Division of Marketing
Agricultural Development and Diversification (ADD) Program

1994 Grant Final Report

Grant Number L94024

Grant Title High School Aquaculture A to Z

Amount Awarded $17,909.00

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ADD GRANT FINAL REPORT

1) Describe the original intent of the grant project.

• How was it projected to benefit Wisconsin Agriculture?

This project was meant to help educate the future workforce and industry people on the importance and benefit of the aquaculture industry.

• Was it necessary to adjust the objectives during the project?

No, the objectives the project were not adjusted; however, the means to accomplishing the objectives had to be adjusted from time to time.

2) Describe the work conducted in this project.

• How did the grant funds assist you in this project?

Without the grant funds we would not have been able to create the educational opportunities that we have been able to create as a result of this project. These funds have been very helpful and worthwhile to helping us educate youth about aquaculture.

• What successes did you achieve with this grant project?

Through this project we were able to create an up-to-date lab that helps students learn about aquaculture through hands-on experiences. Through this project we also able to continue and emhance the pond area and develop a small lab for aquariums that can be used for individual projects. We also continued our Aquaculture course and have added and Aquaculture II course.

• What challenges did you face with your project?

The biggest challenges we faced throughout this project was the unexpected problems such as a power outage and the unknown problems that would develop as we changed or built a system. Also during the time of this project the high school went through a major remodeling and addition project which caused many headaches for us. The building project has been completed forabout a year an a half and we still do not have shade cloth in our green house aera for fish production. Also keeping the students up-to-date on what was happening was very challenging. This was especially as new students came into the program over the course of the project.

3) Describe the public outreach efforts of this project.

• What literature or educational materials were produced through this project?

A curriculum packet was produced that has been distributed to many Agriculture Education Instructors throughout Wisconsin.

• What presentations, field days or other events were given related to this project?

We have given presentations at the Wisconsin Aquaculture Conference, the WAVAI Summer Conference, we had a field day event for Section VIII Agriculture Education Instructors, and we had a field day event for the Outagamie County Agriculture Workers.

• What media outreach did you conduct through this project? Please identify specific papers or stations.

We had coverage of our project on TV 32 in Green Bay, WYNE Radio in Green Bay, the Appleton Post Cresent, and the Freedom School District Newsletter.

4) Describe the results of this project.

- **Did the grant project results meet your original expectations? Why or why not?**

For the most part they did. We accomplished what we set out to do although we had to change things from time to time. We really wanted to expand our pond project, but do to some unforeseen circumstances this was not possible. However, overall our expectations were met amd this project was successful.

- **What new agricultural products, technologies or production methods were developed through this project.**

Raising yellow perch in indoor tanks using a recirculating system.

- **What did you learn from your grant project? What conclusions can you make?**

One important aspect of the Agriculture Education philosophy is to learn by doing. The interesting outcome to project was that not only did the students learn by doing, but just as importantly the instructors learned by doing. This increase in knowledge base will help them in the future. The participants in this project were able to learn more about the importance of aquculture, the types of system designs, construction of a system, water quality, and rearing of a fish species. The conclusion is simple. The students that participated in this project are more knowledgable and more informed about the aquaculture industry. Futhermore, attempts were made to give this knowledge to others through field days, tours, presentations, and demonstrations to the public.

- **How will the grant results affect your business?**

The result of this grant will simply make it easier to continue to educate youth about aquaculture. Without this grant what we have created would not be possible.

- **How will this project benefit the Wisconsin family farm?**

One may argue that this project may not have any benefit to the family farm in Wisconsin and at first glance you may be correct. However, when you consider that the number of production farms for the purpose of dairy and livestock are steadily declining then maybe we are benefiting the family farm in Wisconsin. By educating about an alternative agricultural enterprise such as aquaculture young people have more options to look at in the future. While the family farm may no longer be a dairy farm it may still be operational. That is economically important to the family, the local community, and the state of Wisconsin.

- **What impact will this grant project have on the future of Wisconsin agriculture?**

The impact will be that more people have a basic understanding of a relatively new agricultural enterprise that will be important to the state and nation in the future.

5) How will the Wisconsin agriculture industry be able to use the information from this project?

I am not sure they will. However, the intent of this project was not to provide the agriculture industry with information, but to provide the industry with people who have been given background information that allows them to understand the industry and the problems it is faced with. Our intent was to help inform the general public through hands-on activities as well as academic knowledge.

6) Include any research data that support your conclusions for this project.

There really was no formal research done for this project. Our intent was to create a knowledge base for high school students by creating an effective hands-on learning center.

Milw. Journal-Sentinal 5/8/00

Fish farming finds home at high school in Outagamie County

Associated Press

Freedom — It looks like the inside of a submarine.

With the pipes and hoses and valves and tanks, it is actually a fish farm, tucked away in the nether parts of Freedom High School in Outagamie County.

The fish farm is part of the aquaculture course taught by agri-science teacher Kevin Champeau. The room is a product of the ingenuity of Champeau, who is one of five state nominees for the National FFA's Agri-science Teacher of the Year.

"The plumbing underneath this room is pretty old," Champeau said as water came trickling out of a pipe into a large tank.

"The water lines are only half-inch lines so it takes a long time to fill a tank or add water," he said, as his students conducted tests and measurements to check on the quality of the water.

The ability to make do with existing materials and a proficiency in finding grants has turned what used to be an outdoor pond into a full-blown course in fish management.

Champeau, in his nine years in the district, has taken the standard agriculture curriculum and expanded it to include almost anything that grows or moves, from llamas to landscaping.

"Some people have expressed a concern as they saw our curriculum become more than a traditional ag program," said Freedom High School Principal Richard Lovett.

"But we celebrate that because we have students who are now learning horticulture, landscaping and aquaculture, and at the same time they are developing independent study skills."

Champeau is the lone teacher in his subject area in the high school, but with the help of his counterpart in the middle school, Paul Larsen, the district has been able to put together an integrated agri-science course of study.

"He is able to make courses come to life with real world examples," said Lovett. "He has brought about the marriage of science and agriculture."

That marriage will be consummated next year with the addition of a course in biotechnology.

"He will be teaching that course with a teacher certified in biology," said Lovett. "That is something we have been pushing for, and we are pretty excited about it."

Champeau's scavenging skills also carry over into finding money.

The biotechnology course got off the ground with the help of a $6,800 grant.

"He has worked extremely hard in writing grants, finding resources, working with alumni and working with the state and federal agencies to find money and resources for his programs," said Lovett. "This also allows his students to get involved in other activities from which they would not otherwise benefit."

Champeau refuses to brag, but his enthusiasm is contagious.

"We were the very first school to get involved in aquaculture, where we actually brought the course into the classroom."

Early attempts at studying the fish in the school pond proved unworkable and the jury-rigged indoor facility was the result.

"From there we incorporated it into the classroom," said Champeau. "I let the students make the management decisions."

Among those decisions was an attempt at raising freshwater shrimp.

"We lost them over Christmas vacation," he said, noting the shrimp had grown several times their original size until that point.

"It was a good learning experience. We believe we can get shrimp to grow to market size, and we think we now know what happened to our water quality which caused the die-off."

About 20% of the students in the school have taken at least one of Champeau's courses.

"In this (aquaculture) class, only one student is from a farm," he said. "About 70% of my students are non-farm students, mainly because there aren't as many kids coming from farms anymore."

Asked to define his discipline, Champeau said: "Agri-science is how we can use technology to make a better food or fiber. Agriculture is really an applied science, and we are only recently coming to understand that."

Recvd. 1-27-98
Aquaculture Curriculum
Kevin Champeau
Freedom High School

Introduction

Aquaculture Pre-Test

1. Define aquaculture.

2. Identify 3 species of fish that are grown commerically.
   1.
   2.
   3.

3. Name 3 environmental factors which affect fish production.
   1.
   2.
   3.

4. Identify 2 different environments where aquaculture may be completed.
   1.
   2.

5. Identify 2 different types of systems where fish may be grown.
   1.
   2.

6. List the basic stages of commerical fish production.

7. What is the most limiting resource in aquaculture?

8. How does aquaculture differ from other types of production agriculture?

9. Explain the difference between aquaculture and fish management.

10. What percentage of fish and other seafood products are raised through commerical aquaculture?

AQUACULTURE

A form of agriculture which involves the propagation, cultivation, and marketing of aquatic animals and plants in a more or less controlled environment.

Contrasting Aquaculture And Agriculture

Aquaculture
- Occurs in water
- Limited by oxygen
- Limited by water
- Many animal crops
- Uses wild organisms

Agriculture
- Occurs on land
- Limited by water
- Many plant crops
- Domesticated organisms

Advantages Of Aquaculture

- Consistant quality
  - Product raised in controlled environment
- Continuous supply
  - Closer monitoring of growth cycles, populations, and spawning
- Stable pricing
  - More continuous supply allows for more even pricing of the product
- Freshness
  - Farm - raised product is processed immediately in a more sanitary environment and then placed in a refrigerated environment which may not necessarily be the case with the product obtained from the wild
- Consumer confidence
  - Provide a product that the consumer can depend on
- Future food supply
  - Can fulfill need for increased demand for finfish and shellfish

Contrasting Aquaculture And Fisheries

Aquaculture

- Controlled culture
- Individuals own crops

Fisheries

- Hunting
- Open access of people to crop

Living Organisms In Water

- **Plants**
  - Single - celled (phytoplankton)
  - Submergent plants
  - Emergent plants

- **Animals**
  - Invertebrates
    - Zooplankton
    - Insects
    - Other Arthropods (Shrimp, Crayfish)
    - Mollusks
  - Vertebrates
    - Fish
    - Amphibians
    - Reptiles
    - Birds
    - Mammals

Student Activity
The Pond Walk

Based on the discussion in the classroom on the types of plants and animals found in water take the students to a nearby pond, stream, or lake and have the students find and identify various types of living organisms. The students could draw pictures of these organisms and if possible bring some of them back to view in the classroom. This may require special perservation of the specimens and you may need access to a microscope.

Considerations For Fish Species Selection

- Growth rate
- Does it spawn in capitivty
- Feed requirements
- Optimum temperature
- Physical and chemical parameters
- Can young fish accept food from the onset of first feeding
- Disease resistance
- Market potential
- Will price balance your cost/profit equation
- Is product unique
- Can you meet a demand

Site Selection Considerations

- Topography
- Water source quality
- Water source quanity
- Water temperture
- Size of farm
- Water discharge

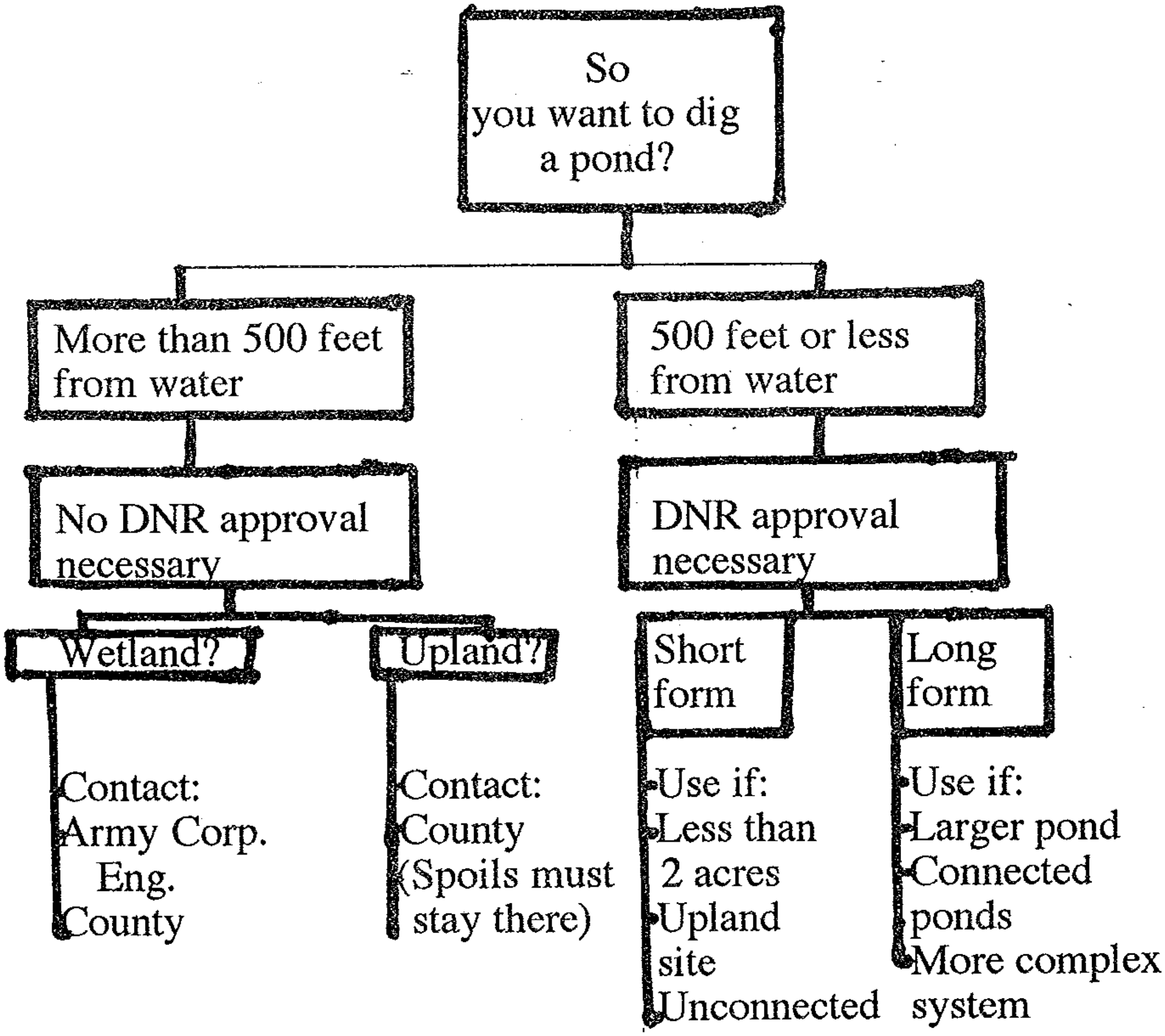
Aquaculture Systems

- Sea or Ocean Ranching
- Cage culture
- Pond culture (Static)
- Raceways (Flow - Through)
- Ponds (Flow - Through)
- Inside tanks (Flow - Through)
- Recirculating systems

Aquaculture Enterprises

- Food-Fish Production
  - Raising fingerlings or stocker fish until they reach a specific size and weight for human consumption
- Broodfish Production
  - Raising and management of sexually mature adult fish to produce eggs or seed stock
- Fingerling Production
  - Raising of fish used to stock food-fish and recreational ponds
- Stocker Production
  - Raising of fish larger than fingerlings to market size
- Fee-Fish Production
  - Raising of fish to be used in lakes or ponds for recreational or fee fishing opportunities
- Baitfish Production
  - Raising of minnows or other small fishes that are sold to wholesalers and retailers that will be marketed to people as a bait for fishing
- Ornamental Production
  - Raising and propagating of a variety of species of tropical or aquarium fishes

Pond Permit Flowchart



History

History Of Chinese Aquaculture

- Began around 3500 years B.C.
- Common carp was first cultured fish
- Book on fish breeding written in fifth century B.C.
- Developed polyculture

Chinese Polyculture

- Four species of carp grown in same pond
- Each species perfers:
  - Different water location
  - Different food

- Species and perference
  - Grass carp
    - Topwater
    - Macrovegetation near shore
  - Big head carp
    - Midwater
    - Zooplankton
  - Silver carp
    - Midwater
    - Phytoplankton
  - Mud carp
    - Bottom
    - Wide range of food

Egyptian Aquaculture

- Began around 2000 B.C. and paralleled the developments that occured in China
- Predominant species was tilapia
- Aquaculture emerged as a result of the irrigation systems for farming

Roman Aquaculture

- Started around 100B.C.
- Primary species were trout and mullet
- Used both freshwater and saltwater
  - Freshwater species used for commerce and food
  - Saltwater species used for amusement and nobility

Ocean Native American Aquaculture

- Occurred in Hawaii in 400 A.D.
- Developed an extensive pond system
- Types of ponds
  - Freshwater ponds
  - Taro fishponds
  - Brackish water fishponds
  - Seawall fishponds
- The system declined with the arrival of the Europeans in 1778

European American Phase Of Aquaculture

- Developed in mid 1800's
- Emphasis on restocking streams and lakes
- Trout and salmon culture was prominent
- Associations emphasis was not fish biology not on aquaculture

World Aquaculture

Top 15 Countries In World Aquaculture

- China
- Japan
- India
- Indonesia
- Korea
- Philippines
- Norway
- Russia
- Thailand
- U.S.
- France
- Vietnam
- Iran
- Italy
- Spain

Aquacultural Biotechnology Factsheet

China

There are more than 500 species of fishes in China. At least fifteen species of wild fish are harvested and 20 are commonly raised in fish ponds. The most popular aquaculture species are carps and breams. China has a long history of fish farming, but intensive farming began in the late 1940's. Freshwater fish farming is concentrated around urban areas.

Aquatic products are the fifth largest agricultural product in China. Besides finfish and shellfish, China's aquaculture includes large-scale cultivation of marine algae which are used for edible products, industrial products and pharmaceuticals. In East China, production of marine plants and animals is economically important. Although few marine finfishes are cultivated, developing this field of aquaculture is becoming more important.

In 1986, China began a major effort to develop biotechnology research, given the country's expanding population and the importance of agriculture. Few fisheries laboratories are conducting current biotechnology research. Many Chinese laboratories lack sufficient facilities, modern equipment, and cleanliness. In addition there is a lack of adequately trained staff.

The overall funding for fisheries research is declining. Actual figures on the amount of funding being provided for research is difficult to obtain. Because of this declining funding, many research institutions have had to either close or look for other sources of funding such as producing commercial products.

China's greatest strength in aquacultural biotechnology is its growing number of trained staff. Over 50 agricultural universities are training young researchers familiar with at least basic biotechnology techniques. China is also making an effort to do research cooperatively with other countries such as the United States, Europe, Australia and New Zealand.

Aquacultural biotechnology research in China includes: fish genetics, transgenic fish, control of diseases, growth hormones, developing new strains of marine and freshwater fish, algae, crustaceans, and molluscs.

In 1994, China began the development of regulations for aquacultural biotechnology. Many of those regulations are based on similar regulations in the United States. Aquacultural biotechnology is now in the research and development stage. Commercial products are a few years away.

Source:

Young, A. L., A. Kapuscinski, E. Hallerman, and D. Attaway. Aquaculture and Marine Biotechnology in China. Report to the Foreign Agricultural Service, USDA, October, 1995.

Aquacultural Biotechnology Factsheet

Japan

More than any other industrialized nation, Japan uses ocean resources the most. Japan is the world's largest fishing nation and the world's largest consumer of fish products. For example, in 1989, the average person in Japan ate 162 pounds of fish. In comparison, the average person in the United States ate 45 pounds of fish. Seafood makes up 45% of the Japanese diet, compared to 4% in the United States.

Japan is the world's leader in aquaculture and the industry is growing rapidly. Japanese researchers are working hard to expand the industry even further by developing species for aquaculture that no one has yet been able to culture, such as bluefin tuna and spiny lobster. Japan is also the world's largest producer of fish fry.

Efforts in aquaculture are strongly supported by all levels of government, especially local governments. The total marine science and technology budget of the Japanese government was $ 457 million in 1992. In addition, industry spends a tremendous amount of money supporting ongoing research--almost 80% of total research funding. Industry funding for marine biotechnology research in 1992 was between $ 297 million and $ 435 million.

The Japanese biotechnology market is large. In 1992, the industry produced $ 5.45 billion in sales and is expected to increaste to $ 28 billion by the year 2000. Japanese industry is heavily involved in marine biotechnology research and it is an emerging field. The total research and development program in Japan for marine biotechnology is larger and more diverse than that of the United States.

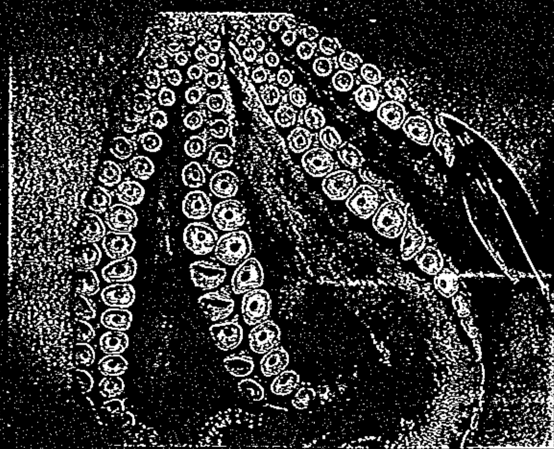
Japan does lag behind Europe and the United States in large-scale field testing. This is partly due to a fairly negative attitude by the Japanese public towards environmental release of genetically engineered organisms. Japan also tends to neglect basic research in favor of research to develop products.

Much Japanese research effort focuses on aquaculture production. This research includes: work on fish growth hormones, developing fish that survive extreme temperatures, cloning fish, and genetic manipulations. Japanese researchers study a wide variety of organisms, including coral, sea urchins, finfish, shellfish, squid and octopus. A great deal of research is also being done with large and small algaes. Japanese researchers are also looking at developing a wide variety of marine natural products including antibiotics, other human medicines, herbicides and pesticides.

Japan does face severe environmental problems, some of which are related to aquaculture production. Until recently, large quantities of pollution were directly dumped into the ocean. This has caused enormous damage along Japan's coastline and destroyed rich fishing grounds. The Japanese people have been growing in their concern about these environmental issues, and have voiced a need for solutions. Aquacultural biotechnology will show enormous growth in this area.

Source:

Zilinskas, R. A., R. R. Colwell, D. W. Lipton and R. T. Hill. The Global Challenge of Marine Biotechnology College Park: Maryland Sea Grant Publication, 1995.



PICKLED OCTOPUS

The Great Tokyo Fish Market

TSUKIJI

TEXT BY T.R. REID

PHOTOGRAPHS BY JAMES L. STANFIELD

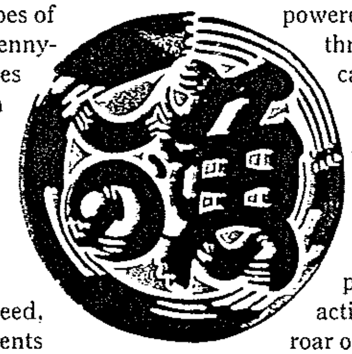
The long, cold trip to Tokyo came to an end for tuna number 197 with a *thud,* a *bonk,* and one last cavernous *clunk* as the huge fish toppled off the truck and skittered across the slippery concrete floor. Two, maybe three days earlier, this torpedo-shaped bluefin had been searching for its supper in the chilly waters off Boston. Now—netted, gutted, flash-frozen to 76 degrees below zero, and transported via cargo jet halfway around the world—197 was itself on the verge of becoming somebody's supper, served up on the polished wooden counter of a sushi bar where diners would pay $11 an ounce for this succulent delicacy.

The place that transformed 197 from just another fish in the sea to one of the world's most expensive foodstuffs is a sprawling, teeming, cacophonous corner of reclaimed land on the edge of Tokyo Bay. Its formal name is the Tokyo Central Wholesale Market, but in Tokyo everybody calls the place Tsukiji (pronounced skee-jee), for the neighborhood where the market stands. Fairly substantial quantities of meat, mushrooms, maple syrup, pickles, potatoes, peaches, and other foods move through this market every day. But the heart and soul of Tsukiji is fish.

Tsukiji is a fish market in the sense that the Grand Canyon is a ditch or Caruso was a crooner. Among the wholesale fish markets of the world, Tsukiji ranks at the top in every measurable category. It handles more than 400 different types of seafood, from penny-per-piece sardines to golden brown dried sea slug caviar, a bargain at $473 a pound. It imports from 60 countries on six continents—indeed, the list of shipments reaching Tsukiji on any given morning reads like a verse from John Masefield's poem "Cargoes": eel from Taiwan, sea urchin from Oregon, octopus from Athens, crab from Cartagena, salmon from Santiago, tuna from Tasmania, and on and on for hundreds of entries. Tsukiji moves about five million pounds of seafood every day—seven times as much as Paris's Rungis, the world's second largest wholesale market, and 11 times the volume of New York City's Fulton Fish Market, the largest fish market in North America. In dollar terms, that comes to 28 million dollars' worth of fish. Per day.

Handling that incoming ocean of seafood is the work of some 60,000 people and a fleet of 32,000 vehicles that seem to operate in a near-constant state of gridlock. At the midpoint of Tsukiji's workday (6 a.m. or so) the crowded sheds and narrow passageways are so clogged with trucks, vans, motorcycles, forklifts, handcarts, and bicycles (with the rider balancing, say, four cases of live shrimp on a shoulder) that you literally can't find walking space.

Not that it's safe just to stand still—if you do, there's always the risk of being mowed down by a *ta-ray*, a three-wheel, gas-powered wagon that zips through the market carrying stacked cases of fish.



The first couple of times I went to Tsukiji, I was overwhelmed by the vastness of the place, the frenzied activity, the constant roar of voices and vehicles. I was struck both by the presence of so many fish and by the mysterious absence of any fishy aroma (it's actually no mystery at all, I learned later; the produce sold at Tsukiji moves through the market so fast that it's long gone before it starts to smell). I remember wondering—as I stepped over long rows of tuna, walked past blue plastic trash cans filled with squirming eels, slipped between stacked wooden cases of flounder flapping their tails—how any city could eat this much fish in a month, much less one day.

But going back more often, I gradually realized that to focus on the bigness was to miss a key point. The real secret here, the reason the place does its job so well, is that Tsukiji is a small town. It's a community where everybody knows everybody else, and everybody works together toward the common goal of moving fish as fast as possible from the sea to the

sushi bar or the supermarket.

"Of course, we know that time is money," says white-haired Kikuo Takayanagi, president of the wholesale firm Daitoyo and a respected elder statesman of the marketplace. "Even so, you always take the 30 seconds to bow, to say hello. We are all neighbors here."

"To understand how Tsukiji works, just remember that Tsukiji is a *mura*," smiles Makoto Nozue, director of the Tsukiji Tuna Association, using the Japanese word for a traditional village. "We feel we work in a community called

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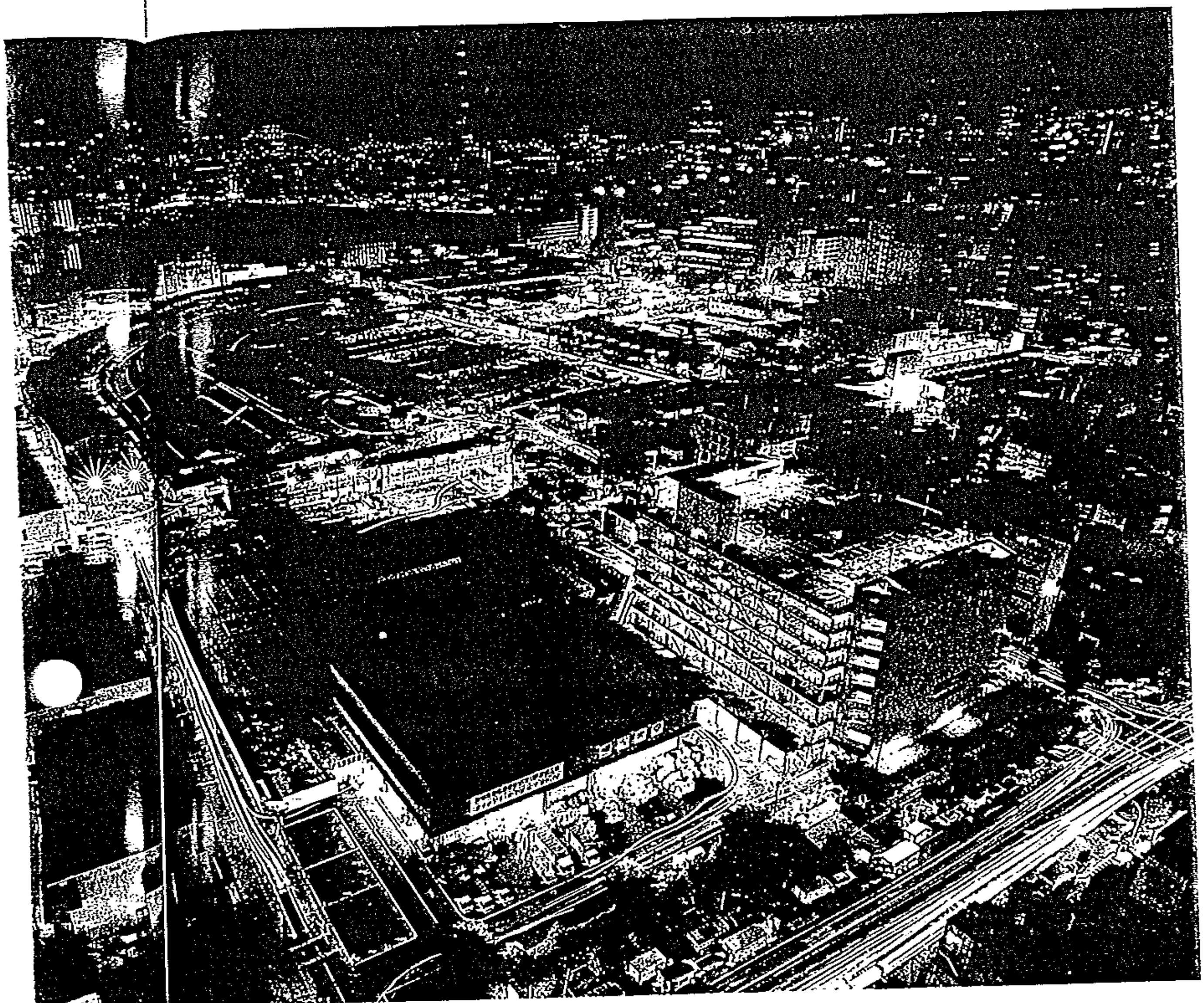
T. R. Reid is a reporter for the *Washington Post* and its former Tokyo bureau chief. He reported on the Kobe earthquake in the July issue. James L. Stanfield last photographed Fiji (October 1995).



While Tokyo slumbers, Tsukiji hustles as trucks deliver five million pounds of seafood—enough to satisfy the region's tens of millions of fish-eaters for a single day. Tsukiji's stylized logo (facing page) translates simply "fish riverbank," but merchants tout the 56-acre megamarket as *Tokyo no daidokoro:* Tokyo's pantry.

:rket. that ite- gi, pres- :m elder place. ke the v hello. e." Tsukiji

Tsukiji-mura. Yes, we are all competitors. But we spend a lot of our lives in this crowded village, and we need to get along."

Like every Japanese mura, the small town called Tsukiji has a clear hierarchy. At the top of the pecking order are the employees of the seven major first-tier wholesalers, who buy up fish around the world and get them to Tokyo. The big seven, in turn, auction off the daily catch to more than a thousand middle wholesalers, who cut, package, and deliver the goods, sometimes to yet another tier of distributors, sometimes directly to stores or sushi bars. There is a separate world of small businesses—knife sharpeners, boxmakers, bootsellers, and three dozen restaurants—on the site to serve the fishmongers.

And yet the privileges of status at Tsukiji tend to yield to the fundamental Japanese social principles of harmony, community, and the avoidance of confrontation. I saw that one morning when I witnessed a traffic accident in the market. A rampaging ta-ray cart slammed into a bicycle. The biker was wearing the uniform of one of the seven top-tier firms; the

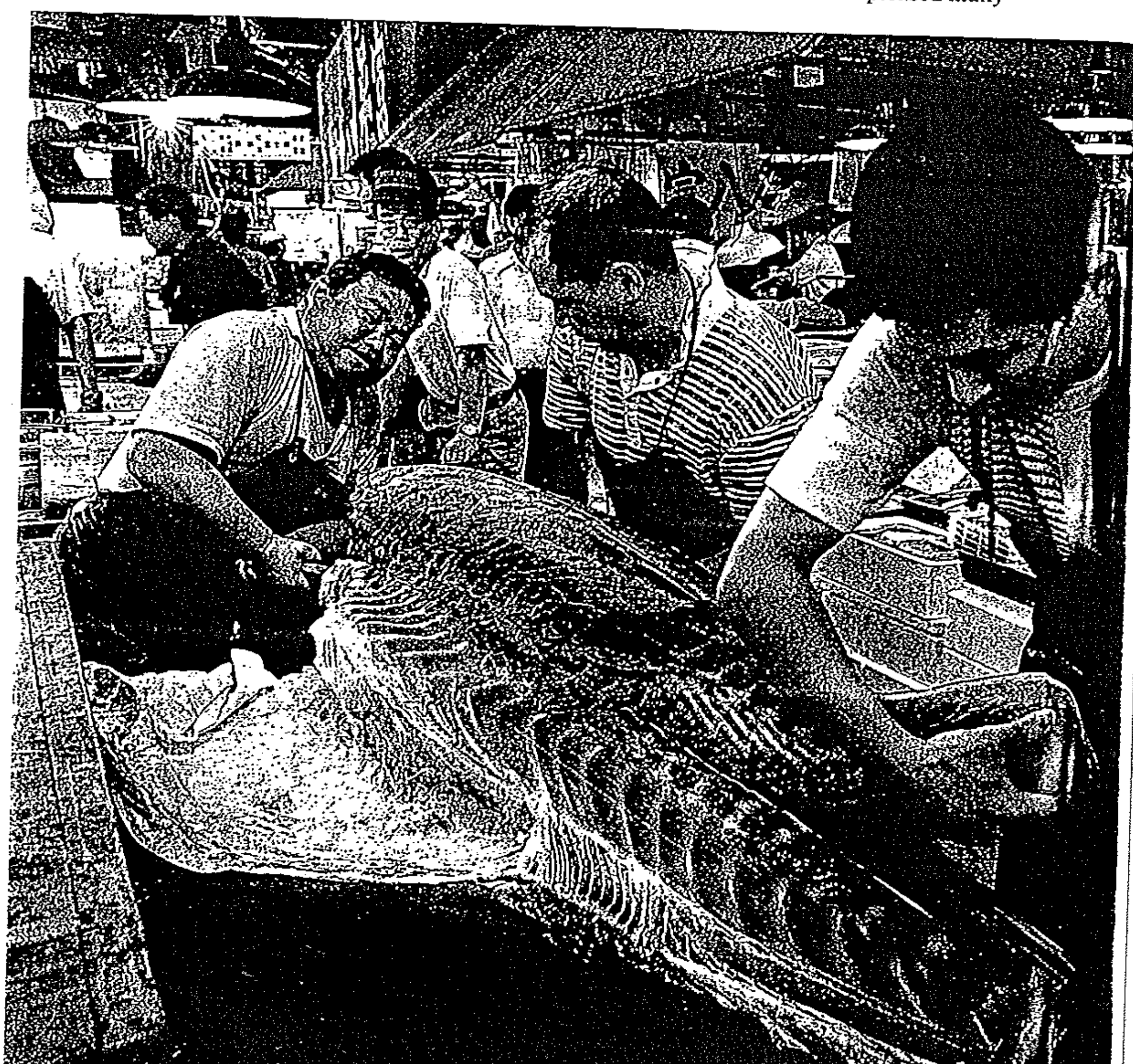
The Great Tokyo Fish Market.

ta-ray driver, who worked for a small wholesale outfit, seemed to be in the wrong. But it quickly became clear that this incident would be resolved by the Japanese version of a no-fault settlement: Both drivers got off their vehicles, took off their caps, bowed deeply to each other, apologized, and then worked together to straighten the bicycle's bent fender and to gather up the cases of fish sent flying in the crash.

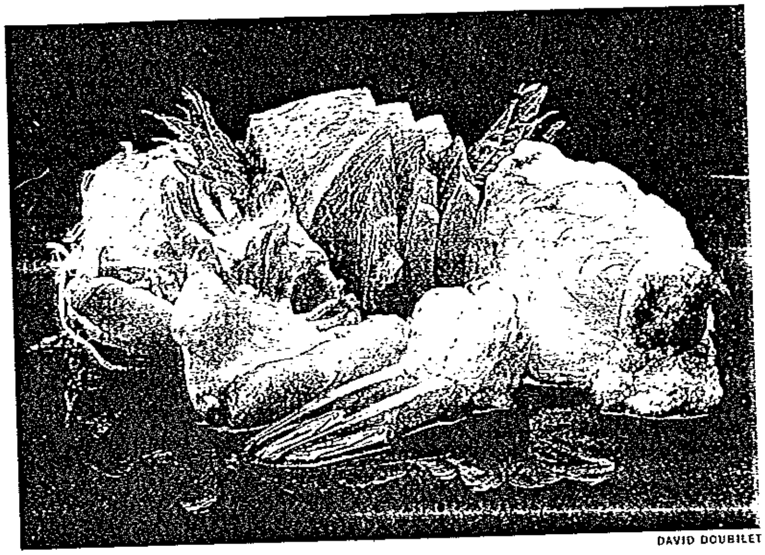
Like every Japanese mura, Tsukiji has its own Shinto shrine, a handsome dark-wood structure with a black fluted roof and an imposing 12-foot-tall *torii,* or gate, out front. It was built here 350 years ago, when the ruling shogun first reclaimed the land, to appease the gods; that explains its name, Namiyoke Inari Jinja, or "hold-back-the-waves shrine."

"People in the fish market come to pray more often than the average salaryman," the amiable chief priest, Hidemaro Suzuki, told me one day as he sat cross-legged on the tatami floor of his shrine. "They are buying and selling every day in auctions, and auctions are a function of fate. So people working here need more contact with the gods."

Sometimes the shrine is a place for carefree escape, such as the festival each June when hundreds of fish-market people pull on bright orange *happi* coats for a grand procession through the neighborhood. Sometimes the shrine is for contemplation; several times a year Suzuki-san leads prayers for the fish that die here. Gathering up his long black kimono, the priest led me over to a large rock in the temple garden, placed by the Association of Sushi Suppliers. "We have pleased many



Wielding a sword-long knife, fishmonger Motojiro Nakata halves a bluefin purchased at the morning auction. Thinly sliced and served with other raw delicacies as sashimi, the translucent flesh delights the eye as well as the palate. Japan's craving for such fare incites relentless fishing—and concerns about dwindling bluefin stocks.



DAVID DOUBILET

humans with fine sushi," the inscription reads, "but we must also stop to console the souls of the fish."

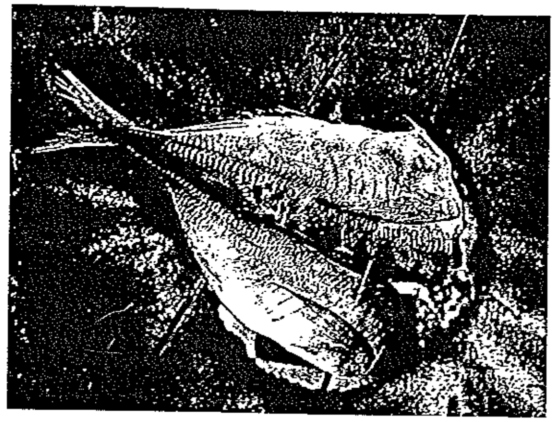
TSUKIJI puts heavy emphasis on education to pass along essential skills to the next generation—yet another resemblance between this place and Japan's small towns. On any given day there will be classes at the market on topics like auction protocol, knife handling, or time-tested techniques for making a spicy *kamaboko*, or fish sausage.

One day I happened upon a course that had literally life-or-death implications. Officials from Tsukiji's Fugu Harmonious Association were teaching the proper way to carve a fillet of *fugu*, the bulbous fish usually known in English as blowfish or puffer. For reasons I've never understood—the stuff always tastes like cardboard to me—fugu is an expensive and cherished delicacy in Japan. Unfortunately, it can also be lethal. Enzymes in organs of the fish are fatal to humans; almost every year some unfortunate diner expires in Japan after feasting on fugu that was not properly prepared.

Accordingly, a national license is required for every fugu chef. The class I saw was preparing candidates for the rigid licensing exam. "I've only got a month to go before the test," 26-year-old Kazuya Yawatagaki told me nervously, hefting an 18-inch knife as he practiced cutting slivers of fugu so thin they were translucent. "There's a written exam that lasts two hours. The next day they hand you a fugu, a knife, and two pans. In 20 minutes you have to put every poisonous part of the fish in one pan and all the edible parts in the other."

Another reason the people of this teeming place see themselves as neighbors in a village is that everyone in the market is bound to an upside-down daily schedule known as Tsukiji time. The market's workday begins just before 3 a.m., when the truck convoys begin to arrive, hauling fresh and frozen fish from around Japan and around the world. By sunrise it is time for the lunch break. When the day's work is essentially done, the people of Tsukiji sit down for dinner and a cold beer—at around 8:30 in the morning.

"Someone working here might live in a nice neighborhood like Shibuya or Funabashi, but how can you have



any friends there?" says Masami Eguchi, a round-cheeked, crew-cut 41-year-old who has worked at Tsukiji for 20 years. "You get up at, what, 2:30 a.m. to go to work, and when you get home, you're already thinking about going to bed. So for us, our 'neighborhood' is really Tsukiji."

As a rising star in the ranks of Chuo Gyorui, the largest of the seven first-tier wholesale firms, Eguchi-san says he has no complaints about his inverted workday. "But my daughter is four now, and she's starting to complain," he adds with a half smile. "She says, 'Papa, you're a grown-up! Why do you go to bed before I do?' "

Eguchi-san needs his sleep, because around five every morning he plays a leading role in Tsukiji's most lucrative daily drama: the tuna auction.

LONGER THAN A MAN and weighing from 200 to 1,000 pounds each, hundreds of tuna arrive in Japan by cargo jet every day. So voracious is the Japanese appetite for fish that even the swordfish caught by a tourist off the coast of Florida is more likely these days to end up frozen in Tsukiji than stuffed on the fisherman's wall; Chuo Gyorui and other first-tier wholesalers contract with agents on the charter docks in Miami to buy those big prizes as soon as they reach shore.

From the airport, the tuna are trucked to Tsukiji and bounced out onto the floor of the big tuna shed. They are lined up in long rows, like so many toppled bowling pins, while workers weigh them and label them with bright red characters. Number 197—a monster of a fish at 622 pounds—happened to be the 197th tuna delivered to the Chuo Gyorui auction area the day it arrived; the man with the writing brush quickly stroked the essential information on the tuna's belly: #197, Boston, 282 kg..

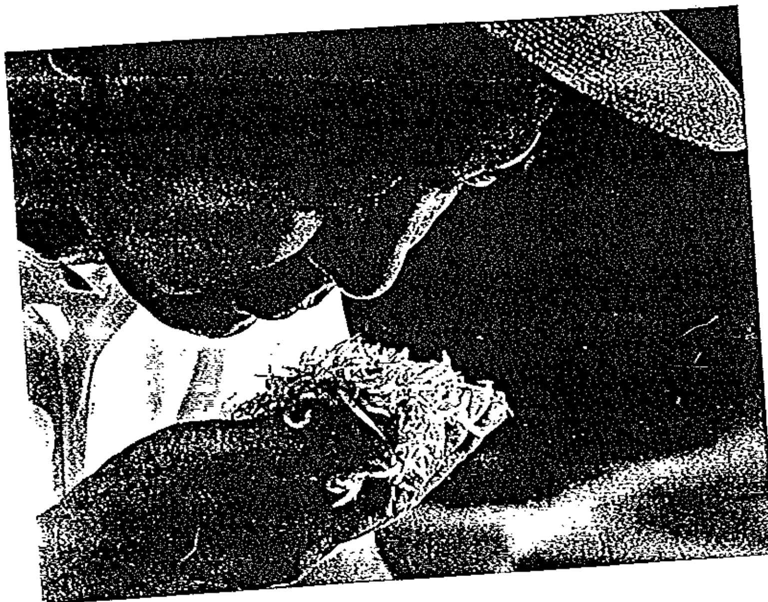
In the crowded market the frozen fish quickly begin defrosting, and a cold, eerie mist rises from the long lines of tuna. Around 4 a.m. an army of phantom figures starts moving through the mist. These are the buyers from several hundred second-level tuna wholesalers, who cut a morsel of dark red meat from each tuna; they feel it, smell it, check its color and oil content, constantly making notes on their hands or scraps of paper.

Eventually, the auctioneers join the throng. Proudly putting on his brown-and-white Chuo Gyorui cap, Eguchi-san sets up shop on a small wooden pedestal, ringing his handbell to announce the start of the sale.

"There are dozens of auctioneers working for the big seven wholesalers," Eguchi-san explained to me one day. "And each one has his own chant, his own rhythm. You have to pick a style that works for you and for the buyers. And you have to work fast. You know, the tuna I sell go for 600,000 yen [$6,800 U. S.], even one million yen apiece, and I have to sell 200 of them in about half an hour each morning."

Eguchi-san's style of selling might be described as "total involvement." With his right arm high in the air and his chubby belly bouncing rhythmically

The lunch-hour rush hits at dawn inside Tsukiji's three dozen eateries, where workers relish such fresh-caught fare as horse mackerel grilled over charcoal (above). Fish has long been the protein staple of seagirt Japan, which consumes more than a tenth of the world catch.



Smell is the surest test of freshness, says buyer Yoichi Kitahara, sizing up a handfu of *shirasu*, or dried young sardines. On the accepted, though naive, notion that women's hands are warmer than men's and thus more apt to lessen peak freshne few women sell fish at Tsukiji. Handling money an ledgers instead of fish, Yo Fukaizawa (below right) be gins her workday with pray

along, he roars out his sing-song call. He constantly scans the arcane hand signals of the buyers circled around him, stepping up the pace, and his own rate of bounce, as the bidding goes higher. When one fish is sold, he swipes quickly at his sweat-soaked face with a sleeve or handkerchief and moves on to the next without missing a beat.

Implicit in this complex ritual of inspection and auction is a concept that might not be immediately obvious to Americans—one that I was educated about over an exquisite dinner of tuna sashimi when I asked Eguchi-san's boss, Hiroyasu Itoh, senior managing director of the Tuna Department of Chuo Gyorui, if all tuna taste alike.

Itoh-san, who has put in some 40 years with his firm, bore my ignorant query with a gentle smile, and replied with a question of his own.

"Reido-san," he said, "why is it that Americans think any fish is just like every other fish? They're not made in a factory, you know. It seems perfectly obvious to us that a bluefin from the cold, rough seas around Tasmania will have different meat than a bluefin from tropical waters. I guess if you cook your tuna with lemon and seasonings, then it all starts to taste the same. But that's another thing I can't understand."

Itoh-san deftly scooped up a slim rectangle of deep red tuna meat with his chopsticks and held it out to me. "Why would you take fish this good, fish that cost 7,000 yen a kilo [about $36 a pound], and cook it? I mean, you kill the flavor! It seems so wasteful."

In fact, virtually all the tuna and more than half of all the seafood Tsukiji sells each day will be eaten raw—either sliced into small rectangles as sashimi or placed as the topping on a cube of sushi rice. And it will all be expensive.

Japan is famous for outrageous prices, of course, and the country's famously inefficient distribution system is a key reason. This is all part of Japan's basic social contract: To make sure that almost everybody has a job, extra layers of labor are added to virtually every economic activity. This is costly in terms of prices, but it also saves a good deal of money, pain, and disruption by ensuring a secure and peaceful population. As the central seafood distribution hub for a nation of fish lovers, Tsukiji vividly illustrates ho this works.

Consider, for instance, tu 197. It was caught by an A can fishing boat. Sold to a nese trading company. Shi via air and truck to a first- wholesaler at Tsukiji. Sol auction there to a smaller Tsukiji wholesaler. Cut, p aged, and transferred to v distributors. Delivered to taurants throughout cent Japan. By the time the fi finally got to the end con tuna 197 had passed thro least seven intermediary nies, each one taking a p along the way. No wond salaryman in a sushi ba up paying five dollars o each half-ounce bite.

BUT IF TSUKIJI se prove the com Western view Japan is expe inefficient, it tends to mine another piece of tional wisdom about J that its markets are cl

Almost every devel nation is running a tr with Japan, and com around the world stil lems getting many g services into this rich

Name: ______________

The Great Tokyo Fish Market
Tsukiji

1. How long ago and where was the bluefin caught?

2. After netting and gutting the fish is flash - frozen to what temperature?

3. People pay how much an ounce for fish in sushi bars?

4. What is Tsukiji's formal name?

5. Many many different types of seafood does Tsukiji handle?

6. How much can dried sea slug caviar be worth?

7. How many countries does Tsukiji import from?

8. How much seafood goes through Tsukiji in a day?

9. Where is the world second largest fish market?

10. How much is the fish worth which travels through Tsukiji in a day?

11. How many people work at Tsukiji?

12. What is a fugu fish?

13. When does the Tsukiji's workday begin?

14. How large are the tuna sold on the market?

15. How much do the tuna sell for?

16. How many are sold in a morning?

17. How is most of the tuna eaten?

18. How many intermediary companies effect the tuna?

19. What is a uni?

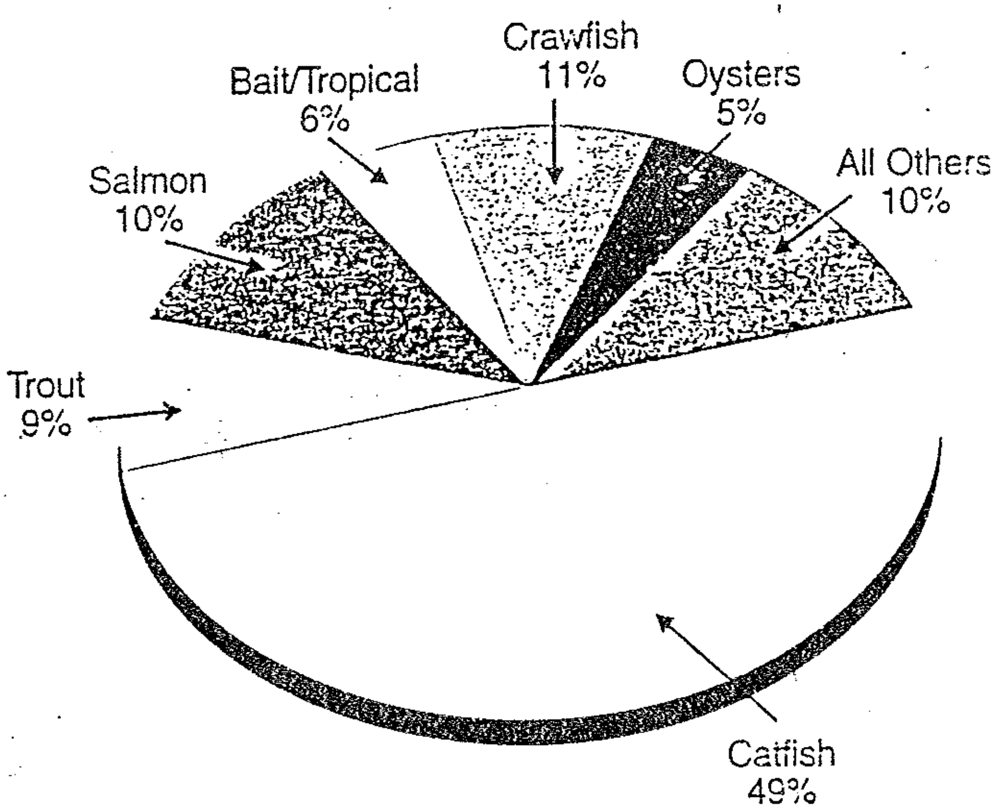
20. Why is the uni important to the U.S. and Japan?

U.S. Aquaculture

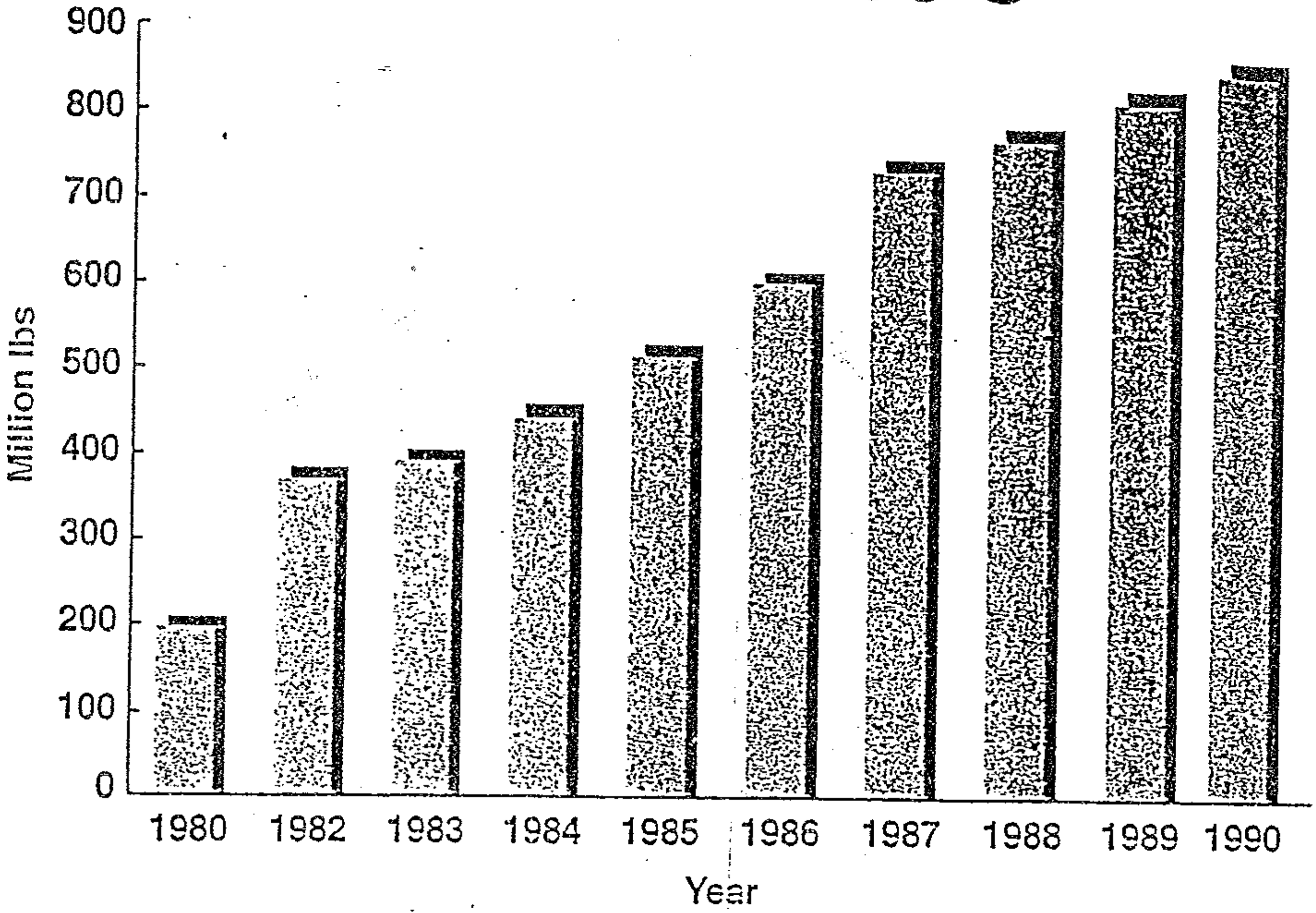
- Annual U.S. production of fish and seafood is over 413,000 metric tons
- 35 states have meaningful aquaculture production
- Several states such as Wisconsin have Aquaculture Development Plans
- There are now more than 20 species of fish being raised in the U.S.
- Currently the U.S.trade deficit in fish and seafood products is over $6 billion which is second only to the deficit created by oil and petroleum products
- It is predicted that within 10 years 25 percent of the world fish supply and 20 percent of the U.S. fish supply will be from aquaculture
- The amount of aquatic food consumer on a per capita basis has increased from 10.4 pounds per person in 1960 to 15.5 pounds per person presently which represents an increase of 65 million pounds per year

Aquaculture Species Cultured In U.S.

Species Cultured in the United States



U.S. Aquaculture Production In 1980's



Important U.S. Fish Species

- Catfish
  - Leading Production States
    - Mississippi
    - Arkansas
    - Alabama
    - Louisiana
- Catfish account for nearly 50 percent of the production within the U.S. aquaculture industry

Important U.S. Fish Species

- Trout
  - Leading Production States
    - Idaho
    - North Carolina
    - California
    - Pennsylvania
    - Utah
    - Virgina

Important U.S. Fish Species

- Tilapia
  - Major Producing States
    - Flordia
    - California
    - Arizona
  - Tilapia imports decreased in 1995
    - Tilapia ranks third in imported aquaculture products on a quanity basis
  - Fastest growing aquaculture commodity

Important U.S. Fish Species

- Salmon
  - Major Producing States
    - Washington
    - Maine
  - Second most imported aquaculture product

Important U.S. Fish Species

- Shrimp
  - Major Producing States
    - Florida
    - Hawaii
  - Shrimp ranks first in imported aquaculture products in a quanity basis

Important U.S. Fish Species

- Crawfish
  - Leading state is Louisiana
  - U.S. producers are facing stiff competition from China's low priced product
  - U.S. exports have dropped 47 percent
    - Changing market standards
    - Increased European tariff

Important U.S. Fish Species

- Mollusks (Oysters and Clams)
  - Major oyster producing states
    - Connecticut
    - California
    - Louisiana
    - Massachusetts
    - North Carolina
  - Major clam producing states
    - Connecticut
    - North Carolina
    - Flordia
    - Virgina
    - Maryland

Other Potential U.S. Aquaculture Products

- Alligator
- Carp
- Perch
- Snails
- Red drum
- Scallops
- Hybrid striped bass
- Bluegill
- Abalone
- Algae
- Sturgeon
- Aquatic plants
- Baitfish
- Crappie
- Bullfrogs
- Walleye

Wisconsin Aquaculture

Developments In Wisconsin Aquaculture

- 1950's the primary fish raised was trout and baitfish (minnows)
- The industry association that helped support Wisconsin Aquaculture was the Associated Trout Growers of Wisconsin which was later changed to the Wisconsin Trout Growers, Inc. and is now known as the Wisconsin Aquaculture Association
- Wisconsin has developed an Aquaculture Plan
- 1991 a bill was signed into law that declared aquaculture as agriculture and gave aquaculturist the same business structure as production agriculturist
- 1994 Bill AB 763 was signed into law which provided funds to the Wisconsin Department of Agriculture for aquaculture related activities

1994 Aquaculture Survey
An Industry Profile

March 1995

GENERAL

It has been stated that the retail value of aquaculture products sold in Wisconsin approaches $45 million. Contributing to this total is the value of food and game fish raised and sold by Wisconsin producers, and, based on a recent study published by UW-Stevens Point, over $35 million worth of baitfish and nonfish products sold through the state's retail outlets.

Information presented in this report is the result of a survey of fish hatcheries in the state. Gross sales from all aquaculture products raised and sold from the 128 Wisconsin commercial operations totaled $8.8 million in 1994. More than 60 percent of these sales, or $5.3 million, come from food and game fish, while baitfish account for nearly 37 percent or $3.2 million. During the next five years, these same operations expect their sales to expand 56 percent to $13.6 million with more than two-thirds of this increase coming from the food and game fish industry and from all current sizes of operations.

Aquaculture Operations by Major Category

Category	Number of operations			Gross sales	
	Commercial	Potential commercial	Total	Dollars (000)	Percent total
Food and game fish	117	57	174	5,300	60.4
Baitfish	39	16	55	3,200	36.5
Nonfish and plants	12	3	15	275	3.1
Total 1/	128	59	187	8,775	100.0

1/Individual operations counted only once.

Nearly 57 percent of the aquaculture operations surveyed are commercial or potential commercial, that is, currently sell or expect to sell fish products. The remaining 43 percent indicated that, while fish are being raised, none are sold.

Aquaculture Operations

Type of operation	Number operations	Percent total
Commercial 1/	128	38.8
Potential commercial 2/	59	17.9
Noncommercial 3/	143	43.3
Total operations	330	100.0

1/Operations currently selling fish products. 2/Operations expecting to sell fish products in the near future. 3/Operations raising fish but not selling products.

Producers raising only food and game fish for sale make up nearly 70 percent of the operations surveyed. An additional 18 percent raise both food/game fish and baitfish while 6 percent raise only baitfish.

Commercial operations reporting sales of less than $10,000 account for 60 percent of the operations but only 2 percent of the total gross sales. On the other hand, the 6 largest operations account for nearly 70 percent of all sales.

Commercial Aquaculture Operations: Number, Gross Sales, and Expected Expansion

Gross sales	Operations		Total gross sales 1994		Expected gross sales next five years	
	Number	Percent total	Dollars	Percent total	Dollars	Percent change
Less than $1,000	38	29.7	20,000	.2	37,200	+ 86
$ 1,000 - 4,999	29	22.7	86,200	1.0	123,600	+ 43
$ 5,000 - 9,999	10	7.8	73,300	.8	210,900	+188
$ 10,000 - 24,999	20	15.6	343,200	3.9	430,700	+ 25
$ 25,000 - 49,999	9	7.0	340,000	3.9	555,600	+ 63
$ 50,000 - 74,999	5	3.9	312,500	3.6	354,400	+ 13
$ 75,000 - 99,999	5	3.9	437,500	5.0	665,000	+ 52
$100,000 - 249,999	6	4.7	1,050,000	12.0	1,163,800	+ 11
$250,000 or more	6	4.7	6,111,800	69.6	10,105,500	+ 65
Total	128	100.0	8,774,500	100.0	13,646,700	+ 56

Wisconsin Department of Agriculture, Trade & Consumer Protection
Division of Marketing
P.O. Box 8911, Madison, WI 53708-8911
In Cooperation with

Aquaculture Operations—Combinations of Categories

Category	Number of operations: Commercial	Potential commercial	Total
Food and game fish only	84	42	126
Food/game fish and baitfish	22	12	34
Baitfish only	10	2	12
Food/game, baitfish and nonfish/plants	6	2	8
Food/game and nonfish/plants	5	1	6
Baitfish and nonfish/plants	1	0	1
Nonfish and plants only	0	0	0
Total operations	128	59	187

Eighty percent of the potential commercial operations expect to begin selling fish in 1995 or 1996.

Potential Commercial Operations—Year to Begin Sales

Year	Number operations	Percent total
1995	24	40.6
1996	23	39.0
1997	5	8.5
1998	1	1.7
Unknown	6	10.2
Total	59	100.0

FOOD AND GAME OPERATIONS

Operations reporting more than 50 percent of gross sales from food and game fish account for 82 percent of the commercial operations and 59 percent of the gross sales. Current sales total $5.2 million and sales during the next 5 years are expected to increase 80 percent to $9.3 million. The majority (57 percent) of operations expect sales to increase during the next five years, while 39 percent report no change.

Sales of live food size fish is the most common method of sale, followed by stockers, fingerlings and dressed food size. Eighty percent of the operations sell or expect to sell 1 or 2 products. The majority of potential operations expect to market their production as live food with more than one-half of these through fee fishing on their place.

Commercial Food and Game Fish Operations: Number, Gross Sales, and Expected Expansion (more than fifty percent gross sales from food and game fish)

Gross sales	Operations: Number	Operations: Percent total	Total gross sales 1994: Dollars	Total gross sales 1994: Percent total	Expected gross sales next five years: Dollars	Expected gross sales next five years: Percent change
Less than $1,000	33	31.4	17,000	.3	31,400	+ 85
$ 1,000 - 4,999	26	24.8	77,200	1.5	114,300	+ 48
$ 5,000 - 9,999	10	9.5	73,300	1.4	210,900	+188
$ 10,000 - 24,999	16	15.2	273,200	5.3	360,800	+ 32
$ 25,000 - 49,999	7	6.7	262,500	5.1	470,600	+ 79
$ 50,000 - 74,999	3	2.9	187,500	3.6	215,600	+ 15
$ 75,000 - 99,999	2	1.9	175,000	3.4	437,500	+150
$100,000 - 249,999	6	5.7	1,050,000	20.4	1,163,800	+ 11
$250,000 or more	2	1.9	3,036,800	59.0	6,265,500	+106
Total	105	100.0	5,152,500	100.0	9,270,400	+ 80

Food and Game Fish Commercial Operations: Expected Change in Future Gross Sales (more than fifty percent gross sales from food and game fish)

Gross sales	Expected increase in gross sales: Number	Expected increase in gross sales: Percent increase	No change in gross sales: Number	Expected decrease in sales: Number	Expected decrease in sales: Percent decrease	All operations: Number	All operations: Percent change
Less than $1,000	16	+189	15	2	- 70	33	+ 85
$ 1,000 - 4,999	12	+114	13	1	- 80	26	+ 48
$ 5,000 - 9,999	7	+262	3	0		10	+188
$ 10,000 - 24,999	11	+ 50	4	1	- 25	16	+ 32
$ 25,000 - 49,999	4	+139	3	0		7	+ 79
50,000 - 74,999	2	+ 22	1	0		3	+ 15
75,000 - 99,999	1	+300	1	0		2	+150
$100,000 - 249,999	5	+ 13	1	0		6	+ 11
$250,000 or more	2	+106	0	0		2	+106
Total	60	+ 91	41	4	-35	105	+ 80

Operations by Types of Sales—Food and Game Species

Type of sale	Number of operations		
	Commercial	Potential commercial	Total
Eggs, green	4	0	4
Eggs, eyed	7	0	7
Fry	18	4	22
Fingerlings	41	13	54
Stockers	50	12	62
Food size, live	72	36	108
Food size, dressed	37	11	48
Processed products	7	2	9
Total 1/	117	56	173

1/Individual operations counted only once.

Food and Game Fish Operations: Number Products Offered for Sale

Number products offered 1/	Number of operations			
	Commercial	Potential commercial	Total	Percent total
1	62	41	103	59.6
2	25	10	35	20.2
3	14	3	17	9.8
4	6	2	8	4.6
5	4	0	4	2.3
6	4	0	4	2.3
7	2	0	2	1.2
Total	117	56	173	100.0

?roducts include: green and eyed eggs, fry, fingerlings, stockers, live and .ressed food size, and processed products.

The following tables identify the number of commercial and potential commercial operations raising each food and game fish species anc :he number of operations raising 1 or more species. At least 50 percent of the operations report only one species being raised for sale. However an additional 27-29 percent report 2 species being raised for sale. Rainbow trout is the most popular species, followed by largemouth bass, bluegill, brook trout and yellow lake perch.

Operations Raising Trout Species

Species	Number of operations		
	Commercial	Potential commercial	Total
Arctic	2	0	2
Brook	40	11	51
Brown	22	4	26
Kamloop	2	2	4
ˡ.ake	1	0	1
ainbow	75	17	92
Гiger	2	0	2
Total 1/	82	21	103

1/Individual operations counted only once.

Trout Operations: Number of Species Raised

Number species	Number of operations			
	Commercial	Potential commercial	Total	Percent total
1	41	12	53	51.4
2	24	5	29	28.2
3	15	4	19	18.4
4	1	0	1	1.0
5	1	0	1	1.0
Total	82	21	103	100.0

Operations Raising Panfish Species

Species	Number of operations		
	Commercial	Potential commercial	Total
Bluegill	38	22	60
Bluegill, hybrid	6	1	7
Crappie	17	10	27
Perch, yellow lake	27	20	47
Sunfish	17	3	20
Tilapia	2	2	4
Total 1/	58	36	94

1/Individual operations counted only once.

Panfish Operations: Number of Species Raised

Number species	Number of operations			
	Commercial	Potential commercial	Total	Percent total
1	29	20	49	52.1
2	14	11	25	26.6
3	10	4	14	14.9
4	5	1	6	6.4
Total	58	36	94	100.0

Operations Raising Salmon Species

Species	Number of operations		
	Commercial	Potential commercial	Total
Atlantic	2	0	2
Coho	4	0	4
Total 1/	5	0	5

1/Individual operations counted only once.

Salmon Operations: Number of Species Raised

Number species	Number of operations			
	Commercial	Potential commercial	Total	Percent total
1	4	0	4	80.0
2	1	0	1	20.0
Total	5	0	5	100.0

Operations Raising Game Fish Species

Species	Number of operations: Commercial	Potential commercial	Total
Bass, largemouth	42	19	61
Bass, smallmouth	17	5	22
Catfish	8	3	11
Muskellunge	9	1	10
Northern pike	13	0	13
Sturgeon	1	0	1
Walleye	28	16	44
Other	3	2	5
Total 1/	54	32	86

1/Individual operations counted only once.

Game Fish Operations: Number of Species Raised

Number species	Number of operations: Commercial	Potential commercial	Total	Percent total
1	22	21	43	50.0
2	16	9	25	29.1
3	6	1	7	8.1
4	3	1	4	4.7
5	5	0	5	5.8
6	2	0	2	2.3
Total	54	32	86	100.0

BAITFISH OPERATIONS

Operations reporting more than 50 percent of gross sales from baitfish account for nearly 16 percent of the commercial operations and 40 percent of the gross sales from aquaculture products. Current sales total over $3.5 million during 1994 but are expected to increase 21 percent during the next 5 years to $4.3 million. Baitfish producers expecting their sales to increase are nearly the same as those reporting no change. The 8 producers indicating an average increase of 136 percent far out gained the 49 percent decrease indicated by 3 producers.

Two-thirds of the baitfish producers sell or expect to sell their products wholesale, while 35-37 percent of the operations sell retail or as forage food. The majority of producers sell their baitfish by only one type of sale.

Fathead minnows are the most common baitfish raised for sale, followed by suckers and shiners. Most of the producers raise more one species.

Commercial Baitfish Operations: Number, Gross Sales, and Expected Expansion (more than fifty percent gross sales from baitfish)

Gross sales	Operations: Number	Operations: Percent total	Total gross sales 1994: Dollars	Total gross sales 1994: Percent total	Expected gross sales next five years: Dollars	Expected gross sales next five years: Percent change
Less than $1,000	3	15.0	2,000		4,200	+110
$ 1,000 - 4,999	3	15.0	9,000	.3	9,300	+ 3
$ 5,000 - 9,999	0					
$ 10,000 - 24,999	4	20.0	70,000	2.0	70,000	n.c.
$ 25,000 - 49,999	2	10.0	77,500	2.2	85,000	+ 10
$ 50,000 - 74,999	2	10.0	125,000	3.5	138,800	+ 11
$ 75,000 - 99,999	2	10.0	175,000	5.0	140,000	- 20
$100,000 - 249,999	0					
$250,000 or more	4	20.0	3,075,000	87.0	3,840,000	+ 25
Total	20	100.0	3,533,500	100.0	4,287,300	+ 21

Baitfish Commercial Operations: Expected Change in Future Gross Sales (more than fifty percent gross sales from baitfish)

Gross sales	Expected increase in gross sales: Number	Expected increase in gross sales: Percent increase	No change in gross sales: Number	Expected decrease in sales: Number	Expected decrease in sales: Percent decrease	All operations: Number	All operations: Percent change
Less than $1,000	1	+500	0	2	- 20	3	+110
$ 1,000 - 4,999	1	+ 10	2	0		3	+ 3
$ 5,000 - 9,999	0		0	0		0	
$ 10,000 - 24,999	0		4	0		4	n.c.
$ 25,000 - 49,999	1	+ 20	1	0		2	+ 10
$ 50,000 - 74,999	2	+ 11	0	0		2	+ 11
$ 75,000 - 99,999	1	+ 10	0	1	- 50	2	- 20
$100,000 - 249,999	0		0	0		0	
$250,000 or more	2	+ 39	2	0		4	+ 25
Total	8	+136	9	3	- 49	20	+ 21

Operations by Type of Sales—Baitfish Species

Type of sale	Number of operations		
	Commercial	Potential commercial	Total
Wholesale	25	11	36
Retail	15	4	19
Forage	16	4	20
Total 1/	39	15	54

1/Individual operations counted only once.

Operations Raising Baitfish Species

Species	Number of operations		
	Commercial	Potential commercial	Total
Chubs	14	3	17
Minnows, fathead	32	14	46
Shiners	17	9	26
Suckers	23	6	29
Other	5	1	6
Total 1/	39	16	55

1/Individual operations counted only once.

Baitfish Operations: Number Products Offered for Sale

Number products offered 1/	Number of operations			
	Commercial	Potential commercial	Total	Percent total
1	25	12	37	68.5
2	11	2	13	24.1
3	3	1	4	7.4
Total	39	15	54	100.0

1/Products include: wholesale, retail, and forage (sales as fish food).

Baitfish Operations: Number of Species Raised

Number species	Number of operations			
	Commercial	Potential commercial	Total	Percent total
1	16	7	23	41.8
2	4	4	8	14.5
3	11	3	14	25.5
4	6	1	7	12.7
5	2	1	3	5.5
Total	39	16	55	100.0

'OOD\GAME FISH AND BAITFISH OPERATIONS

Three operations reporting a 50-50 balance between both food\game fish and baitfish account for only 1 percent or $88,500 of the total gross sales.

Commercial Food/Game and Bait fish Operations: Number, Gross Sales, and Expected Expansion (fifty percent gross sales from each category)

Gross sales	Operations		Total gross sales 1994		Expected gross sales next five years	
	Number	Percent total	Dollars	Percent total	Dollars	Percent change
Total	3	100.0	88,500	100.0	89,000	+ 1

Food/Game and Baitfish Commercial Operations: Expected Change in Future Gross Sales (fifty percent gross sales from each category)

Gross sales	Expected increase in gross sales		No change in gross sales	Expected decrease in sales		All operations	
	Number	Percent increase	Number	Number	Percent decrease	Number	Percent change
Total	1	+100	2	0		3	+ 1

MISCELLANEOUS INFORMATION

Water Systems

Ninety one percent of the operations raise fish in open ponds, with 31 percent raising fish in raceways or tanks. Nearly a quarter of the operations use both ponds and raceways.

Aquaculture Operations by Water System

Water system	Number of operations		
	Commercial	Potential commercial	Total
Open pond	113	57	170
Flow thru, raceways, or tanks	54	4	58
Recirculating system	9	4	13
Cages or nets	7	1	8
Ponds and raceways 1/	42	3	45
Total 2/	128	59	187

1/Also included in count of separate systems. 2/Individual operations counted only once.

Hired workers in Aquaculture

A total of 257 hired workers (including the operator) were reported on commercial operations. One fourth of the operations did not hire any additional workers while 15 of the largest operations reported 39 percent of the workers.

Commercial Operations: Hired Workers on Aquaculture Operations 1/

Hired workers	Workers in aquaculture		
	Number of operations	Total workers	Percent total
1	65	65	25.3
2	25	50	19.5
3	14	42	16.3
4 - 9	13	76	29.6
10 or more	2	24	9.3
Total	119	257	100.0

1/The operator is counted as a hired worker on these operations.

Years in Aquaculture Business

Fifty one percent of the commercial operations have been in business for less than 10 years. However 15 operations report 30 or more years in the aquaculture business.

Commercial Operations: Years in Aquaculture Business

Years in business	Number of operations	Percent of total	Accumulated percent total
1	12	10.1	10.1
2	11	9.2	19.3
3	11	9.2	28.6
4	6	5.0	33.6
5	8	6.7	40.3
6 - 9	13	10.9	51.3
10 - 14	12	10.1	61.3
15 - 19	11	9.2	70.6
20 - 29	20	16.8	87.4
30 - 39	7	5.9	93.3
40 or more	8	6.7	100.0 1/
Total	119	100.0	

1/Calculations may not add to total due to rounding.

Fee Fishing Operations

Fee fishing is or will be permitted on 39 percent of the operations surveyed. Of the total 72 operations, 51 are commercial and 21 are potential commercial operations.

Fee Fishing Operations

Activity	Number of operations		
	Commercial	Potential commercial	Total
Fee fishing permitted	51	21	72

Nonfish Operations

Operations Raising Nonfish and Plant Products

Product	Number of operations		
	Commercial	Potential commercial	Total
Crawfish	4	2	6
Frogs	5	2	7
Hydro vegetables	1	0	1
Water plants	6	1	7
Other	2	0	2
Total 1/	12	3	15

1/Individual operations counted only once.

SURVEY PROCEDURES

The sample for this aquaculture survey included all licensed Class A and B fish hatcheries and a selected number of licensed Class C operations who renewed their 1993 license with the Wisconsin Department of Natural Resources (WDNR). A total of 330 operations were included: Class A, 104; Class B, 213; Class C, 11; and other sources, 2.

Survey material including an introductory letter, the survey form, and a postage-paid return envelope were mailed to all operations. A reminder postcard was mailed 10 days later. All operations not responding by mail were contacted by a telephone enumerator. Fifty-four percent (177 operations) of the responses were received by mail, 39 percent (129) by telephone, and 7 percent (24) were inaccessible, including 5 refusals. Survey forms were, however, completed for these missing operations using information reported on their 1993 WDNR fish hatchery application.

Water and Water Quality

Physical Properties Of Water

- Bipolar molecule
- Creates adhesion and cohesion
- Changes to a solid which is less dense than the liquid form (ice floats)
- Will dissolve almost any compound - some quickly, some more slowly

Forms Of Water*

- Liquid - water solution (32° - 212° F or 0° - 100° C)
- Gas - vapor or steam (above 212° F or above 100° C)
- Solid - ice (below 32°F or below 0° C)

*At sea level

Sources Of Water

- Precipitation
- Oceans
- Lakes
- Rivers
- Springs
- Wells
- Industrial Effluent
- Municipal Water Systems

Water Is The Basis For Life In Aquaculture

Water Provides:
- Oxygen source
- Food source
- Excretory site
- Temperature regulation
- Constant contact with organism
- Harbor for disease

Specific Heat

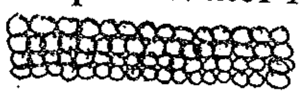
- Amount of heat required to raise the temperture of 1 gram of water 1 degree Centigrade

Water As A Solution

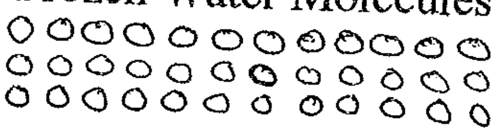
- Combination of solvent and solute
  - Solvent - is the most prevalent compound in a solution
  - Solute - is the compound that has been dissolved
- Water as a solvent
  - Water will dissolve almost anything

Water Density

Liquid Water Molecules



Frozen Water Molecules



- The seperation of water molecules upon freezing allows water to have less density; therefore, allowing ice to float

How Water Changes Cause Stress

- Shock stress - rapid changes in environment
  - Loss in efficiency
  - Possible death
- Chronic stress - long - term exposure to poor environment that is not lethal
  - Decreased efficiency
- Acute stress - environment exceeds organisms' tolerance
  - Death

Quality Considerations Of Water For Aquaculture

- Temperture
- Salinity
- Dissolved gases
- Living aquatic organisms
  - Plants
  - Animals
- Dissolved solids
- Wastes
- pH

Temperature

- Influences metabolism of organisms
- Expensive to regulate
- Select species adapted to available water

Critical Factors Of Water Temperature To Aquaculture

- Controls growth
- Controls spawning

How To Change Water Temperature

- Heating
- Cooling

Species As Defined By Temperature

- Warm Water Species -
  - Water temperature 68°F to 86°F (20°C to 30°C)
  - Examples
    - Sunfish
    - Bass
    - Tilapia
    - Crappie
- Cool Water
  - Water temperature 59°F to 72°F (15°C to 22°C)
  - Examples
    - Yellow Perch
    - Walleye
    - Northern
- Cold Water
  - Water temperture 45°F to 58°F (7°C to 14°C)
  - Examples
    - Salmon
    - Trout
    - Whitefish

Salinity

- Refers to salt content of water
- Salinity is measured in parts per thousand (ppt)
- Salinity ranges from 0 to 40 ppt or more
- Freshwater has little or no salt
- Saltwater has 35 ppt salt
- Brackish water ranges between fresh and saltwater
- Species may be adapted to specific salinity

Salinity Factors

- Water with salinity above 15 parts per thousand usually has high alkalinity and hardness
- Water with high salinity often contains carbonates and minerals in greater amounts than water with low salinity

Dissolved Gases In Water For Aquaculture

- Oxygen (O)
- Nitrogen Forms:
  - Ammonia (NH_3) (unionized)
  - Ammonia (NH_{4+}) (ionized
  - Nirite (NO_2)
  - Nitrate (NO_3)
  - Nitrogen (N_2)
- Carbon Dioxide (CO_2)
- Sulfuric acid (H_2SO_4)

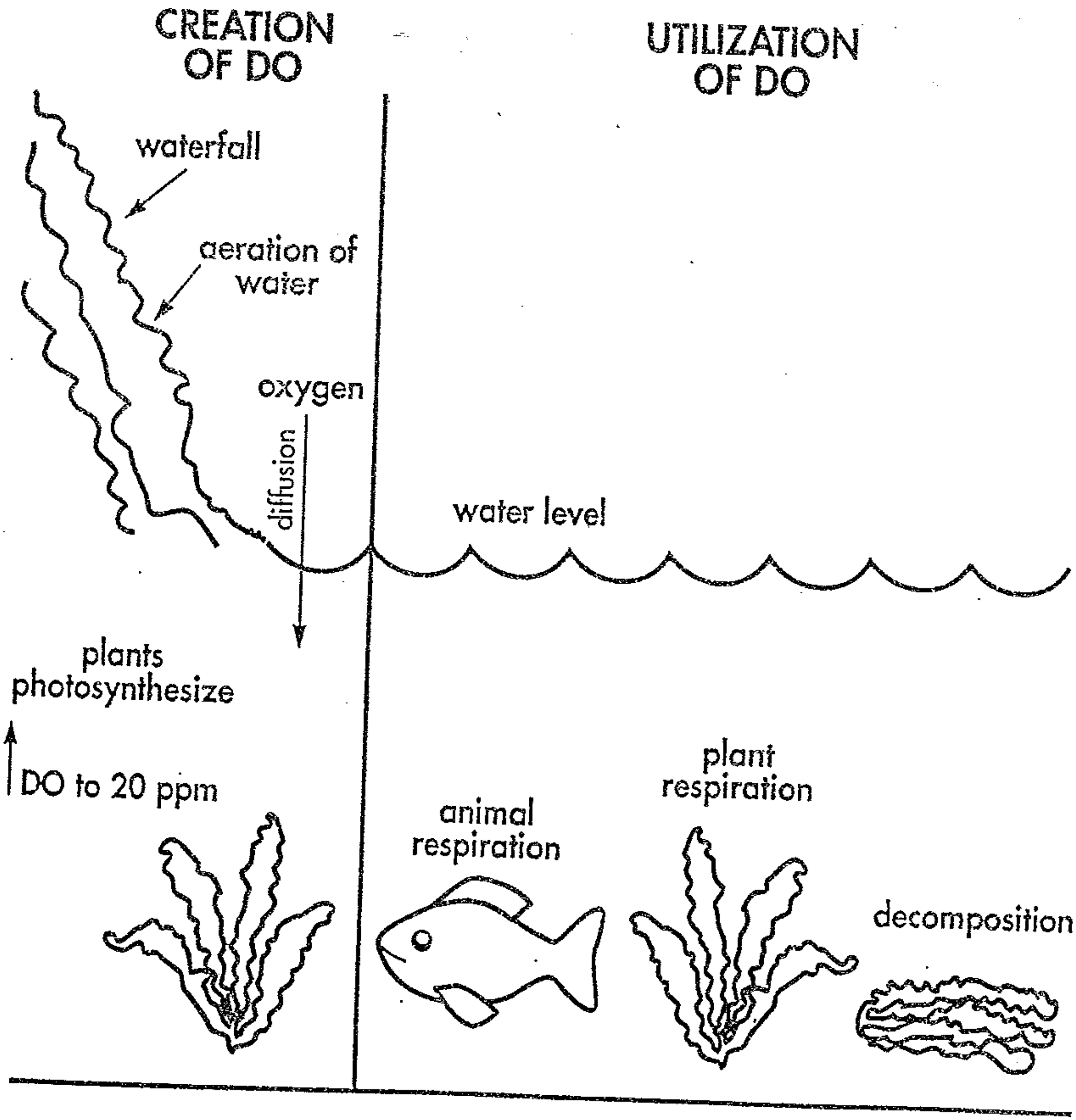
Dissolved Oxygen

- DO = Dissolved Oxygen
- All life minus some bacteria require it
- DO level in water is 20,000 times less than the DO level in the atmosphere
- As temperture goes up, DO goes down
- As elevation goes up, DO goes down

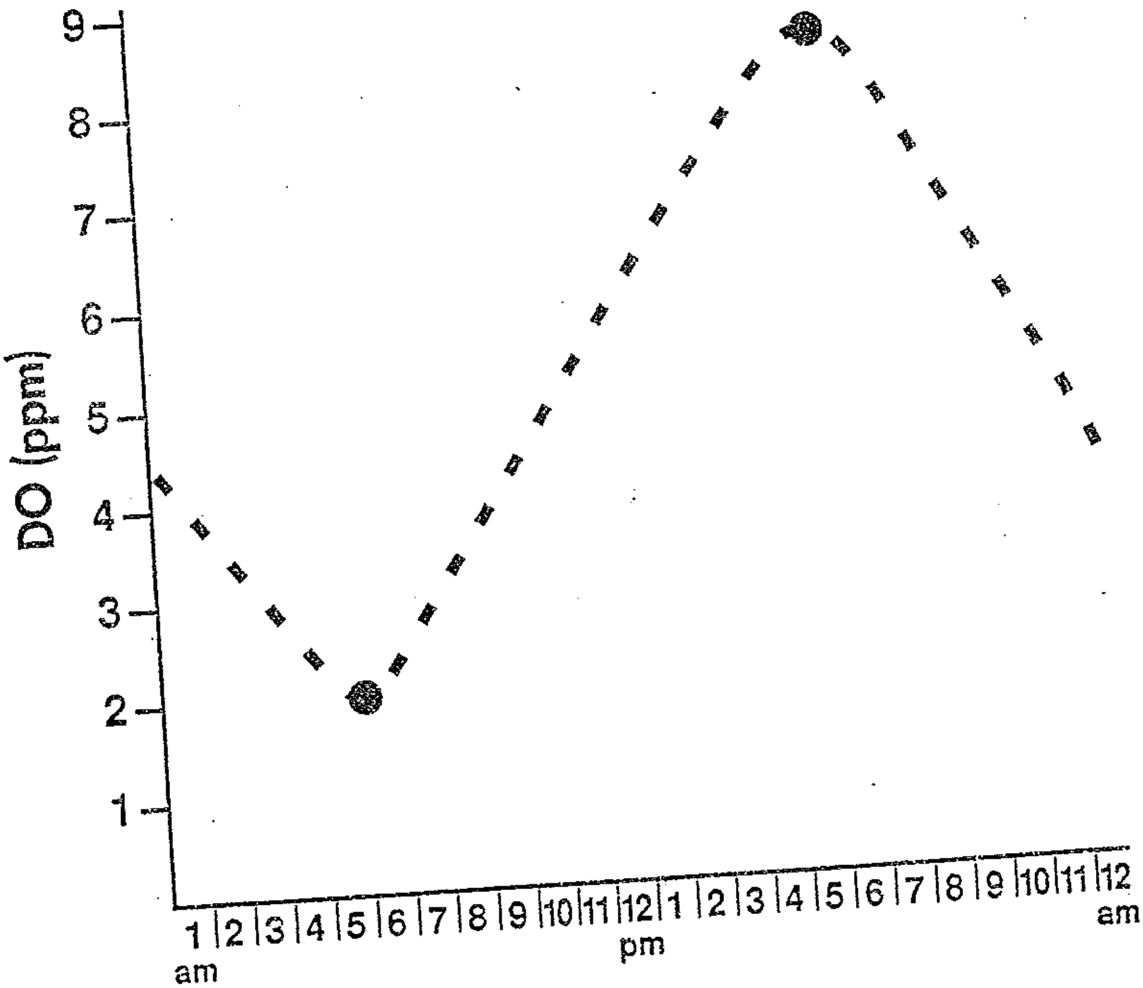
Variables That Affect Dissolved Oxygen

- Temperture
- Salinity
- Elevation

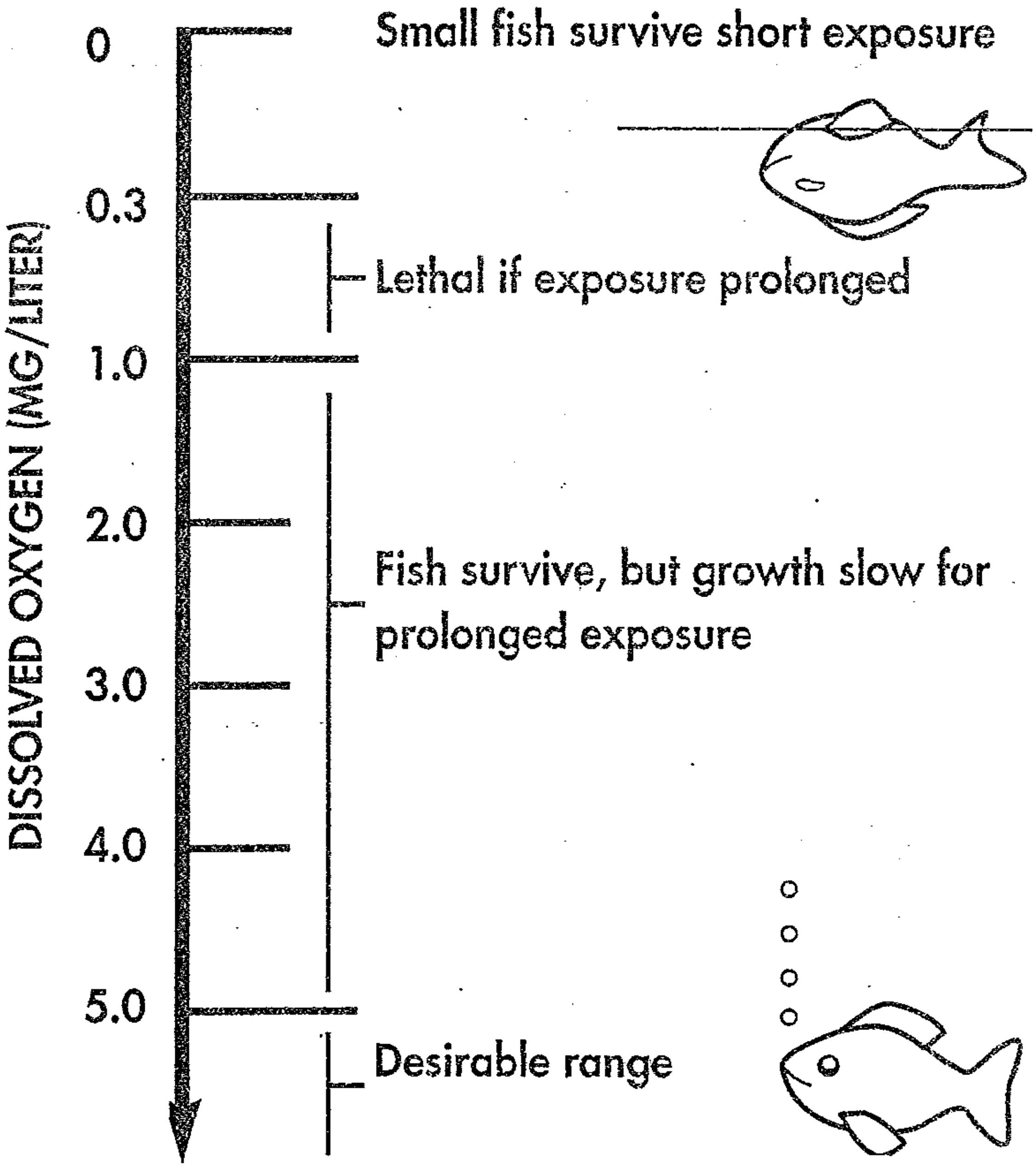
Dissolved Oxygen Cycle



Dissolved Oxygen Daily Cycle



Negative Effects of Low Dissolved Oxygen



Nitrogen

- Unionized ammonia and nitrite forms are most likely to cause problems in aquaculture
- Nitrogen problems are often caused by overfeeding
- Nitrogen gas dissolved in water may cause gas bubble disease in fish when present at levels of 110 percent of saturation

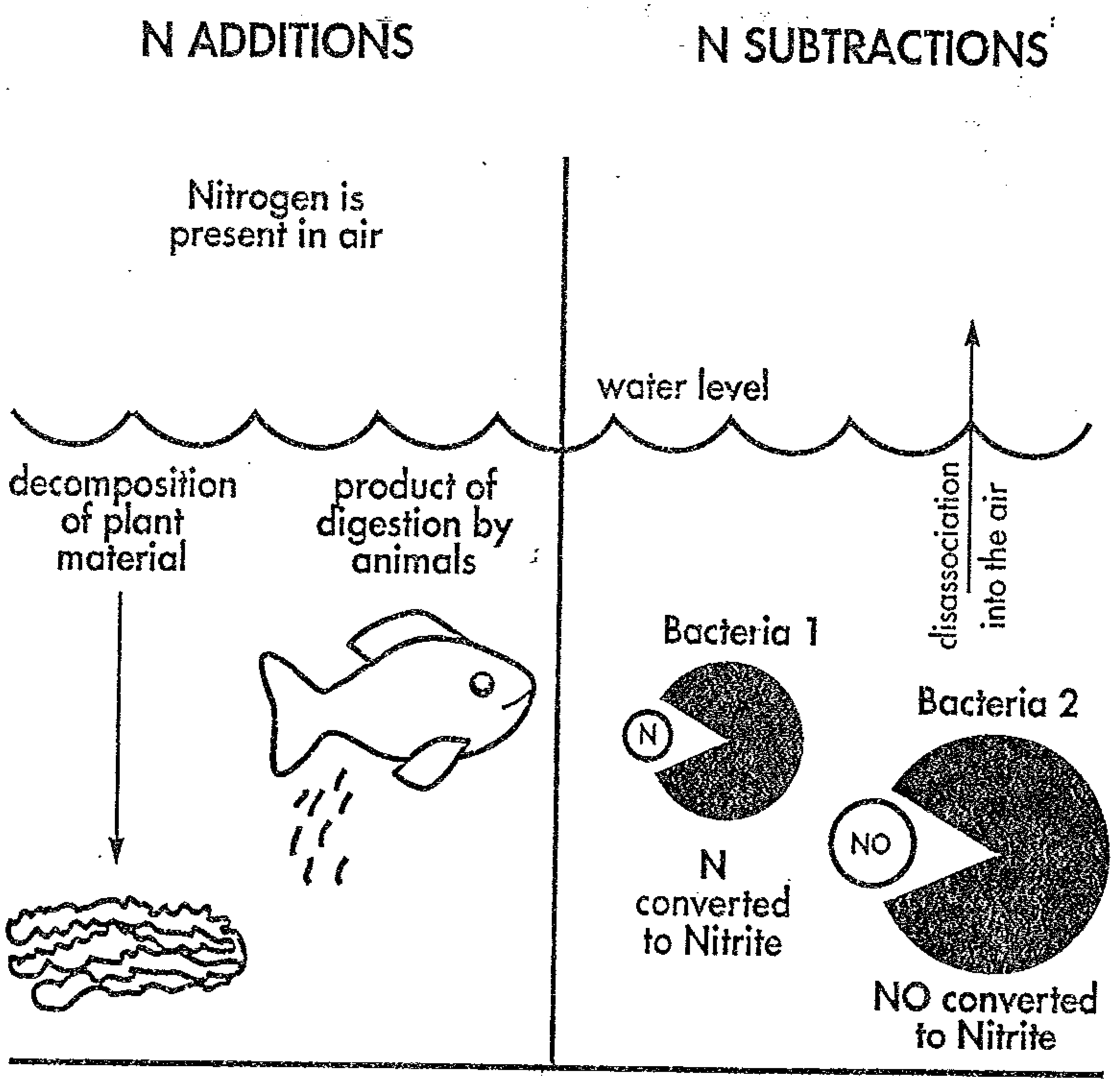
Production Of Ammonia

- Decomposition of uneaten feed
- Animal wastes
- Decomposition of plants

Management Practices To Control Ammonia

- Don't overfeed
- Don't Over-populate
- Use Biofilters
- Aeration

Nitrogen/Ammonia Cycle



High Ammonia Levels May

- Kill Fish
- Damage the tissue of the fish
- Create metabolism problems
- Damage internal organs
  - Kidneys
  - Gills

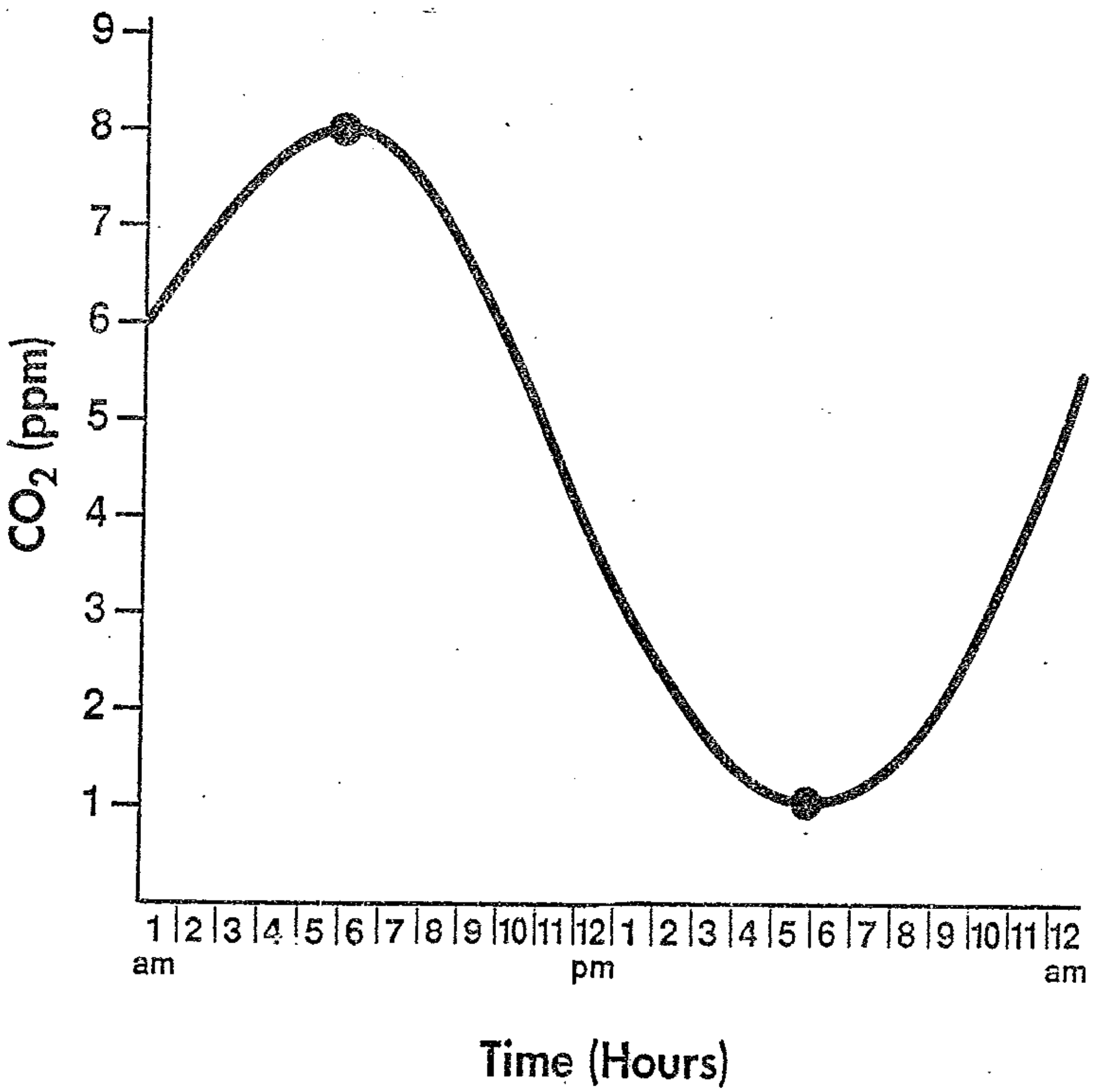
Types Of Aeration

- Mechanical
- Injecting air into water
- Injecting oxygen directly into the water

Carbon Dioxide

- Results from decay of organic matter
- Aerating of the water will help remove carbon dioxide

Carbon Dioxide Cycle



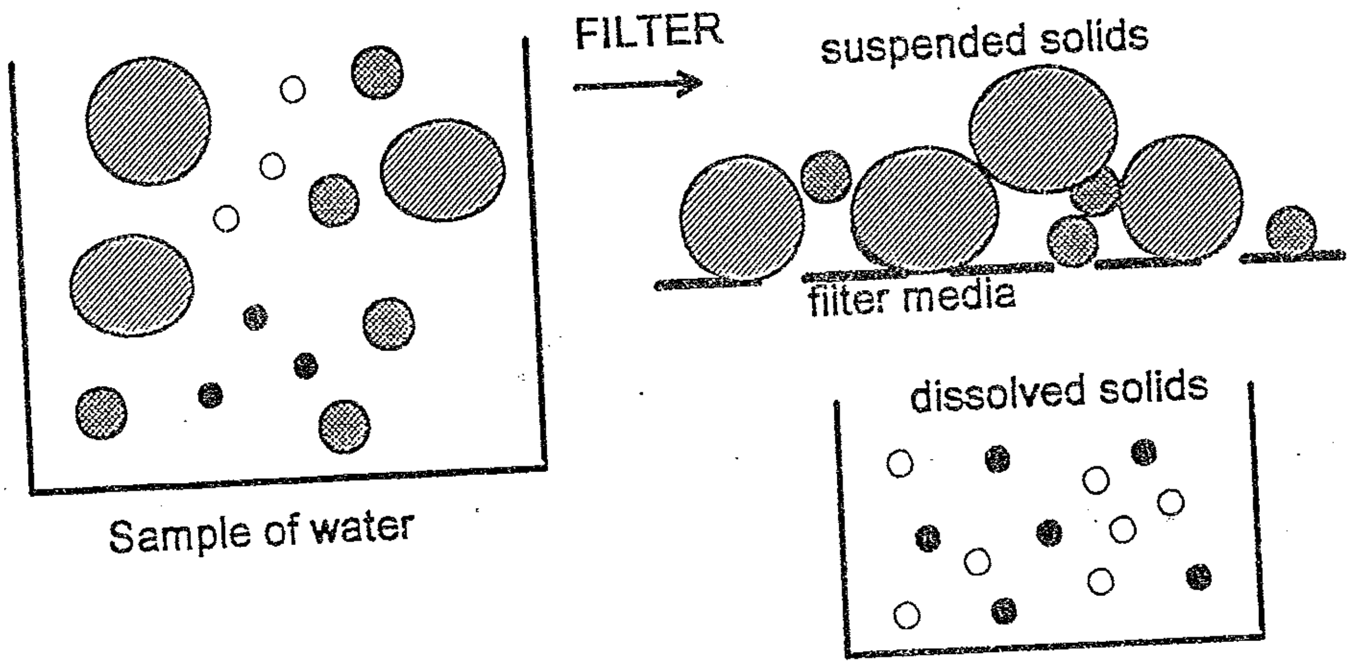
Solids In Water

- Everything in the water that is not gas or water

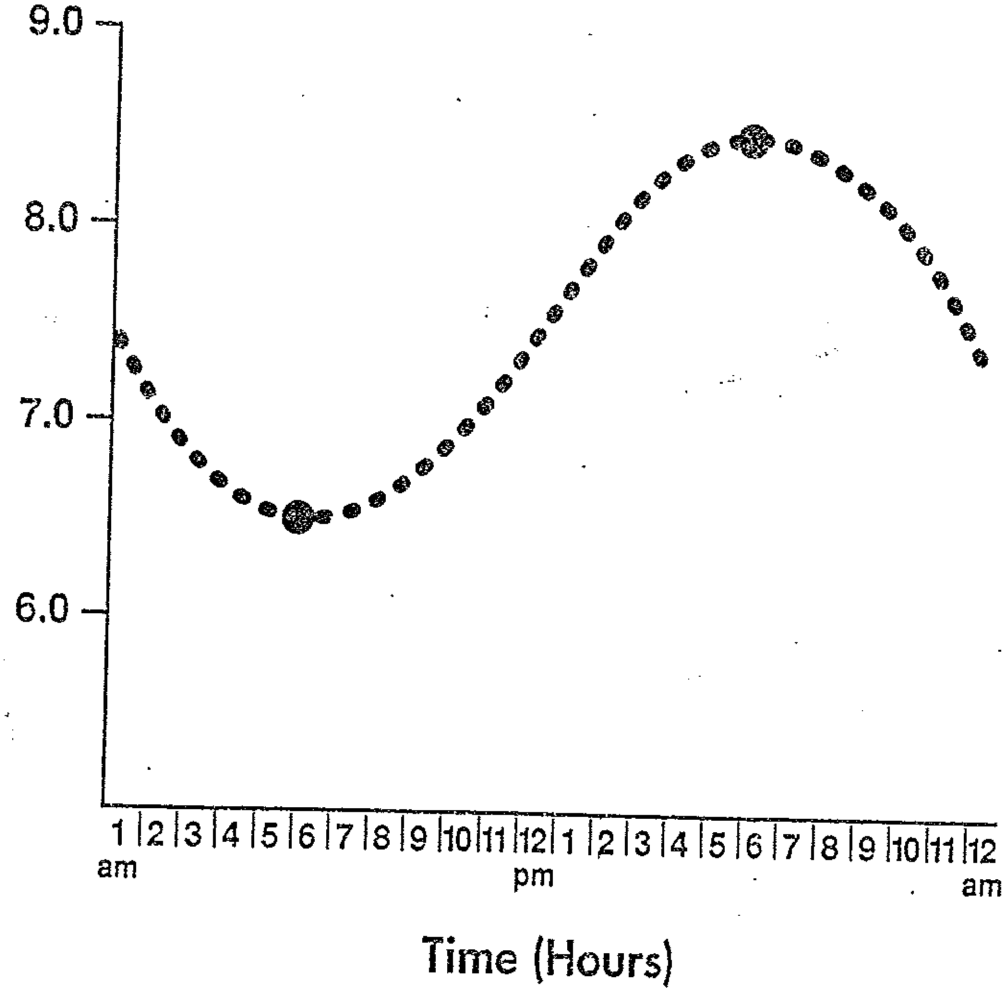
Types Of Solids:

- Suspended Solids -
  - Material in the water that will not pass through a filter of a specified pore size
  - Will make the water turbid or cloudy
  - Will cut down on light transmission through the water, and
  - If present in large concentrations can settle out and smother fish eggs, bottom organisms that fish feed on or can inhibit the fish's ability to see and find food
- Dissolved Solids
  - Those solids that remain after a filtered water sample is evaporated
  - Will not cloud the water
  - High concentrations are usually not stressful
  - Rapid changes in concentration may be stressful
- Total
  - Suspended and dissolved

Diagram Of Solids In Water



pH Cycle


9.0
8.0
7.0
6.0
1 am
2
3
4
5
6
7
8
9
10
11
12 pm
1
2
3
4
5
6
7
8
9
10
11
12 am
Time (Hours)

Water Management Practices To Improve Water

- Avoid overfeeding aquacrops
- Monitor dissolved oxygen
- Use good water
- Control unwanted organisms
- Prevent runoff from entering facilities
- Add water to improve quality

Maintaining Water Quality

- **Problem:**
  - pH (too high or too low)
- **Solution:**
  - Raise pH by adding limestone (caution: Know hardness)
  - Control vegetation
  - Add buffers

Maintaining Water Quality

- **Problem:**
  - Low DO
- **Solution:**
  - Aerate water
  - Flushing
  - Reduce biomass
  - Feed properly

Maintaing Water Quality

- **Problem:**
  – Dissolved gas (supersaturation)
- **Solution:**
  – Aerate water
  – Baffling (Flowing water over baffles)
  – Oxygen injection

Problems From Aquaculture Pollution

- Dead fish and other organisms
- Eutrophication
- Genetic pollution
- Repulsive odors
- Aesthetic pollution

Aquaculture Discharge Considerations

- Department of Natural Resources (DNR) sets discharge limitations for aquaculture operations
- Limitations depend upon two main factors:
  - Location of the discharge - Type of receiving water is critical
  - Type of aquaculture system and the expected chemical nature of the discharge
- Major considerations for discharge quality:
  - If is unhealthy for the fish in the aquaculture system, it is probably unhealthy for the fish and other aquatic life in the receiving water
  - Primary components of concern in the receiving water are:
    - Nutrients, phosphorus, and nitrogen compounds
    - Solids
    - Oxygen depleted water or water that will deplete the oxygen of the receiving water (Biochemical Oxygen Demand)
    - Drugs or chemicals used to treat the fish or fish diseases

Wastewater Pollutants

- Uneaten food
- Fish wastes
- Algae
- Chemical treatments
- Sediments

Wastewater Disposal Concerns

- Environmental concerns
- Obey laws and regulations
- Costs
- Facility design

Treating And Disposing Of Wastewater

- Settling ponds
- Percolation ponds
- Injection wells
- Use for irrigation
- Filtering systems
- Chemical additives

Calculating Water Volume

- **Rectangular Tanks**
  - Formula:
    - Volume In Cubic Feet = length x width x height

  - Example:
    - A tank 75 feet long, 6 feet wide, and 4 feet deep contains how many gallons of water?

    Volume = 75 x 6 x 4 = 1800 Cubic Feet

    Convert cubic feet to gallons by multiplying by 7.481

    1800 cubic feet
    x 7.481 gallons/ cubic foot
    13,465 gallons of water

Calculating Water Volume

- **Round Tanks**
  - Formula:
    - Volume In Cubic Feet = 3.14 x radius squared x depth
    - Remember that radius = diameter/2

  - Example:
    - A tank 16 feet in diameter has a water depth of 6 feet deep, what is the volume?

$$\text{Volume} = 3.14 \times \left(\frac{16}{2}\right)^2 \times 4 = 803.84 \text{ Cubic Feet}$$

Convert cubic feet to gallons by multiplying by 7.481

  803.84 cubic feet
x 7.481 gallons/cubic foot
  6,020 gallons of water

Demonstration Activities With Water

Demonstration 1: Water as a solvent

Take a glass and fill it with water. Add two teaspoons of sugar to the glass of water. Ask students the following questions.

Questions:
1. What happened to the sugar? Why.
2. Identify which of the components is the solvent? Solute?

Demonstration 2: Saturated solution vs. Unsaturated solution

Take two glasses and fill them with water. Add two teaspoons of sugar to one glass and two teaspoons of common table salt to the other glass. Have the students observe what happens in each glass.

Questions:
1. Why does the sugar dissolve while not all the salt dissolved?
2. What does this mean?
3. What are these solutions called?

Demonstration 3: Dissolved oxygen content in water

Using a dissolved oxygen test kit or a dissolved oxygen meter compare dissolved oygen levels from various sources of water. Some suggested samples of water would be water near the top of a pond, tank, or aquarium, water near the bottom of a pond, tank or aquarium, water that has been aerated, water that has not been aerated, warm water, and cold water. After conducting these test compare the amounts of dissolved oxygen and discuss why the results vary from sample to sample.

Discussion Activity On Water Temperture

Referring to the definition of specific heat the students should be aware that water has a very high specific heat. Lead a discussion on how this affects aquaculture and the production of fish. You want to lead the group towards specific areas of discussion such as economics of heating water, how you would heat the water, fish species selection based on water temperture requirements, and how can we deal with the problem of needing warm water for certain fish in Wisconsin.

Name______________________________

Water Volume Worksheet

Formulas: Volume of round tank = 3.14 x (Radius) x Depth
Volume of rectangluar tank = l x w x water depth
There are 7.481 gallons of water per cubic foot

Calculate the volume of water in total gallons for each structure.

1. Round tank 8 feet in diameter and a water depth of 4.5 feet. How many gallons of water are in this tank?

2. Round tank 5.5 feet in diameter and a water depth of 2.5 feet. How many gallons of water are in this tank?

3. Pond that is 45 feet wide, 300 feet long and has an average depth of 8 feet. How many gallons of water are in this pond?

4. Rectangular tank that is 4 feet wide, 40 feet long, and has 2.5 feet of water. How many gallons of water are in this tank?

5. Rectangular tank that is 6 feet wide, 100 feet long, and has 4 feet of water. How many gallons of water are in this tank?

6. Round tank that is 7.25 feet in diameter and has 6 feet of water. How many gallons of water are in this tank?

Water Testing Activity

Using the directions from a water test kit the students are to test a given sample of water for temperture, pH, ammonia, and nitrite. Use the conversion chart to convert the ammonia reading to un-ionized ammonia. For a given species of fish with the exception of Ammonia indicate if each is in the safe range or not. If the reading is unsafe then give suggestions under Management Needed to correct the problem. Another option is for the student to take water test over a given period of time to see how water quality will vary and how this fluxation relates to management issues taking place in the tank or aquarium.

Fish Species:__________________ Date:__________________

		Safe	Unsafe	Management Needed
Temperture in °C	____	____	____	____________
pH	____	____	____	____________
Ammonia	____	____	____	____________
Nitrite	____	____	____	____________
Un-ionized Ammonia	____	____	____	____________

Water Quality Tolerance Guidelines

	Temp.	D.O. mg/l	pH Units	Alkalinity mg/l	CO2 mg/l	Un-ionized Ammonia mg/l	Nitrite mg/l	Hardness mg/l	Chloride mg/l	Salinity ppt
Trout/Salmon	45 - 68°F 7 - 20°C	5 - 12	6 - 8	50 - 250	0 - 20	0 - .03	0 - .6	50 - 350	0 - 1500	0 - 3
Walleye/Perch	50 - 65°F 10 - 18°C	5 - 10	6 - 8	50 - 250	0 - 25	0 - .03	0 - .6	50 - 350	0 - 2500	0 - 5
Sunfishes	60 - 80°F 16 - 27°C	4 - 10	6 - 8	50 - 250	0 - 25	0 - .03	0 - .6	50 - 350	0 - 2000	0 - 4
Hybrid Striped Bass	70 - 85°F 21 - 29°C	4 - 10	6 - 8	50 - 250	0 - 25	0 - .03	0 - .6	50 - 350	0 - 1500	0 - 3
Tilapia	75 - 90°F 24 - 32°C	3 - 10	6 - 8	50 - 250	0 - 30	0 - .03	0 - .7	50 - 350	0 - 5000	0 - 10
Catfish Carp	65 - 80°F 18 - 27°C	3 - 10	6 - 8	50 - 250	0 - 25	0 - .03	0 - .7	50 - 350	0 - 4000	0 - 8
Goldfish/Koi	65 - 75°F 18 - 24°C	4 - 10	6 - 8	50 - 250	0 - 25	0 - .03	0 - .6	50 - 350	0 - 2000	0 - 4
Minnows Shiners	60 - 75°F 16 - 24°C	4 - 10	6 - 8	50 - 250	0 - 25	0 - .03	0 - .6	50 - 350	0 - 2500	0 - 5
Shrimp (Freshwater)	68 - 80°F 20 - 27°C	4 - 10	6.5 - 9	60 - 100	0 - 20	0 - .05	0 - .9	60 - 250	0 - 1500	0 - 3
Shrimp (Saltwater)	60 - 75°F 16 - 24°C	4 - 10	6 - 8	50 - 250	0 - 15	0 - .01	0 - .1	50 - 350	13,000 - 18,000	15 - 35
Mussels (Freshwater)	40 - 50°F 4 - 10°C	4 - 10	6 - 8	50 - 250	0 - 20	0 - .02	0 - .3	50 - 350	0 - 500	0 - 1
Sturgeon	50 - 70°F 10 - 21°C	4 - 10	6 - 8	50 - 250	0 - 25	0 - .03	0 - .6	50 - 350	0 - 2000	0 - 4
Tropical Fish	72 - 84°F 22 - 29°C	4 - 10	6 - 8	50 - 250	0 - 20	0 - .03	0 - .5	50 - 350	0 - 2500	0 - 5
Snails	60 - 80°F 16 - 27°C	3 - 8	6 - 8	50 - 250	0 - 20	0 - .02	0 - .6	50 - 350	0 - 2000	0 - 1
Fresh H_2O Plants	60 - 65°F 16 - 18°C	3 - 6	6 - 7	25 - 150	---	0 - 2	0 - .5	25 - 150	0 - 50	0 - .5

Notes: - Fish will excrete about 14 grams of ammonia for each pound of food eaten. (Feed considered at 35% protein.)

- Some species are also sensitve to nitate above 40ppm.

- To convert ppm total ammonia from test to ppm un-ionized ammonia use the Percentage Of Un-Ionized Ammonia Conversion Chart.

Percentage Of Un-Ionized Ammonia In Water At Different pH's and Temperatures

Temp (C)	pH 6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0
0	.00827	.0261	.0826	.261	.820	2.55	7.64	20.7	45.3
1	.00899	.0284	.0898	.284	.891	2.77	8.25	22.1	47.3
2	.00977	.0309	.0977	.308	.965	3.00	8.90	23.6	49.4
3	.0106	.0336	.106	.335	1.05	3.25	9.60	25.1	51.5
4	.0115	.0364	.115	.363	1.14	3.52	10.3	26.7	53.5
5	.0125	.0395	.125	.394	1.23	3.80	11.1	28.3	55.6
6	.0136	.0429	.135	.427	1.34	4.11	11.9	30.0	57.6
7	.0147	.0464	.147	.462	1.45	4.44	12.8	31.7	59.5
8	.0159	.0503	.159	.501	1.57	4.79	13.7	33.5	61.4
9	.0172	.0544	.172	.542	1.69	5.16	14.7	35.3	63.3
10	.0186	.0589	.186	.586	1.83	5.56	15.7	37.1	65.1
11	.0201	.0637	.201	.633	1.97	5.99	16.8	38.9	66.8
12	.0218	.0688	.217	.684	2.13	6.44	17.9	40.8	68.5
13	.0235	.0743	.235	.738	2.30	6.92	19.0	42.6	70.2
14	.0254	.0802	.253	.796	2.48	7.43	20.2	44.5	71.7
15	.0274	.0865	.273	.859	2.67	7.97	21.5	46.4	73.3
16	.0295	.0933	.294	.925	2.87	8.54	22.8	48.3	74.7
17	.0318	.101	.317	.996	3.08	9.14	24.1	50.2	76.1
18	.0343	.108	.342	1.07	3.31	9.78	25.5	52.0	77.4
19	.0369	.117	.368	1.15	3.56	10.5	27.0	53.9	78.7
20	.0397	.125	.396	1.24	3.82	11.2	28.4	55.7	79.9
21	.0427	.135	.425	1.33	4.10	11.9	29.9	57.5	81.0
22	.0459	.145	.457	1.43	4.39	12.7	31.5	59.2	82.1
23	.0493	.156	.491	1.54	4.70	13.5	33.0	60.9	83.2
24	.0530	.167	.527	1.65	5.03	14.4	34.6	62.6	84.1
25	.0569	.180	.566	1.77	5.38	15.3	36.3	64.3	85.1
26	.0610	.193	.607	1.89	5.75	16.2	37.9	65.9	85.9
27	.0654	.207	.651	2.03	6.15	17.2	39.6	67.4	86.8
28	.0701	.221	.697	2.17	6.56	18.2	41.2	68.9	87.5
29	.0752	.237	.747	2.32	7.00	19.2	42.9	70.4	88.3
30	.0805	.254	.799	2.48	7.46	20.3	44.6	71.8	89.0

Source: Emerson, etal.(1975), J. Fish. Res. BD. Can. 32(12)

Formula For Converting Ammonia To Unionized Ammonia:

$$\frac{\text{Number From Chart} \times \text{Amount Ammonia From Test}}{100} = \text{Unionized Ammonia}$$

Methods Of Moving Water

- Gravity
- Electric-powered pumps
- Engine-powered pumps
- Air-lift pumps

Moving Water By Gravity

- Advantages
  - Lowest cost method
  - No moving parts
- Disadvantages
  - Cannot move water up hill

Moving Water By Electric Pump

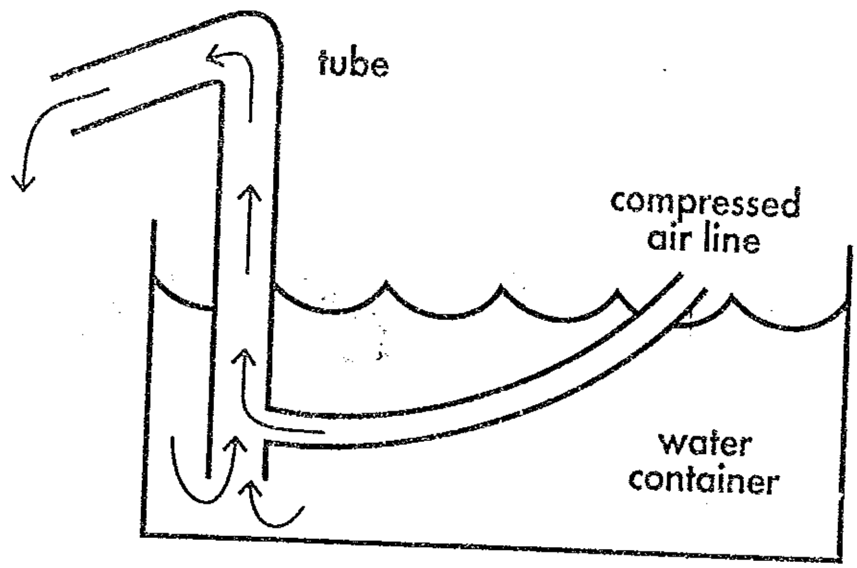
- Many types available
- Used in wells to bring water to the surface and used to move and recirculate water
- Range from one to several thousand gallons per minute
- Advantages
  - Efficient
  - Quiet
- Disadvantage
  - Must be near electricity

Moving Water By PTO Pumps

- Can be run by a tractor or individual engine mounted with pump
- Generally pump over 100 gallons per minute
- Advantage
  - Portable and can be used where electricity is not available
- Disadvantages
  - Less efficient than electric pumps
  - Creates noise and air pollution

Moving Water By Air Lift Pumps

- How Air Lift Pumps Work
  - Compressed air is forced up the tube drawing water with it



- Advantages
  - Quiet
  - Aerates water
- Disadvantage
  - Will not lift water more than a few feet

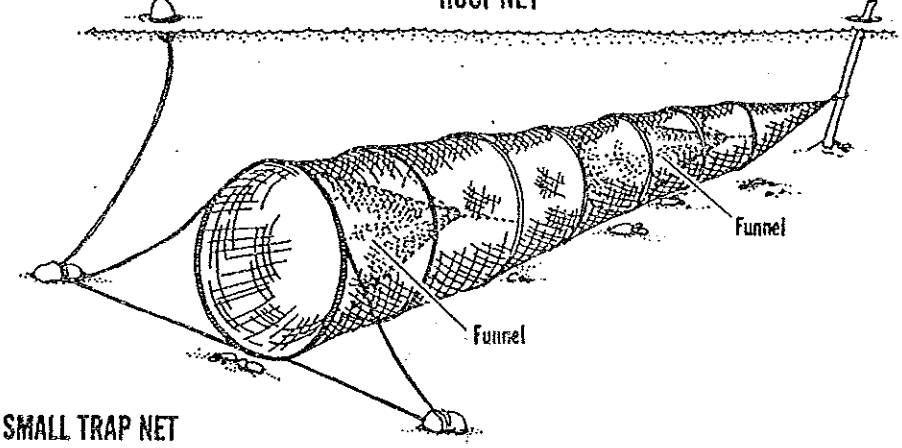
Capture

Fish Capture Techniques

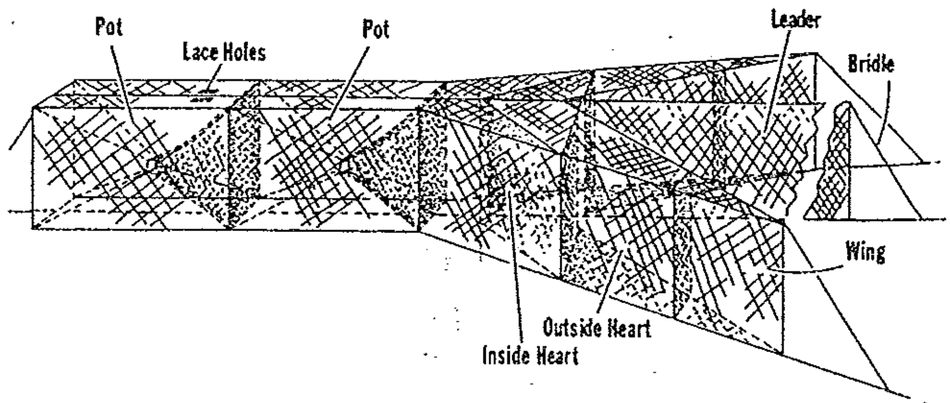
- Passive Capture Gear
  - Capture of fish or other aquatic animals by entanglement or entrapment in devices not actively moved by man or machine
- Groups Of Passive Gear
  - Entanglement
    - Capture animal by holding them ensnared in a fabric net
  - Types of entanglement
    - Gill nets
      - Considered a shallow water gear
    - Trammel Nets
- Entrapment
  - Capture organisms which enter an enclosed area through one or more funnel or V-shaped openings and cannot find a means of escape
  - Types of entrapment
    - Hoop nets
    - Trap nets
    - Pot devices
    - Weirs

Passive Capture Gear

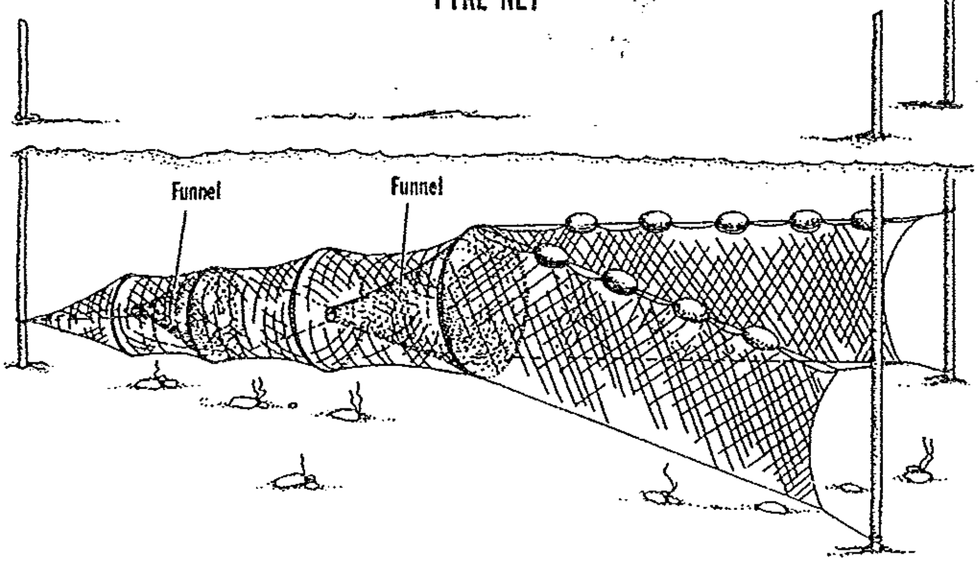
HOOP NET



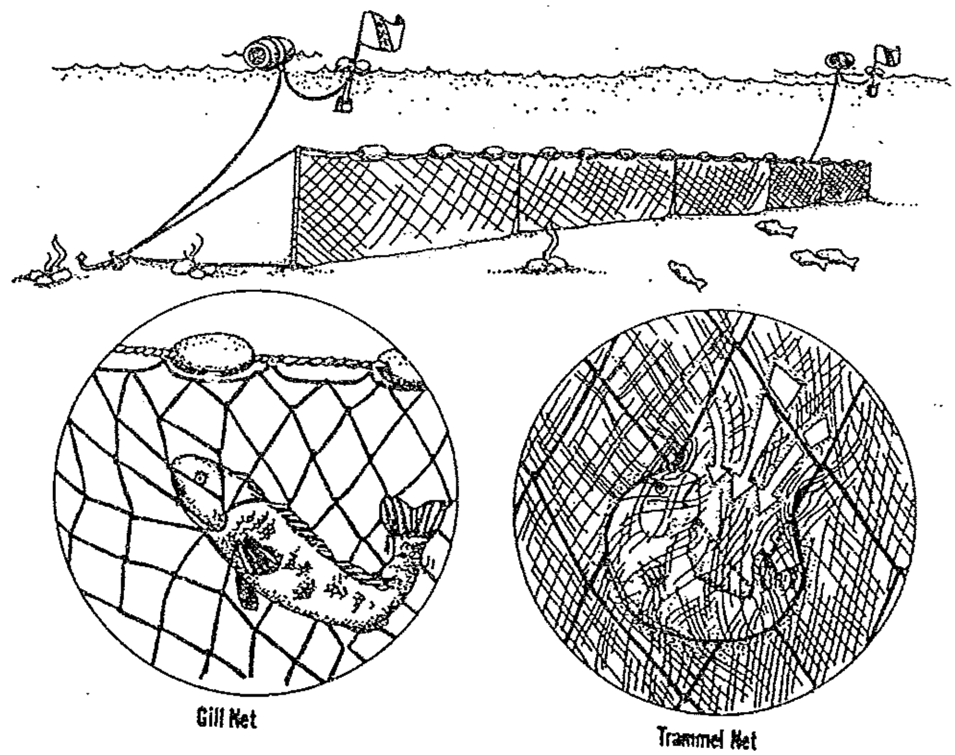
SMALL TRAP NET



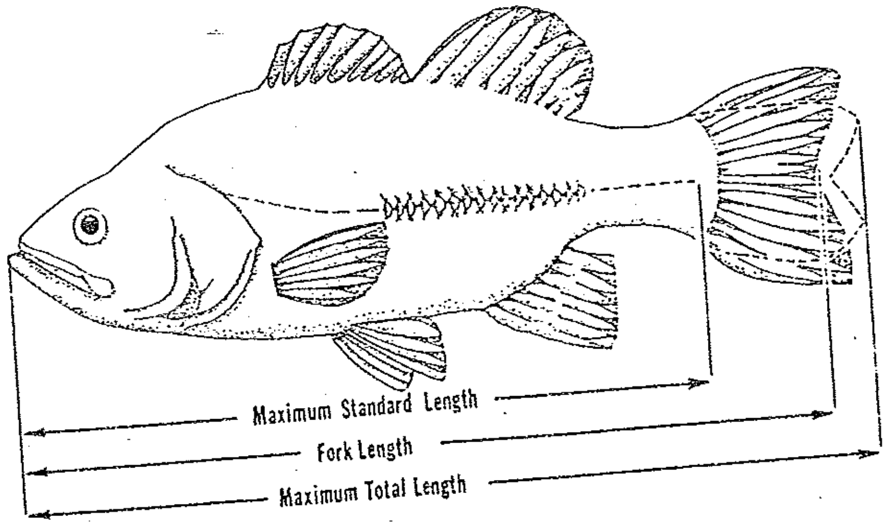
FYKE NET



Passive Capture Gear



Fish Lengths



Fish Metabolism And Growth

Temperature

- Influences metabolism of organisms
- Expensive to regulate
- Select species adapted to available water
- Water has a high heat capacity
- Temperture affects feeding, reproduction, and metabolism of aquatic animals

Ectothermic Animals

- Body temperture same as environment
- No energy used to regulate body temperture
- Energy goes to growth

Factors In Growth Of Aquacrops

- Temperture
- Population density
- Oxygen level
- Water quality
- Food and nutrition
- Light

Population Density

- Number of organisms that exist in a given area
- High density used with intensive systems
- Intensive culture systems require careful management
- Limiting factors are oxygen, food, temperature, and water quality

Body Density

- Fish and crustaceans near that of water
- Less energy to support weight
- More energy for growth

Productive Characteristics Of Aquacrops

- Ectothermic animals
- Body density is similar to habitat
- Save energy in getting food
- Multi-dimensional environment
- More rapid growth rate
- More efficient feed conversion

Efficient Feed Conversion

- Ratio of feed to gain is conversion
- Aquatic species more efficient than terrestrial species
  - Fish = 1 to 4 pounds of feed to 1 pound gain
  - Beef Cattle = 4 to 8 pounds of feed to 1 pound of gain

Growth Rate

- Time and resources required for an aquacrop to reach a certain stage of development
- Goal is to maximize growth and minimize inputs

Fish Anatomy And Internal Systems

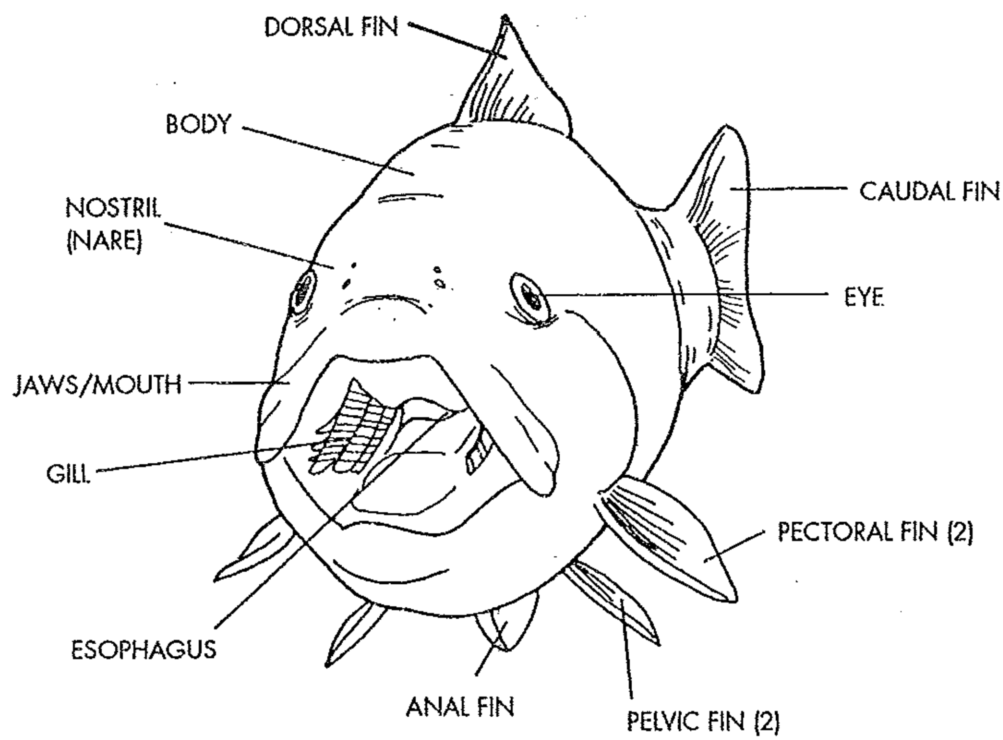
Aquaculture Animal Systems

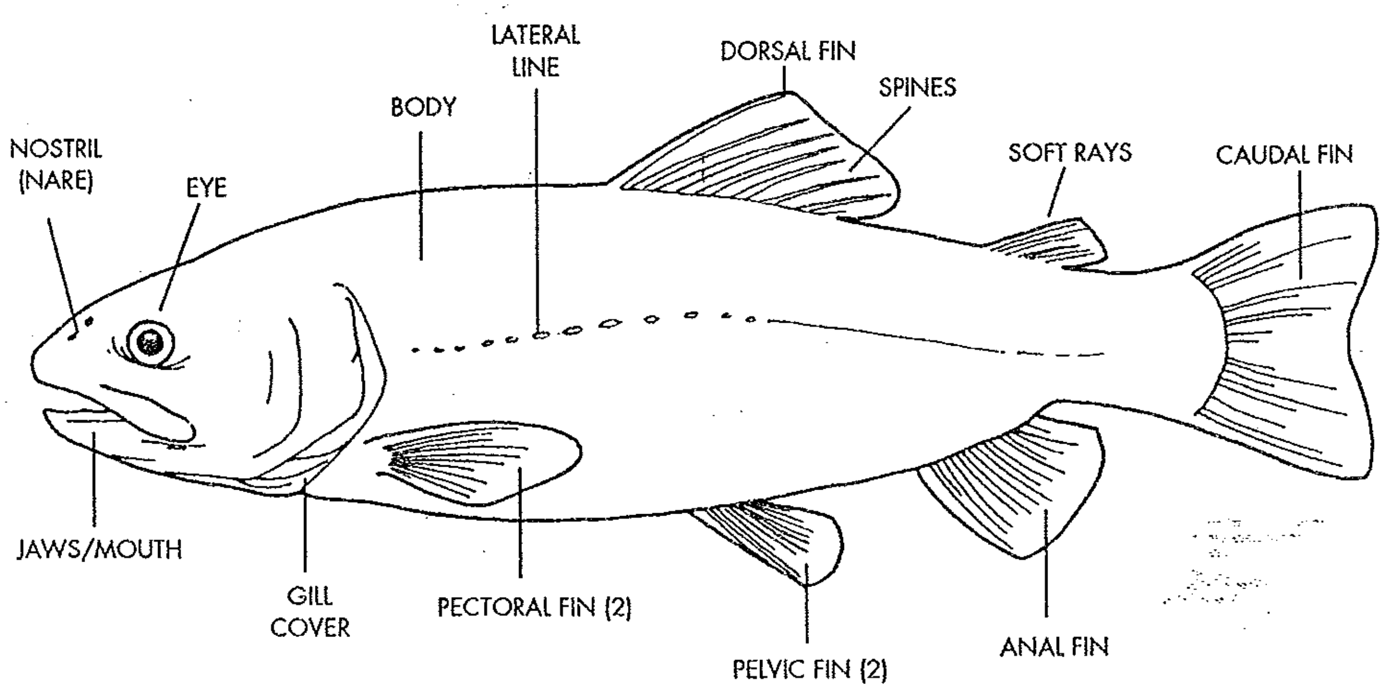
- Skeletal system - provides framework for organism
- Muscular system - provides internal and external body movement
- Digestive system - converts food into a form that can be used
- Excretary system - eliminates wastes from organism
- Respiratory system - provides oxygen to tissues and cells and removes carbon dioxide
- Circulatory system - circulates blood throughout the body
- Nervous system - conveys sensation impulses between brain and body parts
- Sensory system - provides contact with environment through senses
- Reproductive system - generates new organisms of the same species

Finfish

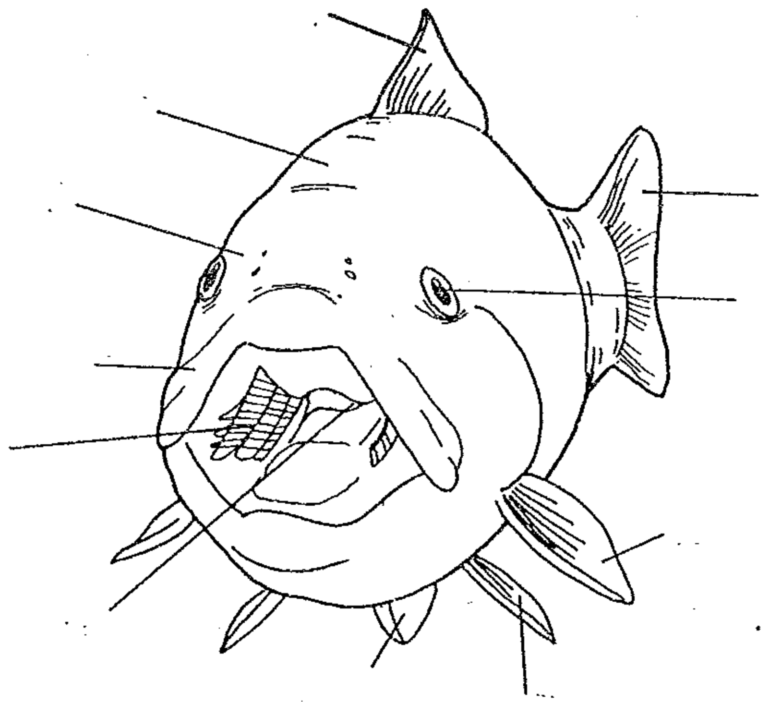
- Bony with hard, calcium based, internal skeletons
- Exterior covering
  - Skin
  - Skin with scales
- Gills remove oxygen from water
- Developed digestive system
  - Algae and detrital eaters (small stomach - long gut)
  - Carnivores (large stomach - short gut)
- Reproduce with eggs and sperm

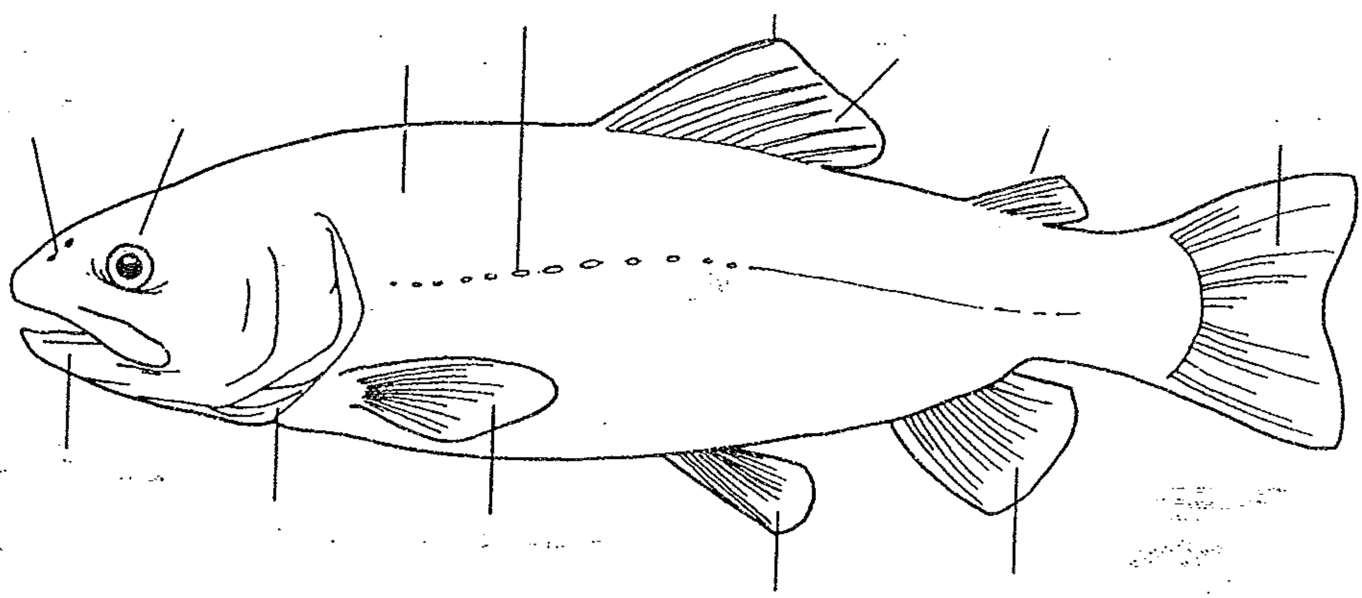
External Anatomy Of Finfish



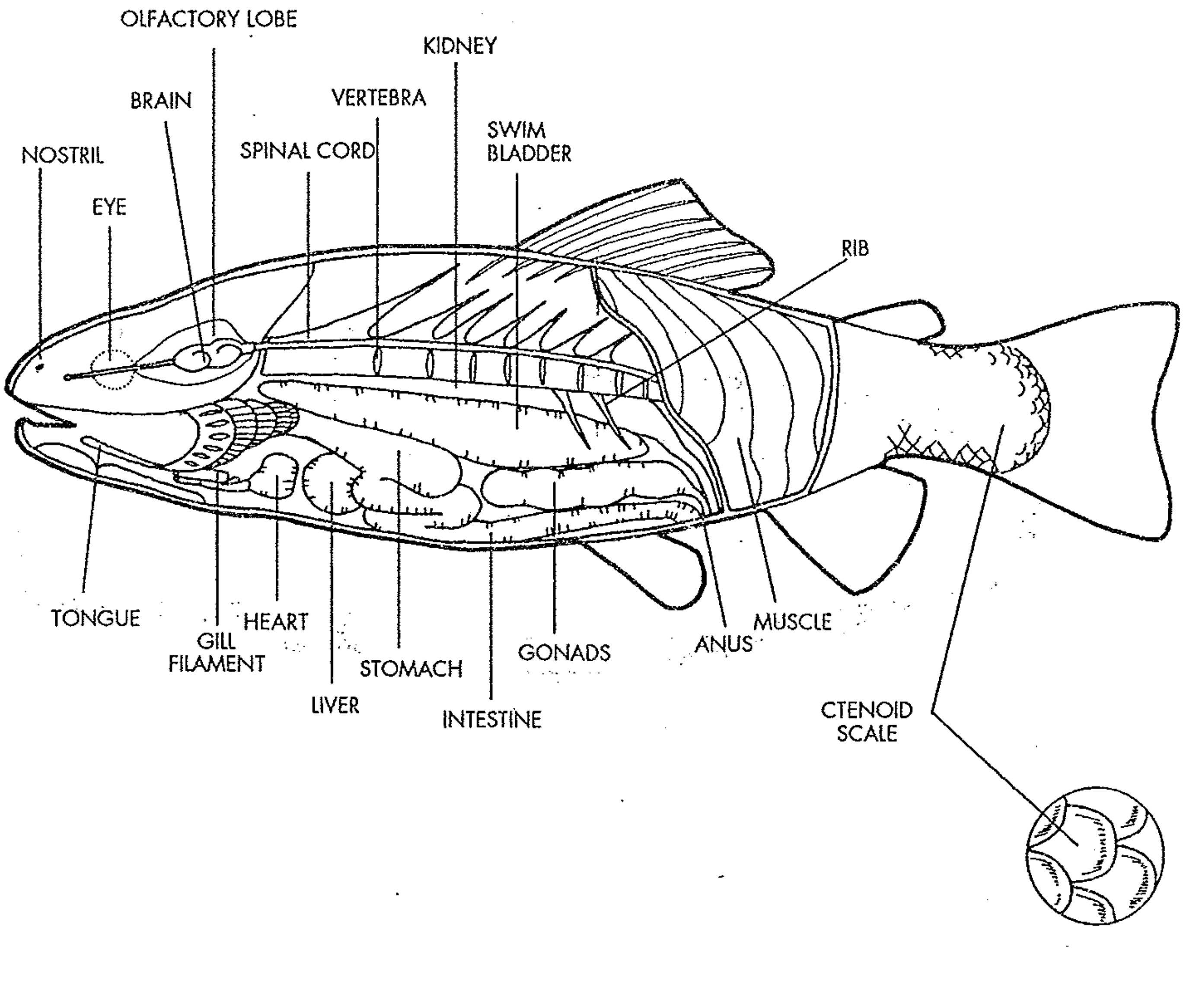


External Anatomy Of Finfish

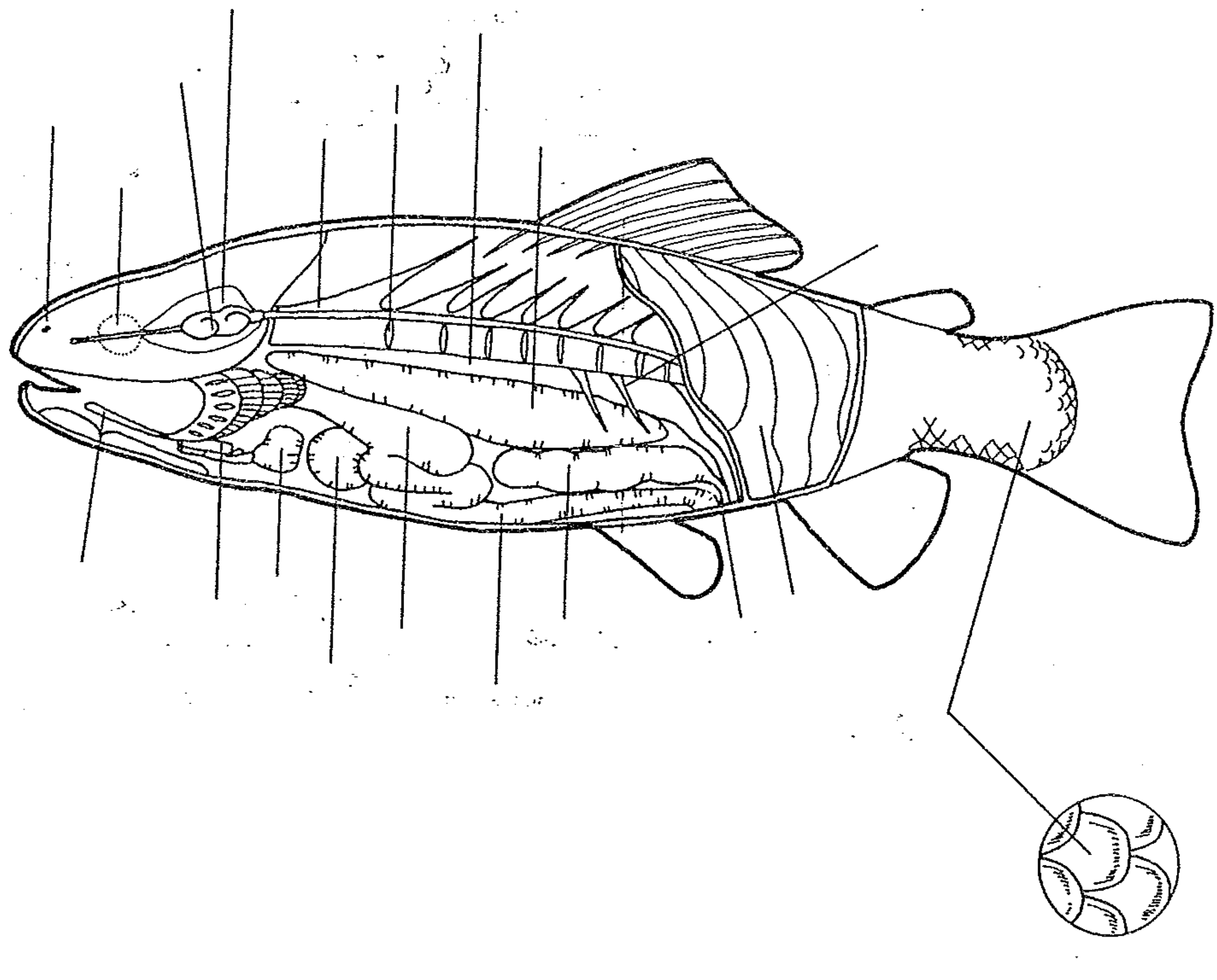




Internal Anatomy Of Finfish



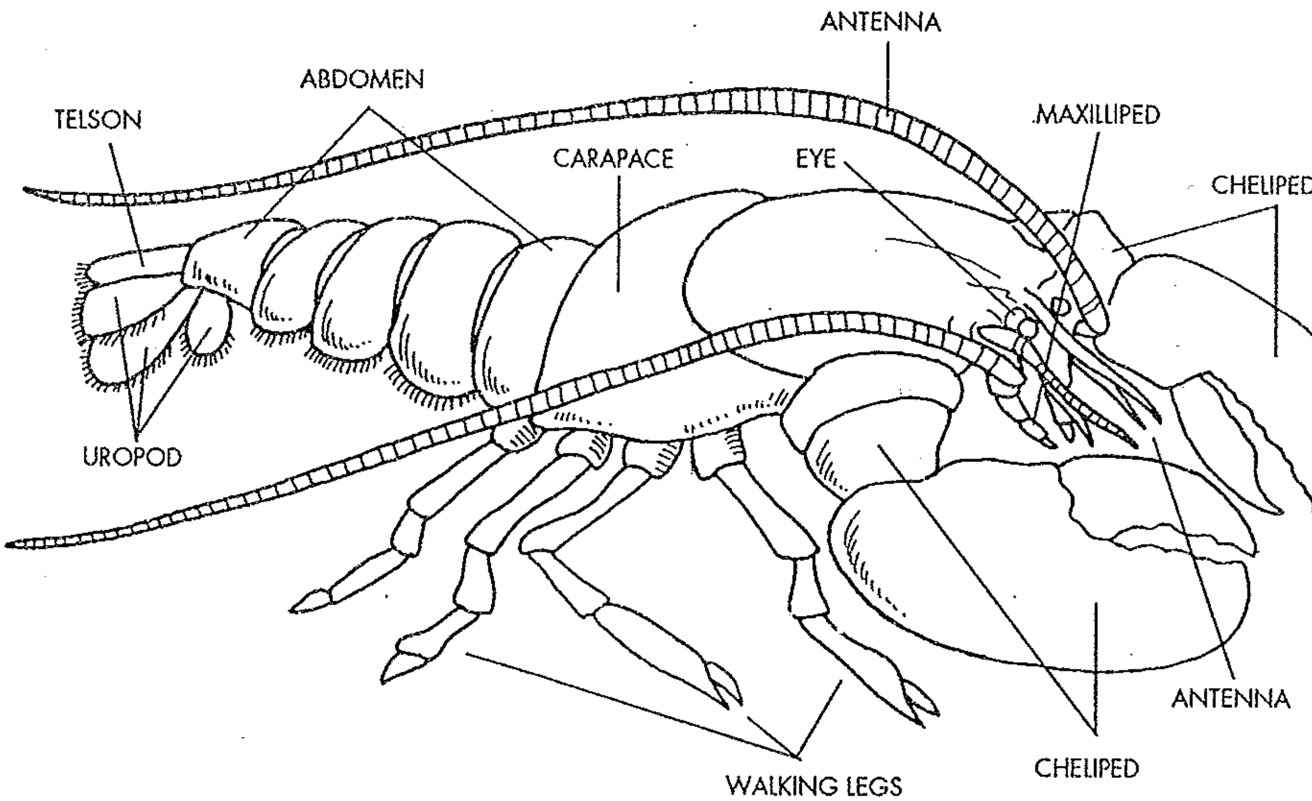
Internal Anatomy Of Finfish



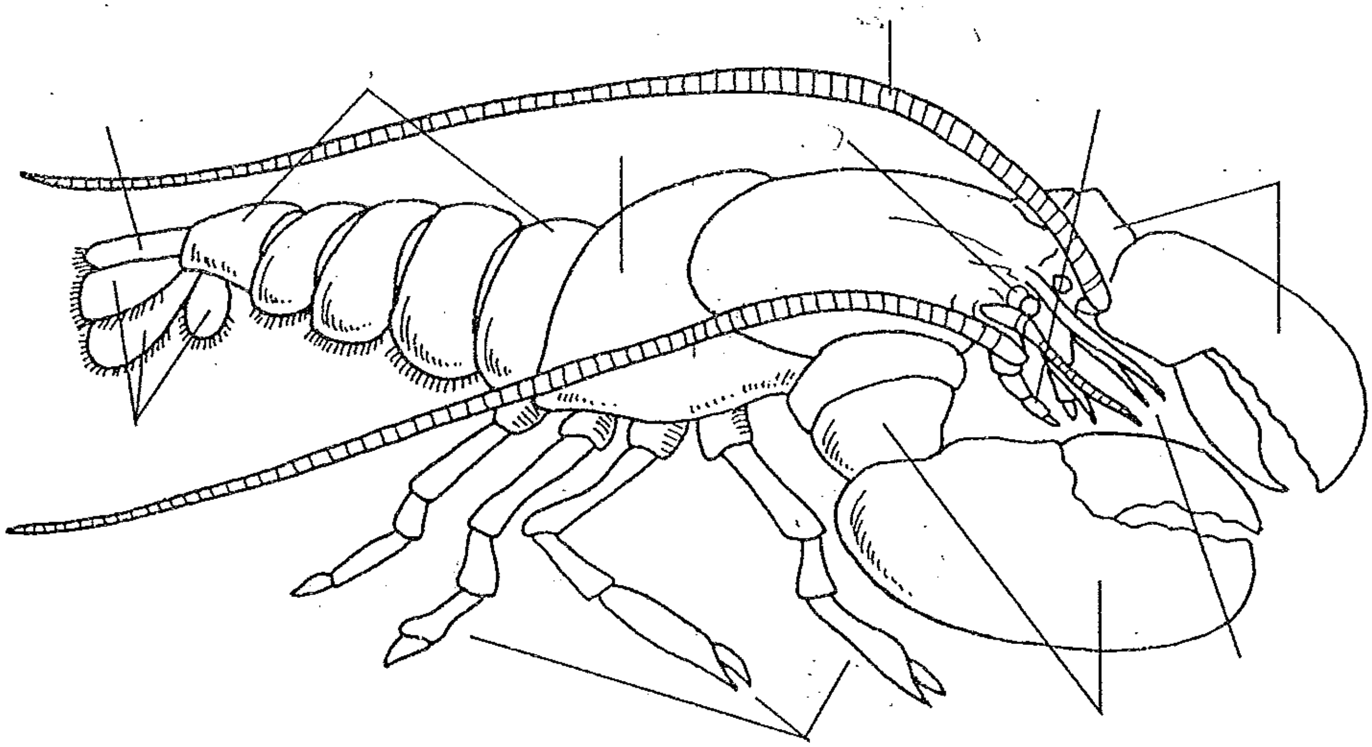
Crustaceans

- Aquatic animals with exoskeletons
  - Skeleton made of chitinous material
- Examples:
  - Shrimp
  - Crawfish
  - Lobster
  - Prawns
- Three body sections:
  - head
  - thorax
  - abdomen
- Can regenerate appendages

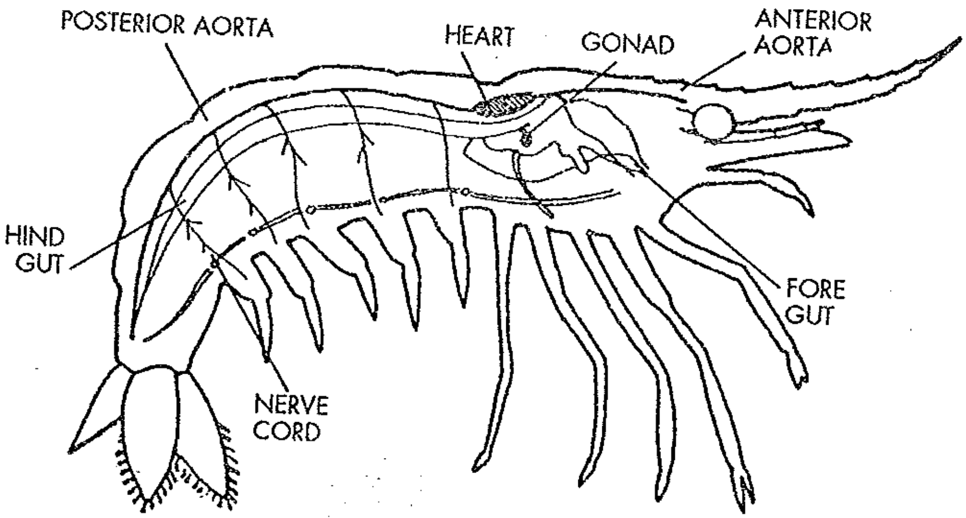
External Anatomy Of Lobster



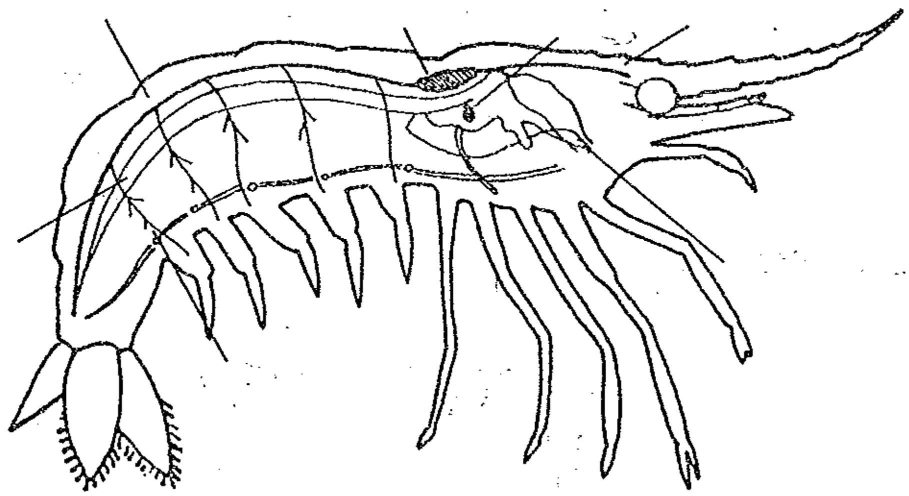
External Anatomy Of Lobster



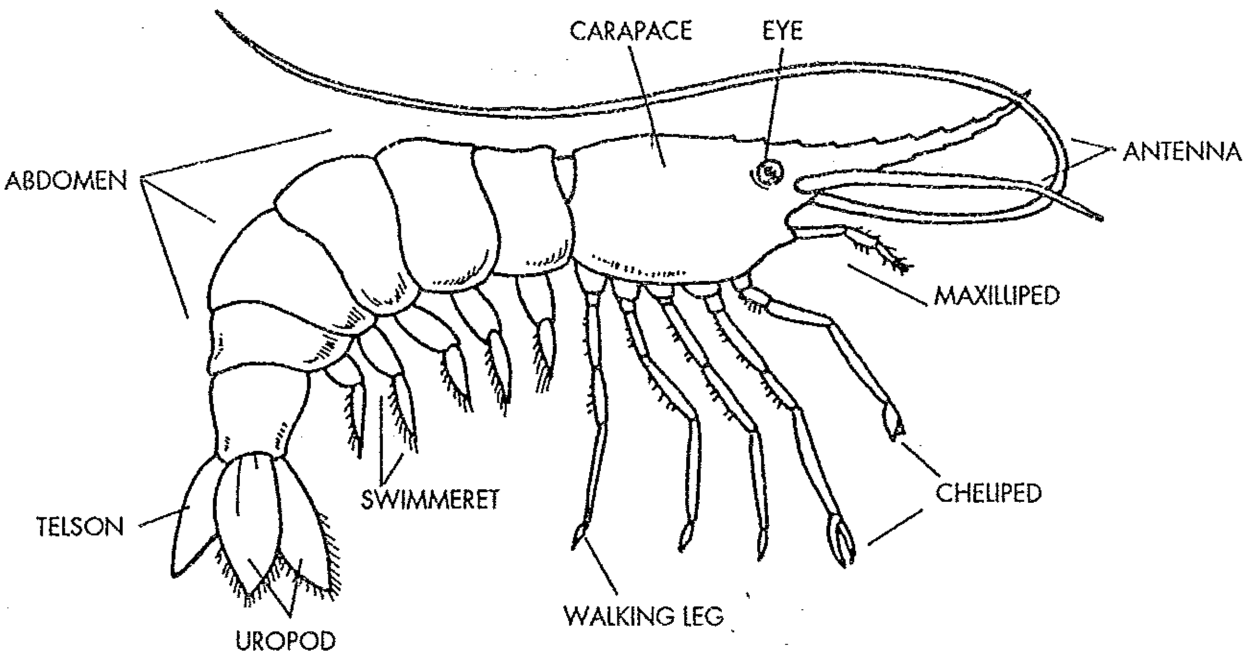
External Anatomy Of Shrimp



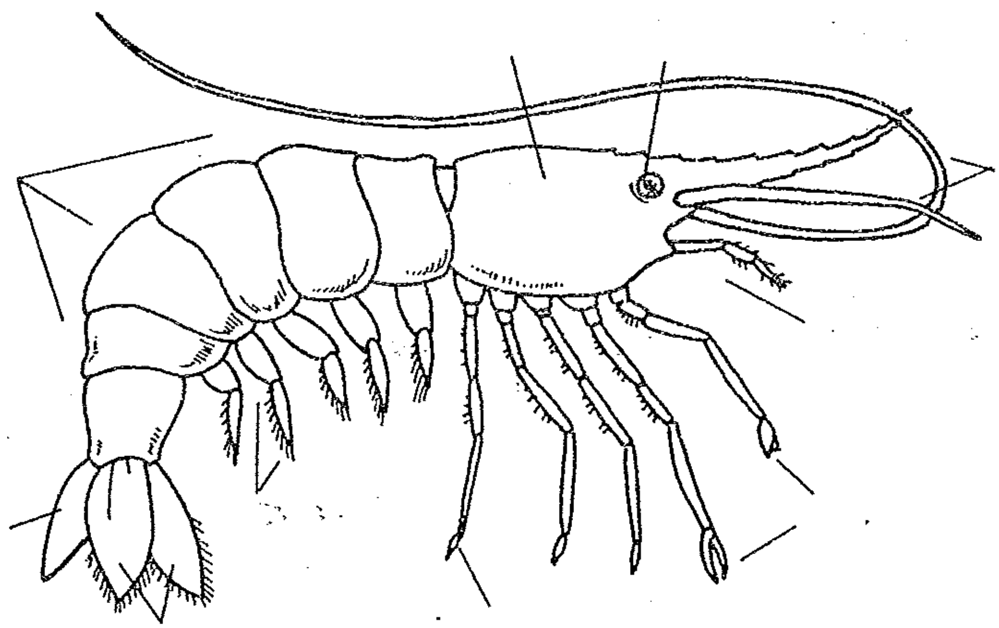
External Anatomy Of Shrimp



Internal Anatomy Of Shrimp



Internal Anatomy Of Shrimp



Mollusks

- Bivalues have two-part shells that can completely enclose the animal
- Examples include:
  - Oysters
  - Mussels
- Shell is calcareous
- Anchor in the water
- Filter feeders
- Reproduce with eggs and water-borne sperm

Algae

- Macro - large forms
  - attach to substrate
  - function similarly to plants with stems
- Micro - small forms
  - important as food for larval fish, crustaceans, and molluscs

Wisconsin Fish Species

Regulations

Types of Wisconsin Fish Hatchery Licenses

- Class A
- Class B
- Class C
- Class D

Class A License

- An artificial fish hatchery facility producing eggs and/or fish for sale or trade
- Hatches eggs or rears fish produced for sale or trade
- Permits public fee fishing for fish so produced

Class B Hatchery License

- Can possess live eggs or fish by purchase or trade
- Rears fish to a larger size for sale or trade
- Permits public fee fishing

Class C Hatchery License

- Can possess live-eggs or fish by purchase or trade
- Can hatch eggs and grow fish but NOT for sale
  - Can sell bait minnows so produced
  - Can sell gamefish back to Class A license holder
  - Can sell fish if consumed on the premises
- Allows the display of live fish
- No public fee fishing is allowed
- State fishing laws do not apply to pond

Class D Hatchery License

- Used in conjunction with a Class A or B license
- Allows an A and B license holder to transfer fish to ponds owned or leased by them other those specified in their license

Student Projects And Activities

Aquaculture Vocabulary Sheet 1

Using the glossary from the textbook entitled Aquaculture Science the students are to define the following terms.

Aquaculture-

Broodstock-

Fingerlings-

Grow-out-

Hatchery-

Larvae-

Mariculture-

Monoculture-

Polyculture-

Salinity-

Self-feeders-

Spawn-

Aquaculture Vocabulary Sheet 2

Using the glossary from the textbook entitled Aquaculture Science the students are to define the following terms.

Amino acid-

Anemia-

Antinutrients-

Antioxidants-

Carnivores-

Caroteniods-

Coenzymes-

Digestion-

Essential Amino Acids-

Essential Fatty Acids-

Extrusion-

Heme-

Herbivores

Lipids-

Marcominerals-

Microminerals-

Omnivores-

Planktonic-

Is aquaculture for you?

Aquaculture is the farming and husbandry of aquatic animals and plants. Aquaculture methods range from extensive pond culture to intensive recirculating systems. It is much more than than just stocking fish in a pond and then cashing a check. It is a very expensive and risky form of agriculture. Still, aquaculture has attracted the attention of farmers, landowners and investors as an alternative agriculture enterprise. Like other forms of farming, aquaculture involved capital investment, labor, management, and above all, risk. If you are considering aquaculture, this checklist can help you determine whether an aquaculture enterprise is feasible for your particular situation. This checklist does not cover all possibilities of course. Answering "yes" to most of the questions won't guarantee success, just as answering "no" won't mean automatic failure. The checklist does address the most important considerations. Steps to a successful aquaculture operation include: reading and studying publications, journals, and books; attending meetings and seminars; joining and participating in the Aquaculture Association; talking with other aquaculture farmers and extension agents; preparing a business plan; and finally, testing your aquaculture plans on a small scale before investing large amounts capital and labor. Ultimately, **YOU** decide if aquaculture is for you!

Yes	No	Marketing
____	____	1. Have you assessed the existing market in terms of species, market size and seasonal demand, potential customers/competition, and wholesale/retail price?
____	____	2. In what form will you market your product (alive, dressed, fillets)?
____	____	3. Do you have the equipment and personnel to harvest, handle, hold, and transport your product?
____	____	4. Are you familiar with the legal requirements to market your product?
____	____	5. Do you have an alternative marketing strategy to fall back on?

Economics

1. Have you developed a realistic, written business plan with monthly objectives and projected cash flow for the first year?
2. Do you have a realistic, written business plan for each of the next three to five years?
3. Do you own or have access to property needed for the proposed aquacultural project?
4. Have you determined cost for construction or improvements to the site?
5. Do you own or have access to the necessary equipment, such as nets, pumps, feeders, graders, live-haul tanks, etc.
6. Do you have the necessary financial resources?
7. Can you secure the capital for start up and operation at a reasonable cost?
8. Will your lender accommodate your production/marketing cycle (which differs from traditional row crops)?
9. Is the profit potential for aquaculture higher than that of other possible investments?
10. Can you afford to wait 6 to 18 months for income until your first crop attains marketable size and can be sold?
11. Are you willing to devote the daily time and effort required?
12. Do you have an adquate cash reserve for unanticipated costs, such as equipment failures, system modification, and crop loss?

Personal

1. Are you willing to work long, hard, irregulat hours (16 hour days, 7 days per week)?
2. Are you comfortable with mathematical problem solving, economics/accounting, and marketing?
3. Are you willing to seek help when you need it?
4. Do you have the technical expertise?
5. If not, can you afford to hire it?
6. Do you know others in the business who will provide help and advice?
7. Do you belong to an aquaculture association?
8. Are you willing to attend short courses in aquaculture, or attend workshops to learn about current practices and new developments?

____ ____ 10. Will your family support your decision?

Site and design

____ ____ 1. Can the proposed site be made suitable for aquaculture production with an exceptable amount of investment?

____ ____ 2. Is the site sufficiently large for expansion if desired in the future.

____ ____ 3. Do you live close enough to the culture site to visit and monitor as needed and insure security?

____ ____ 4. Is an adequate supply of high-quality water available and suitable for aquaculture production?

____ ____ 5. Can you effectively management the waste produced by your operation?

____ ____ 6. Is an economical and dependable source of utilities available (gas, electric, and phone)?

Legal constraints

____ ____ 1. Will your neighbors or other affected groups accept the aquaculture operation?

____ ____ 2. Have you discussed your planned operation with the appropriate state agencies (DNR, EPA, etc.)?

____ ____ 3. Have you identified the permits required to construct and operate an aquacultural operation?

____ ____ 4. Can the required permits be obtained without excessive investment in time, money, and effort?

Production

____ ____ 1. Have you determined what species you want to cultivate, and are there established culture techniques?

____ ____ 2. Have you explored the different production technologies available and identified one that meets your abilities and resources?

____ ____ 3. Are ther dependable sources of fingerlings, or do you have the resources to maintain and spawn adults, incubate eggs, and rear juveniles?

____ ____ 4. Are feed and other essential supplies readily available at reasonable prices?

____ ____ 5. Are back up systems available?

____ ____ 6. Are disease diagnostic services and dependable technical assistance readily available?

____ ____ 7. Is trained, experienced, and dependable labor available?

Fish Feed Activity 1

After the students have a basic knowledge about the nutritional needs of a fish the next step is to determine what size and type of feed a specific fish should be fed. Using the feed chart from Zeigler Feeds have the students determine what size feed should be used for a specific size fish. (This chart and other literature on fish feed can be obtained by contacting Zeigler Feeds at P.O. Box 95, Gardners, PA 17324-0095.)

Fish Feed Activity 2

Using the feed display card show the students the various types of fish feed that can be purchased and discuss the uses of the various types of feed and how the feeds vary. Have the students contact a fish grower to find out what they use as determining factors in selecting a specific type of feed. The students will submit a report in either written or oral form.

(**Note**: The feed display cards can be obtained from either Zeigler Feeds at P.O. Box 95, Gardners, PA 17324-0095 or Silver Cup Fish Feed at P.O. Box 57428, Murray, UT 84157-0428. If you need names of fish growers for students to contact see the Wisconsin Aquaculture Directory. If you do not have a copy of this contact the Wisconsin Department of Agriculture. The address for the department can be found in the Wisconsin Aquaculture Resource Guide in the Appendix.

Freezing Of Fish Worksheet

Using the article on "Home Freezing Of Fish" by David A. Stuiber and available through the University of Wisconsin Sea Grant Institute the students are to answer the following questions.

1. What is the most common mistake that people make when freezing fish?

2. What are the 2 ways that the freezing process at least temporarily interrupts the process of spoilage?
   1.
   2.

3. When buying fresh fish with the intent of taking them home and freezing them you must make sure you buy a quality product. The inspection of fish at the store includes sight, smell, and touch. For each of these criteria summarize what you are looking for.

   Sight-

   Smell-

   Touch-

4. Identify the 2 possible defects that can occur if the product to be frozen is improperly wrapped.
   1.
   2.

5. If you have a fish that is considered large in size and lean and you want to freeze the fish whole how long can it be in the freezer?

6. The article identifies 5 methods of freezing fish. Identify and describe 2 of these methods.
   1.

   2.

Fish Filleting Worksheet

Using the phamplet entitled "Fish Filleting" from the University of Wisconsin Sea Grant Institute the students should complete the worksheet on filleting.

1. What is the most effective way to sharpen a knife?

2. Summarize the 5 steps in filleting a fish.

Aquarium Project

This project is designed as an individual or small group activity. The materials and directions can be changed to alter the project to fit the needs of the individual or small group.

Materials:
- 10 gallon aquarium
- 50 watt, 10 inch heater
- Floating thermometer
- Six inch wide net
- Outside power filter that pumps 50 to 100 gallons per hour
- 18 watt flourescent light
- Top to keep fish in
- Food
- 10 pounds of fine gravel or course sand
- Rocks or piece of driftwood
- Dechlorinator
- One bunch of cabomba
- Two sagitarria or two valisneria plants
- One sword or cryptocoryne plant
- One male and two females of any of the live bearers (swordtails, platies, mollies or guppies)

Directions:
- Wash and aquarium out
- Rinse gravel or sand and rocks or driftwood until clean
- Add the gravel or sand and rocks or driftwood to the aquarium
- Put a bowl with water in it on top of the gravel or sand and leave in the aquarium until you have the aquarium almost full of water (the bowl will help the gravel or sand from being stirred up)
- Add plants
- Add the heater and filter
- Add filter
- Fill aquarium within to one-half inch of the top
- Add cover and light
- Plug in filter, heater, and light
- Using the thermometer, adjust the heater until it is going on and off when the temperture is 72 degrees
- After 24 hours add fish, floating them in their bags for at least 15 minutes before releasing them
- After another 24 hours, you can start feeding the fish

Project Goals:

- To produce some live bearing fish
- Live bearing fish are recommended because:
  - they are extremely domesticated and do well in an aquarium
  - since the young come out of the female ready to swim and eat they are easier for the beginner to raise
  - if you provide enough cover you will only need one tank for both the parents and the young
- To keep records of what happens in the aquarium and the various management practices used and when

Key Points:

- Feed fish once or twice per day what they will eat in about 10 minutes
- If using tap water dechlorinate the water before using either by letting it sit for 24 hours before use or by using a dechlorinator
- When adding water to the aquarium add water that is the same temperture as the water in the aquarium
- When your aquarium starts to fill up with fish transfer some to new aquarium

Aquarium Project

This project is designed as an individual or small group activity. The materials and directions can be changed to alter the project to fit the needs of the individual or small group. This project will use two seperate tanks with the first being the breeding tank and the second being the rearing tank. The individual participant or small group should pick a species of fish with some importance to aquaculture. The participant(s) will want to study various types of fish, but will probably want to choose something important to their area. Remember the different fish need different space requirements so the size of the aquarium you need may be different depending on the fish species.

Materials:
- 10 gallon aquarium (Or Larger)
- 50 watt, 10 inch heater
- Floating thermometer
- Six inch wide net
- Outside power filter that pumps 50 to 100 gallons per hour
- 18 watt flourescent light
- Top to keep fish in
- Food
- Spawning media
- Produce your own live foods for the fry (Easiest way is to hatch out brine shrimp eggs which be found at most aquarium dealers)
- 10 pounds of fine gravel or course sand
- Rocks or piece of driftwood
- Dechlorinator
- One bunch of cabomba
- Two sagitarria or two valisneria plants
- One sword or cryptocoryne plant
- Fish

Materials Needed For Hatching Brine Shrimp Eggs:
- Noniodized salt
- Small aquarium air pump
- Air line tubing and air stone
- Brine shrimp net or fine cloth filter
- Gallon jar

Directions For Hatching Brine Shrimp Eggs:
- Soak eggs in water for one hour
- Add salt according to the directions on the package of eggs
- Aerate the water in the jar

- After 24 hours turn off the aeration
- Using a siphon take baby brine shrimp out of the bottom of the jar and feed to the fry fish

Project Goals:
- To produce fish
- To keep records of what happens in the aquarium and the various management practices used and when

Key Points:
- Feed fish once or twice per day what they will eat in about 10 minutes
- If using tap water dechlorinate the water before using either by letting it sit for 24 hours before use or by using a dechlorinator
- When adding water to the aquarium add water that is the same temperture as the water in the aquarium
- When your aquarium starts to fill up with fish transfer some to new aquarium

Aquaculture Fish Species Database Activity

Choose a fish species of your choice and research the characteristics of the fish. Things to include in this report or computer database are common name, scientific name, family, description, habitat, natural food, natural distribution, natural history, behavior, reproduction, spawn, larvae, adults, edible qualities, problems, feeds, stocking density, market, and local market price.

Growth Rate Activity

Determine the following information about the aquatic and terrestrial crops. Use reference books in agronomy, livestock production and aquaculture to gather the information.

Species: Beef Cattle

Time required to grow to maturity: ______________________

Size at maturity: ______________________

Reproduction characteristics: ______________________

Kind of feed required: ______________________

Habitat: ______________________

Edible qualities: ______________________

Species: Chicken

Time required to grow to maturity: ______________________

Size at maturity: ______________________

Reproduction characteristics: ______________________

Kind of feed required: ______________________

Habitat: ______________________

Edible qualities: ______________________

Species: Rainbow Trout

Time required to grow to maturity: ______________________

Size at maturity: ______________________

Reproduction characteristics: ______________________

Kind of feed required: ______________________

Habitat: ______________________

Edible qualities: ______________________

Species: Yellow Perch

Time required to grow to maturity: ______________________

Size at maturity: ______________________

Reproduction characteristics: ______________________

Kind of feed required: ______________________

Habitat: ______________________

Edible qualities: ______________________

Species: Select a fish species of your choice and list here: ______________________

Time required to grow to maturity: ______________________

Size at maturity: ______________________

Reproduction characteristics: ______________________

Kind of feed required: ______________________

Habitat: ______________________

Edible qualities: ______________________

Species: Select a fish species of your choice and list here: ______________

Time required to grow to maturity: ______________

Size at maturity: ______________

Reproduction characteristics: ______________

Kind of feed required: ______________

Habitat: ______________

Edible qualities: ______________

Conclusions:

____

____

____

Water We eating?
Adapted from AQUATIC project WILD

Description:
This activity can be used to introduce the topic of aquaculture. This activity will take about 2 to 3 class periods.

Objectives:
1. Identify food derived from aquatic sources and their geographic origins.
2. Describe the importance of aquatic environments as food sources.
3. Compare food costs per serving and quanity of protein of v s foods.

Content:
The class will develop a list of aquatic food items by visiting a local market. Divide the class into teams to search for aquatic foods. Each team takes one aile of the store. The teams should record the price, percent protein, source of origin, and size of container. Classify foods by source, tabulate results and distribute to entire class.

Test Questions:
1. Name 5 specific foods derived directly from aquatic sources; list their country or region of origin.
2. Name an aquatic plant or animal that you can find in a local store that is also found growing or living in your state.
3. Name an aquatic product that is used in food production, but is not necessarily eaten directly. How is it used?

Motivation and/or Activities:
1. Ask students to list all things they would expect to find in a grocery store that come from aquatic environments.
2. As a class, design a form to record information about aquatic foods found in the market.

Resources:
1. Food market willing to have students visit
2. World map
3. Magazines, food labels
4. Nutritive Value of Foods, Bulletin 72, USDA Printing Office

Aquaculture Products

Assignment: Visit a local grocery store, meat market or seafood shop and survey the fish and seafood sold in the store. How is the product found? Fresh, frozen, or canned. Is the product a freshwater product or a saltwater (marine) product? Is the product produced locally?

Name:______________________________ Name of Store:____________________

Date of Visit:_____________ Signature of Store Person:____________________

Store Contact Phone Number:____________________

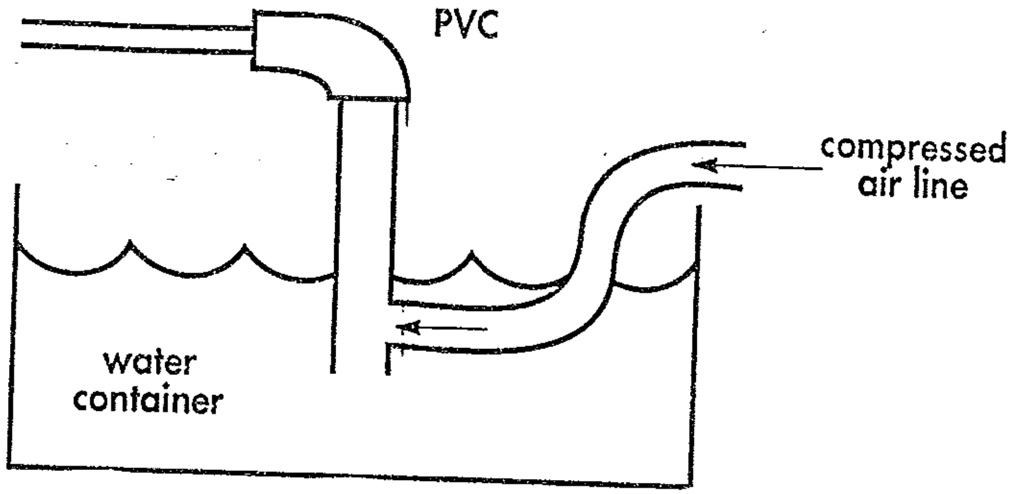
Product	How Processed	Local	Fresh or Salt Water

Name______________________

Pond Construction Worksheet

Using the information provided from the publication entitled the "Design and Construction of Diversion Ponds for Aquaculture" from the Minnesota Extension Service as well as other information provided in class you are to draw a pond design that you would use if constructing a pond for aquaculture use. With your drawing include the dimensions and percent of slope that you will have on the sides of the pond. Once you have completed the drawing write a rationel as to why you want the dimensions you have decided on.

Construct An Air Lift Pump Activity



Materials Needed:

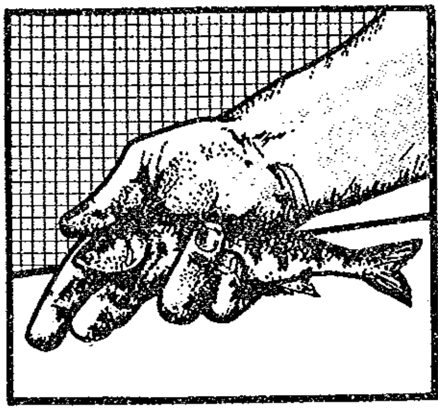
- 1/2" thick wall PVC, 2 to 3" in length
- 1/2" PVC elbow
- Container to hold water
- Compressed air and air line
- Fitting
  - Threaded on one end with a hose barb on the other end
- Drill a hole in the PVC pipe
- Tap threads
- Screw in fitting
- Attach compressor hose

Sources

Sources of Information

- The National Council for Agriculture Education Aquaculture Curriculum
- Aquaculture Science Textbook
- Aquaculture - An Introduction Textbook
- Wisconsin Department Of Natural Resources
- Aquaculture Buyers Guide
- National Geographic
- Notes from Fred Binkowski
- Notes from Conferences and Workshops
- Wisconsin Sea Grant Publications
- Illinois-Indiana Sea Grant Publications
- University Of Flordia, Cooperative Extension Publications
- University Of Minnesota, Cooperative Extension Publications
- University Of Wisconsin, Cooperative Extension Publications

Appendix



AQUACULTURE

Wisconsin Aquaculture Resource Guide

Aquaculture is of growing importance worldwide. In its many facets, aquaculture includes production of all kinds of aquatic species — animal and plant — for food, stocking, bait and industrial uses.

Recreational fishing is becoming more dependent on aquaculturally produced stock, and aquaculture is increasingly meeting consumer demands for edible fish and shellfish. Some experts predict aquaculture output will increase as much as 400 percent worldwide, and Wisconsin could share in this growth.

Wisconsin's opportunities lie in several directions. Public and private facilities in the state are being called upon to supply more warm- and cold-water species both for stocking recreational fisheries and as food fish for consumers. Aquaculture development in Wisconsin is being guided by an industry advisory committee with assistance from the university and several state agencies.

This pamphlet is designed to serve as an introductory reference for people interested in starting a fish farm or an aquaculture operation.

ORGANIZATIONS

For an industry perspective and information on raising a variety of fish species, contact:

Wisconsin Aquaculture Association
PO Box 15
Lewis WI 54851
(715) 653-2271

Wisconsin Aquaculture Industry Advisory Council
801 Badger Road
Madison WI 53704
(608) 266-9586

World Aquaculture Society
Louisiana State University
16 E Fraternity Lane
Baton Rouge LA 70806
(504) 388-3137

TECHNICAL ASSISTANCE

Fish Production

The University of Wisconsin Sea Grant Institute provides education and assistance in raising various fish species. For information, contact:

Aquaculture Specialist
UW Sea Grant Advisory Services
Center for Great Lakes Studies
600 E Greenfield Avenue
Milwaukee WI 53204
(414) 382-1700

Fish Propagation

Information on the propagation of fish by the Wisconsin Department of Natural Resources can be obtained from:

Fish Propagation Specialist
Wisconsin Department of Natural Resources
PO Box 7921
Madison WI 53707
(608) 267-7865

Fish Health

Information on fish diseases and general fish health can be obtained from:

Fish Health Specialist
Wisconsin Dept of Natural Resources
PO Box 7921
Madison WI 53707
(608) 266-2871

Fish Disease Specialist
US Fish & Wildlife Service
PO Box 1595
La Crosse WI 54602-1595
(608) 783-6451

Food Processing

The University of Wisconsin Sea Grant Institute provides education and assistance in the processing of fish for food. For information, contact:

Fisheries Development Specialist
UW Sea Grant Advisory Services
Room 115B, Babcock Hall
University of Wisconsin-Madison
Madison WI 53706
(608) 263-2087

The Wisconsin Department of Agriculture, Trade & Consumer Protection regulates fish processing under Chapter 97, Stats. For information, contact:

WDAT&CP Food Division
801 W Badger Road
Madison WI 53701
(608) 266-2227

State Regulations

The Wisconsin Department of Natural Resources regulates aquaculture in relation to fish stocking, water quality, water use, importation of fish species and licensing of private hatcheries. For local information, contact the local DNR Fish Manager, or:

Lake Michigan District Fisheries Supervisor
Wisconsin Dept of Natural Resources
1125 N Military Avenue
PO Box 10448
Green Bay WI 54307
(414) 492-5800

Northwest District Fisheries Supervisor
Wisconsin Dept of Natural Resources
Highway 70 West
PO Box 309
Spooner WI 54801
(715) 635-2101

Southern District Fisheries Supervisor
Wisconsin Dept of Natural Resources
3911 Fish Hatchery Road
Fitchburg WI 53711
(608) 275-3338

North Central District Fisheries Supervisor
Wisconsin Dept of Natural Resources
107 Sutliff Avenue
PO Box 818
Rhinelander WI 54501
(715) 362-7616

Southeast District Fisheries Supervisor
Wisconsin Dept of Natural Resources
2300 N Dr Martin Luther King Drive
PO Box 12436
Milwaukee WI 53212
(414) 263-8500

Western District Fisheries Supervisor
Wisconsin Dept of Natural Resources
1300 W Clairemont Avenue
Call Box 4001
Eau Claire WI 54702
(715) 839-3700

Business Development

The University of Wisconsin-Extension Small Business Development Centers offereducation in business planning and one-to-one counseling. For information, contact:

UW-Eau Claire	(715) 836-5811
UW-Green Bay	(414) 465-2089
UW-La Crosse	(608) 785-8782
UW-Madison	(608) 263-2221
UW-Milwaukee	(414) 227-3240
UW-Oshkosh	(414) 424-1541
UW-Parkside	(414) 553-2620
UW-Stevens Point	(715) 346-2004
UW-Superior	(715) 394-8351
UW-Whitewater	(414) 472-3217

The Wisconsin Department of Development helps small businesses identify the required permits and financial support. For information, contact:

Small Business Ombudsman
Wisconsin Department of Development
123 W Washington Avenue
PO Box 970
Madison WI 53707
(608) 266-5489

Business Permit Center
(800) 435-7287

Marketing

Counseling on the marketing of aquaculture food fish products can be obtained from the Wisconsin Department of Agriculture, Trade & Consumer Protection. For information, contact:

WDAT&CP Marketing Division
801 W Badger Road
Madison WI 53701
(608) 266-7181

UNIVERSITY RESEARCH

The University of Wisconsin conducts aquaculture research at several of its campuses. For additional information, contact UW Sea Grant.

UW-Madison
Aquaculture Center
University of Wisconsin-Madison
103 Babcock Hall
Madison WI 53706
(608) 263-1242

UW-Milwaukee
Aquaculture Institute
Great Lakes Research Facility
600 E Greenfield
Milwaukee WI 53204
(414) 382-1700

UW-Stevens Point
Cooperative Fisheries Research Unit
College of Natural Resources
University of Wisconsin-Stevens Point
Stevens Point WI 54481
(715) 346-2178

PUBLICATIONS

Many of the publications listed below are available at local public libraries or through inter-library loan.

Periodicals

Aquaculture Letter (biweekly)
3400 Neyrey Drive
Metairie LA 70002

Aquaculture Magazine (bimonthly)
PO Box 2329
Asheville NC 28802

Northern Aquaculture
4611 William Head Road
Victoria BC V8X 3W9

The Progressive Fish-Culturist (quarterly)
American Fisheries Society
5410 Grosvenor Lane Suite 110
Bethesda MD 20814

Water Farming Journal (monthly)
3400 Neyrey Drive
Metairie LA 70002

World Aquaculture (quarterly)
Louisiana State University
16 E Fraternity Lane
Baton Rouge LA 70806

Books

Culture and Diseases of Game Fishes. H.S. Davis. 7th Reprinting. Berkeley and Los Angeles: University of California Press, 1973.

Culture of Non-Salmonid Freshwater Fishes. Robert Stickney, ed. Boca Raton: CRC Press, 1986.

Fish Hatchery Management. Robert G. Piper, ed. Washington: U.S. Department of the Interior, Fish & Wildlife Service, 1982.

The Freshwater Aquaculture Book: A Handbook for Small-Scale Fish Culture in North America. William McLarney. LC84-80961, ISBN 0-88179-002-8. Hartley and Marks, 1984.

Management of Lakes and Ponds. George W. Bennett. LC83-6091, ISBN 0-89874-626-4. Reprint of 1970 edition text. Krieger, 1983.

PUBLICATIONS (Continued)

Principles of Warmwater Aquaculture. Robert Stickney. New York: Wiley, 1979.

Trout and Salmon Culture: Hatchery Methods. Robert Conklin Lewis. State of California, Department of Fish and Game, 1976.

■ Reports

Wisconsin Aquaculture: A State Plan. State of Wisconsin: Wisconsin Aquaculture Study Committee, 1988.

■ Pamphlets

Choosing an Organizational Structure for Your Aquaculture Business. S.T. Kohler and D.A. Selock. South Illinois University. North Central Regional Aquaculture Center Fact Sheet #103, June 1992. (Available from UW Sea Grant)

Handbook for Common Calculations in Finfish Aquaculture. Gary Jensen. Louisiana Agricultural Experiment Station & Louisiana Cooperative Extension Center. Louisiana State University Agricultural Center, August 1988.

Making Plans for Commercial Aquaculture in the North Central Region. D.L. Garling. Michigan State University. North Central Regional Aquaculture Center Fact Sheet #101, March 1992. (Available from UW Sea Grant)

Pond Culture of Walleye Fingerlings. L.M. Harding, C.P. Clouse, R.C. Summerfelt and J.E. Morris. Iowa State University. North Central Regional Aquaculture Center Fact Sheet #102, March 1992. (Available from UW Sea Grant)

Sea Grant Aquaculture in the Great Lakes Region — A Publications List. Great Lakes Sea Grant Network. Piketon, Ohio: The OSU Piketon Research & Extension Center, 1991. (Available from UW Sea Grant)

Use and Application of Salt in Aquaculture. L. Swann and S. Fitzgerald. Purdue University. North Central Regional Aquaculture Center Fact Sheet #105, June 1992. (Available from UW Sea Grant)

Additional copies of this publication are available from:

University of Wisconsin
Sea Grant Institute
1800 University Avenue
Madison WI 53705-4094
(608) 262-0645

University of Wisconsin Great Lakes Research Facility
Aquaculture Institute
600 East Greenfield Avenue
Milwaukee WI 53204-2944
(414) 382-1700

University of Wisconsin-Madison
Aquaculture Center
103 Babcock Hall
Madison WI 53706
(608) 263-1242

Wisconsin Aquaculture Association
PO Box 15
Lewis WI 54851
(715) 653-2271

Wisconsin Department of Agriculture, Trade & Consumer Protection
801 W Badger Road
Madison WI 53701
(608) 267-9644

Wisconsin Department of Natural Resources
Fisheries Management
101 S Webster Street
PO Box 7921
Madison WI 53707
(608) 266-1877

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