1

CHAPTER ONE

Disease development

Celia R. Lavilla

The need for more and more food fish to feed a growing population gave rise to aquaculture. Today, aquaculture yields have increased, with more harvests coming from farms in Asia.

Aquaculture has three phases – the (1) hatchery, (2) nursery and (3) grow-out phases. Most hatchery operators use tanks to hold the young organisms that they grow. In the nursery and grow-out phases, tanks, ponds, and floating cages hold the farmed animals until harvest time.

In aquaculture, any one of three production systems may be used in growing the chosen species. These are the extensive, semi-intensive, or intensive production system. Choice of a system depends on the desired density of animals to be farmed in a given area. In the intensive system, fish are farmed in high stocking density. High stocking density results in exposure of the animals to stress that often leads to disease. Disease outbreaks, in turn, cause production losses due to lower harvests or aquatic products of poor quality.

Disease is defined as any abnormality in structure or function displayed by living organisms through a specific or non-specific sign (symptom). Infectious organisms, wrong management practices and environmental problems can cause disease in farmed aquatic animals. Tissue or organ damage, reduced growth rate, or death may indicate disease in fish. The consequence of disease includes rejection of aquaculture products and the loss of productivity. Persistent disease occurrence might cause the collapse of aquaculture ventures and threaten the sustainability of the industry as a whole.

Because of their harmful effects, disease and environmental problems have gained worldwide attention. Although economic losses due to diseases in aquaculture are difficult to measure, data gathered from the export of various aquatic commodities may serve as indicators for losses or gains in production. For example, China's export figure for farmed shrimp in 1992 was 140,000 metric tons. In 1993, shrimp export went down to only 30,000 metric tons. Viral disease caused the 79% reduction. Translated to export earnings, the country lost about a billion dollars from shrimp alone. An ADB/NACA (1991) estimate of losses in aquaculture due to disease was about US$1.36 billion in 15 Asian countries in 1990. The situation is even worse at present with viral disease plaguing shrimp culture facilities worldwide.

HOW DISEASE DEVELOPS

The development of disease in a particular aquaculture system involves several factors: the farmed fish (host), the disease-causing organisms (pathogens) and the surroundings (environment). A complex interaction exists among these three factors as represented in the diagram of three overlapping circles (Fig. 1-1). For a disease situation to exist, there should be a potential pathogen, a susceptible host, and environmental conditions that bring about either increased virulence of the pathogen, or decreased resistance of the host.

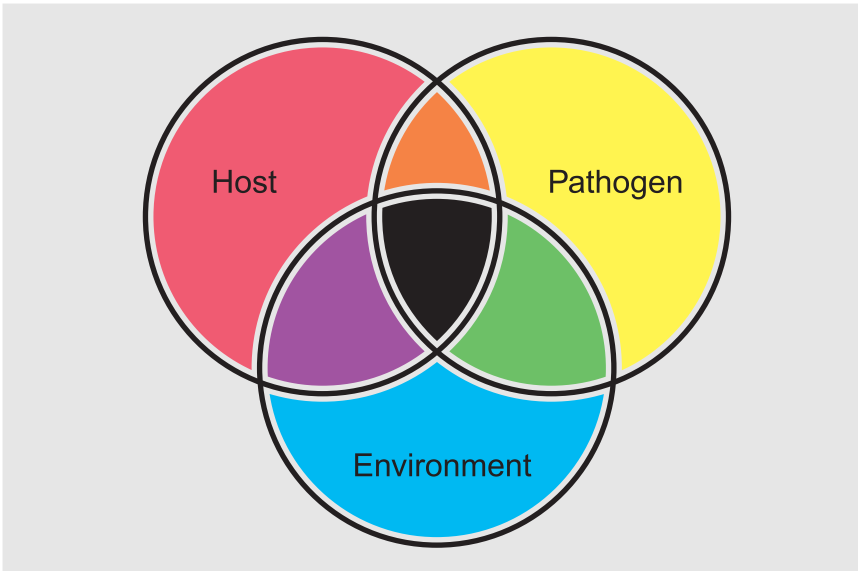

Figure 1-1. Snieszko's (1974) diagram of the effects of environmental stress on outbreaks of infectious diseases of fish. Factors that are related to the disease organism, host, and environment must be present for the disease state to occur. In the diagram, the blackened triangular area resulting from the overlap of three circles signifies this

Hosts

A host (fish or any farmed aquatic animal) can be either resistant or susceptible to a given disease. Resistance or susceptibility of the host depends on (a) age or size of the host organism, (b) species, (c) defense mechanisms employed and (d) the health of the fish, including its nutritional state.

Pathogens

Agents of diseases or pathogens can be classified into physical, chemical, and biological agents. Extreme temperature changes and radiation, such as ultraviolet rays from the sun, are examples of physical agents. Chemical agents can cause illness in aquatic organisms in a variety of ways. Environmental contaminants, toxins, nutritional imbalances and drug and chemical overdose are classified as chemical agents of disease.

Biological agents may initiate disease. They are the primary focus of attention when dealing with infectious diseases. These agents include viruses, bacteria, fungi and parasites. They are often called infectious disease agents. They can be present in the water or in sediment as part of the normal flora. Their presence and number are largely influenced by environmental factors like temperature, dissolved gases, pH, and availability of food. The two major characteristics of an infectious agent are (a) capability for direct transmission and (b) ability to multiply in the host tissue. The mode of their transmission is either (a) vertical or (b) horizontal. In vertical transmission, infectious agents transfer from parent to offspring. The female or male broodstock may be carriers of diseases, and transfer them to their offspring through the egg or sperm. In horizontal transmission, infectious agents come in contact with the hosts through the water, the feeds or through carrier animals that are in the environment.

Environment

The environment of cultured fish is composed of the water and its holding system like tanks, ponds, cages, pens, etc. Stability of the environment, especially in the physico-chemical parameter of the water brought about by the fish culture activity itself or by natural causes, will determine the health of the fish. Fluctuations in temperature, pH, salinity or dissolved oxygen beyond the optimum range for the host may lead to stress and disease. The key to successful fish culture is to understand and manage the environment of the host organism. Understanding the role of the environment in affecting the nature and cause of disease is essential to the prevention and control of disease.

Human Factor

The human element is an important consideration in the farming of aquatic animals. Aquaculture technicians and other personnel should have adequate knowledge and understanding of the species they culture to assure the success of an aquaculture operation. Lack of experience or insufficient personnel may lead to costly mistakes and poor yield. Farming strategies should consider the crucial role of the people involved in every stage of production.

Stress in Disease Development

Handling, overcrowding, malnutrition, or poor environmental conditions are stressful to cultured fish. Stress is defined "as the sum of the physiological responses the fish makes to maintain or regain its normal balance." Response and adaptation to stress takes place in three phases (adapted from Roberts 1978):

a. In the *alarm stage*, the fish attempts to escape from the problem.

b. If escape is not possible, the fish's body attempts to react to the environmental change. This is the *adaptive stage*, where the fish tries to adjust to the change and reach a new equilibrium, both physiologically and behaviorally, to survive the new environmental conditions. Although fish may successfully adapt to new and changing conditions, its growth, reproductive capacity and disease immunity may not be maintained as in the previous level because, at this stage, the fish deals with the stress as a priority. It is in this stage that disease problems are more likely to occur. Extended exposure of fish to environmental deterioration disturbs its normal function and decreases its chances of survival

c. If the environmental change is so great that the fish cannot adapt to it, then the fish stress response finally reaches an *exhaustion stage* and the fish dies.

Abrupt change in salinity, pH or temperature, especially at levels beyond the animals' tolerable range, cause significant stress in fish and make them succumb to secondary infection due to opportunistic microorganisms. Exposure to stress may also weaken the defense mechanism of fish.

DISEASE DIAGNOSIS

Disease diagnosis involves recognizing the occurrence of an abnormality and identifying its cause. Diagnosis of fish disease is a relatively new service available only fairly recently and the range of laboratory procedures is still limited. The eventual findings are not always very definitive, though the elimination of certain possibilities may still prove useful. A meaningful diagnosis is most likely where the fish are under the closest supervision, and where the fish farmer is able to provide data on environmental parameters and management practices employed.

Signs of Diseases

A sick fish often exhibits some disease signs before it dies. The first indication may be reduced feeding. Abnormal changes in fish color and behavior are among the earliest signs seen in affected fish. The fish may stay away from the school, or swim at the surface or along the tank sides. The fish may also exhibit flashing, scraping on the bottom of projecting objects, darting, whirling or twisting, and final loss of equilibrium. In addition to these changes, body surface abnormalities and lesions may be observed externally or internally. Specific disease signs associated with various diseases are presented with the diseases covered in this book.

Diagnosis

Fish disease diagnosis follows a format similar to that applied to other animal species, with more importance given to water quality parameters because of their direct effect on fish. A good history of the disease should be supported by personal observations before performing postmortem examinations. Following a gross appraisal, the most usual routine procedures are parasitological examinations, bacteriology, and histopathology. The last two procedures may require laboratory support. The following lists of on-site and laboratory procedures to investigate disease outbreaks are recommended by Anderson and Barney (1991):

On-site investigation:

- Examine fresh materials from healthy, moribund, and dead fish;
- Collect fish tissue samples;
- Measure environmental conditions (temperature, oxygen, etc.);
- Investigate physical factors and rearing conditions; and
- Gather information on time-course of mortalities.

- Deliver suitable samples with accompanying information to the diagnostic laboratory as soon as possible.

Laboratory procedures:

- Presumptive identification of pathogens (viral, bacterial, fungal, parasitic, etc.);
- Positive identification and confirmation;
- Test for drug sensitivity and effectiveness; and
- Evaluation of recommendations and reports of additional analysis (histopathology, toxicology, etc.).

Correct diagnosis is essential in selecting the best management approach to correct the problem and the best possible treatment for the disease. It will be useful as a reference for installing future disease-preventive aquaculture procedures and practices. Because diagnostics require suitable laboratory facilities and trained personnel, final diagnosis of fish disease should be performed in accredited Fish Health Laboratories.

Surveillance and Monitoring

Hatchery or farm personnel can initiate disease diagnosis at the farm level. This is done through regular monitoring of cultured populations, feed, and environmental inputs to detect the presence of opportunistic pathogens. One must be familiar with the normal condition of the fish to be able to easily spot any changes or abnormalities. Without an adequate record of the normal health status of the fish, deviations from the normal cannot be assessed. Consistent record keeping is vital in monitoring the health status of any cultured population. The keeping of records is also necessary to enable farm personnel to identify environmental problems, learn from past mistakes, and to minimize production costs.

The need for regular monitoring is directly related to the intensification of the production system. For extensive systems without feed inputs, it may be enough to provide minimal monitoring. In hatchery operations, and when engaged in the semi-intensive or intensive systems, however, regular monitoring procedures should be applied. Some examples of needed monitoring procedures are periodic microscopic evaluation of gill tissues to assess the level of microbial gill fouling, daily microscopic examination of larvae from culture tanks, and evaluation of culture tank water algae and other feed inputs.

When a disease outbreak is encountered, data gathered on the pattern of losses, the species and sizes of fish affected, and the duration of the epizootic can provide a great deal of useful information. Sudden explosive die-off involving all fish present usually indicates the presence of an acute environmental problem. This may be manifested by lack of oxygen, the presence of a lethal chemical toxicant, or by lethal temperatures. Mortality that starts with the appearance of a few sick fish, unusual behavior, or loss of appetite can signal the onset of infectious disease. These diseases can be more or less acute or prolonged in duration and the mortality ranging from high percentage of fish dying on a daily basis to low percentage of mortality over several weeks (Fig. 1-2).

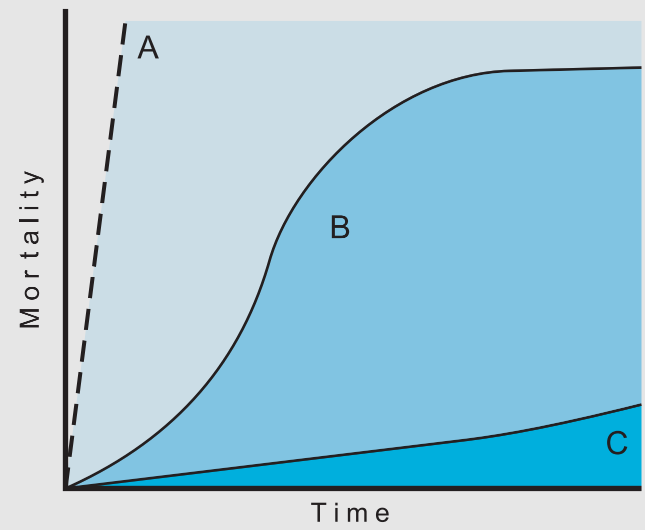

Figure 1-2. Hypothetical patterns of mortality of fish suffering from various kinds of diseases. (A) Acute environmental failure; (B) Acute infectious disease; (C) Chronic infectious disease

Ease in monitoring and collecting samples depends on the development stage and market value of the fish. The number of samples obtained from specific batches of fish is important. This is because adequate monitoring and diagnosis are impossible without sacrificing animals. Table 1-1 shows the recommended number of samples needed to represent a certain population of hatchery-reared shrimp larvae being monitored.

Table 1-1. Recommended number of samples for different populations of larval shrimp being monitored.

Larval population (Number of Larvae)			Sample size
1,000	to	199,000	20
200,000	to	399,000	40
400,000	to	599,000	60
600,000	to	799,000	80
800,000 up			100

However, if the prevalence of a certain disease without clinical manifestation needs to be assessed, then the number of animals to be examined should be based on assumptions that would yield statistically significant results. Table 1-2 gives the number of samples to be examined given an assumed prevalence of the disease.

Table 1-2. Recommended number of samples to test under various assumed prevalence of disease in the population

Prevalence of disease in the population (assumed)	Number of samples to test
1% or higher	300
2% or higher	160
5% or higher	60
10% or higher	30

SUMMARY

Disease occurrence is one of the biggest deterrents to sustainable production in aquaculture. It is therefore important to enhance awareness among various sectors of the importance of health management in the aquaculture industry. This can be done through education and information dissemination.

Students in fisheries and veterinary medicine need to have adequate background information on the aquatic animal disease and health management to understand the problems and needs of a fast-growing aquaculture industry. Recognizing disease signs early and using mortality pattern as a clue to the disease agent involved will not only make diagnosis easier, but it will also prevent massive losses by timely implementation of remedial measures.

REFERENCES/SUGGESTED READINGS

ADB/NACA. 1991.Fish Health Management in Asia-Pacific. Report on a Regional Study and Workshop on Fish Disease and Fish Health Management. ADB Agriculture Department Report Series No.1. Network of Aquaculture Centres in Asia-Pacific. Bangkok, Thailand

Anderson DP, Barney PJ. 1991. The role of the diagnostic laboratory in fish disease control. Annual Review of Fish Diseases: p 41-62

Brock JA. 1996. Some consideration of human factors as variables in disease events in marine aquaculture, p158-162. In: Main KL and Rosenfeld C (eds) Aquaculture Health Management Strategies for Marine Fishes. The Oceanic Institute, Honolulu, Hawaii

Brock JA, Main KL. 1994. A guide to the common problems and diseases of cultured *Penaeus vannamei.* The Oceanic Institute, Honolulu, Hawaii, USA. 242 p

Brown L (editor). 1993. Aquaculture for Veterinarians: Fish Husbandry and Medicine. Pergamon Press, Tokyo, Japan

Flegel TW, Fegan DF, Sriurairatana S. 1995. Environmental control of infectious shrimp diseases in Thailand, p 65-79. In: Shariff M, Arthur JR, Subasinghe RP (eds.) Diseases in Asian Aquaculture II. Fish Health Section, Asian Fisheries Society, Manila, Philippines

Lio-Po G. 1988. Prawn health in aquaculture, p 130-133. In: Chiu YN, Santos LM and Juliano RO (eds). Technical considerations for the management and operation of intensive prawn farms. UP Aquaculture Society, Iloilo City, Philippines

Plumb JA. 1999. Overview of warmwater fish diseases. Journal of Applied Aquaculture 9: 1-10

Post GW. 1983. Textbook of Fish Health. T.F.H. Publications, Inc. Ltd. Hong Kong

Roberts RJ (editor). 1978. Fish Pathology. Bailliere Tindall, New York

Snieszko SF. 1974. The effects of environmental stress on outbreaks of infectious diseases of fishes. Journal of Fish Biology 6: 197-208