COURSE CODE: FIS503

COURSE TITLE: Production of other Marine Products

NUMBER OF UNITS: 3 Units

COURSE DURATION: Three hours per week

COURSE DETAILS:

Course Coordinator: Dr. F.I. Adeosun

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Office Location: Room D206, COLERM

Other Lecturers: Dr. I.T. Omoniyi and Dr. A.A. Idowu

COURSE CONTENT:

Ecology, life histories of crustaceans and aquatic molluscs, culture of shrimps, oysters, crabs, crayfish, lobster, cockles, periwinkles, marine gastropods, frogs, edible sea weeds and free water plants. Deep sea and shore farming of some products. Processing and preservation of marine products.

COURSE REQUIREMENTS:

This is a compulsory course for all students in Department of Aquaculture & Fisheries Management. In view of this, students are expected to participate in all the course activities and have minimum of 75% attendance to be eligible to write the final examination.

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READING LIST:

Oyster farming method: retrieved online (http://www.chefs-resources.com/Oyster-Farming-Methods)
Oyster culture technique: retrieve online (http://www.marinellishellfish.com/oyster-culture.html)

LECTURE NOTES

PRODUCTION OF OTHER MARINE PRODUCTS (2 UNITS)

The Course synopsis is further outlined on lecture basis as follows:

Lectures 1 - 4: Ecology, life histories of crustaceans and aquatic molluscs

Lecture 5 - 8: Culture of Shrimps, Oysters, crayfish, crabs, periwinkles and frogs

Lecture 9: Culture of edible sea weeds

Lecture 10 - 11: Sea and Shore farming of some products
Lecture 12: Processing and preservation of marine products.

ECOLOGY AND LIFE HISTORIES OF CRUSTACEANS

At elementary level, crustaceans are a class of primarily aquatic arthropods. The name crustacean is derived from the Latin words 'crusta' meaning hard shell. The class is large
(about 26,000 known species) and includes a variety of aquatic animals such as shrimps, crabs, lobsters, barnacles, water fleas etc. Some crustaceans occur in the seas and freshwaters, some are semi-terrestrial. They are mostly free-living, but few are parasitic. The common names shrimps and prawns are used interchangeably but it has now been resolved at FAO Convention to call marine and brackish water forms shrimps and freshwater forms prawns. Technically, the prawns have pleura of 2nd abdominal segment overlapping with 1st and 3rd segments ventrally.
But in shrimps, the somite of 2nd abdominal segment overlaps the 3rd somite. Before
commercial importance of crustaceans could be appreciated, the characteristics and the relationships need be mentioned.
The main diagnostic features of the Class are:

- The occurrence of 2 pairs of pre-oral appendages which are antenniform and sensory
in functions i.e. possession of 2 pairs of antennae.
- The body consists of the head, the thorax and the abdomen with a tendency for the
head and anterior segments of the thorax fusing to form a cephalothorax.
- The head consists of six segments and bears 3 pairs of post-oral appendages which act
as jaws; mandibles, the maxillules and the maxilla.
- The trunk appendages vary in number, forms and functions occurring on every
segment and they are typically biramous.
- Respiration is usually by means of gills or through the general body surface.
- Excretion is by means of green glands.
- The sexes are usually separate but some members are hermaphroditic e.g. barnacles.
- The typical crustacean larva is the Nauplius which has 3 pairs of appendages -
antennules, antennae and mandibles.

Make a well labeled lateral view of Penaeid shrimp.

CLASSIFICATION

Order: Decapoda
Suborder: NatantiaReptantia
Infraorder: PenaeideaCarideaMacruraBrachyura
PenaeidaePalaemonidaePandalidaePortunidae
Penaeus(*Portunus*
Crabs)
Metapenaeus
(Shrimps)

AstacidaeNephropidaePalinuridae
AstacusHomarusPanulirus
(FW Crayfish) (Clawed lobsters) (Spiny rocky lobster)
The order Decapoda is distinguished by its first 3 pairs of thoracic limbs modified into maxillipeds while the other 5pairs are walking legs (hence, the name Decapoda meaning 10 legs). The 1st pair of walking legs are often enlarged to form chelae or chelepeds. This order consists of 2 sub-orders.
a. Natantia - swimmers (b) Reptantia - the crawlers. The suborder natantia includes the shrimps and the prawns which are adapted for swimming. They show adaptation for swimming as their bodies are laterally compressed, legs are long and slender, and are of no use for walking.
The cephalothorax is prolonged into a rostrum which acts like a keel. The pleopods are fringed with bristles or setae which increase the surface area for swimming. The antennae are usually large and used as a rudder during swimming.
The sub-order Reptantia is more numerous decapods which are highly modified for crawling.
They include crabs, lobsters and hermit crabs. The crawling adaptations are:
(i) bodies tend to be dorso-ventrally compressed (ii) have heavy legs that can support the body for crawling (iii) pleopods are small and not modified for swimming (iv) antennae are small.
The true crabs belonging to the infra-order brachyuran meaning short-tail and flattened dorsoventrally. The abdomen is greatly reduced and flexed tightly beneath the cephalothorax.
There is terrestrial crab which burrow and go to sea to breed. Uropods are lacking in both male and female crabs. The hermit crabs differ from true crabs in having receptacle abdomen which is not flexed beneath the cephalothorax. The abdomen in hermit crab is asymmetrical and with thin soft non-segmented cuticle. Hermit crabs occupy mollusk shell to enjoy movement (Phoresy association).
Decapods provide a good source of human protein, even surpassing the bivalve molluscs. The decapodsmolluscs together comprise the so called shell-fishes. The fishing of decapods constitute an important industry. For example, *Penaeus*shrimps are caught in large numbers off

the coast of Nigeria. Shrimps and prawns account for over 1million tons/year in Indian and Pacific oceans. Mexico is said to be the richest shrimp fishing area of the world and the commercially important shrimp include *Penaeusduorarum*(also in Nigeria coast), *P.Schmitti, P. aztecus*. In British water, important shrimp include the (*Crangoncrangon*(brown shrimp), *Pandalusmontagni*(Pink shrimp). Lobsters also contribute to the world crustacean fisheries especially the European lobsters. *Homarus vulgaris* found in the coast of Britain where they are mostly caught in baited pots. The freshwater prawn, *Macrobrachiumvollenhoenii*is caught all the year round at Asejire lake near Ibadan.

LIFE HISTORY - Sexes are separate in most cultivated decapods especially Penaeid shrimps.

A few species e.g. *Pandalussp*(caridean) change sex at some time during their lives.

Mating occurs when the female is in a soft shelled condition (i.e. newly moulted) and the mating results into the deposition of one or more spermatophores (containing many sperms) in, on or close to the genital aperture/opening of the female. Note that mating can occur with hard shelled female in spiny lobster (Palinuridae) and penaeid shrimps which have setose genital region (i.e. openthelyca). These crustaceans with open thelyca(thethelycum-singular) rely on bristles or cement to hold the spermatophore in place externally. Lobster and certain species of penaeid shrimps have a closed thelycum or pouch to retain the spermatophores until spawning occurs.

Spawning is the release of eggs either directly into the sea especially in the penaeid shrimps or to the brood chamber beneath the abdomen. The eggs are fertilized as they are spawned but in species with internal sperm storage this may occur several hours or even days after mating according to species. Sperms from one mating are sufficient to fertilize more than one batch of eggs in lobsters and penaeid shrimp with closed thelyca.

Penaeid eggs hatch a few hours after spawning and each larva is left to fend for itself as it develops through about 12 free-swimming planktonic stages of nauplius, protozoea and mysis transforming or metamorphosing into a post-larvae (See Diagram A). The nauplii feed on internal stores of yolk while the protozoea stages filter unicellular algae from the water. The mysis stages feed voraciously on zooplankton (rotifers) and in this respect they are like the larvae of caridean prawns and lobsters (See Diagram B), the phyllosoma larvae of spiny lobster (Diagram C) and crabs (Diagram D). Incubation in non-penaeid decapods lasts from a few weeks in the prawn to as long as 4 months in lobsters. During this period, the female tends and ventilates the clutch until hatching occurs. During incubation, the early nauplius and protozoea stages are often by-passed in the egg so that when hatching occurs, the larvae are almost immediately able to catch and feed on zooplankton. For instance, an extreme case of abbreviated development occurs in freshwater crayfish where there is no free-living larval phase and the post-larvae hatch directly into juvenile (See Diagram E).

Crustaceans especially the penaeid shrimps are cannibalistic and unless the young can escape from the mother they stand the risk of being eaten. It has been reported that neither the presence of shelter nor the availability of adequate food eliminates cannibalism, but the absence may increase it.

Note: as the exoskeleton (ext. shell) of crustaceans is capable only of limited expansion, growth occurs throughout life through moulting or ecdysis i.e. shedding of exoskeleton at intervals. The rate of growth is a function of the frequency of moulting and the increase in size at each moult.

The frequency of moulting varies naturally between species, with size and age. Young shrimp larvaemoult 2 or 3 times in a day, juveniles every 3-25days depending on temperature and species, while adult lobsters are crayfish may only moult once every year or two years. Adverse nutritional or environmental conditions can decrease the frequency of moulting and size at each moult. Crustaceans often eat cast shells which is a convenient source of minerals that would have been lost. Mineralization of the new shell is affected by the availability of calcium ions, HCO_3^- and pH in the surrounding water and in the diet.

Attend class for some biological data on life histories of penaeid and caridean shrimps. The diagrams are provided during lectures.

AQUATIC MOLLUSCS (MOLLUSCA)

The Phylum Mollusca constitute the 2nd largest animal phylum. There are about 80,000 living and 35,000 fossil species of molluscs.

Basically, molluscs are triploblastic, bilaterally symmetrical and non-metamerically segmented
coelomates. The molluscan body consists of three parts; the head, the foot and the two eyes. The
foot is ventral, muscular, flat and used for creeping. The dorsally situated dome shaped visceral
mass is covered by the mantle, a fold of skin which secretes the dome-shaped shell. The mantle
overhangs the visceral mass posteriorly to form a mantle cavity. The mantle cavity contains (i) the gills or ctenidia (ii) the hypobrachial gland (iii) the anus (iv) kidney opening and (v) the
osphradium-a chemoreceptor. The buccal cavity contains the unique radula, a toothed belt used
for feeding. The phylum is divided into classes:

(i) Class Monoplacophora - deep sea molluscs
(ii) Class Aplacophora - primitive small molluscs
(iii) Class Polyplacophora – Clutons
(iv) Class Scaphopoda - Elephant tusk’ molluscs
(v) Gastropoda - Snails, slugs, abalones
(vi) ClassCephalopoda - Octopus and Cuttlefish
(vii) Class Bivalvia or Lamellibranchia - Oysters and mussels.

We are concerned with class Bivalve/Lamellibranchs. This class contains the Clams,
Cockles, Oysters, Mussels etc. They are aquatic, occurring in fresh and sea waters. They
constitute the 2nd largest molluscs with 30,000 species, more uniform in structure than the
gastropods. Most features of bivalve are adapted to burrowing in soft substratum, some have
become borers into rocks and wood, mussels and oysters are sessile, while a few swim. Bivalves
are the most successful of all the molluscan group based on number of individuals and ecological
bioenergetics. Bivalves posses the most efficient mechanism to collect the largest crop of green
plants in the world i.e. phytoplankton - which is responsible for their success. Bivalves form the
food of bottom living fishes, constitute important source of protein for man. Many are now
cultured e.g. Oysters, Clams, Mussels.

The burrowing habit of bivalves into substrates is as a result of modifications of the molluscan
plans made as:

1. The body is laterally compressed for easy passage into the substratum
2. The foot is transformed from a flat-soled crawling organ to a tongue or wedge (Hatchet

shaped) structure which can be protruded for burrowing into soft substratum.

3. The mantle is enlarged and transformed into two lobes (left & right) that envelope the whole body and enclosing large mantle cavities which are now lateral in position.

4. It is because the mantle consists of two lobes, the shell secreted by the mantle consists of two valves (Bivalvia) held together by a dorsal ligament. Two adductor muscles run horizontally between the two valves - one anterior, the other posterior.

5. Correlated with the burrowing sedentary habit, bivalves become ciliary feeders. The ctenidia becomes modified into a filtration or food procurement apparatus. The lips are transformed into two ciliated gutters, the labial palps which convey the food particles collected by the ctenidia to the mouth.

6. Also correlated with the adoption of a burrowing mode of life, the posterior edge of the mantle lobes are modified into siphons to maintain contact with the water column while burrowing.

7. The head and the associated sense organs (eyes and tentacles) which are prominent in ancestralmolluscs have all disappeared leaving only the mouth. The buccal mass, radula and jaws are also lost. The brain is not well developed.

They have their sexes separate or united and free living Veliger larvae are usually produced.

Bivalvia/Lamellibranchia
ProtobranchiaTaxodontaDysodontaPseudolamellibranchia
Primitive bivalve Ark Clams MytilaeOstreidaePectinidae
MytilusedulisOstreaedulisPecten
(mussels) (flat oyster) *maximus*(Scallops)

In Nigeria, some commercial molluscans in the class Bivalvia include A*nadarasenilis* (Archidae) and *Crassostreagasar*(Ostreidaea). From the primitive bivalves which were shallow burrowers, some forms have evolved or radiated to become (a) attached or sessile valve e.g. Oyster and mussels (b) swimmers e.g. *Pecten*(c) deep burrowers e.g. *Tellina, Donax*(d) borers e.g. *Teredo*(ship worm).

*Crassostreagasar*is a mangrove oyster that is cemented to rocks or *Rhizophora*mangrove roots by large right shell valve. The left valve is smaller and forms a lid. The anterior adductor muscle is completely lost and the posterior adductor is enlarged and becomes central in position. Being sessile, the foot is lost. Some oysters incubate their eggs in the mantle cavity while their larvae are planktonic. Usually collected for food in Nigeria many Oysters are now cultured in Europe and Japan.

Mytilus- Mussel is attached to rocks (hard surfaces) by beard-like hyssus threads secreted by byssal gland in the fingerlike foot. The anterior adductor muscle is very small thereby making the anterior end to be narrow. The siphons are short and the mantle lobes are not fused ventrally. Found in Takwa bay (Lagos) in large amount.

*Pecten*swims by clapping movements of the valve brought about by contraction and relaxation of the striated part of the single adductor muscle. Correlated with its mobility, numerous eyes and tentacles are developed along the mantle edges which are also muscular and control water exit.

*Tellina, Donax*are active deep burrowing clams. Their long, separate siphons are used like vacuumclearers for sucking in detritus from the surface of sea bottom (i.e. deposit feeders)

Teredo(ship worm) - is highly specialized bivalve which burrows into wood. It damages boats and other wooden structures in the sea. The shell is small and used as auger-blades in boring woods. The enlarged fused siphons dominate the morphology. The siphons are not accommodated within the shell and secrete a calcareous tube that lines the burrow in the wood.

Discussion on some ecological data of Mangrove molluscs and necessary diagrams are to be provided during lecture hours. Attend all.

Life History - Sexes are separate and the reproductive organs occupy the upper portion of the foot and open just in front of the renal aperture on each side. In male, the sperms shed into the mantle cavity pass out with the exhalant current and enter the mantle of female through the inhalant siphon. Eggs discharged into the mantle cavity of female are fertilized. Fertilization is internal. Life history is highly abbreviated. The eggs hatch into free-living Veliger larvae that transform to the juveniles. Salinity is the most crucial factor for their growth while the food

preference is an important consideration in molluscs aquaculture. In aquaculture practice, the
molluces rely on natural foods for their growth.
* Internet lecture material is not enough for students to excel very well in examinations. Attend
lecture classes punctually and regularly to enhance your performance in this Course.

PROCESSING AND PRESERVATION OF MARINE PRODUCTS

Food Processing and Preservation, branch of manufacturing that transforms raw animal, vegetable, or marine materials into tasty, nutritious, and safe food products. The industry has its roots in ancient times, as humans have always needed to obtain food and store a portion for later use. Prehistoric humans may have dried fruits in the sun and stored meat in cold areas, such as caves. The modern food processing and preservation industry was born in 1809, when French chef and inventor Nicolas Appert, searching for a better way to provide food for Napoleon's army, devised a method for sterilizing food in tightly sealed glass bottles. Today a wide variety of methods are available to maintain and enhance the appearance and taste of food. Food processing and preservation methods also create products that are convenient for consumers, such as products that are ready to eat or require minimal preparation and cooking. Combining these methods with modern distribution networks makes seasonal crops available year-round in grocery stores all over the world.

PROCESSING AND PRESERVATION METHODS

Food processing encompasses all the steps that food goes through from the time it is harvested to the time it arrives on supermarket shelves. At simplest, processing may involve only picking, sorting, and washing fruits and vegetables before they are sent to market. Some processing methods convert raw materials into a different form or change the nature of the product, as in the manufacture of sugar from sugar beets, oil from corn or olives, or cheese from milk. Processing may also involve an extremely complex set of techniques and ingredients to create ready-to-eat convenience foods. Food preservation refers specifically to the processing techniques that are used to keep food from spoiling. Spoilage is any change that makes food unfit for consumption, and includes chemical and physical changes such as bruising and browning; infestation by insects or other pests; or growth of microorganisms, such as bacteria, yeast, and molds.
Some food preservation techniques destroy enzymes, proteins that are present in all raw foods, which are responsible for the chemical and physical changes that naturally occur after harvesting. Food preservation techniques also help eliminate the moisture or temperature conditions that are favorable for the growth of microorganisms. As they multiply and grow, microorganisms are capable of causing food-borne illness. They also break down foods, producing unpleasant changes in taste, texture, and appearance changes that we recognize as spoilage. Although people have known about spoilage and some preservation methods to prevent it for centuries, it was only in 1857 that French chemist Louis Pasteur demonstrated the role of microorganisms in the process.

1. Curing

Curing is one of the oldest forms of food preservation. It is used to preserve meat and fish, yielding common products such as bacon, ham, frankfurters, and corned beef. Curing involves adding some combination of salt, sugar, spices, vinegar, or sodium nitrite to animal foods. Smoking, a flavoring technique and preservation method, is another ancient technique that is commonly used with curing. Smoking involves cooking meat or fish very slowly over a low wood fire. Curing and smoking preserve food by binding or removing water so that it is not available for the growth of microorganisms. These methods impart a distinctive color and flavor to food and, in some cases, eliminate the need for refrigeration. Some studies, however, show that curing agents such as sodium nitrite may combine with other chemicals to form cancercausing
nitrosamines. In addition, cured products tend to be very salty, and the sodium in salty foods has been linked to hypertension, also known as high blood pressure. Smoked meats and fish may contain toxic and even carcinogenic compounds that they absorb from wood smoke.

2. Drying

Cultures throughout the world have used drying to preserve food, probably since prehistoric times when people learned that dried foods—for example, fruits left out in the sun—remain wholesome for long periods. In modern times, the dried foods industry greatly expanded after World War II (1939-1945) but remains restricted to certain foods, including milk, soup, eggs, fruits, yeast, some meats, and instant coffee, that are particularly suited to the process. Three basic methods of drying are used today: sun drying, a traditional method in which foods dry naturally in the sun; hot air drying, in which foods are exposed to a blast of hot air; and freezedrying,
in which frozen food is placed in a vacuum chamber to draw out the water.

Removing the water preserves food because microorganisms need water to grow and food enzymes cannot work without a watery environment. Removing the water also decreases the weight and volume of foods, thereby reducing transportation and storage costs. However, dried foods may be less convenient for consumers because most must be rehydrated before consumption. In addition, most dried foods only reabsorb about two-thirds of their original water content, leaving the rehydrated product with a tougher, chewier texture than the original. Some scientists and consumer groups have raised concerns about the sulfites commonly added to fruits before drying to prevent browning. These chemicals may cause severe allergic reactions in people with asthma or other people sensitive to the chemicals.

In freeze-drying, frozen food is placed in a special vacuum cabinet. There, water escapes from the food by sublimation, a process in which ice changes from a solid directly to a vapor without first becoming a liquid. Freeze-dried foods retain their original flavor, texture, and nutrients upon rehydration but must be packaged in moisture-proof, hermetically sealed containers. Freezedrying is an expensive process used for such products as instant coffee, dried soup mixes, strawberries, mushrooms, and shrimp. Flash freezing is a process of supercooling foods to temperatures of -195°C (-320°F) through the use of liquid nitrogen. The process reduces cellular deterioration and increases retained moisture so that foods are tastier when they are unfrozen.

3. Canning

Canning is used to preserve a wide variety of foods, including soups, sauces, fruits, vegetables, juices, meats, fish, and some dairy products. Canning preserves food by heating it in airtight, vacuum-sealed containers. The can is filled with food, and air is pumped out of the space remaining at the top of the can to form a vacuum. The container is sealed, heated in a cooker called a retort, and then cooled to prevent overcooking of the food inside. This process removes oxygen, destroys enzymes involved in food spoilage, and kills most microorganisms that may be present in the food. Canned foods are popular because they are already partially prepared and cooked, can be stored without refrigeration for long periods, and are generally low in cost. However, because of the high temperatures required for sterilization, canning affects the color, texture, flavor, and nutrient content of foods. Fat-soluble vitamins and minerals are barely affected by heat processing, but water-soluble vitamins, especially thiamine, riboflavin, and vitamin C, can leach into canning or cooking water that may later be thrown away during preparation. Up to half of the original content of water-soluble vitamins in a canned product can be lost in this way. Rapid, high-temperature processes generally conserve nutrient content best, as every 4.4° C (18° F) rise in processing temperature yields approximately a ten-fold increase in microbial destruction, with littleadditional nutrient loss.

4. Additives

Food additives are chemicals that are added to food in small amounts. Direct additives are added deliberately during processing to make food look and taste better, maintain or improve nutritive value, maintain freshness, and help in processing or preparation. Some additives help preserve food by preventing or slowing chemical changes and the growth of microorganisms in food. As many as 3,000 substances are approved by the Food and Drug Administration (FDA) for use as direct additives. An additional 10,000 substances are present in foods as indirect additives. These substances enter food incidentally during handling or from processing equipment or packaging. Food additives have been used for thousands of years. The salts and other chemicals used in curing are additives, and before the advent of canning and mechanical refrigeration, chemical additives were the only means of preservation available. Additives were not limited to use as preservatives, however. People in ancient Rome added certain chemicals to wine and cooked vegetables to improve the color of these foods. Other examples of additives that have been used since ancient times include yeast and baking powder used as leavening in baked goods.

Advances in the knowledge of chemistry have greatly expanded the number of additives that are used in foods. Such recent additions to the ranks of food additives include artificial sweeteners, such as aspartame and saccharin; fat replacements, such as simplest; and colors, such as FD&C yellow No. 5, which is used in beverages, ice cream, cereals, and other foods.

The development of new chemical additives has also played an enormous role in the growth of convenience foods. Additives that help ensure the quality of convenience foods include anticaking agents, such as calcium silicate and magnesium stearate, to prevent lumps in dry mixes; humectants, such as glycerol, propylene glycol, and sorbitol, to help retain moisture in breads and cakes; emulsifiers, such as egg yolk, lecithin, and monoglycerides, which bind oil and water to improve the uniformity and smoothness of foods; and stabilizers and thickeners, such as guar gum, carrageenan, and gelatin. As the use of food additives has grown, so has public concern about the type and amount of these additives and their potential to cause cancer or other illnesses in human beings. Some studies have suggested that saccharin, nitrites, and other additives may cause cancer, but these results remain controversial. At the same time, some additives may actually provide a health benefit. For example, the vitamins used to fortify foods such as bread and milk are additives.

5. Freezing and Refrigeration

Low-temperature storage as a preservation method probably began when prehistoric humans stored meat and other foods in ice caves. However, mechanical refrigeration and large-scale freezing are relatively recent innovations. Mechanical refrigeration was pioneered by American inventor John Gorrie in 1842, but a mechanical refrigeration system suitable for widespread commercial use was not developed until the 1870s. American inventor Clarence Birdseye developed procedures, equipment, and packaging for quick-freezing in the 1920s and in 1953 frozen TV dinners were introduced by C. A. Swanson and Sons. Storage at low temperature slows many of the enzymatic reactions involved in spoilage and reduces the growth rate of microorganisms (though it does not kill them). To minimize microbial growth, refrigerators should be kept at 0° to 4° C (32° to 40° F) and freezers at or below 0° C (32° F). Refrigeration is advantageous because it does not cause chemical or physical changes to food. Freezing allows foods to be stored for longer periods than refrigeration because it inhibits enzyme activity and microbial growth to a greater degree. The greatest disadvantage of freezing is that the water in food expands and forms ice crystals. The ice crystal formation disrupts the structure of plant and animal cells, giving frozen food a softer texture after thawing. Newer technologies in which freezing occurs more rapidly help minimize this problem: Faster freezing, such as flash freezing, means that smaller ice crystals form, resulting in less damage to cells. Foods that should be refrigerated include meats, fish, eggs, milk, some fruits, and some vegetables. Many of these foods can also be frozen. Frozen produce is often high in quality and can rival the flavor of fresh. In many cases, produce frozen and stored under proper conditions contains more nutrients than produce picked unripened and allowed to mature during transportation. Briefly cooking vegetables in boiling water before freezing, a process known as blanching, inactivates enzymes altogether and reduces discoloration and nutrient loss.

6. Controlled Atmosphere Storage

Fruits and vegetables are sometimes stored in sealed warehouses where temperature and humidity are closely controlled, and perhaps most importantly, the composition of gases in the atmosphere is altered to minimize spoilage. Usually, the concentration of oxygen is reduced, the concentration of carbon dioxide is increased, and ethylene, a gas naturally produced by plants that accelerates ripening, is removed from the atmosphere. This controlled environment helps slow the enzymatic reactions that eventually lead to decomposition and decay, and may increase the time that produce can be stored by several months. Ripening rooms, in which ethylene gas is added to the atmosphere, also help produce higher quality fruits and vegetables. This technology enables produce to be picked before it is ripe, for easier handling, and then ripened quickly and uniformly under controlled conditions.

7. Aseptic Packaging

Aseptic packaging is now commonly used for packaging milk and juice. Like canning, aseptic packaging involves heat sterilization of food, but unlike canning, the package and food are sterilized separately. Food can be sterilized more rapidly and at lower temperatures in aseptic packaging than in canning, allowing the food to retain more nutrients and better flavor.

Containers are sterilized with hydrogen peroxide rather than with heat, permitting the use of plastic bags and foil-lined cartons, which would be destroyed by heat sterilization.
These containers cost less than the metal and glass containers used in canning and also weigh less, reducing transport costs. Aseptically packaged foods will keep without refrigeration for long periods of time, perhaps even years. They are growing in popularity because of their low cost, good taste and nutrition, and convenience.

8. Irradiation

Irradiation is a process in which food is passed through a chamber where it is exposed to gamma rays or X rays. These high-energy rays are strong enough to break chemical bonds, destroy cell walls and cell membranes, and break down deoxyribonucleic acid (DNA), the substance that carries genetic information in all cells. Irradiation kills most bacteria, molds, and insects that may contaminate food. Irradiation also delays the ripening of fruits and sprouting of vegetables, permitting produce to be stored for longer periods of time. Because irradiation involves minimal heating, it has very little effect on the taste, texture, and nutritive value of food.
The FDA first approved irradiation for use on wheat and wheat flour in 1963, and later approved its use on white potatoes, spices, pork, some fresh produce (onions, tomatoes, mushrooms, and strawberries), and poultry. In 1997, in response to several food-borne illness outbreaks and increasing public concern over the safety of the food supply, irradiation was approved for use on poultry products. In 1999, irradiation was approved to curb pathogens in raw meats including ground beef, steaks, and pork chops. Irradiation is also used to preserve some meals eaten by astronauts during long-term space missions. Some consumer groups have raised concerns that irradiation might cause the formation of toxic compounds in food. Because of these and other concerns, only a limited amount of irradiated food has been sold in the United States.

9. Fermentation

Fermentation is a chemical reaction carried out by many types of microorganisms to obtain energy. In fermentation, microorganisms break down complex organic compounds into simpler substances. Although chemical changes and microbial growth usually mean food spoilage, in some cases fermentation is desirable and microorganisms are actually added to foods. For example, in the production of beer, wine, and other alcoholic beverages, yeasts convert sugar into ethyl alcohol and carbon dioxide. In the making of yogurt and cheese, bacteria convert lactose, a sugar found in milk, to lactic acid. Alcohol, acids, and other compounds produced in fermentation act as preservatives, inhibiting further microbial growth. In addition to its use with alcoholic beverages, cheese, and yogurt, fermentation is used to produce yeast bread, soy sauce, cucumber pickles, sauerkraut, and other products.

10. Pasteurization

Pasteurization involves heating foods to a certain temperature for a specific time to kill harmful microorganisms. Milk, wine, beer, and fruit juices are all routinely pasteurized. Milk, for example, is usually heated to 63° C (145° F) for 30 minutes. Ultra-High Temperature (UHT) pasteurization, a relatively new technique, is used to sterilize foods for aseptic packaging. In UHT pasteurization, foods are heated to 138° C (280° F) for 2 to 4 seconds, allowing the food to retain more nutrients and better flavor.

11. Genetic Engineering

Genetic engineering is aimed at improving the food supply even before harvest or slaughter by improving yields, increasing disease resistance, and enhancing the nutritional qualities of various foods. Broadly speaking, genetic engineering refers to any deliberate alteration of an organism's DNA. Genetic manipulation has been practiced for thousands of years, ever since humans began selectively breeding plants and animals to create more nutritious, better tasting foods. In the past two decades, genetic engineering has become increasingly powerful as scientific advances have enabled the direct alteration of genetic material through the use of recombinant DNA. Genes have been cut and pasted from one species to another, yielding, for example, disease-resistant squash and rice, frost-resistant potatoes and strawberries, and tomatoes that ripen—and therefore spoil—more slowly. However, genetic engineering is controversial, as some critics argue that its possible environmental impact has not been sufficiently studied.

FOOD PACKAGING

Regardless of the processing or preservation method used, proper packaging of food is essential to make sure the food remains wholesome during its journey from processor to consumer. Packaging contains food and makes it easier to handle, and protects it from environmental conditions, such as temperature extremes, during transport. It locks out microorganisms and chemicals that could contaminate the food, and helps prevent physical and chemical changes and maintain the nutritional qualities of food. For example, milk is often stored in opaque containers to prevent vitamins from being destroyed by light.

Both the type of food and the processing method used affect the choice of packaging. For example, since oxygen makes fats go rancid, oils are packaged in containers that are impermeable to oxygen. On the other hand, oxygen-permeable plastic wraps allow fruits and vegetables to “breathe” and ensure that meats will maintain a vibrant red color. Metal and glass containers have traditionally been used in canning because these materials can withstand the high temperatures and changes in pressure that are involved in this processing method. The development of metal cans in the early 1800s represented the birth of the modern packaging industry.

The first British patent for a tin-plated steel container was issued in 1810 to British inventor Peter Durand. Canned foods were produced for the British armed forces in 1812 and offered commercially to the public two years later. Today, food cans are made of steel with various coatings to resist corrosion. Beverage cans are made of aluminum because it is lightweight and easy to manufacture. In addition to metal, glass is often used for packaging heat-sterilized foods. Glass is impermeable to oxygen and water and does not change the flavor of food. Another advantage of glass is that it is transparent, enabling the consumer to see the product inside. However, glass is not impact-resistant and is relatively heavy.

Plastic, by contrast, is lightweight and unbreakable, and it has become an extremely common material for use in food packaging. Most plastics used in food packaging are heat resistant so that they can go through high temperature sterilization processes. Plastic is made into a wide variety of shapes, including bottles, jars, trays, and tubs, as well as thin films that are used as bags and wraps. By itself, paper is not frequently used in packaging, except for certain dry foods, such as flour and sugar. When paper is coated with plastic or other materials to make it stronger and impermeable to water, it can be more widely used. Paperboard is often used for cartons, and plastic-coated paperboard for packaging frozen foods. Cartons and containers for shipping are usually made of corrugated cardboard. In recent years, environmental concerns have influenced food packaging. Scientists are working to develop packaging that is recyclable, biodegradable, or more compact so that it will use less landfill space, as well as to eliminate unnecessary packaging. Programs to recycle glass and aluminum beverage containers have been started all over the country. Plastic beverage bottles can be recycled as clothing or other products in addition to food containers. Aseptic packaging and several other new methods are compact and use a minimal amount of materials.

FOOD DISTRIBUTION

After food is processed and packaged, it enters an extensive distribution network that brings food products from the manufacturer to various retail outlets across the country and even around the world. Modern, high speed methods of transportation—trucks, trains, and planes—and reliable methods of environmental control—especially refrigeration—enable even perishable food to be transported great distances. Distribution networks help satisfy consumer demand for variety, making available, even in remote areas, foods that are not locally grown or processed. In fact, although food distribution is all but invisible to the average consumer, it plays a vital role in ensuring the availability of even the most basic foodstuffs. The now-famous bread lines and bare supermarket shelves shown in images of the former Soviet Union were brought about not so much by inadequate food production as by the lack of an efficient distribution network to bring the food to the consumer. Some large grocery store chains have the resources to buy food products directly from processors, transport the products, and store them in warehouses until they are needed at the store. However, for independent grocery stores and other small retailers, food wholesalers fulfill these roles. One type of wholesaler is a cooperative wholesaler, which is owned by the retailers that buy from them and usually sells only to these member-owners. In contrast, voluntary wholesalers are public companies that sell to any retailers without having membership requirements. Some food is sold directly to a retail store without going through a wholesaler first. This is common for foods such as bread and dairy products that must be delivered fresh every day or every few days. Smaller manufacturers often use food brokers as agents to arrange for their products to be shipped to retailers or warehouses. Through these various distribution channels, food makes its way to food retailers, such as restaurants, fast food outlets, supermarkets, convenience stores, specialty shops, drug stores, and some department stores.

Supermarkets are the predominant type of food retailer in the United States. They arose during the Great Depression (1930s) as a way of providing cheaper food products to consumers. The main cost-cutting measure was to have customers select products off the store shelves rather than having a clerk fill a client's order. In addition, these early supermarkets were located on the outskirts of town where land was cheaper. Since the first supermarket opened in Queens, New York, in 1930, the concept has spread throughout the world.

GOVERNMENT MONITORING AND REGULATION

For hundreds of years, governments have had an interest in regulating food processing to ensure the safety and wholesomeness of the foods consumed by their citizens. The earliest known food law was written in Japan in AD 702. In Britain, the first Pure Food Laws were enacted during the 1860s to combat adulteration, the secret use of additives to stretch wholesome foods with cheaper, non nutritious (and sometimes dangerous) ingredients. This practice became common during the Middle Ages (5th century to 15th century), when cities began to grow and urban populations no longer got their food directly from the farm, creating an opportunity for deception by middlemen. Today, several United States government agencies carry out inspections and enforce a comprehensive system of regulations governing food processing, packaging, and distribution.

Among the first regulations in the United States for protecting the food supply was the Meat Inspection Act of 1906. It was inspired in part by the 1906 novel The Jungle by Upton Sinclair, which described unsanitary conditions in Chicago stockyards. The Meat Inspection Act required inspection of cattle, hogs, sheep, and goats intended for interstate commerce, as well as the monitoring of slaughter and processing procedures. When poultry became more popular during the 1950s, a similar law, the Poultry Products Inspection Act of 1957, subjected poultry producers to the same scrutiny.

Today the Food Safety and Inspection Service, a part of the U.S. Department of Agriculture (USDA), carries out inspections of meat and poultry processing. Animals are inspected by USDA veterinarians before they are slaughtered to eliminate animals with disease from the food supply. This phase of inspection includes blood tests of randomly selected animals from each flock to make sure residues of antibiotics or pesticides, if present in the animals' blood, do not exceed acceptable levels. Animals are also inspected after slaughter for disease or contamination of carcasses, and processing procedures, recipes, and labels on products are also monitored.

Meat and poultry inspections follow a method known as Hazard Analysis Critical Control Points (HACCP), which was developed during the 1960s by the National Aeronautics and Space Administration (NASA) to ensure that foods produced for astronauts were safe. HACCP involves a thorough analysis of the steps of processing to determine which steps involve the greatest risk of contamination. Monitoring and inspection then focus on those critical points.

The FDA is responsible for monitoring and inspecting most all other food products. The FDA enforces the Food, Drug, and Cosmetic Act of 1938, which prohibits the shipping of adulterated or mislabeled products in interstate commerce. FDA inspectors visit food processing plants and warehouses to monitor all phases of processing, packaging, and distribution. Samples of food products are analyzed by FDA chemists to ensure the foods are wholesome and unadulterated and do not contain harmful substances, such as levels of pesticides above the limits set by the Environmental Protection Agency (EPA). In 1958, amendments to the Food, Drug, and Cosmetic Act gave the FDA authority to regulate the use of additives in foods. The Delaney Clause, which was part of those amendments, prohibits approval of additives that cause cancer in human or animal tests. Some people have criticized this clause for being too inflexible, because some studies show very small increases in cancer risk and some studies that show a risk of cancer in animals may not be relevant to humans. Since 1969, the FDA has set standards for inspection of retail food stores, restaurants, and cafeterias, although local health departments are responsible for carrying out those inspections. Package labels are also regulated by the federal government. What began as an effort to make sure that labels were accurate has now expanded to require labels that provide more information to increasingly healthconscious consumers. The 1938 Food, Drug, and Cosmetic Act prohibited mislabeling of food. In 1964 the Truth in Labeling Act required the package label to provide an accurate description of the weight, volume, or count of the package contents, a description of the contents, and the name and address of the

manufacturer.
The Nutrition Labeling and Education Act of 1990 required that all packages include a label, headed “Nutrition Facts.” This label must list the serving size and number of servings per package, and detail the food’s content of various nutrients (including carbohydrates, proteins, fats, vitamins, and minerals). These labels help people compare different food choices and select those that fit their diet (see Human Nutrition).
In 2004 the U.S. Congress enacted the Food Allergen Labeling and Consumer Protection Act. The law went into effect in January 2006. It requires food manufacturers to clearly label ingredients in their products that are derived from the eight major food allergens: crustacean shellfish, eggs, fish, milk, peanuts, soybeans, tree nuts, and wheat. These eight food groups account for 90 percent of food allergy cases in the United States. Under the law, food labels must contain a box near the ingredients list that specifies the food allergens in the product. Within the ingredients list, the common name for a food allergen must be provided next to the scientific or technical name. See also Allergy.

DEEP SEA AND SHORE FARMING OF SOME PRODUCTS

The world's ever-growing population is eating more and more fish and the oceans can't keep up. Fishing has depleted wild stocks of tuna, swordfish, cod and many other species.
A school of fish raised in a deep-sea Kona Blue fish farm off the coast of Hawaii.
Some scientists say the answer is a massive growth of fish farming — a so-called "blue revolution" to help feed the planet. So far, fish farming has occurred on land or in protected harbors. But some see a future with large-scale off-shore fish farms in waters hundreds or thousands of feet deep.
One of the first companies venturing off-shore is Hawaii-based Kona Blue. It is raising fish in giant, netted cages off the coast of Hawaii, submerged in waters some 200 feet deep. Some scientists say that farming in such deep waters can avoid environmental concerns raised by fish farms close to shore. If you get too many caged fish in a harbor, the fecal matter will pollute it. But offshore at the Kona Blue site, powerful ocean currents constantly flush so much water through the farm that Kona Blue reports it can't detect any change in nutrient levels up-current versus down-current of the farm.
A big challenge, of course, for off-shore aquaculture is designing a fish farm that can survive the open ocean. Anyone who read the book or saw the movie *The Perfect Storm* got a sense of the forces that are unleashed on the ocean's surface.
The trick has been to sink the giant cages down well below the surface of the water and tie them to a series of anchors using high-strength polymer ropes. The only things exposed above water are several large metal feed buoys. One experimental fish farm off the coast of New England has survived several northeasters with 40-foot waves and high winds.
A Kona Blue worker checks on the 'farm': This giant, 80-foot-tall netted cage is used to house fish submerged in waters off the coast of Hawaii that are about 200 feet deep. Courtesy Kona Blue
Fish farms have been a boon to fish lovers around the world. About 30 percent of the seafood eaten in the United States this year will come from so-called "aquaculture" farms, most of them in Asia.
But fish-farming operations, which traditionally operate near the shore, have raised environmental concerns. According to one study, a fish farm with 200,000 salmon releases nutrients and fecal matter roughly equivalent to the raw sewage from 20,000 to 60,000 people.
Kona Blue's Neil Sims says inshore farming has become much cleaner in recent years. And he and other scientists say farming far offshore — in waters hundreds of feet deep, with strong currents — goes a long way toward diluting any waste, making it a very appropriate place for large-scale aquaculture.
Some environmentalists, though, are still concerned about the environmental controls in new federal legislation that would set up a regulatory framework for open-ocean aquaculture.
Rebecca Goldburg of Environmental Defense, an advocacy group, worries that, in its current form, the legislation leaves too much environmental regulation up to the discretion of the National Oceanic and Atmospheric Administration (NOAA).
Goldburg worries this could leave the door open for irresponsible deep-water aquaculture that might create pollution problems, perhaps similar to those seen from large-scale industrial hogfarming

on land. (Hog farms have been linked to groundwater pollution, not to mention olfactory unpleasantness.) For example, a big enough fish farm in the Gulf of Mexico, where waters are already nitrogen-saturated, could cause problems.

Escapes present another area of concern. When the fatter, slower farmed salmon get loose, they can breed with threatened species of wild salmon. Goldburg says that's like breeding dogs and wolves. It pollutes the wild gene pool with much slower and dumber wild salmon that have trouble surviving and making it back up river to spawn.

That said, even Goldburg says that Neil Sims and the other top scientists and executives at Kona Blue are being environmentally responsible. The Kona Blue team is monitoring the sea water around their farm, and the company says it has found no discernable environmental impact. Goldburg notes that the company is also farming a species native to the area, and is not genetically altering or selectively breeding the fish in any way. So any escapes that occur won't affect the surrounding wild species of fish.

There is one other potential problem. Right now, carnivorous fin fish such as salmon are fed a fish-meal made with wild-caught feed fish such as herring. Goldburg says it takes about three pounds of feed fish to raise one pound of salmon on a farm. She says that's not exactly a "sustainable" model, since farming fish relies on catching so many wild fish out of the oceans. But Kona Blue's Sims says big strides have been made in replacing some of the fish in the fish meal with vegetable products. He expects the percentage of wild-caught fish in fish meal will fall sharply in years to come. And he's hopeful that more of the fish feed can be made with fish byproducts: heads, tails and trimmings which would otherwise go to waste.

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PRODUCTION OF OTHER MARINE

Culture of shrimps, oysters, crabs, crayfish, lobsters, cockles, periwinkles, marine gastropods, frogs, edible sea weeds and free water plants

Culture of Shrimps

Shrimp is the most important commodity, by value, in the international seafood trade. The shrimp industry has grown exponentially in the last decades, and growth is expected to continue for years to come.

A new and better technology to culture shrimps is being used by many enterprising shrimp farmers nowadays known as **Green water technology,** a technique that cultures shrimps in water that is abundant in phytoplankton i.e. Chlorella, turning the water green hence, its name.

In this system, tilapia is also grown in the reservoir or net cages/ pens in the ponds. The green water produced from tilapia helps control the growth of luminous bacteria that is bad for the growth of the shrimps.

The green water technology consists of: pond preparation, water culture/fertilization, stocking and stock sampling, feeding management, water management and aeration, and harvest and post-harvest handling.

Pond preparation

To prepare the pond, it should be dried and drained of water for three weeks until the soil at the bottom is cracked. The muck or the black soil at the bottom of the pond should be scraped off. Then the ponds are flooded with water and dried for another week. Hydrated lime at a rate of 2 tons per hectare is applied before the final flushing and sun drying.

When the pond is clean and dry, double hapa nets (10×10x1.5 meters) should be installed at the center of the pond. Bamboo catwalks from the dikes to the pens should be installed to facilitate easy feeding and monitoring of fish.

Water culture/fertilization

After installing the pens, the ponds should be filled with seawater to a maximum depth of 1.0-1.2 meters and the gates should be sealed. The water depth should be maintained by installing a depth gauge. To make sure that the water is free from predators and other possible competitors, teaseed powder (20 ppm) should be applied. Fine mesh screens should be installed at each outlet of the flume to prevent predators from entering the pond during pumping.

Stocking and stock sampling

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To check the growth and condition of the shrimps, the stock should be sampled after 30 days from culture and every 10 days thereafter. For tilapia, stock sampling should be done monthly.

Feeding management

For shrimps, they should be fed right after stocking. Shrimp feeds are broadcasted around the pond with a portion of the feeding ration left in the feeding trays. Four trays measuring 0.25 square meter should be installed to monitor the amount of feeds consumedeveryday. During the first 30 days, blind feeding is practiced. About 200 grams of feed per 10,000 postlarvae is given. One to three hours after feeding, the trays are lifted and the amount of feed consumed is estimated. From 40 days of culture, the shrimps are fed five times a day, i.e., 6:00 AM. 10:00 A.M., 2:00 P.M., 5:00 P.M. and 10:00 P.M. at 20%, 10%, 10%, 35%, and 25%, respectively of the total feeding ration.

Tilapia are fed 5% of the body weight. They are fed twice a day at 8:00AM and 2:00 PM and the ration is adjusted based on the average body weight of the fish every sampling period.

Water management and aeration

After 30 days of culture, 10-20% of the water in the pond is drained and replaced with water from the reservoir ponds. It should be noted that the water from the reservoir ponds should be allowed to stay for at least 4-5 days before they are used to replenish the water in the shrimp rearing ponds.

The ideal amount of dissolved oxygen is maintained by using six paddlewheel aerators. In the first 60 days, only four aerators are alternately operated for 24 hours. Another aerator is installed in each tilapia pen to increase the circulation of water and phytoplankton in and out of the pens.

Harvest and Postharvest handling

Shrimps are harvested when they weigh at least 30 grams. Harvesting is done by draining the water and collecting the shrimps using a harvest net installed at the pond gate. The collected shrimps are placed in water with crushed ice to maintain their quality. The shrimps are then sorted according to size and placed in boxes with crushed ice to be shipped to shrimp processing plants where they are packed for export purposes.

Source: “Green Water Technology” 2003 by Mr. Valeriano L. Corre, Jr. of the University of the Philippines in the Visayas, Miag-ao, Ilo-ilo, photo from shrimpfarming.tripod.com

Oyster Culture Techniques

The four most common oyster culture techniques are:

- Beach culture
- Bag culture
- Suspended culture
- Dike culture

Beach culture is the simplest and most common method of growing oysters in the Pacific Northwest. Generally, oyster spat is purchased from a hatchery and spread onto a farms beach in the intertidal zone. Spat can be purchased at different levels of development, with the more mature product costing the most. Once spread onto the beach, spat are vulnerable to natural predators like crabs, starfish, birds, and oyster drill snails as their shells are still very thin. To overcome this, some farms will cover the spat with netting or put them into fenced pens. Beach culture produces the slowest growing oysters, as they are subject to wind, wave, and tidal abuse that tend to wear away their fragile new shells. They end up being the thickest shelled oysters, and usually the easiest to open, because of this slow growth. They tend to be grayish in

appearance, as the sun bleaches the color out of their shells over time.
Bag culture is also common. Large mesh bags containing oyster spat are attached to lines that are in turn staked to the beach in the intertidal zone. The oysters are considerably more protected than those that are beach cultured, as the mesh bags keep many predators at bay and will also protect the oysters from some of the weather abuse that slows their growth. In addition, it will block a significant amount of the sunlight that bleaches the color out of their shells. Predictably, the shells of bag cultured oysters are thinner than those of beach cultured oysters, and their appearance is more liable to include some combination of blues, purples, tans, browns, and whites, depending on the mineral content of the water in which they are grown. These oysters will mature more quickly than those that are beach grown, however, this method is more labor intensive. In order to produce oysters that get the increased growth rate and that are well shaped, the bags must be thinned out regularly as the product grows in size, and they must be flipped over numerous times to keep any prevailing winds or currents from piling the oysters into one end. Oysters left piled together will grow much more slowly, and worse, they will grow poorly shaped… long thin (snaky) shells, shells without much cup, or shells with their hinges wrapped around underneath them.

Many farms now utilize a combination of these two methods, starting spat in bags and then transferring them to the beach as they get a little bigger and heavier. By allowing oyster spat to start in bags on the beach, a farm can increase their survival rate significantly. By allowing them to finish directly on the beach, they allow the oysters time to develop harder shells and stronger abductor mussels, while saving themselves the time and expense of dealing with the bags as the oysters start to increase in size.
Suspended culture involves hanging nets or trays containing spat from some means of flotation system. Rafts, buoys, and long lines supported by a series of buoys are common means of achieving this. Oysters grown this way are not in the intertidal zone at all, but are in the water all the time, rising and falling with the tide. They are well protected from most predators, and get no exposure to the bleaching effects of the sun that would otherwise dull their appearance. Suspended culture oysters grow the most quickly, as they are feeding 24 hours per day, seven days per week. This is a real plus for an oyster farm, since they are turning their investment in spat back into cash very quickly, but it involves a compromise. This growing method produces shells that are thinner than either of the other techniques mentioned, and one must be careful not to chip their fragile edges. In addition, it produces oysters that have weak abductor muscles. Oysters use their abductor muscles to keep their shells tightly closed when they are out of the water. Without the daily exercise that Mother Nature provides intertidal oysters, the muscles of suspended culture oysters are comparatively weak. They will tend to open up and dry out more quickly than oysters culturedintertidally, but most farms growing suspended culture oysters attempt to overcome this by packing their oysters in boxes cup side down. By doing this, they minimize water loss when the muscles do relax, as the liquid in the deep bottom cup is trapped. Farmers utilizing this technique must, like those using the bag technique, keep their trays or nets thinned out, as high densities create poorly shaped oysters.
Dike culture involves building low rock or cement walls around pools to keep the water in when the tide goes out. Diking portions of the intertidal zone ensures that the oysters are always covered by water. This allows them to feed continuously while protecting them from freezing in the winter and from getting too hot in the summer. Dikes are used primarily in the culture of Olympia oysters.

Crab culture

Crab farming as a practice is not common in Nigeria. In the early seventies when some fishpond operators in Bicol, Visayas, and Southern Tagalog in Philippines started to culture crab as a subsidiary crop in milk fish or bangus ponds.

The crab species Scylla serrata is the biggest and most important member of the family of edible crabs in the Philippines.
Mud crab, or alimango, is considered a delicacy and has become a popular fare in seafood restaurants. It is sought for its very tasty aligue or ripe eggs in the ovary.
Crabs abound in estuaries, mangroves, swamps and tidal waters, living both as a scavenger and a cannibal.

Breeding and Spawning

The mating period of crabs is usually long. When mating, the female is carried by the male, clasping her with three pairs of walking legs. In this condition, it is very easy to catch them. After five days, the female is finally released by the male. Mating usually occurs for four months, during the period May to September. Prior to that, in April, the females develops eggs or aligue.
Crabs spawn in the sea. The newly hatched larvae called zoea are free-swimming. They are carried by the tide to the coast where they migrate to live-in estuaries, swamps and mangroves. Fertility is very high among females. As much as a million eggs can be laid but mortality is also high because of inclement climatic conditions.

Molting

This is an indispensable stage in the life cycle of crabs. During molting, they shed their covering or carapace. This happens when there is an abrupt increases in the size of their body. After shedding the old carapace, the crab is left with a very soft covering. It becomes an easy prey to other animals and to survive, the crab buries itself under the mud until the soft shell hardens.

Culture and Cultivation Methods

Small crabs or crab seeds are caught by fishermen in seashores, swamps and other natural habitats. They are gathered and sold to fishponds operators.
Crabs are raised in brackish water fishponds. Crab and can be raised simultaneously. It is, however, not advisable to culture crabs together with prawns, because when prawns undergo molting, crabs eat them.

Choosing the Crab Farm

Choosing a site for crab farming is not difficult. First, there should be adequate supply of estuarine water because good and stable salinity is conducive to growth. Smaller ponds are advisable since they are easier to manage. Make sure the soil is clay or clay loam. This kind of soil is capable of retaining water. If possible, the site should be free from floods. The depth of water is also important. Advisable depth is one meter to prevent exposure of cultured crabs and stop them from boring holes through the dikes. For easy harvesting, the site should have good drainage. This also facilities the practice of pond freshening whereby the water is cleansed by letting in fresh seawater. Available of crab seeds in the area is also important. This ensures a steady number of young crabs for rearing and the continued operation of your farm.

Managing the Crab Farm

For crab farming, the ponds are prepared just like any bangus fishpond but the side of the dikes should be very firm to discourage the crabs from burrowing through. Place banatan or bamboo screen along main dikes to prevent escape of crabs. About 2,000 to 4,000 crab seeds, 2 to 5 cm in length and size, would be needed initially. Stock them directly in the rearing ponds. Feeding is not a problem since young crabs feed on algae and decaying organic matter. As they grow, crabs become carnivorous. Supplement their feed with trash fish and leftover food. Their rate of growth is rather slow. It takes five to six months for crabs to grow into marketable sizes.
Application of fertilizer is helpful. This enhanced the growth of natural food like moss in the ponds.

Harvesting

This is done with different kinds of trap like the bamboo cage, lift net, scissors net, fish corrals and gill nets. Crabs are ready for the harvest and marketing when the piece or two reaches up to a kilo. They are sold alive and can stay out of the water even for a week. They should, however, be kept in damp containers and periodic moistening is important. Feed them with trash fish and other kitchen refuse.

Handling

Adult crabs in captivity are tied with dried nipa strings. Both pincers are tied close to the abdominal cavity to prevent crawling. When transported, proper handling is important. Place them in baskets or tiklis to avoid getting trampled or crushed.

Crayfish culture

Freshwater crayfish are highly regarded as a delicacy as they are very similar to shrimp or lobster in taste and texture...high protein and low-fat.

The crayfish is a very promising aquaculture species.

Fish farmers have become major players in this bottomless market in only a couple of years. Small scale family run operations are harvesting 'short lobsters' in less than a year, and the start-up costs are low. Included in the book are photos, food and feeding regimens needed to raise crayfish to giant size, well managed pond factors, hatching and juvenile production, stocking methods, sources of supply, sale & processing tips, and marketing recommendations. This book is easy to read, well organized, and packed with hard to find information. Targets the small farmer or homesteader.

Look at the huge crawfish to the right. That's a 5 gal. bucket they're in! How did they get so big? The answer is simple...ideal growing conditions. These are a common variety of crayfish found all over the U.S. except the South where summers are too hot for them. Given the right conditions, they can attain this size (and larger!) in a single season. After the first year, crayfish are 'self-stocking', meaning they propagate naturally if allowed to. It is more efficient to raise the young in tanks (giving a 98% survival rate), but that requires a little more effort. Careful harvesting can produce ever-larger specimens if the largest crayfish are returned to the pond to reproduce.

The best production is obtained with a combination of natural and processed feeds.

Natural sources include hay, grass and other vegetation. Processed feeds includerange pellets, dog food, sinking fish food, and of course crayfish feed. Stock can be obtained from existing crayfish farms as juveniles or adults, or one can capture a local variety of crawdad quite easily.

(left) This is a somewhat rare variety of crayfish (Pacifasticus), found in Pacific Northwest streams and lakes. It grows much larger than other varieties in the U.S.; unfortunately it takes 18 months or so to mature and breed. This makes it not too well suited for culture..except in that region.

Sometimes called a 'short lobster, this variety can be raised indoors in tanks. These can be relatively easy and inexpensive to establish and manage. Using tanks can create an extended growing season, necessary in colder climates. Other benefits of tank culture include..controlled environmental factors (turbidity, temperature, waste management), safety from predators, and controlled feed intake--all of which produce maximum growth rate, highly efficient reproduction rates, and the highest possible weight at harvest.

Simple selective breeding can increase the size and disease resistance of successive generations, as in the now famous 'Super Shrimp' of Mexico.

Frog Farming

Raising and selling frogs on a commercial basis has **not** proven to be successful economically in Nigeria. Its collection in the wild and cherished as delicacy in some parts of the country have observed especially in riverine areas. Although farming for frog legs sounds promising, operating a profitable frog farm seems to be more of a myth than a reality. Those few individuals who claim to be successful frog farmers generally are distributors engaged in the selling of adult frogs, tadpoles, or frog eggs,

frequently harvested from the wild.
Many "frog farms" turn out to be natural in marshy areas, swamps or shallow ponds with abundant food and habitat suitable to the needs of wild frogs at some frog farms.

Culture method

Culture methods simply consist of getting an enclosure whereby the shoreline area is increased and fence are erected to exclude predators and retain the frogs, and stocking is effected by collection of wild frog eggs or tadpoles. The frogs usually are left to raise themselves.

Intensive indoor frog culture techniques have been developed for the production of laboratory frogs used in medical and biological research. At present, however, it is doubtful that these indoor culture techniques can be applied economically to the culture of large frogs for human consumption.

Edible Frogs

A number of species of frogs, including the green frog (*Ranaclamitans*), the leopard frog (*Ranapipiens*), and the pickerel frog (*Ranapalustris*), are harvested from the wild and sold as a luxury food - frog legs - in expensive restaurants. However, the bullfrog (*Ranacatesbeiana*) has the greatest potential for culture.

The common bullfrog, often referred to as the "Giant Frog" or "Jumbo Frog," is the largest native North American species, often reaching 8 inches in body length. Because of its large size, the bullfrog is the most preferred and commonly attempted species for farming.

Breeding and the Life Cycle

Bullfrogs lay their eggs in shallow standing water during the Spring (April and May) in temperate climates. The large, floating, jelly-like egg mass produced by a single female may cover an area about 3-5 feet square and include from 10,000 - 25,000 individual eggs. The eggs hatch in 1 - 3 weeks, depending on the water temperature, into larval frogs that commonly are called tadpoles. Bullfrog tadpoles chiefly are vegetarians, spending most of their time grazing on microscopic plants and bottom algae.

Frogs and other amphibians are coldblooded animals that grow slowly, not a particularly desirable trait for farming. The rate of growth of the bullfrog tadpole varies with the climate, length of the growing season, and available food supply. Even in temperate climates, it may take a year or more to transform the tadpole into a young bullfrog. Another year or more is required to produce a mature, marketablesize bullfrog. Therefore, in the mid-latitude states like Virginia, development from egg to a mature bullfrog of harvestable size may take over 3 years, even under ideal conditions.

Artificial Feeding

Feeding is the critical process in culturing frogs successfully. Poorly fed frogs are susceptible to disease and frequently resort to cannibalism (eating younger bullfrogs and tadpoles), thereby reducing the harvestable population. Frogs and tadpoles reared outdoors will obtain some natural foods, but for intensive commercial culture of frogs in high densities, supplemental food must be supplied.

Bullfrog tadpoles are mainly vegetarians and will consume most soft plant matter and some animal feed. Acceptable tadpole foods include such items as boiled potatoes, meat scraps, or chicken viscera. Recycling butchered frog scraps is a convenient way to reduce food costs, but may transmit disease.

Once the tadpole has metamorphosed into the adult frog (i.e., the legs are fully developed and the tail is absorbed), feeding becomes especially difficult. Adult frogs feed exclusively on **moving animals**, primarily small insects. They generally refuse to eat dead or at least non-moving food. Japanese researchers reportedly have been able to induce frogs to eat dead silkworm pupae by using small motorized trays that mechanically roll the silkworms back and forth to simulate live animal motions.
Live animals, such as minnows, crayfish, and insects, also are placed in these trays to condition the frogs to feeding from these mobile platforms. Although this technique

may work, most American frog farmers rely on stocking or attracting live food animals. Smaller species of frogs, tadpoles, crayfish, and minnows can be stocked as food items for bullfrogs although the expense of live feed is high.

The use of strong flood lights to illuminate the shoreline at night will attract flying insects and provide additional food for frogs. However, this technique is not sufficient to supply enough food to sustain the high frog densities needed for a commercial operation. At present, live food, adequate in quantity and quality, remains the greatest problem for would-be frog producers.

Pond Design

A mature bullfrog may require as much as 7m of shoreline as its exclusive feeding territory. Territorial behavior firmly limits the number of frogs that can coexist in a small area. Available shoreline area (the ratio of land to water edge) is a critical factor. The total size of the pond is not as important as shoreline, because frogs use shallow shore lands to rest and feed. Large expanses of deep, open water are seldom used by frogs.

Regularly shaped round or square ponds have less shoreline in proportion to area than small irregular-shaped ponds. Therefore, increasing the length and irregularity of the shoreline by constructing long narrow ponds with numerous islands, shallow bays, or coves will increase the carrying capacity of frogs in a given area. Some growers increase the amount of shoreline, by constructing ponds as a series of narrow ditches. Ponds should be deep enough to protect the adult frogs and tadpoles from extremely hot or cold temperatures. Accordingly, the depth of the pond must vary with the climate. In the southern U.S water from 0.4m deep is adequate, but in the North, much deeper water (2 - 4m) may be required to assure the over-winter survival of frogs hibernating in the bottom mud. Pond should have shallow areas because frogs normally rest and feed in shallow waters.

Predatory fish, snakes, snapping turtles, cats, foxes, and water birds that feed on adult frogs and tadpoles should be fenced out. Enclose the pond with a mesh fence about 3 feet high. A vertical fence, topped with wings, one inclined outward and the other inward, will exclude predators and keep frogs in. Birds are especially difficult to exclude, but, in small ponds, a wire net stretched above the shallow shoreline area may offer some protection. Some loss due to predatory animals should be expected.

Water Quality and Quantity

An abundant supply of high quality water must be readily available to the frogs throughout the growing season. For good growth, water temperature should remain relatively constant at 20° to 26° C. The pH of the water should be slightly acidic. Dissolved oxygen always should be present because tadpoles, as fish, breathe by gills and are dependent on the available oxygen. Pesticides and other dangerous chemicals often are toxic to frogs, and even non-lethal concentrations could restrict the sale of frog legs for human consumption. Pesticides can be distributed widely by winds and water currents. However, with care and intelligent site selection, most pollution problems can be avoided.

Harvesting

Techniques for collecting and harvesting pond-cultured bullfrogs are the same as those used in capturing wild frogs. These methods include nets, hand capture, spearing, and fishing with a hook and line. Hooks baited with live insects, earthworms, or artificial lures (a piece of red cloth or yarn) are dangled in front of the frog. Spearing and band capture techniques are done most effectively at night, using a bright spotlight to momentarily daze and immobilize the frog. Obviously, new methods to efficiently harvest large numbers of frogs need to be developed.

Diseases

The most common disease of frogs, red-leg disease, is due to a bacterial infection (Aeromonas), often resulting from overcrowded conditions. The best preventative methods are adequate nutrition and space. Infected individuals should be isolated immediately, and treated with antibiotics. In severe cases, it may be necessary to drain the ponds and allow them to dry out for several weeks.

Economic Factors

Good management and operational skills are critical to an aquaculture enterprise. The success of aquatic farming depends largely on the cost to grow and market for the product. Before attempting to raise frogs or any other aquatic crop, the prospective culturist should conduct a survey of the local or regional markets to determine the current supply, present and expected demand, price elasticity, extent of competition, and other socioeconomic factors.

Large numbers of wild frogs imported into the United States or captured locally and sold at low prices will reduce the potential profitability of frog farming. Market price fluctuations of frog legs are volatile. Prospective frog farmers realistically should assess their own financial status because most aquaculture enterprises require a high initial investment, have a number of associated "hidden" costs, and produce low realized return on short term investments.

Expectations of large or easy profits are extremely unrealistic.

As in agriculture, aquatic farming a risky business. A number of unpredictable and uncontrollable catastrophes include prolonged droughts, severe floods, toxic chemicals, intense predation, infectious diseases, and contagious parasites literally can destroy an entire year's crop overnight. Prospective frog farmers should be well aware of these and other associated risks and be prepared to sustain some periodic losses.

At present, there is no well-established frog farming industry in Nigeria. Current practices and past efforts at commercial frog farming have been unsuccessful largely because of physical, chemical, biological, and economic constraints. Opinions concerning the feasibility of frog farming in Virginia range from the optimistic to those that maintain it is not possible economically.

Considering the current state of the art, frog farming as a **commercial** venture appears to have severely limited potential. However, as intensive hunting and increased drainage of natural wetlands continue to reduce the wild frog populations, the demand for frogs may reach a critical point, permitting skilled culturists to profitably farm frogs.

Declining Wild Amphibian Populations

Wild populations of frogs, toads, salamanders and other amphibians are declining throughout the world. Scientists suspect greater atmospheric ozone and the increased incidence of ultraviolet radiation, acid rain, and other forms of environmental pollution, but the exact causes for the rapid disappearance of frogs and other amphibians are unknown. Researchers fear extinction of many species of amphibians worldwide. This decline will reduce the supply of wild frogs for food and for farming operations. It also may impose new regulations and restrictions on frog farming enterprises.

In Virginia and most other states, it is lawful to capture and possess no more than a few wild native or naturalized amphibians for private use and not for sale. A permit for capturing, holding, propagating, and selling of wildlife, including amphibians, is required in most states.