special group of nitrogen fixers.

PHOSPHATES IN WATER

1. Normally are present in minute amounts, less than 0.1ppm.
2. Are a macronutrient for green plant growth.
3. Tends to be removed by bottom muds.
4. Usually are the first plant nutrient to become limiting in plant growth.

POTASSIUM IN WATER

1. Non-toxic at levels normally found.
2. A macronutrient for green plant growth.
3. Present to some extent in many soils and ground water.
4. Not limiting to plant growth as often as phosphorous or nitrogen.

RADON IN WATER

1. Byproduct of radium.
2. Sometimes found in deep source point geothermal waters.
3. Presence indicates potential public health concern.

SODIUM IN WATER

1. Highly soluble.
2. Low level of toxicity to fishes.
3. Important in the buffer system when associated with carbonates and bicarbonates.
4. High alkalinities are related to abundant levels of sodium carbonate and bicarbonate in fertile waters.

SULFATES IN WATER

1. Common in water supplies in many parts of the country.
2. Often combines with calcium, magnesium, iron and aluminum.
3. Is seldom a direct factor in the well being of fish.
4. More than 100ppm may affect the durability of concrete.

ZINC IN WATER

1. Salts of this metal are usually very soluble.
2. Toxicity to fish has been reported at a level of 0.04ppm in soft water.
3. Fish eggs and sac fry are sensitive to low amounts.
4. Calcium minimizes effects, while copper synergizes (compounds or enhances) the effects.
5. New galvanized pipe carrying soft or acid waters may pick up enough zinc to be toxic to fishes.

5.9 Water quality monitoring

Although water is relatively stable, both chemical and physical changes can occur. These changes may occur either rapidly or progressively over long periods. Both seasonal and diurnal factors occur which can change the ability of the pond to support life. The addition of animals, feed, plankton production or mortality, chemical additions (either accidental or intentional), weather changes (wind, rain, rapid temperature fluxuations) can individually or collectively modify the physical and chemical character of the water to the point where it will no longer support or will limit the growth of the target species.

A monitoring program, using daily data logs, needs to be undertaken for each pond during the entire growout/production phase. A daily log should be kept which includes physical as well as chemical information on each pond, as well as climatic data. Data logs, once established, can help determine "problem periods" during the year and alternative management proceedures can be planned, in advance.

Figure 5-6 represents typical daily logs for one pond for two separate days. Date and time are chronological reference points. Observation time should be consistent from day to day, as certain physical/chemical factors vary with the time of day (dissolved oxygen is one example). Differentiation between ponds

Figure 5-6. Sample daily logs for one pond for two days.

Date: July 4, 1982 Time: 0630
Pond: 104
Climatic data Ambient Temperature: 96.2°F
Weather: 0% cloud cover, slight wind ~5mph NNW

Pond data

	Intake	Outlet	N1	N2
Temperature	72	71.5	72	72
D.O.	6.9	6.8	6.9	6.9
pH	8.3	8.3	8.3	8.3
NO_2	MDC	MDC	MDC	MDC
Turbidity	24"	24"	24	24

Comments: no surplus food pellets left from last feeding

Date: July 10, 1982 Time: 0625
Pond: 104
Climatic data Ambient temperature: 82.5
Weather: 80% cloud cover, heavy rain 0.25in, from 0130-0430. strong gusty winds 20-30 mph. NNW

Pond data

	Intake	Outlet	N1	N2
Temperature	72.0	71.0	71.0	72.0
D.O.	6.0	6.2	6.1	6.1
pH	8.3	8.3	8.3	8.3
NO_2	MDC	MDC	MDC	MDC
Turbidity	10"	8"	8"	8"

Comments: This is 2nd day of storm. No critical D.O.'s so far.

NOTE - MDC is a notation for minimum detectable concentration, the reading taken was below the tests ability.

is necessary only if more than one pond is in production. Weather conditions, when coupled with other factors, can indicate potential problems. Pond data are, of course, the major points of concern. The data should be collected from set points or positions along the pond. In large ponds several locations should be checked to avoid "dead spots" in the pond. Multiple check points are particularly necessary when monitor-dissolved oxygen.

Problems involving dissolved oxygen usually are the result of too little rather than too much. The oxygen concentration of water varies with the time of day, with the lowest point occurs just prior to sunrise. A simple method has been designed to indicate when the oxygen may reach critically low levels (4ppm and lower). This method was developed by Boyd, Romaire, and Johnston (1978. Transactions of the American Fisheries Society, 107(3): 484-492). in small experimental ponds.

The method is based on the fact that a decline in dissolved oxygen (D.O.) in ponds, during the night, is usually a straight line with respect to time. The method requires measuring the D.O. concentration at dusk and plotting this point on a graph A second measurement is taken 2 to 3 hours later and plotted.. If a straight line drawn between these points is extended to a point where it crosses the 4ppm level; you can estimate at what time during the night corrective action can be taken. Although

animals may not die at 4ppm they are, at this point, subjected to stress. The results of stress are variable, but none are good. Stress may cause the animals to "go off feed" or quit eating for several days or it may be related to disease. Figure 5-7 is an example of this method. If the 4ppm cross point is reached after sunrise, no problem should occur as natural photosynthetic processes begin to produce oxygen again.

It should be remembered that this is not a foolproof method. Many factors can influence the rate at which oxygen is removed from pond water during the night. This method is, however, a good indicator of potential problem periods.

If an oxygen shortage is foreseen, several things can be done to either avoid it or to limit its effects. The easiest and sometimes least costly is to increase the water flow rate into the pond. The increased flowrate, coupled with either bouncing or spraying the incoming water and using a bottom water overflow outlet is frequently the only step necessary to avoid trouble. Other methods involve the use of mechanically or electrically powered aerators or agitators, such as turbines or paddle wheels. These devices require a high initial investment and can be costly to operate. The United States Soil Conservation Service recommends the addition of 50 to 100 pounds of superphosphate fertlizer per surface acre as an immediate solution, when animals show signs of oxygen stress.[2] Long term repercussions and species sensitivity should be considered before following this course.

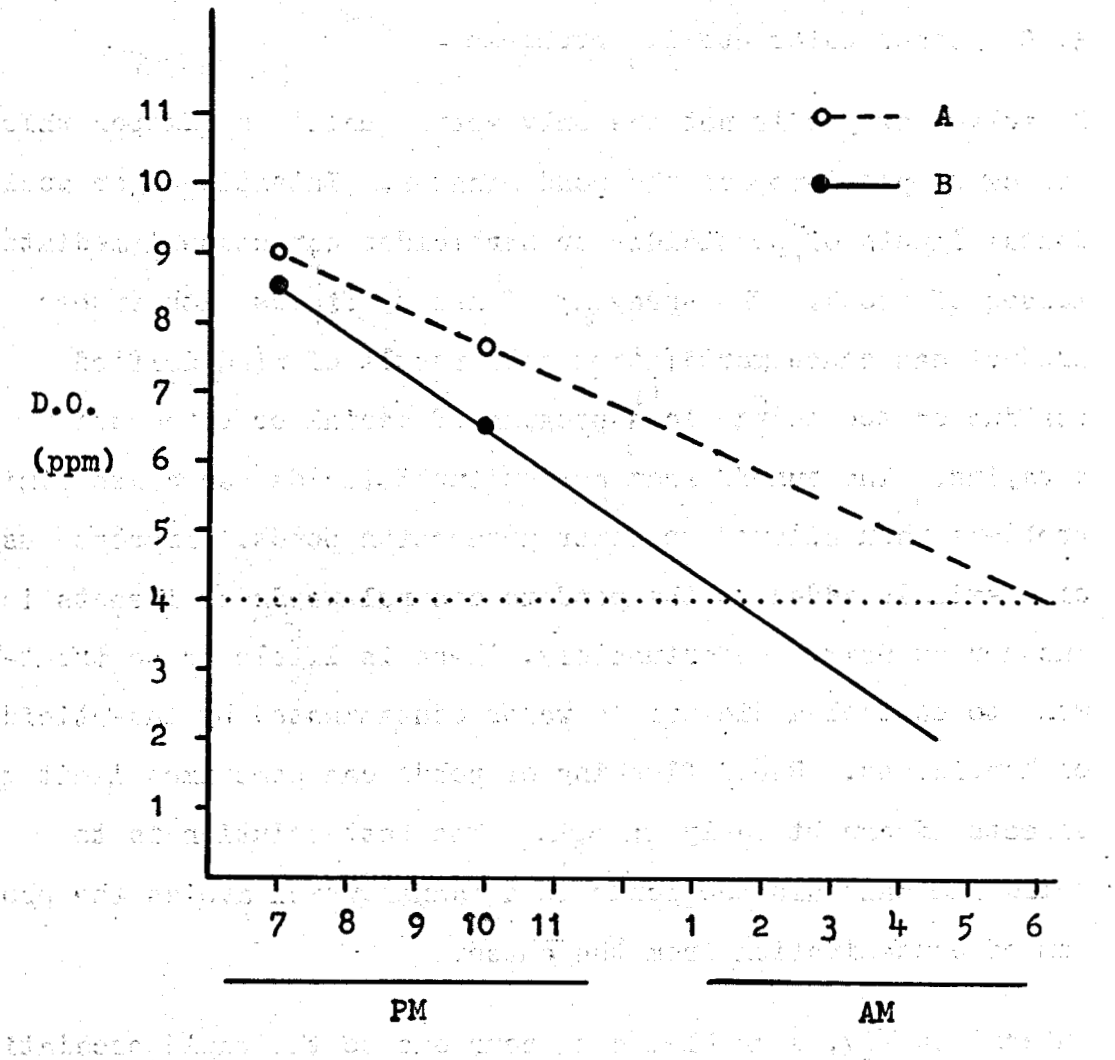


Figure 5-7. Oxygen prediction graph for two data sets. Sample set A (9ppm at 7PM and 7.6ppm at 10PM) indicates no oxygen problem as the critical stress point (4ppm) is reached after sunrise (6AM). Sample set B (8.5ppm at 7PM and 6.5ppm at 10PM), however, shows the critical point is reached at 1:30 AM, indicating that corrective action should be undertaken.

5.10 Other water quality problems

Dissolved oxygen is not the only water quality parameter which can cause problems for the pond manager. Intentional or accidental inputs of pesticides or herbicides can cause immediate losses of stock. The spraying of nearby fields with either product can cause mortalities as a result of wind drifted residue or too energetic a program of aerial or broadcast spraying. The runoff from agricultural fields can cause similar problems when allowed to enter production ponds. Improper use of chemicals added to the pond to control weeds or insects is another culprit. Unfortunately, there is little or no treatment to control a die-off in water contaminated by insecticides or herbicides. Rapid flushing of ponds can sometimes limit the effects if caught early enough. The best solution is to build and maintain the ponds in a manner which avoids the problem of contamination from the outset.

Intermittantly, a problem can occur due to the rapid escalation (bloom) of a population of a toxic algal species. This species takes over the pond and causes mortality through one of two methods. The algae modifies pH levels in the pond to those unacceptable to the target species. The other method is the production of one of two kinds of toxins (poisons) by the algae itself. Endotoxins are those contained in the algae itself and cause mortality when consumed. Exotoxins are byproducts given off by the algae into the water. Table 5-1 is a guide to the

conditions occuring when problems result from oxygen depletion, toxic algal blooms and pesticide or herbicide contamination.

It should be remembered that a one time addition of chemicals may cause immediate mortality. It is also possible for long term problems to occur as the result of continuous exposure to low (sub-lethal) levels of chemicals or continuous problems with oxygen depletion, whatever the cause. The problems usually manifest themselves as chronic low level mortality, where a few animals are lost every day over an extended time period.

Mortality can also occur when the normal nitrification process in the pond is disturbed. Nitrification is the process of converting ammonium to nitrite and then to nitrate. Nitrification is an aerobic process carried out by bacteria normally occuring in pond waters. The converted nitrates are a major source of nitrogen for plant growth. The nitrites and ammonia, however, are toxic to fish if they are present in high concentrations. Nitrites react with hemoglobin, in vertebrates, to form methemoglobin. Methemoglobin is a form of hemoglobin which is unable to carry oxygen. Direct toxicity is the other method by which both nitrite and ammonium are problems.

Table 5-1. Conditions occurring when either oxygen depletion, pesticides/herbicides or toxic algal blooms create water quality problems.

Conditions	Problem		
	Pesticide or Herbicide Contamination	Oxygen Depletion	Toxic Algal Bloom
Time of Day	Anytime	Early AM, before sunrise	During bright sunshine
Water Color	Normal or clear if herbicide	Grey, streaked, or dark	Dense green, red or brown
Water Odor	Normal	Foul, presence of H_2S (rotten eggs)	Normal to musty (from blue-greens)
Size Animal Affected First	Small	Large	Small
Phytoplankton	Normal or absent if herbicide	Dead cells	Abundant (single species)
Oxygen Level	Variable - herbicides cause low O_2	Low	High
pH	Variable	Low (acid)	High (basic)

5.11 Monitoring equipment and supplies

The equipment and supplies necessary for water quality monitoring vary widely in both cost and ease of handling. The individual should consider both fiscal and physical needs. The cost per unit effort (or result) should be weighed against the ease of handling, and the total use requirements, before any equipment is purchased.

The following is a list of some of the options available:

Temperature	-	Simple mercury or alcohol bulb type, glass thermometers. Range should exceed the minimum and maximum expected and read in 0.5°F increments.
		Temperature probes with digital or solid state meters.
pH	-	Paper test strips, for limited or wide range.
		Test kits which use a water sample plus a chemical additive to produce a color, which is compared to a standard or a chart for results.
		pH electrodes with digital or solid state meters; electrodes must be calibrated using standard solutions.
D.O. (dissolve oxygen)	-	Test kits (see pH)
		D.O. probe with digital or solid state meter.*

* Some meters are available which combine oxygen and temperature.

Turbidity	- Secchi disks, either home made or commercially available. Maximum visible depth is measured. Placing your hand in the water is convenient and readily available.
	Meter with sample cell.
Nitrites, Ammonia, Sulfides, etc.	- Test kits (see pH).
	Specific ion electrodes, with digital or solid state meters, calibration against standards is necessary.

The necessary monitoring equipment can be obtained from scientific supply houses or some items may be obtained through local pet or hardware stores, and those carrying swimming pool supplies.

5.12 Special considerations

A. Geothermal water allows the attainment of optimum species temperature requirements if water flow rates and depths are well supervised.

B. Geothermal water allows year round growth of algae and other aquatic plants, this entails the continuous maintenance of outflow screens.

C. Because of the higher temperatures associated with geothermal water, it is important to frequently check pond water dissolved oxygen levels. Water at higher temperatures is less able to hold oxygen.

D. Optimizing pond water temperatures through use of geothermal water means the animals grow more evenly year round. Subsampling must be carried out more frequently than in areas where growth is seasonal.

E. Based on the continuous growth rate data, feeding rates must be adjusted more frequently.

F. Based on the continuous growth rate data, harvesting is possible year round.

G. The culture sites for raising of animals in geothermal water are usually outside the normal geographic and temperature ranges of the animals. These animals are unable to tolerate the extreme environmental changes which can occur in these locations. The water quality and animal behavior must be carefully monitored during these fluctuations to allow rapid mitigation of the effects.

H. As feed degrades more rapidly in warm water, continued checks and adjustments must be made based on consumption rates. This is necessary to avoid over feeding and reduce the potential for eutrophication.

I. The availibility of a consistent supply of warm water allows targeting of plankton blooms to provide optimum conditions for growth of young animals.

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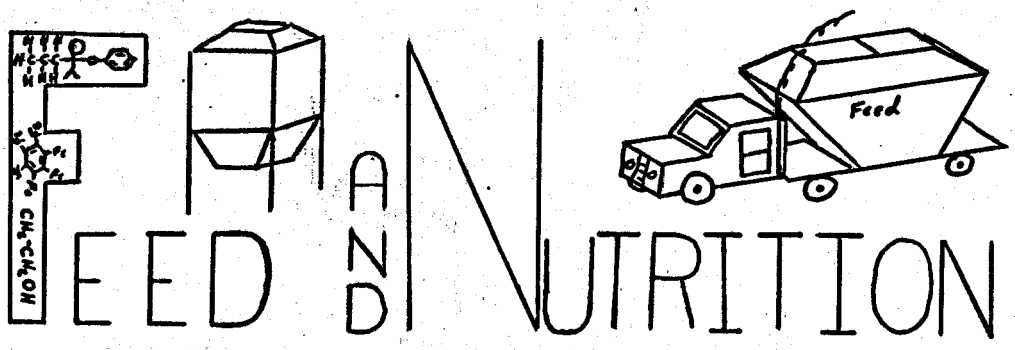
2) Warm-Water Fishponds. 1977. U.S. Dept. Agriculture. Farmers Bulletin No. 2250. 14p.



6.0 Aquaculture and diet

In general, the importance of nutrition and diet in aquaculture was ignored until the 1960's. At that time, aquaculture changed from utilizing large amounts of low cost labor, land and production obtained solely through consumption of native pond organisms. The rising demand for fish as both a food and recreation source, as well as rapidly escalating labor and land costs necessitated the change. The result has been a shift from systems where aquatic animals obtained all their food from naturally occurring foods in the surrounding waters, to systems which are either entirely or partially supplemented.

The subject of feed is important to the prospective aquaculturist because it it constitutes one of the priciple expenses of the project. In order to keep its cost within reasonable limits, it is necessary to understand the following general information.

6.1 Feed efficiency

When large culture animals are fed small particle feed or feeds containing large amounts of feed dust, the result is a low feed conversion efficiency. Feed conversion efficiency is expressed as a ratio and is the weight (in pounds) of feed required to produce one pound of animal. Production facilities are often satisfied with a 3:1 conversion or efficiecy ratio (3 pounds

of feed are necessary to produce 1 pound of animal).

Another problem associated with supplementary feeding is eutrophication resulting from the breakdown of unconsumed feed in ponds. This usually results in decreased levels of dissolved oxygen, increased growth of undesirable phytoplankton and an increase in undesirable waste metabolites. In order to minimize these negative effects and increase feed efficiency, most commercial fish feeds are processed into sizes and textures appropriate to the feeding preferences of the cultured species. The addition of various binders allows feed to maintain its form when placed in water.

6.2 Types of feed

Two method of feed production are utilized; they are pelleting and extrusion. Pelleting uses heat, moisture and pressure to combine individual ingredients into large single units (pellets). The quality of a pellet refers to its resistance to crumbling and stability in water. High quality pelleted ration should be retained on a 1/8 inch mesh screen when immersed in water for 10 minutes, with no more than 10 percent of the original weight being lost. No more than 4 percent fines should be present in bagged pellets. Pellet sizes vary, table 6-1 lists physical properties and specifications.

Table 6-1. Physical properties and specifications for pelleted ration.

Size	Specifications
Fry diet or starter meal	100% to pass through 595u opening (U.S. number 30 sieve)
Number 2 pellet	1/8 inch diameter, 1/8 inch long
Number 3 pellet	1/8 inch diameter, 3/8-1/2 inch long
Number 4 pellet	3/16 inch diameter, 1/4-1/2 inch long
Number 5 pellet	1/4 inch diameter, 1/4-1/2 inch long

Ration must be adapted to both the type and size of the culture species. Juvenile prawns and fry are frequently fed fry diet or starter meal.[2] As the culture animal grows, the size of the feed can be increased. The quantity of ration fed is also changed as the animals grow. However, this subject is covered in the pond management chapter of this guide (see sections 5.4 and 5.5).

Extrusion is the second means of feed manufacture. It too is formed by combining heat, moisture, and pressure. However, higher levels of these are used in extrusion processing than are used in pelleting. The feed is squeezed through die holes at the end of an extruder barrel, under high pressure. Part of the water in the superheated dough vaporizes and causes expansion, resulting in a low density pellet.

Extruded feeds are different from pellets in two ways:

1. Some extruded feeds float. This may be desirable for use with some culture species. Floating feed allows the culturist to observe the aniamls when they surface to feed and to note the amount of feed consumed.
2. Extruded pellets are generally more resistant to disintegration in water.

Extrusion processing is also a valuable tool in the manufacture of crustacean feed. Crustaceans are deliberate feeders and require diets which will remain stable in water for a much longer time than conventional fish pellets. Pregelatinized starches, alginates, carboxymethyl cellulose, and other hydrocolloidal materials with good binding properties are used in making crustacean feeds.

6.3 Diets

It is necessary to supply diets formulated to the specific nutrient requirements of the culture species. The optimum content of a diet varies with both size and age of an animal, as well as the average daily temperature of the water. Fish and shrimp cannot regulate their body temperature; it fluctuates with that of the environment. Animals with this state are called poikilotherms, or sometimes "cold blooded". The metabolic rate and therefore the nutritional requirements depend on the temperature of the surrounding water.[3]

Animals respond to higher dietary protein percentages at higher temperatures. Conversely, little or no growth should be expected at very low temperatures. Diets with 75 percent animal material and 25 percent plant material have been suggested as a suitable daily supplement for freshwater prawns, when fed at a 5 percent rate.[2] However the cost of such a diet precludes its use for commercial production.

The following tables are examples of practical diets. These diets have been used under varying conditions of water quality and temperature and assorted species. Regional and seasonal variations in the cost and availability of ingredients require the potential aquaculturist to accept a product which conforms to the majority of constituents. At the same time, cost as compared to feed efficiency should be evaluated. Names in parentheses are the institutions responsible for the diet formulas.

Table 6-2. Thirty-six percent protein diet (Stuttgart Formula)

Ingredient	Diet Number 1 (kg)	Diet Number 2 (kg)
Fish, menhaden, meal mech. extd. 60 % protein	12.0	---
Fish, herring, meal mech. extd. 70% protein	---	10.0
Blood, meal 80% protein	5.0	5.0
Poultry, feathers, hydrolized meal	5.0	5.0
Soybean, seed wo hulls, meal solvent extd, 49% protein	20.0	20.0
Cotton, seed wo hulls, meal solvent extd., 50% protein	10.0	10.0

Table 6-2 cont'd.

Ingredients	Diet Number 1 (kg)	2 (kg)
Corn, distillers solubles	8.0	10.0
Fermentation solubles, dehydrated	8.0	10.0
Rice, bran with germ	25.0	25.0
Rice, hull fines	---	10.0
Rice milldust or other organic dust, which will pass a U.S. number 80 screen	10.0	---
Alfalfa, meal dehydrated, 17% protein	3.5	3.5
Salt, trace mineral with iodine	1.0	1.0
Vitamin premix, complete	0.5	0.5

Table 6-3. Thirty-six percent protein diet (Auburn number 4)

Ingredient	Percentage in Diet
Soybeans, seeds, meal solvent extd. 44% protein	45
Wheat grain, ground	22
Wheat, middlings, 9.5% fiber	10
Fish meal, mechanically extd., 60% protein	9
Corn, distillers solubles, dehydrated	7.5
Fat, animal	2.5
Organic pellet binder	2.5
Dicalcium phosphate	1.0
Vitamin premix	0.5
Trace mineral premix	0.08

Table 6-4. Thirty-two percent protein diet, for high density culture (Skidaway).

Ingredient	Percentage in Diet
Fish, menhaden, meal mech, extd. 60% protein	10.0
Corn, gluten, meal 41%protein	20.0
Soybean, seed, solvent extd., 44% protein	35.0
Corn, dent, yellow, grain	28.95
Cattle, tallow	2.50
Dicalcium phosphate	3.00
Sodium chloride	0.25
Vitamin premix	0.25
Trace mineral premix	0.05

Table 6-5. Twenty-five percent protein diet, pelleted (Kansas).

Ingredient	Percentage in Diet
Wheat, bran	40.5
Sorghum, grain	17.5
Alfalfa, meal	10.0
Fish, meal mechanically extd.	8.3
Soybean, meal solvent extd.	8.5
Meat and bone meal	6.6
Corn, distillers solubles, dehydrated	5.0
Blood, meal	1.9
Dicalcium phosphate	0.57
Salt	0.5

Table 6-5. cont'd.

Ingredients	Percentage in Diet
Methionine, DL	0.09
Vitamin premix	0.13

Table 6-6. Broiler starter diet. This diet or variations of it is used by many prawn culturists, especially those in Hawaii, Puerto Rico, and overseas.[4,5,6]

Ingredient	Percentage in Diet
Protein	23
Fiber	5.5
Fat	3.0
Moisture	13.0
Ash	7.0
Calcium	0.8 - 1.2
Phosphorus	0.7 - 1.1
Nitrogen-free extract	48.5

6.4 Feed storage

Feed is usually purchased in bulk quantities or by the sack (usually 50 pounds). Bulk feed is normally stored in large bins, holding several tons each. These bins are generally constructed to allow a vehicle to be driven underneath, for easy access to the feed chute or hopper. Regardless of the quantity of feed purchased, it needs to be properly stored.

Fish feeds stored in cool, dry conditions will retain full nutritional value. Ninety days is the maximum time recommended for storing feed at ambient temperature. High moisture conditions can cause mold growth. Some molds produce toxins (poisonous compounds). Mold inhibitors can be added in warm, humid areas.

Some nutrients are sensitive to oxidation and decompose over time. Anti-oxidents may be used to retard their decay. Vitamins, such as ascorbic acid, are sensitive to heat. The half life of this vitamin in pelleted feed is approximately 3 months at 79°F and 50 to 90 percent relative humidity. Effects of nutrient breakdown will be more serious for those species receiving all of their nutrients from feed, than for species with access to pond organisms. Special care must be taken with feed intended as a complete diet.

6.5 Special considerations

A. Utilization of feed is higher in warm water. Growth rates are more uniform and tend to be more rapid in geothermal water.

B. As animals grow faster in warmer water; pellet size and/or composition may need to be changed more often.

C. Warmwater species have different feed requirements than cold water species. Various types of feed may need to be kept on hand to feed all culture animals. This is especially true when using geothermal water in downstream or cascade aquaculture systems.

D. Feeds may degrade more rapidly in warm water. Extra binders may be required for feeds used in geothermally oriented aquaculture systems. However, continual monitoring of feed consumption is still necessary to avoid overfeeding and potential eutrophication.

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Willis, S.A., R.W. Hagood, and G.T. Eliason. 1976. Effects of Four Stocking Densities and Three Diets on Growth and Survival of Post-larval Macrobrachium rosenbergii and M. acanthurus. Proc. 7th Annual Meeting, World Mariculture Society, 655-665.

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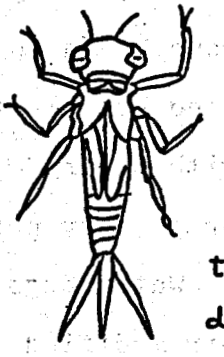
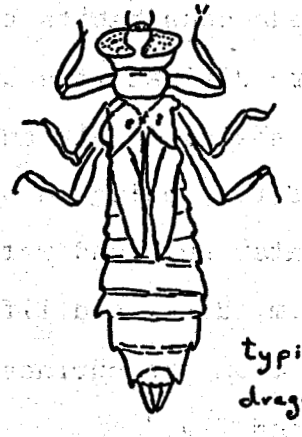
PREDATORS, COMPETITORS AND THEIR CONTROL

7.0 Definitions

"Predation" is the interaction where one species kills and feeds on a second species, "Competition" results when one of two or more species suffer in its ability to obtain food, nesting sites, shelter, or some other requirement for life. "Parasitism" is not covered in this section as it has been graphically demonstrated, "predators live on capital while parasites live on income."[1] The practice of economical aquaculture requires that grow out areas be designed to minimize predation and interaction of competitive species.



typical damselfly nymph (8-30mm)

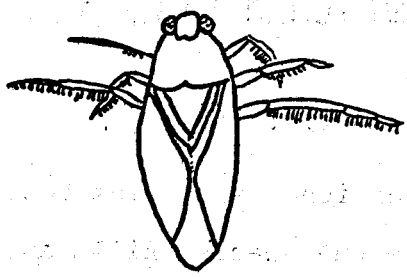


typical dragonfly nymph (20-48mm)

7.1 Items of concern

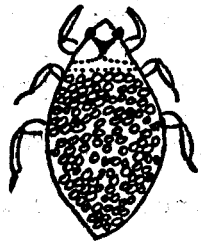
Post larval shrimp and small fish usually are reared by Aquafarms International Inc. (AII) in mono-species nursery ponds. Aquatic

insects present the greatest threat. The nymphs of damsel and dragon flies, as well as larval and adult water bugs and water beetles are all found in static waters. They all are carnivorous.[2] The nymphs (niads) live at the bottom of a pond where, with their "chewing" mouth parts, they prey on small animals. Water bugs catch prey with their modified front legs and kill them with "piercing and sucking" mouth parts.[3] The whirligig beetle is well-prepared for its predaceous habits because its eyes are divided; the upper half is for seeing in air and the lower half for seeing in water. Some water bugs and water beetles can swim, dive, and lift themselves from the surface of the water and fly.[4]



Backswimmer adult
Water bug (12mm)

Whirligig beetle
(11mm)



Male
"Giant water bug"
with eggs on back
(25mm)

It should be remembered that not only are birds directly responsible for predation on culture animals, but also carry parasites which can be transmitted to fish, as secondary hosts.

7.2 Methods of control

Control measures include several methods ranging from management practices to physical control. The economic cost of the various techniques must be carefully calculated and weighed against the benefits. Management techniques utilized include removal of roosting or potential nesting sites during pond construction and development. Pond bank construction can effectively minimize feeding and wading areas. Non-management control measures include one of three forms: scare tactics, exclosures and depredation.

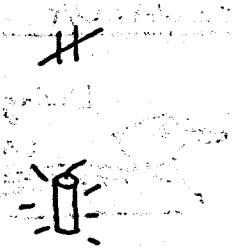
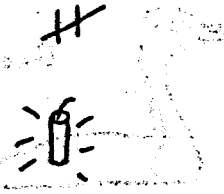
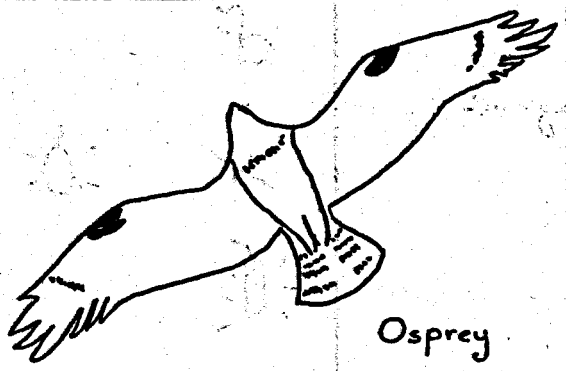
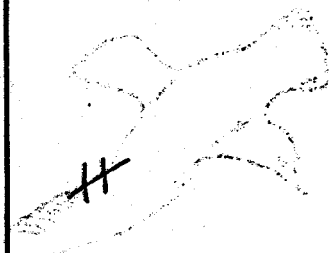
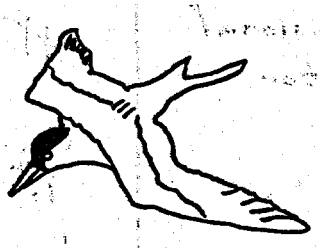
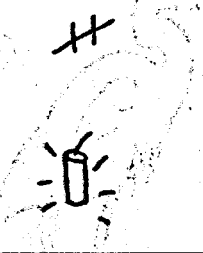
Scare tactics are artificial creations or simulation of noises, physical disturbances or conditions which act to frighten animals and cause them to avoid the area. Scare tactics include the use of noisemakers such as electric cannons, cracker (bird control) shells, and alarm or distress calls. The use of lights and/or sprinklers are also to be considered.

Exclosures are physical barriers which prohibit access to the feeding site. They can range from completely fencing an area to the use of overhead lines and wires which limit access to the water.

Depredation can also be considered, however, most of these birds are migrating and are protected by both state and federal laws. Local authorities should be contacted before any control measures are taken. Depredating ducks may be legally done during waterfowl season. However, this option should only be considered after all other possibilities have been explored, and only with close co-operation and supervision of trained wildlife personnel.

Table 7-1 outlines potential avian predators, their rate of occurence and possible methods of control.

Table 7-1. Potential avian predators, their occurrence and methods of control.

PREDATOR	OCCURRENCE	CONTROL
 Green Heron	Seasonal resident	
 Kingfisher	Year round resident	
 Osprey	Rare visitor	
Tern 	Seasonal vagrant	

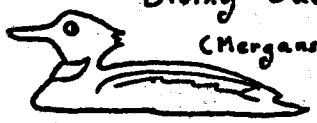
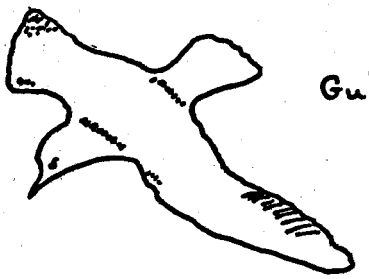
 Alarm - Distress Calls

 Exclosure

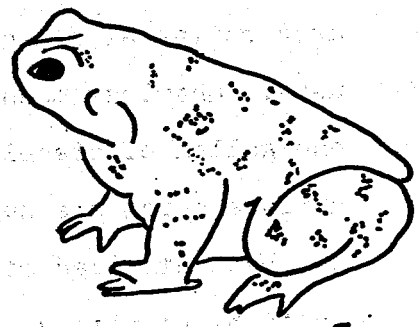
 Lights

 Noise Makers

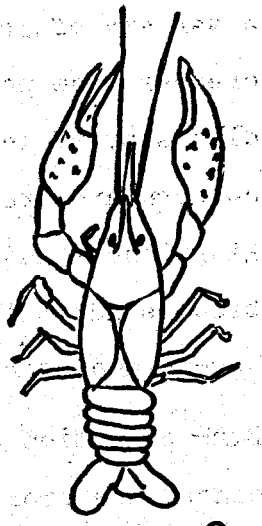
 Water Sprays

PREDATOR	OCCURRENCE	CONTROL
 Diving Duck (Merganser)	Seasonal resident	
 Grebe	Seasonal resident	
 Gull	Vagrant	
 Great Blue Heron	Occasional visitor	

Other predators, including raccoons, muskrats, frogs and wild fish must also be considered. The control of wild fish is facilitated by the utilization of well water or the use of screens and/or filters for natural or surface water sources. Frogs can be controlled by scooping out egg masses and harvesting adults. Raccoons and muskrats may be trapped and moved. Local humane societies and wildlife personnel will often provide traps and assistance. One last predator should be considered, The species, Homo sapiens, can and will cause sizable losses and often willfully inflict damage on both culture animals and surrounding physical property.



Frog



Crayfish

Tadpoles and crayfish must be considered as competitors. They compete for both food pellets and available space. The tadpole problem can be avoided by removal of egg masses before they hatch. The crayfish can be avoided by careful

Control of these pests and competitive species is largely a matter of good pond management. Competition is avoided by keeping very small animals with others of their own kind and size. Numbers of insects can be reduced by eliminating unnecessary breeding areas, keeping pond surface area to bottom area ratios at a minimum and drying nursery pond areas between uses. Chemical means such as "three gallons of diesel fuel or one gallon of diesel and one gallon of crankcase oil per surface acre" are suggested solutions for minnow ponds but have not been utilized at this facility. No insecticide is known by us to be permitted, at this time, by the FDA for use in food fish ponds.[5]

The culture of fish and shrimp in open ponds or raceways attracts a variety of predators. As the size of the culture animal increases from post larvae through subadult stages, the size and diversity pf their predators also increases. Of most critical concern are predatory birds (diving ducks, grebes, gulls, herons, kingfishers and terns) and their control. As the culture animal becomes adult the list of predatory birds expands to include blue herons and ospreys.

Bird predation problems vary with individual species, their abundance, the proximity of facilities to nearby nesting or roosting sites, the availability of alternative feeding sites, and other factors. Consequently, results obtained from a specific control may vary and frequently a combination of methods may be required.[6]

selection of source water and/or screening. However, both tadpoles and crayfish rapidly turn from competitors to a food source as the culture animal grows to adulthood, and therefore do not usually pose a serious threat.

7.3 Special considerations

A. Use of geothermal water allows year round growth of some aquatic animals which would otherwise be seasonal predators or competitors.

B. Year round culture is possible with geothermal waters. The resulting constant food source can act as an enticement to both aerial and terrestrial animals.

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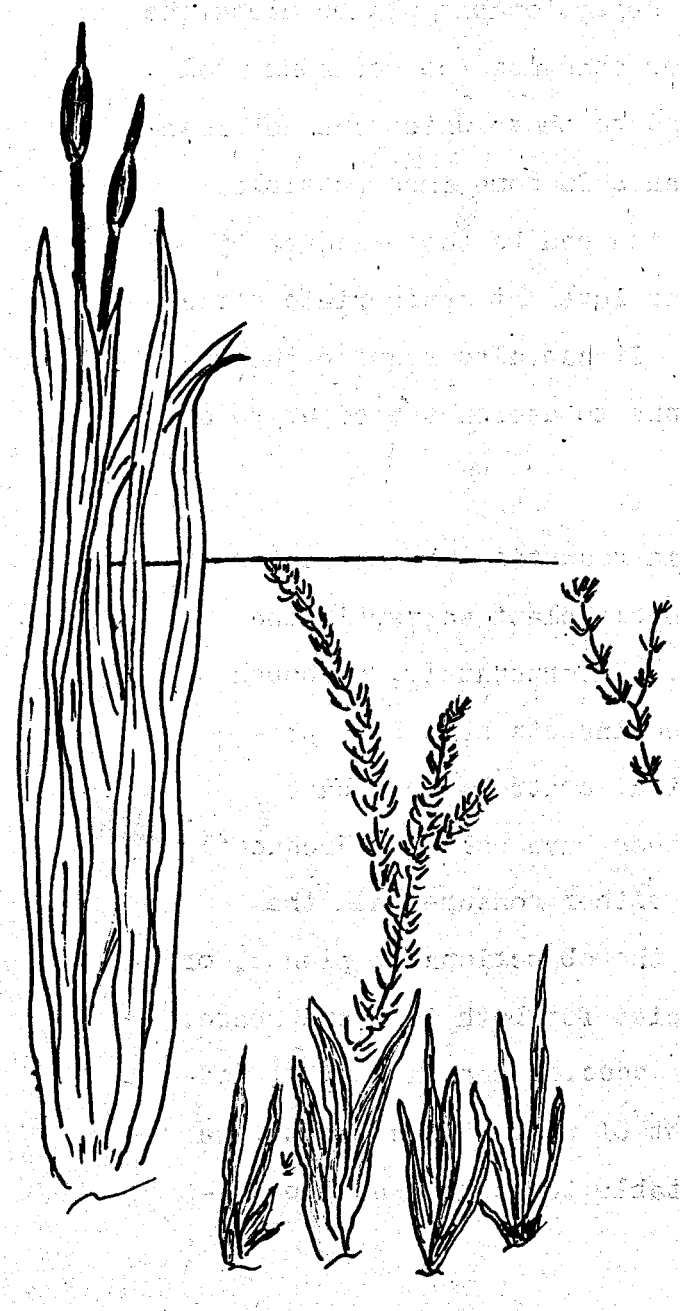
AQUATIC VEGETATION



8.0 Aquatic plants

Aquatic plants fulfill several roles in their aquatic environment. They provide shelter, remove nutrients, add dissolved oxygen, stabilize pond banks and bottoms, and are food for aquatic animals.

The presence of aquatic plants can, however, inhibit your use of their aquatic environment. Since limited use of aquatic plants is desirable and in some cases necessary, you may need to control them if they become a pest by interfering with use of a particular aquatic environment.[1,2]

8.1 Methods of control

There are three methods of control available to the pond manager:

Mechanical control and environmental manipulation -- Mechanical control ranges from the complicated and expensive use of underwater mowers to those as easy as cutting, pulling or digging up a few objectionable plants along the edge of a pond. Modifying or changing the environmental conditions existing in a pond to those which are detrimental to the objectionable plants is sometimes possible. This environmental modification can be accomplished by raising or lowering the water level at appropriate times to flood or dry vegetation. It can also require the reworking of existing pond banks to deepen the edges to a minimum depth of 18 inches.

Biological control -- The introduction of a predator which consumes the objectionable plant matter is the basis of biological control. Unfortunately, although many species of both fish and insects have been proclaimed the ultimate biological control, most have created more problems than they have solved. Frequently the introduced species has either consumed all the beneficial plants, avoiding the objectionable plants, or out competed the target species for both food and space. Worse still, the introduced species has, at times, modified the aquatic environment of natural systems to the point where it became unsuitable to sustain native spe-

cies. The grass carp (Ctenopharyngodon idellus) has shown some promise as a biological control for some plant species, in certain situations. However, due to the potential danger it poses, 35 states (including California) have banned or strictly limited importation and stocking of grass carp. Local wildlife and fisheries representatives should be contacted before considering any biological control.

Chemical control -- The use of herbicides can be both economical and safe. However, there are several limitations which must be considered:

1. is the chemical registered by the Food and Drug Administration (FDA) and your state for food fish use.

2. will it affect the target species in production. Some "legal" chemical herbicides are toxic to some food fish species.

3. do you know your problem weed. Some herbicides are species specific (they work only against specific types of plants).

4. do you know your pond volume or surface area (see Pond Construction), so you can both obtain the appropriate quantity and use the correct treatment rate.

5. have you read the precautions on the label.

No control or inadequate control of an aquatic weed means that you selected the wrong chemical, used an inadequate treatment rate, chose the wrong formulation, or improperly applied the chemical.[1] Excessive use of an herbicide, use at the wrong time, or use of the wrong chemical can result in a partial or total loss of all the animals in the treated pond. Worse still, improper treatment can render a pond unsuitable for any further production.

In summary, aquatic weed control requires the following:

1. Identification of the problem weed.

2. Choosing the most economical, efficient and legal method.

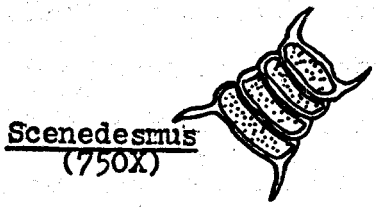
3. If you choose a chemical method of control, be sure it is safe, legal, and effective.

4. Calculate pond area and volume to be treated.

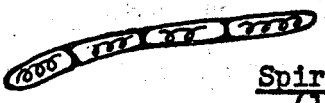
5. Follow label instructions and precautions.

Aquatic vegetation control requires the identification of the weed in question. To help in the identification, vegetation has been grouped into four different biological types. These types refer to the manner in which aquatic plants grow.

Clorella
(1500X)

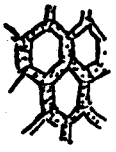


Scenedesmus
(750X)

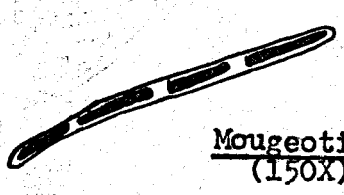


Spirogyra
(150X)

Hydrodictyon
(20X)



Cladophora
(150X)



Mougeotia
(150X)

8.2 Type I algae identification

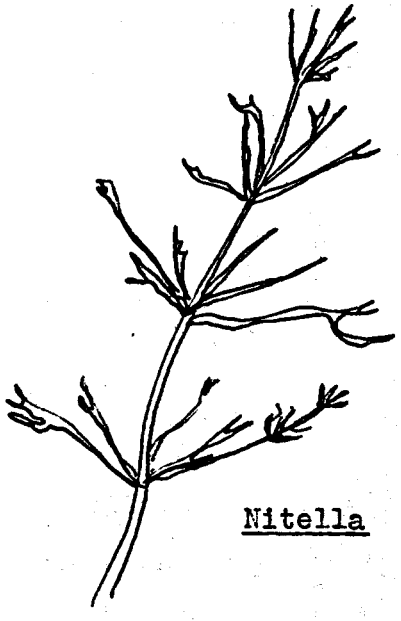
Type I. Algae - There are many forms of algae which occur in fresh water. These plants are responsible for the majority of problems in private and commercial fish ponds. There are three different types of algae, they are:

a) Planktonic algae - also called phyto plankton. These are microscopic, free floating plants which give a green, bluish-green or brown color to water. Examples include the following genera - Chlorella, Scenedesmus.

b) Filamentous algae - these are long, thin, threadlike, strands, filaments or nets of plant material. They often form floating mats or scum. Examples include the following genera - Spirogyra, Hydrodictyon, Mougeotia, Cladophora.

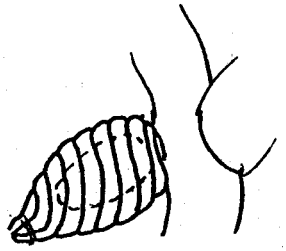
c) Muskgrass or stoneworts - these are larger, more highly develcped forms of green algae. They are a branched algae resembling flowering plants. They have a stem with whorls of leaves or branches. The two most common kindss are Chara, which feels rough and gritty, and Nitella, which is smooth. Both have red reproductive structures (Oögonium) at leaf nodes.

Chara

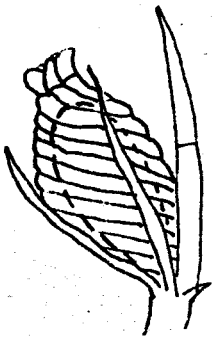


Nitella

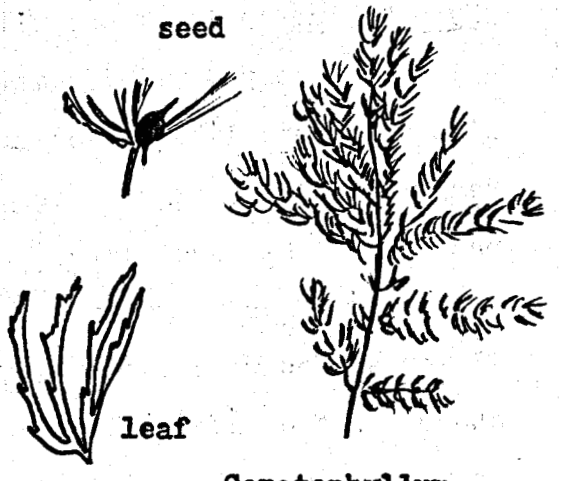
Oögoniums



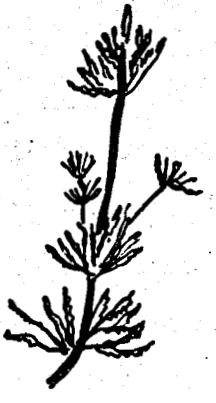
Nitella



Chara



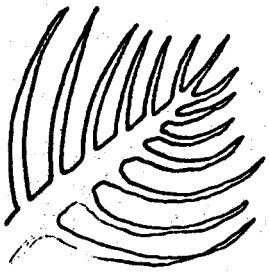
Ceratophyllum



8.3 Type II plant identification

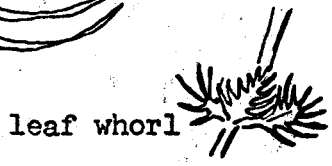
Type II. Submersed plants - These plants are usually rooted in the pond bottom and occasionally reach the surface. This group includes several genera, they are:

a) Coontail or hornwort (Ceratophyllum sp.), never grows above water. Usually it does not have roots. It appears olive-green when seen through the water, has elongated stems, the leaves are in whorls, and each leaf is divided into thread-like divisions, with serrations (teeth) along one side. The seeds are nut like and appear, without stalks at the leaf axils. There are several species of coontail and their forms can be highly variable.



Myrophyllum

leaf



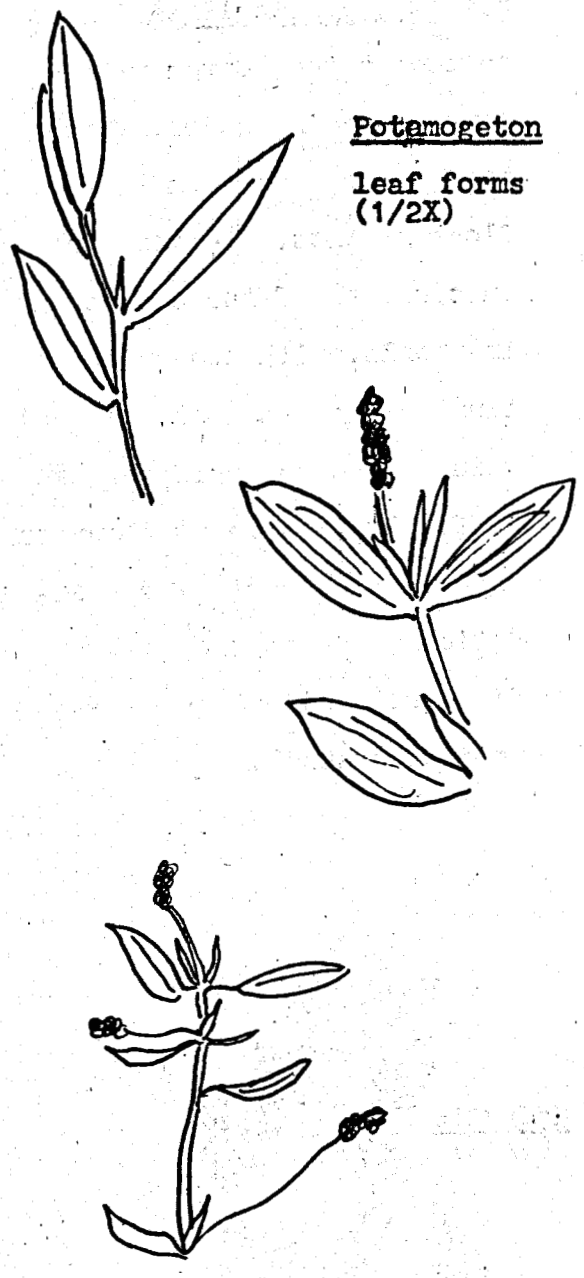
leaf whorl

b) Parrot-feather or water milfoil (Myrophyllum sp.) - These plants all have finely divided, feather like or thread like leaves arranged in alternate or whorled patterns. They are rooted, with strong stems and some have flower spikes which protrude above the the water. Leaves growing at the tips of stems may differ in size and shape from those at the base.

seed

Najas

c) Bushy pondweed (Najas sp.) is a rooted, underwater plant with slender, branching stems. The leaves are narrow, ribbon like, and enlarged at the base. The leaves are coarsely or finely toothed (spined) along the edges and occur in whorls or alternately along the stem. They produce single seeds in the leaf axils.



Potamogeton

leaf forms
(1/2X)

d) Pondweed (Potamogeton sp.) is the largest group of truly aquatic seed plants. Stem and leaf forms are variable, often with two kinds of leaves occuring on the same plant; either floating and firm textured or submersed and membranous. Leaves may be small and thread-like to large, oval or lance shaped. The leaves alternate on the stems, but may be bunched or paired toward stem tips. These plants are difficult to identify to species, as well as difficult to control.

e) Hydrilla - this plant has not been found in Coachella Valley, however it has been found in the Imperial Valley. It is not native to the United States but now infests more than a half-million acres in the southern United States.[3]

actual size

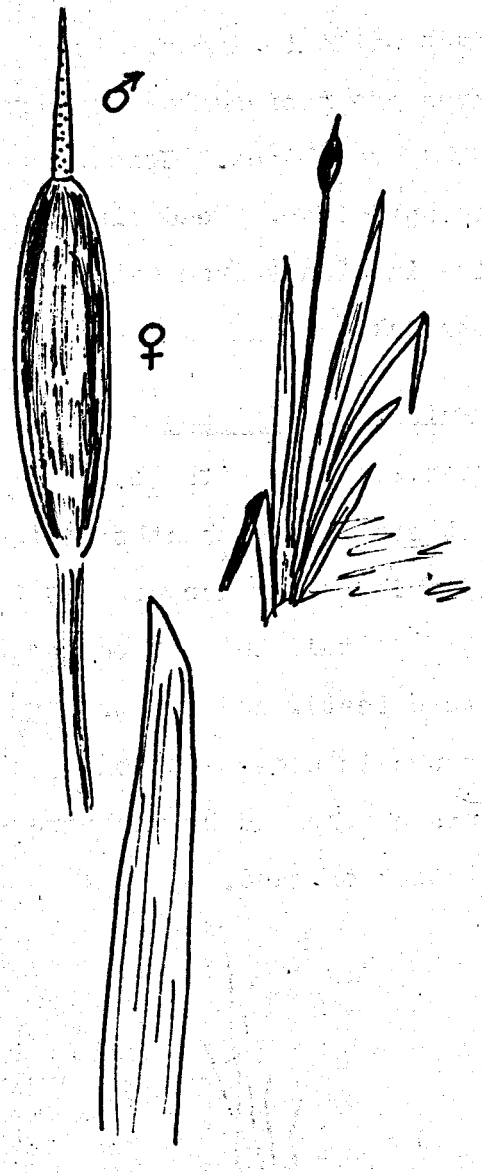
Hydrilla verticellata is rooted to the bottom with long branching stems, which break loose and form large floating mats. Leaves are in clusters of three to six in whorls, with two or three tiny spines along the central vein on the underside of the leaf. It is able to flourish under a wide variety of conditions, and is the most difficult and expensive pond weed to control.

leaf rib with spines

serrated leaf

NOTE : Hydrilla is sometimes confused with Elodea or Egeria.

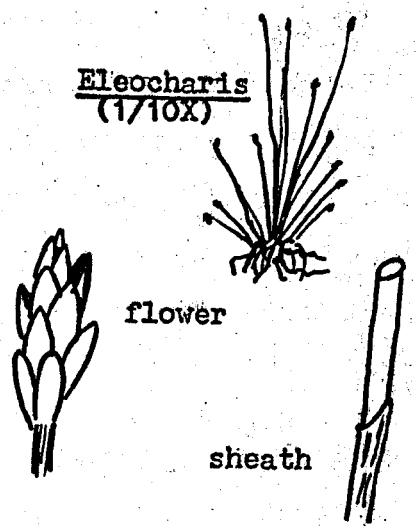
Hydrilla (1/4X)



8.4 Type III plant identification

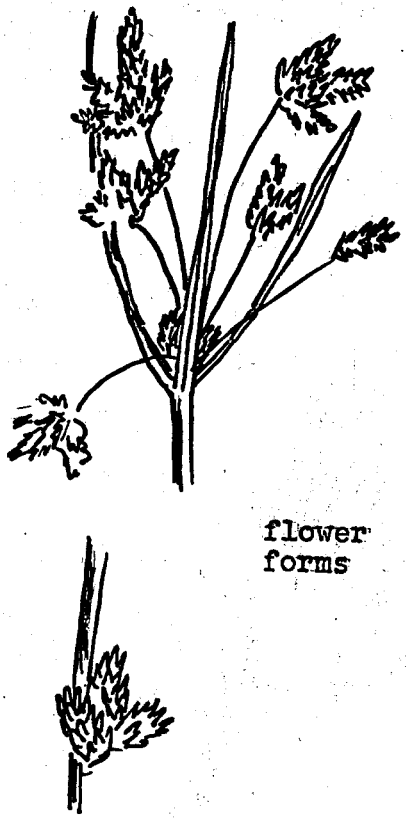
Type III. Emersed plants are those which are rooted on the pond bottom or along the shore, and extend above the water surface. There are three types which occur, they are:

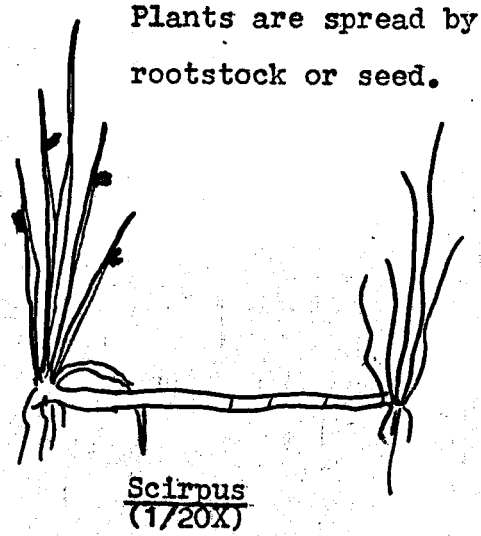
a) Cattails (Typha sp.) - This is the largest group of weeds considered, in both size (leaves reach 6 to 8 feet tall) and spread (one acre of cattails may actually be only a few plants). Cattails are often the first invaders in a new pond, and can appear anywhere it is wet. The flowers are in cylindrical spikes, with the male portion above the female. Leaves are long and flattened. Cattails spread by underground root-stock or wind born seed.

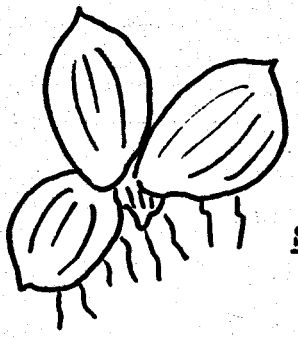


b) Spike rushes (Eleocharis sp.) are small emergent plants with leaves without blades. The leaves are represented by sheaths at the stem bases. Stems end with spikelets. Seed clusters arise in clumps from matted rootstock.

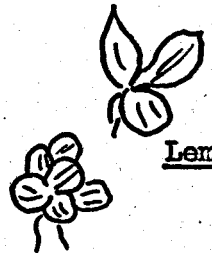
c) Bulrushes (Scirpus sp.).are marginal plants with slender, erect stems with sheaths at the base. The stems are usually 2 to 3 feet tall but may be larger (5 to 8 feet), and are triangular to round in cross section. Plants are spread by underground rootstock or seed.



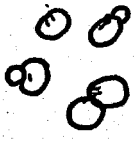




Spirodela



Lemna



Wolffia

8.5 Type IV plant identification

Type IV. Floating plants - Those plants which float on the water's surface and are not rooted in the bottom are included in this category. In Coachella Valley, the prime, naturally occuring example of this group is duckweed (family Lemnaceae). In less arid climates, other examples include water lettuce, water fern, and water hyacinth.

a) Duckweed (family Lemnaceae) consist of several genera, all are amongst the smallest of the water plants. The plants float, without leaves but have globose or flattened fronds. The plants may or may not have roots. Reproduction is mainly vegetative, by a division of the plant body (budding). The most common genera are: (a) Lemna sp., little duckweeds, (b) Spirodela sp., large duckweed, and (c) Wolffia sp., watermeal.

8.6 Special considerations

A. Geothermal water allows year round growth of some plant and algae species. These can be either beneficial or a nuisance, depending on the species and its population size. Hence, management is necessary for both identification and control, if necessary.

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9.0 The area in and around ponds sustains its own population of resident and transient animal species. These animals range in size from tiny protozoans to racoons and coyotes. These creatures dwell either in pond waters or in the surrounding environment. Some species require both habitats for survival; aquatic for a portion of their life cycle and terrestrial or aerial for another phase. Both toads and dragonflies are examples of this situation.

This section of the guide has been designed to help an observer identify and understand the animals seen at the culture site. Animals are divided into two major groups, based on structural differences, vertebrates and invertebrates. Vertebrates are those animals possessing a vertebral column (backbone) or an internal body skeleton. Invertebrates are those lacking an internal skeleton or backbone. Further division occurs by separation of the animals into their respective phyla. Animals are grouped into the various phyla on the basis of having had a common ancestor.[1]

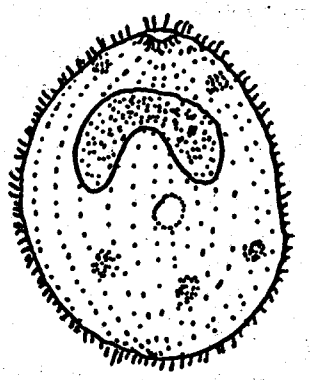
9.1 Invertebrates

The invertebrates are extremely diverse in size, body plan and devices for adaptation to their respective habitats. They are not only more diverse in their anatomical features, but are much more numerous than vertebrates, both the number of species

and the number of individuals.[2] More than 90 percent of both living and fossil animal species have been identified as invertebrates.

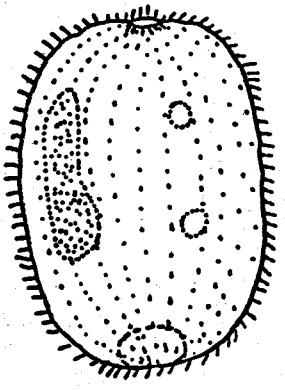
9.2. Protozoa

These one celled animals are usually seen as individuals only with a microscope. Some protozoans feed on live foods such as algae or bacteria; others subsist on decaying substances, and a few manufacture their foods. Protozoans can be separated into four groups: ciliates; flagellates; sarcodinia; and suctoria.[3]



Ichthyopthirius
(μ 100-1,000)

The shapes of some protozoans is so similar that identification might seem confusing. Ichthyopthirius is a large ciliate that causes "white-spot" or Ich" disease in fish. Prorodon is a much smaller free living ciliate. "Ich" is one of the few protozoans that can be seen by the naked eye, but it takes the low power objective of a microscope to see the large horse-shoe shaped nucleus that positively identifies this organism.[4]

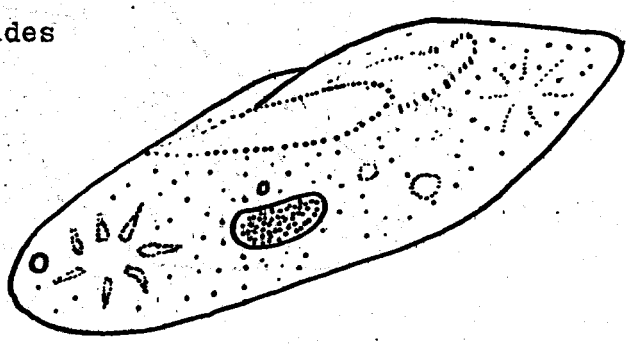


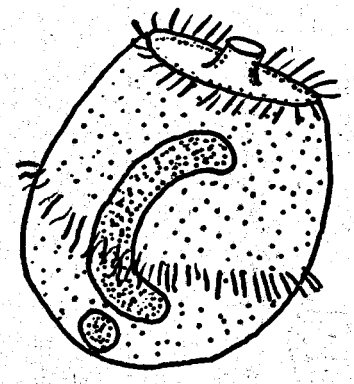
Prorodon (μ 30-130)

Ciliates

This classification of protozoa is characterized by the possession of short hair-like cilia and a macro (large) and micro (small) nucleus.[5] The cilia are used for locomotion and/or food gathering. Both Ichthyopthirius and Prorodon are examples of this group.

There are many species of the very common ciliate Paramecium. Decaying vegetation provides feed for this group.

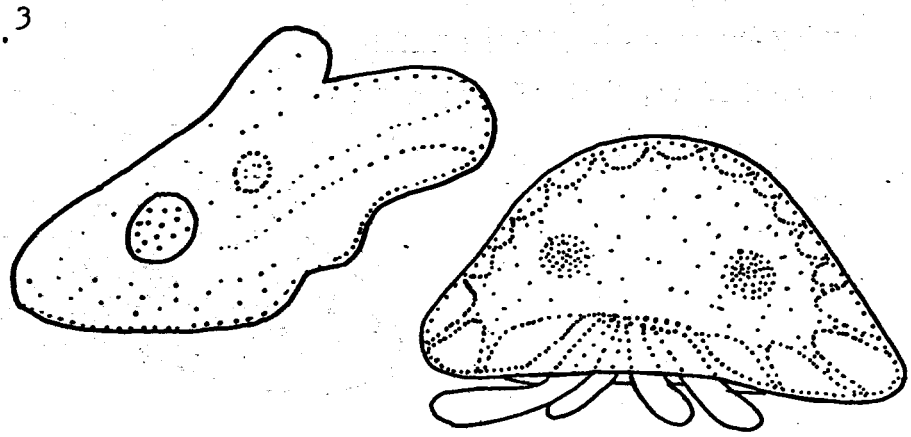




In turn, the paramecium are preyed upon by the Didinium (μ 80-200). These ciliates have a "snout-like" projection at the front of their body. They swim about at top speed trying to pierce anything they contact. When this snout contacts a paramecium, it is penetrated and swallowed bodily.[2]

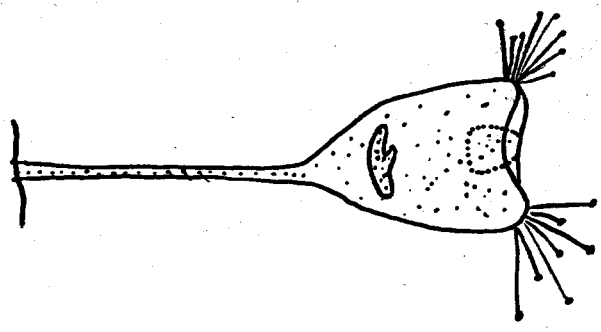
Sarcodina

This group, also known as rhizopoda, has pseudopodia or "false-feet".[5] The flowing movements of their protoplasm are both the means of locomotion and the method of capturing food. Amoebas are the classic examples of this division, with their "soft" free form shape. However, other sarcodinians may be enclosed in a hardened "shell". Arcella and heliozoans are examples of the shelled type of fresh water protozoan.[3]



Suctoria

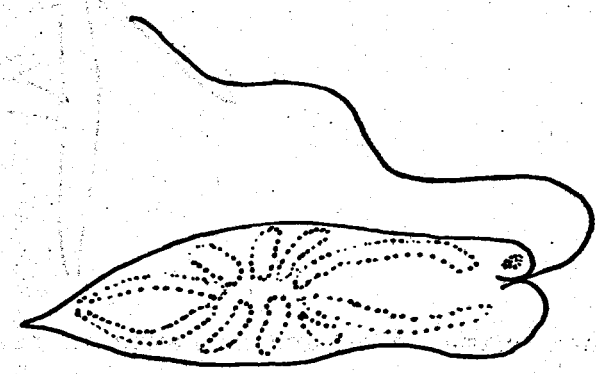
Many of these animals are parasites and some cause disease. Free living suctorians have sucker-like "arms" or tentacles for grasping and eating food. Young suctorians possess cilia. Adults are attached to substrate by a long stalk, which might remind the observer of the more advanced coelenterate, the Hydra.[3]



Flagellates

Flagellata is a class of Protozoa characterized by possession of one or more long whip like flagella. Flagellates include both animal and plant like forms. As some forms can produce their own food from chlorophyll in their bodies, they are claimed by botanists and zoologists alike. Another group is more animal like, capturing and eating other organisms.[3]

Euglena is one of the most common plant-like flagellates occurring in fresh waters. It possesses a single flagella.[3]

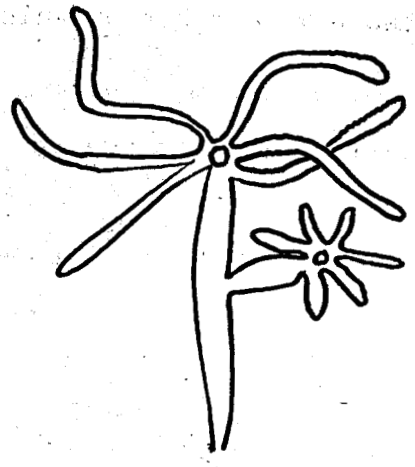


Volvox is another commonly occurring plant-like flagellate. It is, however a colony of unicellular animals, each with two flagella and a red eyespot. The spherical colony rolls over and over, always with the same end forward.[3]

Both groups of flagellates can occur in sufficient numbers to make the water appear green. Perhaps the most "notorious" flagellate, Gonyaulax, is one which lives in salt water and is responsible for a condition known as "red-tide".[2]

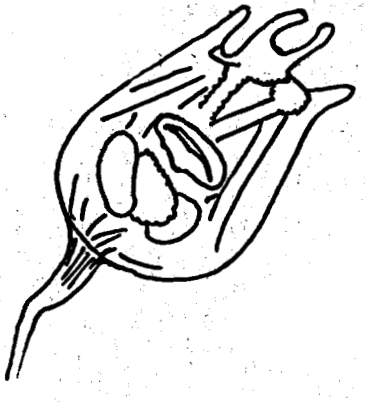
9.3 Coelenterata

The phylum Coelenterata includes animals whose main body cavity is also the digestive cavity and is connected to the outside by a mouth.[6] Most Coelenterates are marine, but Hydras and a single species of jellyfish can be found in freshwater.[7] Hydras, usually less than an inch long are the representative in the Coachella Valley area. Although Hydras are present in ponds, they are more readily observed in an aquarium.



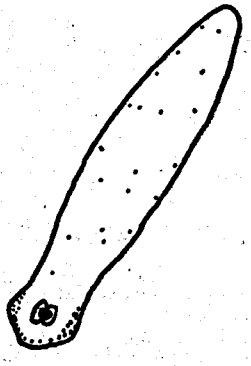
9.4 Rotifera

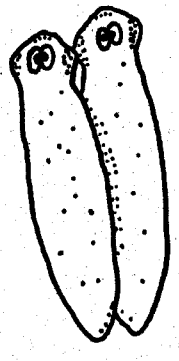
Rotifers or wheel animalcules are so named in reference to the rotating movement of the hair-like projections (cilia) on the front of the body.[7] Their shape varies from worm-like bottom dwellers or flower-like attached dwellers to rounded forms which float near the surface. They may live singly or in colonies. All rotifers are bilaterally symmetrical.[3]



9.5 Worms and worm-like animals

Worms and worm-like animals belong to several unrelated groups. These include flatworms, earthworm types, and leeches.[7] Free living flatworms, turbellarians, are infrequently observed. The small size, less than an inch, makes this worm easier to observe in an aquarium situation. Neither of the other two groups is found in a natural population at A.I.I.'s site. Other animals that appear at first observation to be worms, are upon closer examination found to be insect larvae.

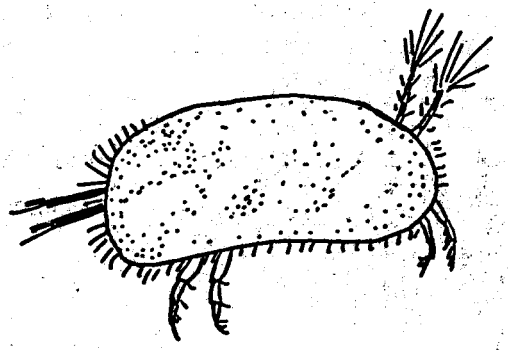




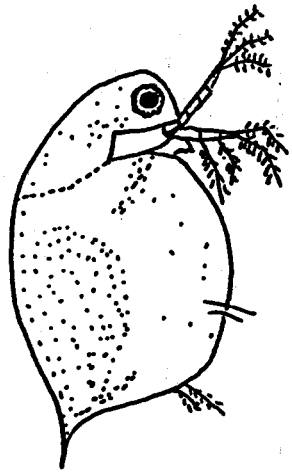
9.6 Arthropoda

This large phylum of invertebrate animals has jointed legs, chitinous exoskeletons, and segmented body parts. Three classes of arthropods are abundant around ponds; crustaceans, insects, and arachnids.[7]

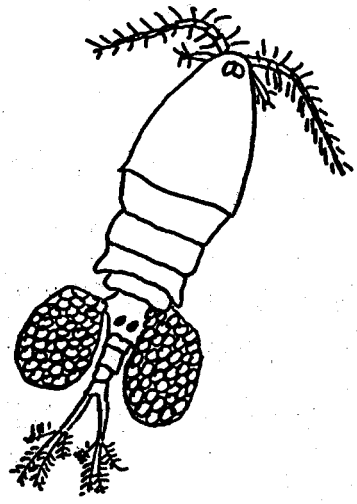
Crustaceans



Seed shrimp or ostracods are usually less than 0.1 inches long. These clam-like scavengers are common in mats of algae, other vegetation, and mud bottoms.[7]



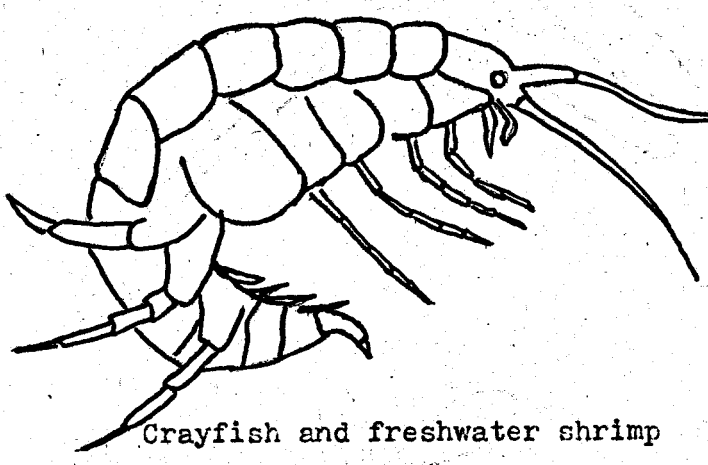
Water fleas or cladocerans are frequently 0.02 inches long. This tiny crustacean eats algae, microscopic animals, and organic debris.[7]



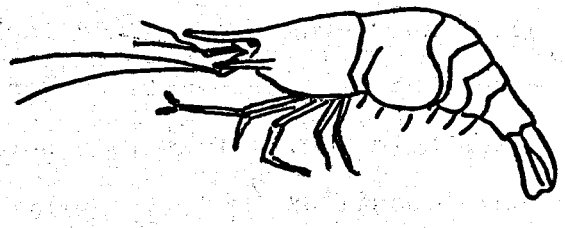
Copepods are ubiquitous small, crustaceans that usually feed on algae, bacteria, and organic debris. The ovigerous female is easily recognized as one or two

egg sacks develop during the breeding season. The majority of copepods found in fresh water are an important part of the diet of fish.[7] However, certain species are fish parasites, and can inhibit growth and productivity.

Scuds or amphipods usually live close to the pond bottom and avoid light. They are scavengers on plant and animal debris. These crustaceans are flattened from side to side, and grow as large as 0.5 inches but are usually much smaller.[7]



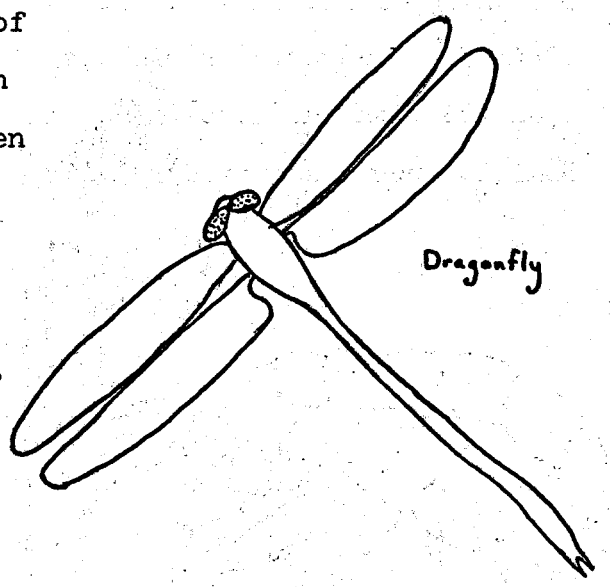
Crayfish and freshwater shrimp are decapods. Pond crayfish are an east coast native that have populated waterways in the Coachella Valley area. Crayfish usually hide in burrows or under objects during the day, but are active at night.[7] The small fresh water shrimp, Palamonetes paludosus has ex-



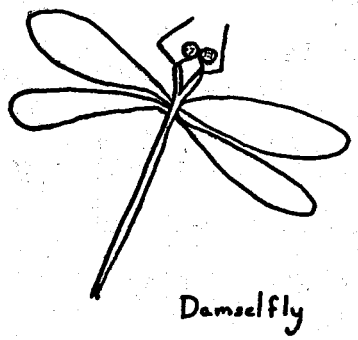
tended its range into the valley, but is rarely found.

Insecta

There are thousands of species of insects that spend their life in and around water.[7] Of the eleven orders of true aquatic insects; dragonflies, damselflies, bugs, beetles, and trueflies are the most observable (see chapter 7).

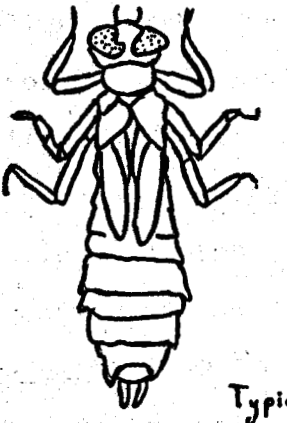


There are approximately four hundred species of dragon and damsel flies in North America.[7] The two groups are easily differentiated both in flight and at rest. Dragonflies are more brightly colored and larger than the damselfly. Damselflies hold their wings upward and backward when at rest, while dragonflies hold their wings in a horizontal position.[7]



Dragonflies and damselflies both mate in flight and and the females deposit their eggs in the water.

Some species complete their life cycle of egg, nymph and adult in three months; others may take up to five years to complete this cycle.[7] The change from nymph to adult takes place on a submersed object. The nymph attaches itself to this object and climbs slowly out of the water. The outer skin splits lengthwise on the upper body surface and the adult emerges. Once its wings have dried it can fly away. One often finds these abandoned nymph husks while working in or around the ponds.



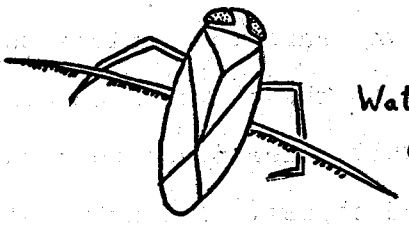
Typical Dragonfly Nymph

Typical Damselfly Nymph

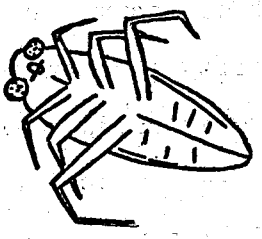
True bugs (Hemiptera)

The true bugs have mouth parts designed for both piercing and sucking.[7] Most aquatic bugs use these parts to feed on insects or other small invertebrates. These bugs will be seen swimming, diving, or walking on the water's surface. Water boatmen (Arctocorixa interrupta) and backswimmers (Notonecta undulata)are among the most common true bugs that swim in the water. These bugs capture a bubble of air at the surface and hold it while swimming. The bite of the backswimmer is quite painful.

Water treaders are small true bugs living only on the surface. They feed on the animals found there.



Water boatman (1.0 in.)

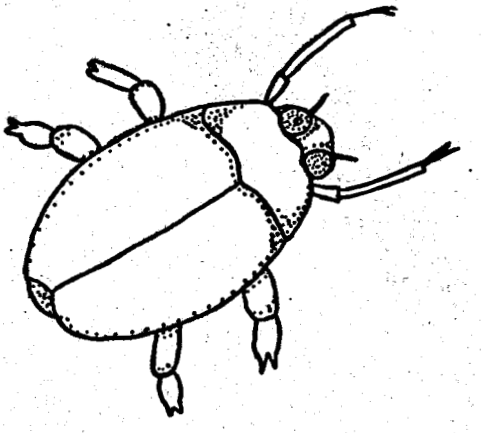


Backswimmer (0.5in.)

Water Treader (0.5in.)

Beetles (Coleoptera)

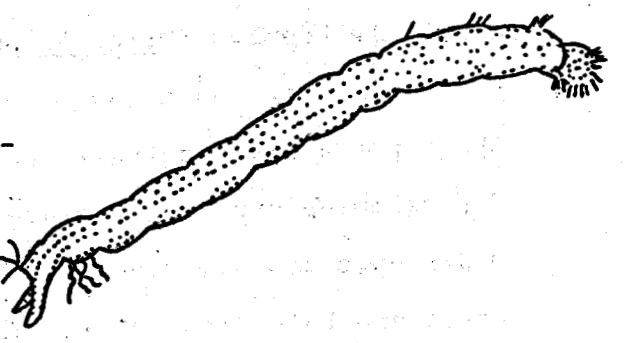
Whirligig beetles (Dineutes americanus) are a representative pf this group. Both adults and larvae are aquatic. As adults these predators use their short, fan shaped, middle hind legs for skimming over the surface of the water and for diving. Their eyes are divided into two parts allowing them to see above and below the water. The adults are mostly scavengers, however, their larvae are voracious, carnivors and should be considered a predator.[7]



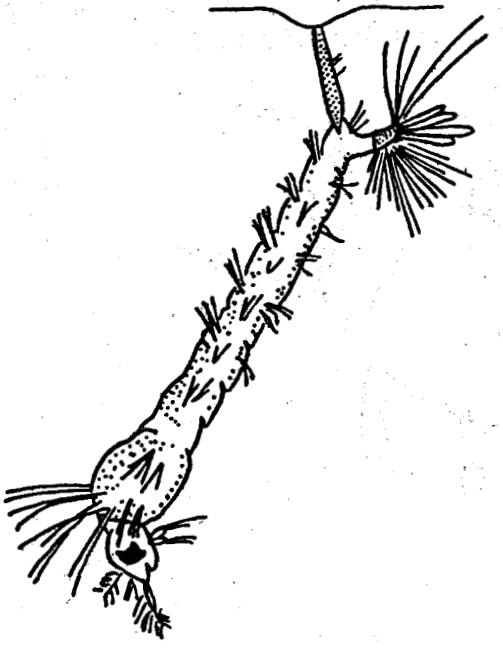
True flies (Diptera)

True flies include midges, mosquitos, horse and deer flies, as well as the common house fly. Although most of these flies are aerial in habitat as adults, the larvae of midges, mosquitos, deer and horse flies are aquatic. These larvae provide an important food source for other aquatic animals.

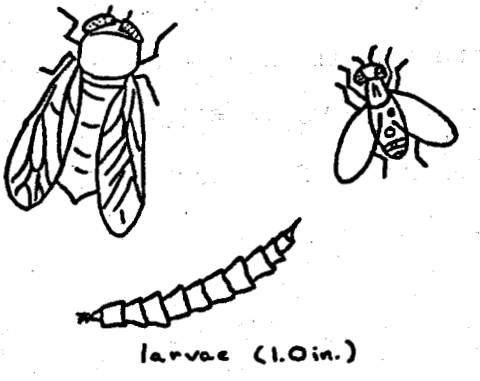
Midge larvae (Chironomus sp.). The larvae of this midge is popularly known as a bloodworm. Their bright red color is due to the haemoglobin in their blood. These larvae are an important food source for other aquatic organisms.[7]



Mosquito larvae. These larvae can be found hanging head downwards from the water's surface. Breathing tubes are used for respiration. When the water is disturbed, they retreat to the bottom until lack of oxygen forces them to come to the surface again. Vegetable Matter is their source of food.[7] They too provide an important food source for other aquatic animals, especially fish.

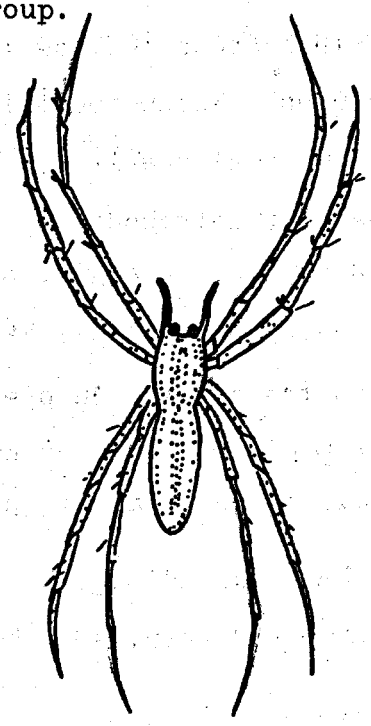


Horsefly (Tabanus sp.) and deerfly (Chrysops sp.) larvae are aquatic. The larvae of the horsefly can be as long as an inch, but those of the deerfly are smaller. Both larvae feed on worms, snails and other animals.[7]

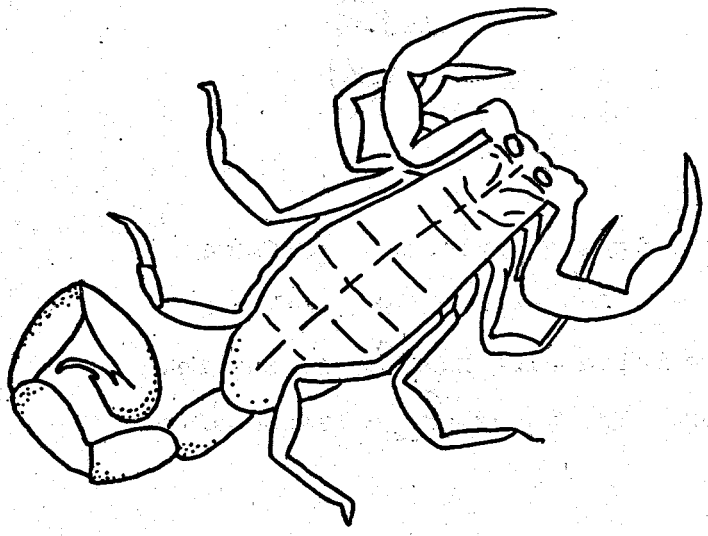


Arachnida

Among the animals frequently found around and sometimes on the pond are Arachnids. These insect like animals have eight legs. Spiders and scorpions are both included in this group.



Many kinds of spiders may be found under rocks or vegetation near the ponds and some may be found on the water.[7] Insects make up the bulk of a spiders diet, but occasionally those spiders building their web ober the water have been known to catch small fish and tadpoles. However, some spiders are capable of gliding across the pond's surface, while others can dive into the pond.[7]



Scorpions may be found under rocks and other dark places, sometimes near ponds. Like spiders, they have poison glands and kill their prey by injecting venom into them. The sting of the scorpion lies at the tip of the abdomen. Two poison glands lie in the swollen base of the stinger and open individually near its tip.[2]

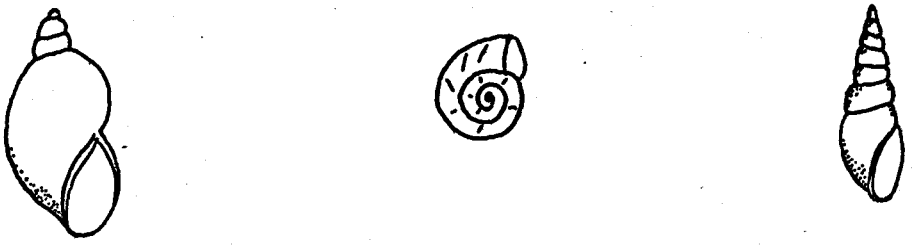
9.7 Mollusca

Mollusks are soft-bodied animals having a shell which surrounds their soft parts. Examples of these animals are the snails and clams frequently found in freshwater ponds. Less typical members of this group include the ubiquitous land slug, marine squid, and octopus. These special members have either a modified, reduced or internal shell.[1]

Snails (Gastropoda)

Gastropods are single shelled. The shell may be rounded, flattened or spired. The soft "body" of the snail can be withdrawn completely into the shell. An operculum or "door" covers the shell's opening for protection. Gastropods feed mainly on plants and dead material. They, in turn, are food for many other animals.

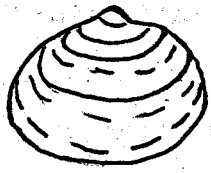
Examples of this group include the rounded pond snail, the flattened spired ramshorn, and the highly spired cornucopia.



Pond snails and ramshorns lay their eggs on submerged surfaces. These gelatinous masses contain many tiny eggs which develop into miniature adults then hatch. Cornucopia also have eggs, but retain them within a special body chamber. The young are released after hatching.

Clams (Pelecypoda)

Animals of this group have two valves (shells) which cover the soft body. They feed and breath through tube like siphons. One siphon brings in water and food. This water passes over the gills and the spent water is pumped back out through the other siphon. Clams are eaten by other animals and fish. Reproduction occurs either when eggs and sperm are broadcast into the water, meet and the eggs are fertilized; or when sperm are siphoned in and fertilize the eggs which are held in special brood sacs. The larvae are expelled and progress through numerous stages until they "settle out" and mature into small clams. Individual clams are both male and female but are not self fertile.



9.8 Vertebrates

Vertebrates are those animals having a backbone. Thos animals with backbones are generally larger and better known. In and around ponds there are, of course, fishes, amphibians, reptiles, birds, and mammals.

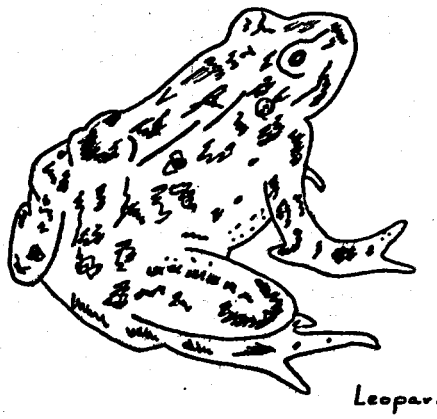
9.9 Pisces (Fish)

In pond culture all fish are selected and wild fish are screened out of the ponds. If a manager sights an unknown species the fish should be caught and identified as soon as possible. The nature of this foreign fish will determine to what degree the planned

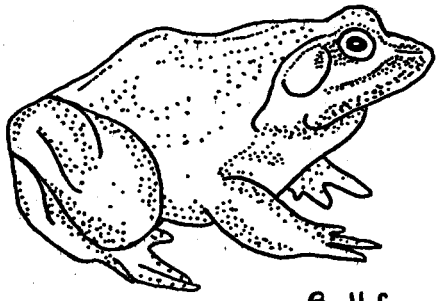
culture system is disrupted. In some cases it will be necessary to destroy the invader.

9.10 Amphibia (Frogs and Toads)

Frogs and toads live in or near water. Mating occurs either in or near the water. The gelatinouseggs require a high moisture environment to develop and hatch. Toad eggs are laid in gelatinous strings, while frog eggs are found in gelatinous masses. The larval stage, the tadpole, is entirely aquatic with maturation requiring periods of 2 weeks to 2 years.[7] This maturation time depends on species, water temperature, and food availability. Tadpoles feed on algae, but adults are carniverous. The call of a frog is a familiar sound around the pond, but it is sometimes forgotten that toads also have a distinct call.



Leopard frog



Bull frog
(3½ to 6 in.)

Two frogs of the genera Rana and a number of toads of the genera Bufo are commonly found in the California desert area.[9]

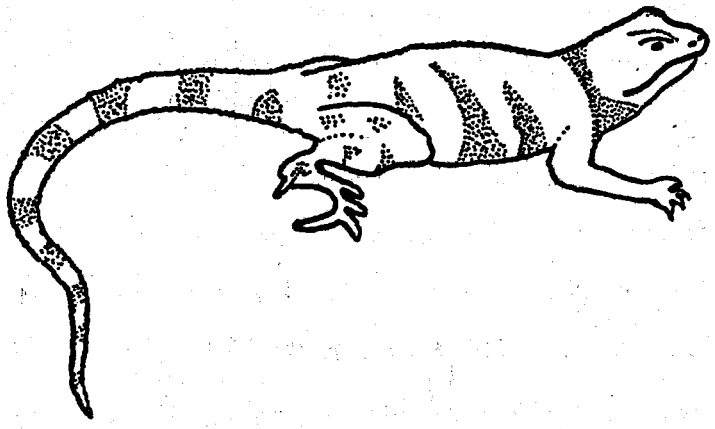
9.11 Reptilia (Snakes, Lizards and Tortoises)

Snakes and lizards are pond area residents but the desert tortoise is only a theoretical visitor

There are no true water snakes in the desert, but terrestrial snakes may spend some time in the water. Most snakes are harmless but caution should be exercised as both rattlesnakes and sidewinders may surprise an unwitting pond manager out on an early morning tour.

Lizards found in this area are harmless and have very little interaction with pond culture. Insects and vegetation are typical sources of food for this group.

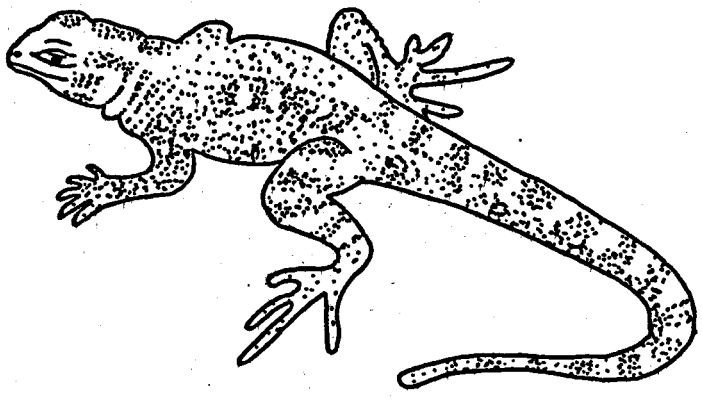
Rattlesnakes (Crotalus sp.) are among the most famous and feared of all snakes in North America.[10] Rattlesnakes or rattlers are poisonous. The poison is injected through two fangs that fold against the roof of the snake's mouth. Most rattlers have a rattle at the end of their tails. However, contrary to popular opinion, you cannot tell a snakes age by the number of rattles. Rattlesnakes, like other snakes, eat mice, rabbits and birds. With the exception of the sidewinder (C. cerastes), other snakes found in the area are not poisonous.



Sceloporus magister
(8-12 in.)

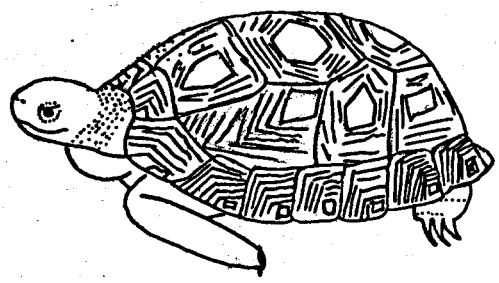
The desert spiny lizard (Sceloporus magister) is easy to identify as it is larger than most lizards seen in this area. Its skin is very rough and it has a blackish collar. It is sometimes mistaken for a true collared lizard (Crotaphytus sp.) which has two transverse collar bars.[11]

Uta stansburiana
(4 in.)



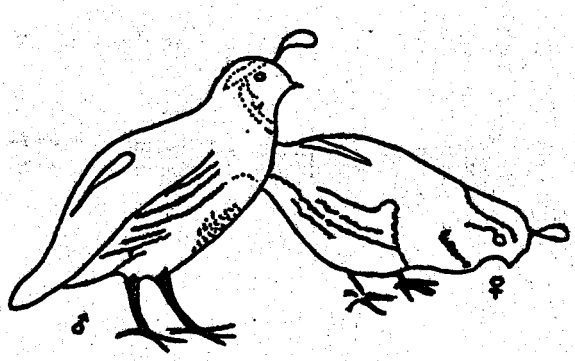
Lizards of the genus Uta take their name from the Ute Indians.[11] This very fast runner is an adept snatcher of flies, spiders, and scorpions. It is one of the few lizards of the Colorado Desert that are active all winter, during the warmer parts of the day.

The desert tortoise is an infrequent sojourner, whose presence is harmless and innocuous.[11] If one were to be sighted, it should be remembered that this is one of the species protected by law.



9.12 Aves (Birds)

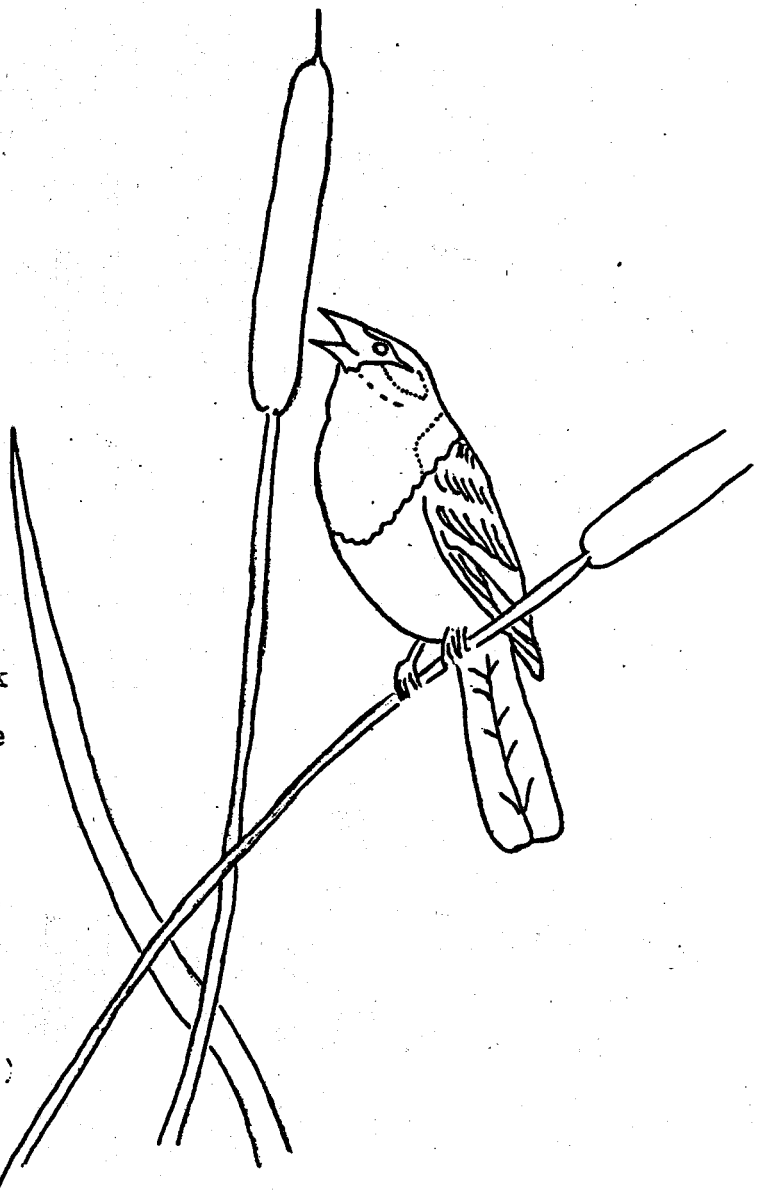
Birds of a few groups are semiaquatic and will tend to linger or set up housekeeping at your ponds. Even more species will pass through for a shorter stay. Most birds will not interfere with pond activities, but for the more common of those that do refer to chapter 7. Some birds are so visual or verbal a pond manager can detect old friends and permanent residents. Coveys of Gambel's quail meet the feed truck and yellow-headed blackbirds seem to supervise pond management. There are a number of field guides available for wildlife identification (see selected references).



Gambel's Quail, Laphortyx gambelii

This quail, common to drier habitats, is usually seen in flocks, feeding on the ground. It is similar in appearance and habits to the California quail. The distinguishing characteristic is the plain belly of the Gambel's quail and the scaled belly markings of the California quail.[12]

Length: $8^1/_2$"

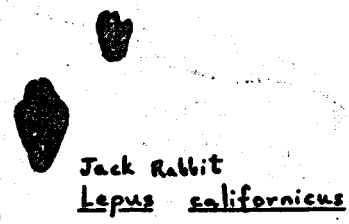


Yellow-headed blackbird, Xanthocephalus xanthocephalus

These birds are common in cattail and tule marshes. It is the only North American bird that has a yellow head and black body. The call is a distinctive low, hoarse croak.[12]

Length: $8^1/_2$"

(after: Birds of North America)



Jack Rabbit
Lepus californicus

Cotton Tail
Sylvilagus audubonii

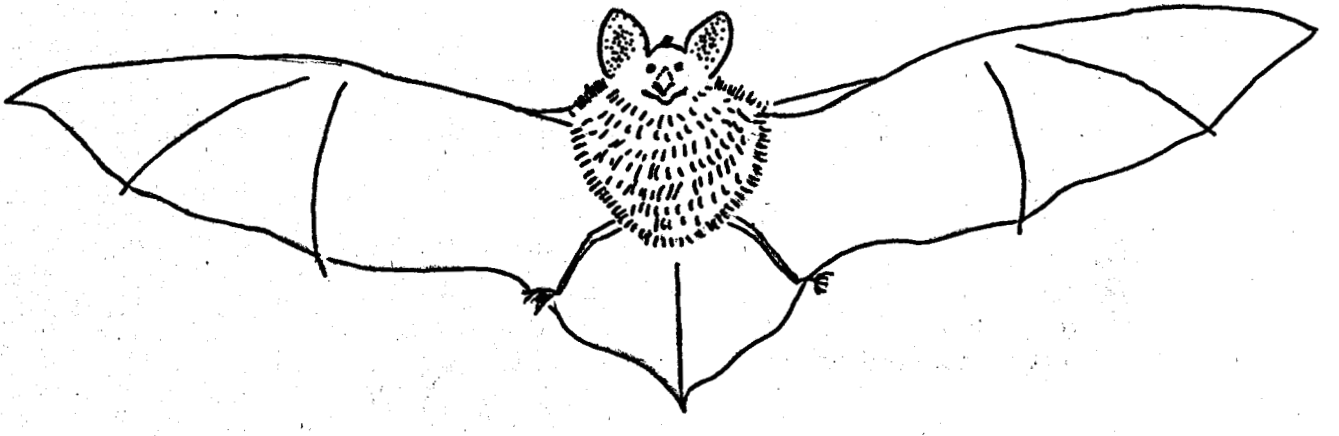
Coyote
Canis latrans

Raccoon
Procyon lotor

All prints 1/6 of natural size
from "The Mammals"

9.13 Mammalia

A number of mammals live around the ponds. Muskrats actually live in the water and have been a problem in the Coachella Canal. It is possible that they might be found in ponds and cause dike damage. Fish and Game could offer assistance or advice to a farmer with this problem. Other mammals will use the ponds as a water source. Coyotes, jack rabbits, and cottontails might be sighted. Bats come out at dusk and hunt insects over the water. Racoons visit ponds for water and food. They may prey on the cultured species (see chapter 7).



9.14 Summary

The construction and maintenance of ponds for aquaculture creates habitats suitable for a wide variety of non-culture species. These associated animals vary widely in size, shape, and habits. Some of these animals are compatible with the culture operation and can easily coexist with both the culture species and the pond manager. Others require either cautious coexistence or avoidance. This section was included as both an introduction and over-view of these non-culture, associated animals. This should be a starting point for further searches for information.

9.15 Special considerations

A. Utilization of geothermal water allows continued survival of some associated animals which would otherwise be seasonal. This survival can provide continuous supplemental natural food.

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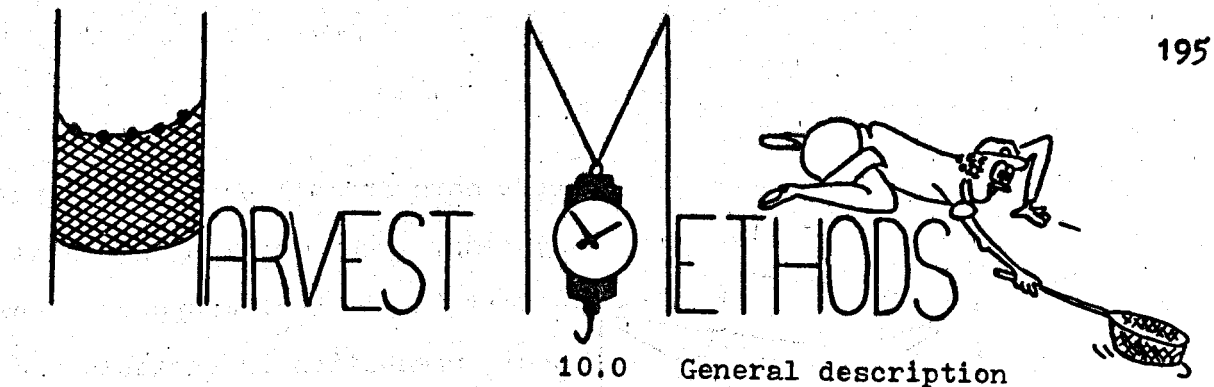
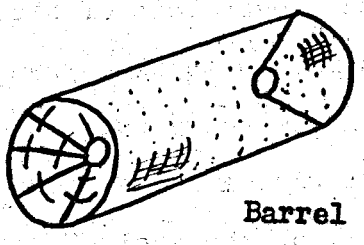
HARVEST METHODS

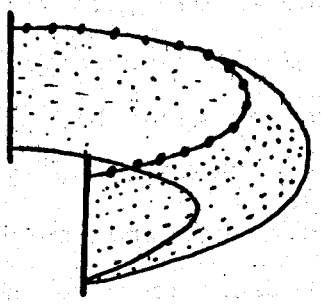


10.0 General description

Prawn harvest equipment ranges from simple traps to elaborate seines and trawls. Manpower requirements for their use vary as widely, from labor intensive to machine extensive. Whether an active (seines or trawls) or passive (traps) harvest system is used will depend on personal preference, business intentions, available markets, and labor pool.[1]

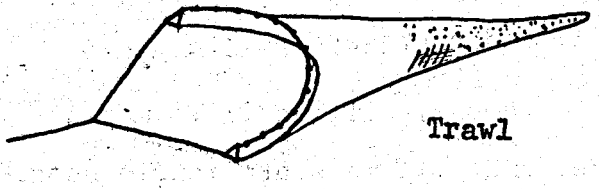


Barrel Trap



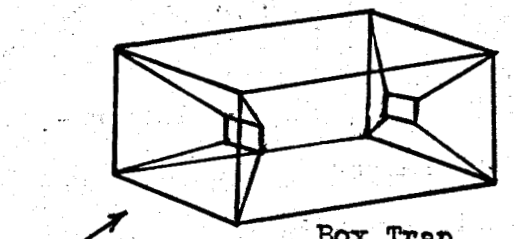
Seine

Active gear must be moved or manipulated in order to achieve capture. This applies to towed or dragged fishing gear, which will be discussed later. Passive gears are those which capture animals enter voluntarily, requiring little active participation on the part of the captor.



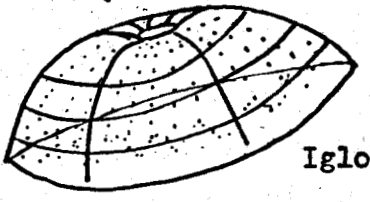
Trawl

Traps, trammel nets, gill nets, and



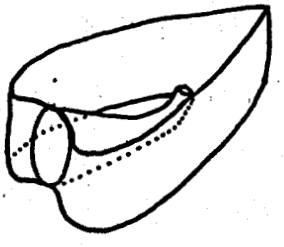
Box Trap

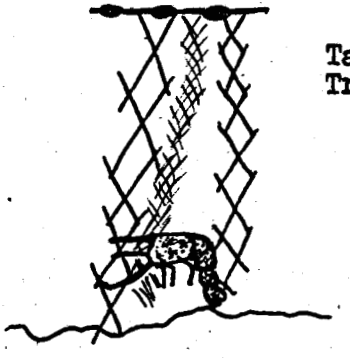
entrance



Igloo Trap

Heart Shaped Trap





Tangle/ Trammel Net

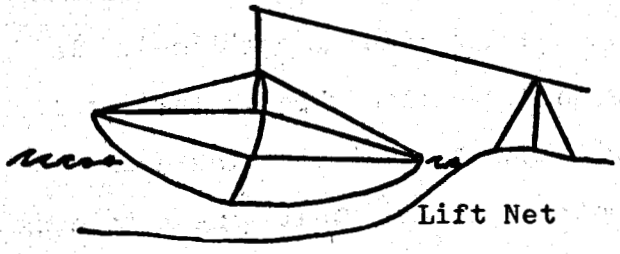
lift nets are all examples of passive systems. They require the least unit effort in terms of manpower. However, their production is variable and can be species or size dependant.

10.1 Traps or pots

Traps or pots, regardless of size, include a chamber with an entrance modified to allow entry but not exit of the catch. Animals are attracted by either bait or the shelter offered by the traps. Bait is a substance which entices the animal into the trap by its 'odor'. Various products of synthetic, animal or vegetable origin are used as bait. However, before a bait is utilized, consideration should be given to its effect on water quality. Traps can be purchased from suppliers or homemade. The basic types used include - igloo, box, barrel or funnel, and heart shaped.

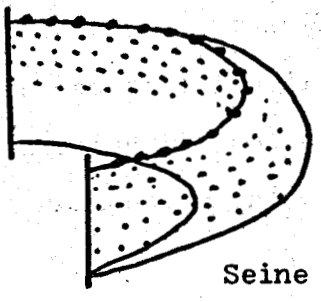
10.2 Trammel, gill and lift nets

Trammel and gill nets are tangle nets. They ensnare the animal as it attempts to 'swim' or walk by. They are avail-



Lift Net

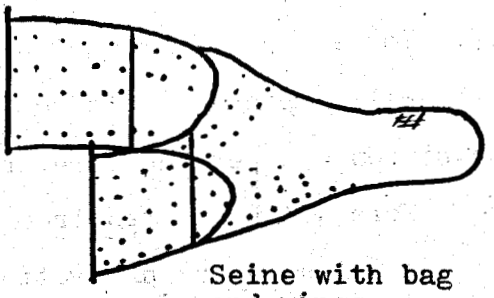
able in various mesh sizes, lengths and widths. Lift nets capture animals by enclosing them as they move over the net. Bait is sometimes used to encourage the animals to congregate.



Seine

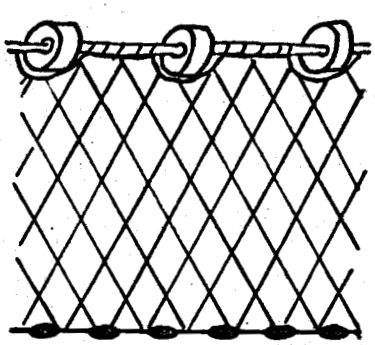
10.3 Active methods: seines or trawls

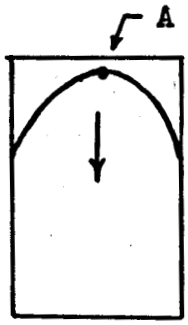
Several things should be remembered when considering active fishing methods (seines and/or trawls). These methods can increase catch rates with a higher catch per unit effort. However, they tend to be heavy and require a high initial investment and constant upkeep. In addition, a degree of 'technical expertise' is required to learn their proper use. This use varies for different pond configurations, species variations and size delineations. When contemplating any harvest method, its cost should be considered against individual time and efficiency requirements.



Seine with bag and wings

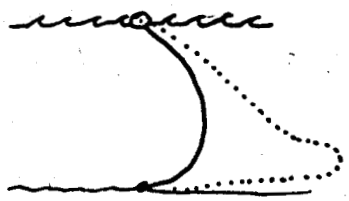
Basically, a seine is a panel or series of panels (wings) made of netting with weights on an attached





Pond overview, showing net placement and direction of pull.

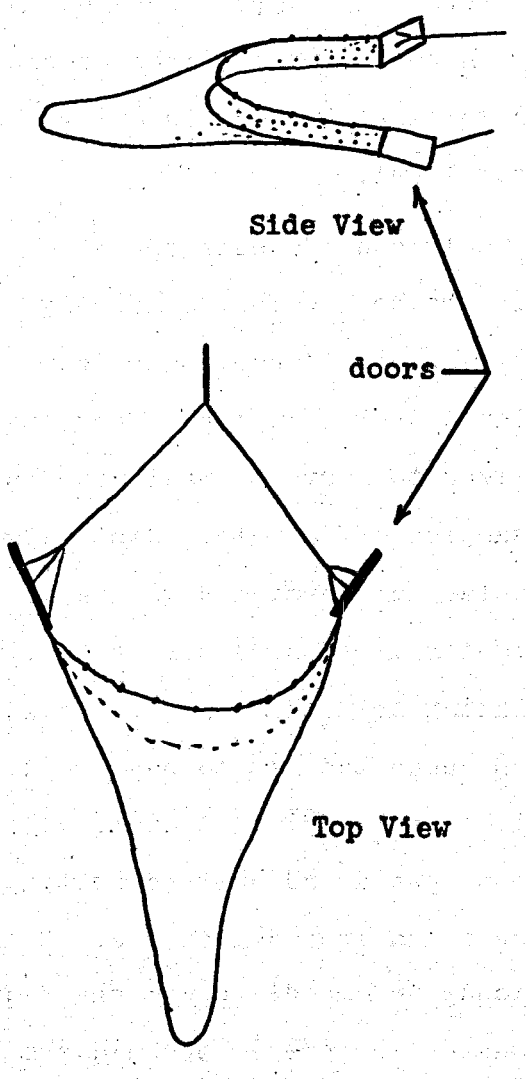
Cross section of net at point A above, showing bulge (solid) or bag (dotted).



bottom line (lead line) and floats on the top line (float line). The seine is pulled through the water, with the lead line riding along the bottom and the float line remaining at the surface, in a semi-circular pattern. The bulge is the net is usually sufficient to contain the catch. Additional features called bags can be added to the seine and act to secure the catch in a small area.

In order to seine an entire pond, the length and width of the net should be approximately 33 percent longer and wider than the pond itself. The amount of floatation or weight will depend on both bottom composition and peraonal preference. More weight is required to keep the net down on hard bottoms.

Trawls are seines modified to be pulled from one line or one point. The opening or mouth of the seine is kept open through use of



Typical trawl

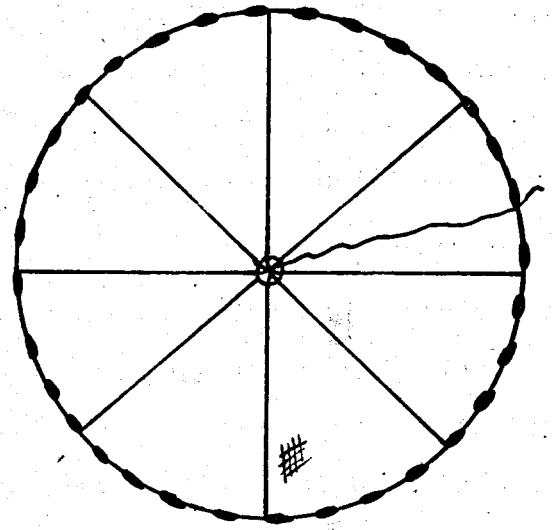
'otter boards' or 'doors'; whose shape, when properly rigged and pulled through the water, pulls them forward and outward. A lead line, float line and bag are also part of a trawl.

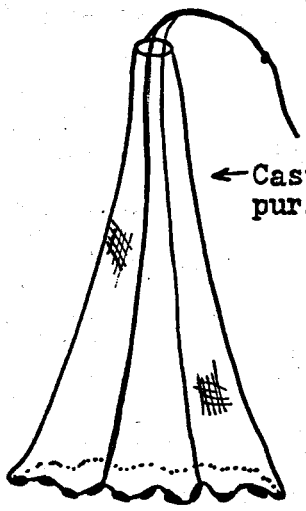
Both seines and trawls come in a wide variety on sizes, shapes, and materials. They can be handmade, purchased complete, or the components purchased separately and assembled (see the Appendix for a list of suppliers).

10.4 Construction materials

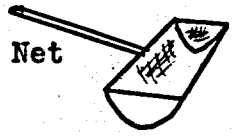
Construction materials vary as widely as the designs. Cotton, nylon monofilament, and woven nylon are themost common net materials. Polypropylene or nylon cord are the most frequently used line materials. The majority of netting purchased is synthetic rather than cotton, as cotton 'rots' with both age and water exposure. However, some care is still necessary to insure maximum life from synthetic fiber nets.

Cast Net, open





←Cast Net, not pursed



Dip Net

Nylon breaks down from exposure to sunlight twice as fast as cotton.[2] Dips for nets may be purchased and vary in both content, from creosote base to plastic, and viscosity, heavy versus light.

Cast nets and dip nets are also active methods. They generally require a one to one, user to implement relationship. They are utilized to harvest small numbers or subsamples of animals. Cast nets are circular nets designed with a weighted perimeter line and a series of lines radiating from the center. These lines cause the net to bag or purse as it is pulled in. A cast net is thrown upward and outward so that it lands in an extended circle. Both patience and muscle power are required to master the proper techniques. Dip nets are small hand held nets used to catch animals by scooping them up.

10.5 Net repair

When discussing nets, keeping you equipment operating and in good repair is very important. Nets should be frequently checked for signs of wear or damage. The major problem encountered is rips or tears and holes. If left unattended, these tend to increase in size and cause decreased catches through escape. A section on net mending can be found in Appendix A.

10.6 Special considerations

A. Harvest can be continuous rather than seasonal, as year round growth is possible in geothermal aquaculture projects. Therefore, harvest equipment must be geared for continuous rather than seasonal use.

B. Special holding or processing facilities may be required if harvesting warm water animals during periods of cold weather is contemplated.

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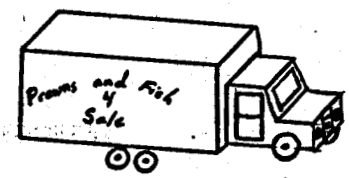
MARKETING



11.0 Introduction

After the work of growing and harvesting the farm reared, aquatic produce is successfully completed, the job is not finished until the product is marketed. Marketing is that phase of business management that determines the outcome of our efforts. This is probably the least understood and most inefficient area in aquaculture.

Time and experience can present many answers but the road to a successful marketing experience can be made more smooth with planning and by purchasing some experience from a knowledgable marketing person. If the farm was planned with a consulting firm, marketing can be part of the package. If the farm is "self planned" the produce might be best sold to a processor or wholesaler as marketing is their field of expertise.

11.1 Types of markets

To reach target customers, professional marketing managers use a three-step process of market segmentation. It (a) develops a description of the total market; (b) divides the total market into identifiable, reasonably homogeneous sub-markets; and (c) develops the most effective strategy to reach various segments of the total market.[1]

Marketing aquaculture products is unique for each farm and seasonal

situation. Strategies can be developed after answering numerous questions and assembling a clear (well defined) picture of the available possibilities. Potential production data are necessary to determine whether marketing will be conducted on a year round or seasonal basis. These data will also help determine the scope of the marketing program. A farmer with one small pond which will be harvested once per year with production of less than 100 pounds will not need as extensive a program as the farmer with a large continually producing facility.

Most aquaculture produce sold goes to one of two areas; either processing plants or conventional fish markets. However, various distribution channel options are open to the farmer, all with the ultimate aim of reaching an ultimate consumer. Distribution systems range from the very simple to the very complex.

Most goods, however, utilize one of the following channels:[1]

1. Producer — consumer
2. Producer — retailer — consumer
3. Producer — wholesaler — retailer — consumer
4. Producer — agent/broker — wholesaler — retailer — consumer

Direct marketing between the producer and the consumer usually results in higher prices paid to the producer (farmer). However, it also involves added labor for processing, delivery and actual sales personnel. In addition, advertising well in advance, direct contacts, and sanitary handling and sales facilities are essential and require special permits and licenses from state and local tax and health authorities.

The retailer or wholesaler position is often assumed by a processor, who after taking delivery of the product assumes the responsibility for finally getting the product to the consumer. The farmer is usually paid either on a flat rate basis for delivered product, or on the current market value for the product at the time of final sale.

Agent/brokers are essentially salesmen who try to obtain the highest possible price available from a variety of market sources. They receive a portion of the sale price as a commission. They deal with the available product form.

It should be noted that the cost of delivery is usually assumed by the producer, unless other arrangements are made ahead of time.

11.2 Produce form

Animals to be sold whole, with minimal processing, command a large proportion of the present day aquaculture produce market. Most of the animals sold in this manner go to one of two areas, either processing plants or conventional fish markets. On the farm processing is being carried out by some growers in Hawaii. Most of these animals are sold fresh and usually are dressed on order.

Processing plants often flash freeze the whole prawn, tail only, or tail with shell removed. Fish are generally filleted, steaked, or dressed to order. These products are then packed and shipped according to their market specifications. Produce destined for conventional fish markets is usually iced, limiting shelf life as well as sales volume.

11.3 Marketing aids

Organizations which offer help to farmers desiring specific marketing assistance are listed below:

1. National Marine Fisheries Service - has a marketing specialist available on a regional basis.
2. Small Business Administration - both helps organize and offers loan assistance.
3. Service Corps of Retired Executives (S.C.O.R.E.) this organization has members in almost all fields of business available for guidance.
4. Private consulting firms.

Additional marketing aids include the use of consumer information distributed by media or on individual "sample" cards. This type of information usually lists the nutritive values, serving size, and frequently compares the product with other forms of protein. Recipes are sometimes included as well as other serving suggestions. This type of advertising, for that in reality is what it is, is generally carried out by the retailer or by fisheries/aquaculture associations in attempt to familiarize the public with the product (Figure 11-1).

Figure 11-1. Consumer information cards. These are examples of consumer information products, available where the product is sold retail. The 3 by 5 inch card format is convenient for both the shopper/cook and the retaier.

HOW MUCH TO BUY PER SERVING:
Shrimp is sold according to size or count per pound.
Small ..... 45-65 per lb.
Medium ..... 30 per lb.
Large ..... 6-15 per lb.
Two pounds raw shrimp in shell yields one pound cooked.

Shrimp

NUTRITION INFORMATION*
Amount — 3 ounces

Calories	100
Protein	45% U.S.RDA
Niacin	8% U.S.RDA
Iron	15% U.S.RDA
Vitamin A	2% U.S.RDA
Calcium	10% U.S.RDA

*USDA Bulletin #382

TO COOK: Simmer, do not boil, one pound raw shrimp in one quart water 5-8 minutes. Drain and chill. De-vein before using.

DE LUXE SHRIMP SALAD
(Serves 10 - 12)

2 tbsps. unflavored gelatin
¾ cup cold water
1½ cups tomato soup
1 8 oz. pkg. cream cheese
1½ cups mayonnaise
1¾ cups celery, finely chopped
¾ green pepper, finely chopped
1 tbsp. minced onion
1½ cups cooked shrimp
3 tbsps. lemon juice
1 tsp. salt
¼ tsp. pepper

Soften gelatin in cold water and dissolve in hot tomato soup. Cool. Thoroughly combine remaining ingredients and gradually stir in gelatin mixture. Pour into 2½ quart fish mold. Chill until firm. Unfold and serve on crisp lettuce leaves with a French dressing.

11.4 Timing your sales

Depending on the distribution system utilized and on the frequency of harvest, timing your sales may affect the overall profitability of your operation. Processors may determine the periodicity of your harvest and sales. However, for the smaller operator, the projected harvest date may be the sole influence, particularly if weather conditions will affect the survivability of the culture species if held for longer periods. If the culture species can be held for extended periods, it is possible to capitalize on peak demand periods, such as holidays or low competitive product availability. Marketing specialists can outline these periods, as well as defining product prices on a seasonal basis.

11.5 Summary

The most important item to remember in marketing your product is that you are selling service. Other fish and other foods are available. To successfully sell your product you must promote its unique flavor, the convenience of your service and the wholesomeness of your operation. If you succeed in <u>your</u> promotion of <u>your</u> product <u>your</u> animals will be a success. This concept applies regardless of what distribution channel you follow.

11.6 Special considerations

A. Marketing can be carried out year round as animal growth and hence production levels are continuous in geothermal water.

B. As market sized animals are available continually throughout the year, marketing can be aimed toward peak demand periods, such as holidays. Alternatively, marketing can be aimed toward periods when other similar products are not available.

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APPENDIX

GLOSSARY OF TERMS

OMNIVOROUS - eating a diet of both plants and animals (cf. carnivore, herbivore).

CARNIVORE - flesh eater.

HERBIVORE - plant eater (cf. carnivore, herbivore).

HETEROSIS (HYBRID VIGOR) - increased vigor of growth, fertility, etc., in a cross between two genetically different lines, as compared with growth, etc., in either of the parental lines.

HYBRID VIGOR - see heterosis.

VERTEBRATES - general biological term referring to fish, amphibians, reptiles, birds, and mammals, i.e. those animals having a skull which surrounds a well developed brain and a skeleton of cartilage or bone (cf. invertebrate).

INVERTEBRATE - collective term for all animals which are not members of the vertebrates, i.e. those lacking a backbone or spinal column (cf. vertebrate).

OTOLITH - granule of calcium carbonate in vertebrate inner ear (e.g. fish). Several such granules are attached in fine processes of sensitive cells, the latter communicating via nerves with the brain. The pull of gravity on the granules and therefore on the cell-processes registers the position of the animal in respect to gravity.

OPERCULUM - cover of gill slits of fish and Amphibia.

PHYTOPLANKTON - plants of sea or lake which float or drift almost passively. They are mostly very small. Plankton occurs mainly near the surface, where the plants get suitable illumination. It is of great ecological and economic importance, providing food for fish and whales (cf. zooplankton).

ZOOPLANKTON - aquatic animals that drift or float with currents, waves, etc.. They have limited influence on their direction. Most of these are microorganisms but they range in size to jellyfish.

CONVERSION TABLES

Temperature

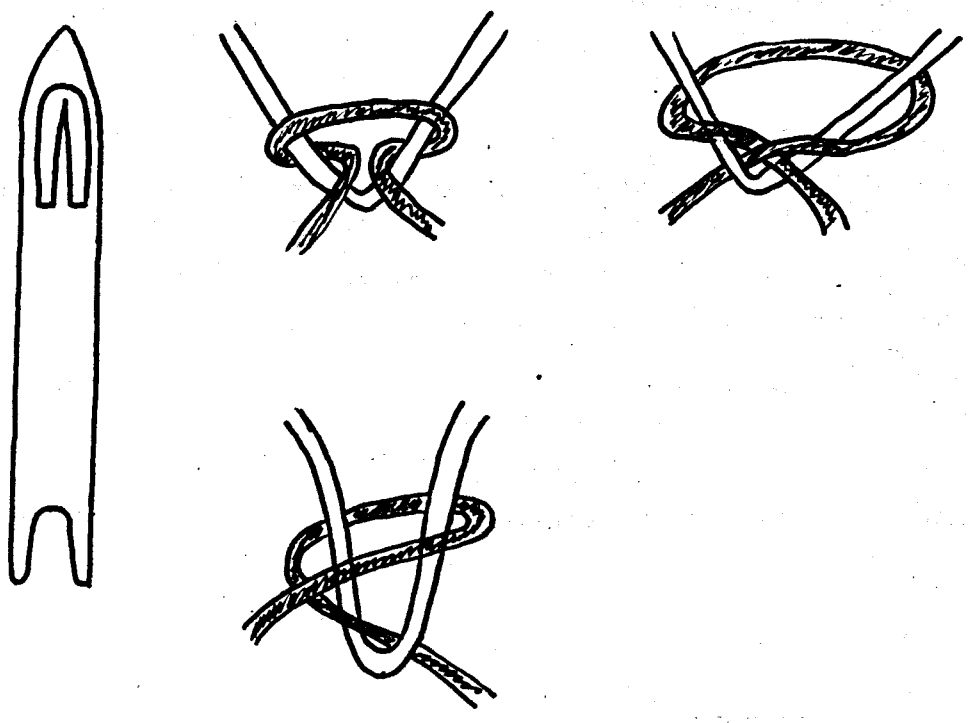
°C	5	10	15	21	22	23	24	26	27	28	29	30
°F	41	50	59	70	72	73	75	79	81	82	84	86

Size - Area Conversions

1 acre-foot = 1 acre of surface area covered by one foot of water
= 43,560 cubic feet
= 2,718,144 pounds of water
= 326,000 gallons of water

1 cubic foot = 7.5 gallons
= 62.4 pounds of water
= 28,354.6 grams of water

1 gallon = 8.34 pounds of water



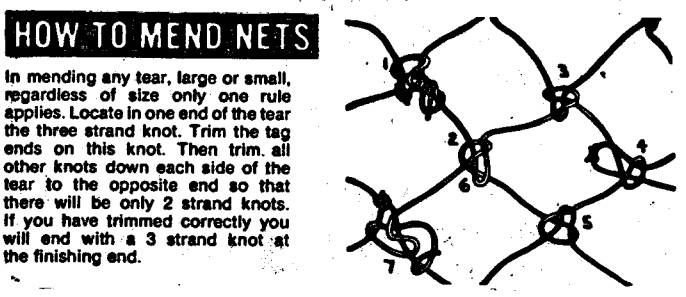


Figure A-1. Typical knots and needle used for net repair. Mending nets requires both patience and practice. Many net and twine companies include repair instructions with their catalogs. These instructions are from catalog number 83, Memphis Net and Twine Co., Inc., Memphis, Tennessee. Other sources of net mending information include public libraries and fishing co-ops.