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AQUACULTURE AND RISK MANAGEMENT

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1. INTRODUCTION

1.1 The Importance of Profitability

The purpose of all aquaculture enterprises is to produce aquatic animals or plants *at a profit*. All operational processes and management decisions are therefore directed to that end. If there are disruptions in production through accidents, poor management decisions, or for any reason, then profitability is in jeopardy. The welfare of the saleable aquatic animals or plants produced on the farm is therefore the most important activity of all individual aquaculture enterprises, and the focal point of all attention by the farmer and his employees.

However, as in other agricultural industries, profitability is not only influenced by activities on the farm. Food producers as a whole recognize two additional processes which influence profitability of their enterprise. These are (i) post-harvest handling and marketing activities, and (ii) the preparation of the product by the consumer. Thus, in addition to their own personal responsibility for growing a healthy animal or plant on the farm, producers have a continuing vested interest in the responsibility of others to market quality fresh products and prepare popular dishes for the final consumers. Unfortunately both of these activities are also potentially vulnerable to risks which prevent their final objectives being achieved, and thus reduce potential profitability for the middlemen and the producers.

In summary, the economic survival and strength of the aquaculture industry as a whole is entirely dependent and subordinate to the principal tasks of producing, marketing, and preparing quality aquatic products profitably and without risk. Fortunately, good farmers and industrial "middlemen" know the likelihood of these risks occurring. Through their experience they select the appropriate management technique to avoid or minimize these risks, and to keep all three activities on the most profitable course. This is the essence of risk management.

1.2 The Reality of Risks

Any process, by definition, involves a change or a series of changes over time. A process can be natural or man-made. The degree of change from the beginning to the end of a process is dependent on many factors. In the case of man-made processes, such as those characteristic of manufacturing industries, the end is almost certainly predictable, but for the processes of nature there are many factors which make the end unpredictable.

Most natural physical and chemical processes take place slowly over extremely long periods and therefore have the appearance of stability and predictability; on the other hand, biological processes, which by definition deal with life, occur over short periods of time and are highly susceptible to change or misdirection.

It is not possible, with a high degree of statistical certainty, to expect that the simplest biological process will achieve its predicted end in its appropriate time. There are too many hazards or risks, even at the level of the lowest forms of life. Some of these risks are totally beyond the control of the process. Almost every life form is part of the dynamic food web of nature. It is estimated, for example, that in nature only one egg out of ten thousand from the female flatfish survives to become another breeding adult. The risks to any one biological process are therefore so numerous and varied that they are almost impossible to catalogue, or to describe their magnitude, or to predict their frequency of occurrence.

Aquaculture is an industry built on biological processes. As pointed out previously it is an industry entirely dependent on the welfare of aquatic animals and plants which have to be produced and sold to generate profit. Consequently, by deduction, it is an industry which must be classified among a group of high risk food producing industries, which include meat, poultry, and cereal production, and market gardening.

1.3 The Concept of Risk Management

A high risk industry is not necessarily one which must be avoided by investors. Invariably high risk industries provide significant opportunities for high and/or rapid returns on investment. But it is obvious that the investment has to be carefully researched first, and the risks of the venture carefully weighed. Thereafter, the venture must be watched with constant vigilance. A technique for constantly monitoring and evaluating an investment, and its risks, is called "risk management".

Because of not one but three biologically-dependent activities (as identified in 1.1), which may occur between a farmer and his profits, aquaculture is recognized as a high risk industry. It is therefore important that the farmer is highly circumspect in his identification and management of the most likely risks to each of the three processes, and the commercial consequences. A grasp of the economic dimensions of potential risks which threaten each process is critical. The skill of the farmer in placing a value on each risk influences its priority and therefore the attention paid to its control. This is invariably the determining factor in the success or failure of any farming venture.

The "common sense" school of management recognizes that for every process there is a group of potential risks which can be identified individually and given priority. In many cases they can be avoided by careful attention; for example, fire is well known to be a major cause of death and injury, and the chances of escaping and saving property are greatly enhanced if early warning of fire is given. It is therefore sensible to have smoke detectors in the farm buildings.

There is another group of risks which also can be identified but which can be excluded from consideration, either because their incidence is beyond any reasonable human effort (or expense) to control, or because the chances of their occurrence are too statistically insignificant to consider. For example, in the fish farming world it is not worth a farmer analyzing every bag of fish feed before use on the theory that it may be contaminated. The chances of contamination are so small that they are outweighed by the cost of testing and the loss of feed tested. Therefore, to lessen the risk more cheaply, the farmer makes certain that the feed is purchased from a reliable manufacturer. Equally, the statistical chance that an aeroplane will fall on a farm is so insignificant that the risk can be discarded.

It is relatively easy, at both the personal and the commercial levels, to identify those risks which are either beyond human control (and expense), or statistically insignificant. However, there remains a large "grey" area of potential risks. Some of them can be identified with care, and an attempt made to value them. The aquaculture producer can then attempt to manage them for the benefit of himself and his business.

The process of managing risk is based on the individual analyses of three fundamental activities, which are taken in sequence, and subsequent synthesis of the results into a programme of management action. The three activities are:

- *identification of risk,* or discovering the source(s) from which a potential risk may arise,
- *Measuring risk,* or evaluating the impact on an individual or an organization in the event of a potential risk occurring, and
- *Managing and controlling risk,* or selecting the most effective method(s) to deal with a potential risk.

These three components have, in turn, many sub-components. All these must be reviewed and analyzed when a risk management exercise is undertaken. Guiding the farmer in making a review and analysis, and formulating a risk management strategy, are the subjects of the following sections.

2. IDENTIFICATION OF RISK

Aquaculture is an industry of great diversity. This is because there are a large number of species produced; almost 200 species of aquatic animals and plants are recorded by the Food and Agriculture Organization of the United Nations (FAO), and there are many systems and farming practices which vary according to different resources in different parts of the world. Consequently any attempt to produce a simple framework for the identification of the most common risks is not easy, even within a genera of animal or plant species. For example, the risks of trout production in Denmark are substantially different from those in Italy; and the risks for cage farming salmon in Scotland are different from those in North America or in New Zealand. Similarly, in the Philippines the risks of on-shore pond production of milkfish are different from those of shrimp production.

In addition, the exposure to different types of risk can change during the life cycle of a species. These differences may be subtle if the species has a simple life cycle, or they may be dramatic if the species has a complex life cycle with major metamorphoses. The pre-smolt production of young salmon in the freshwater hatchery stage, for example, has risks greatly different to those during grow-out in offshore marine cages. Consequently there is a range of differences in terms of risk between one species and another, and each with its own sub-set of associated risks.

Fortunately, despite all the complicating differences arising out of the peculiarities of species and life histories, there is a substantial number of components of production which are common from one practice to another. For example, moving water in a controlled way is a common denominator of many production practices; so too is the treatment of water in hatcheries, such as heating, filtration, and sterilization. The engineering associated with the mooring of structures in the sea is a common element of several practices in the industry, for example, sea cages used for marine fish farming or floating rafts for growing molluscs. Similarly, although all aquatic animals and plants have different life histories, many species are subjected to the same pathogens, fungal infections, and parasites which, for farming purposes, may often require the same biological and chemical treatments.

Finally, equally common to all production systems and practices, and which have no relationship to species or life history, are the pure risks, such as the climatic perils of high winds, unusual wave forces, floods, drought, abnormal temperature conditions, and natural hazards of earthquakes and volcanic activity.

The following framework summarizes the principal areas of risk faced by the farmer in the pursuit of profitability in the aquaculture industry. They are separated into (i) *business risks,* that is, risks directly related to the business of producing aquatic animals and plants; and (ii) *pure risks,* that is, the risks of life and business in general.

Business Risks

a) *Production risks*

i)	Operational risks	Risks which interrupt the production cycle, such as mechanical failure, failure of technical processes, late delivery of supplies and services.
ii)	Technological risks	Risks associated with lack of adequate technology, such as hatchery propagation, or lack of technical information and expertise.
iii)	Financial risks	Risks due to government financial policies, use and dependence on government policy instruments, terms of credit, changes in operational costs.
iv)	Social risks	Risks due to actions of special interest groups, such as environmentalists and conservationists.

b) *Market-related risks* — Risks due to loss of product quality, lack of market information, actions of third party (the marketing middleman).

c) *Consumer-related risks* — Risks due to loss of consumer appeal, health regulations, actions of third party (the consumer)

Pure Risks

i) *Physical risks of nature* Risks due to extreme climatic and meteorological conditions (wind, flood, drought, earthquake, volcanic action).

ii) *Social and political risks* Risks due to theft, malicious damage, and fraud.

iii) *Liability* Risks due to legal actions against the farm.

The examples are far from exhaustive but they indicate the principal types of risk for each process which are important for farmers in the aquaculture industry to consider. In their own right, each area is worthy of identification and should be given appropriate thought in the context of the particular operations of each individual farm, its location, the market system, and the target consumers of the product. To neglect this exercise possibly creates a third risk category, namely *management risks*, which would identify elements of poor planning and poor business control.

2.1 Business Risks

The business risks are those directly related to the production of aquatic animals and plants, and the associated commercial business of the industry. The risks are conveniently sub-grouped into three activities or processes described earlier, namely production on the farm, marketing, and preparation for consumption.

2.1.1. *Production risks*

Production risks are the principal concern in the daily routine of the farmer, as the production process is his sole responsibility. There are many and varied risks in the production process which can reduce profitability, compared with those which may occur in the subsequent processes of marketing and consumption.

Production risks can be conveniently categorized into (i) operational, (ii) technological, (iii) financial, and (iv) social risks.

(i) *Operational risks*

A large number of farms have failed to attain profitability in one or more years because of accidents or major disruptions in the production process. A principal cause of disruption in daily operations is often mechanical failure of plant and equipment. Mechanical failure is an area of weakness which requires expert engineering assistance.

The most important plant and equipment on the farm are those maintaining life-support systems, for example, those which deliver water, or provide aeration and oxygen. Farms can be divided into two types depending on their systems for life-support, namely (a) those which depend, to some degree or other, on the natural movement of water bodies to deliver water (such as gravity flow, tidal movement, and wind-assisted circulation), and (b) those which require water delivered by mechanical means.

The former include the simple ongrowing practices which are located in natural water bodies and watersheds, and which do not require any mechanical or human intervention to deliver water. Among these operations are floating cages, submerged cages, floating rafts, net pen enclosures, and self-sustaining ponds. Although these practices have some specific risk management elements of their own, such as appropriate moorage systems and pollution, they are all considered relatively simple and uncomplicated in terms of their life support system.

The latter, those which require controlled water delivery, include operations relying on artificial ponds, tanks, raceways, and all hatchery complexes. All have inherent risks of mechanical failure. Failure may be with pumps, pipework, valves, any heaters or filters, or water treatment processes. It may be primary mechanical failure of components themselves, or mechanical failure due to a break in utility services (electricity, gas, and mains water), or fractures in the system due to accidents (caused by physical damage or sudden low temperatures). Risks associated with mechanical life support systems are significant for the farmer to a high degree.

A number of farming practices are not dependent on regular water delivery but function on water treatment and recirculation. A life support system is even more at risk of failure when there are a number of mechanical components. For example, recirculation systems are often constructed as "package" units, with all mechanical components having back-up components and safety systems. However, these only add to the mechanical complexity of the system and increase the risk of equipment failure almost exponentially.

Life support systems using mechanical recirculation have a use on farms, for example, in cases where water resources become suddenly and unexpectedly limited. They are also of use for "low-density" activities, such as quarantine tanks, broodstock tanks, and also in stock transportation. However, with life support systems for high-density production, the risks of mechanical failure are high, and there are greatly increased biological risks associated with them. They are used invariably in locations where water resources are in short supply, and when the high value of the product justifies the initial large capital investment and operating costs.

The risk of disruption in daily operations of the farm's life support system is alleviated to some degree by the automatic alarm system. However, automatic alarm systems are themselves mechanical devices capable of failure. Furthermore, they invariably only monitor a limited part of a site. Furthermore, they invariably only monitor a limited part of a site. Alarm systems also require a human response, and by the by the right individual capable of dealing with the problem quickly. Although useful to the mechanical operations on a farm, alarm systems often provide a false sense of security.

The alternative or supplement to the automatic alarm is the interested and well trained reliable watchman (who may have the secondary job of site security), with a telephone or radio link to the farmer or technical staff.

The life support system is the principal system of the farm, and must function constantly. The response to any mechanical failure of the system must be fast, and the action taken must be appropriate. Automatic alarms have trained on the interpretation of each alarm, and the consequential actions required.

There are a number of routine activities in the daily operation of any farm which may be described as "hazardous" to the stock, and create risk. Typical hazards are those which expose the stock to a new environment, albeit temporary; for example, all handling activities required for such things as injection of veterinary medicines to treat pathogenic organisms, counting, weighing, measuring, or transferring stock around the farm, and also the use of chemical baths.

Finally, yet another potential breakdown in the smooth operation of the plant is the lack of supplies, particularly seed from hatcheries, and feed from manufacturers. It is vital that the farmer has prompt delivery of quality seed at the time required, and it is necessary that a farm has facilities for the proper storage of feed and other supplies.

Risks to lost production through disruption in the production process can be alleviated by livestock insurance. Insurance is a proven technique for the farmer to divert risk (see section 4.3). However, as production risks are so diverse, some underwriters will often only agree to share the risk, and often restrict the cover in various ways. The stock mortality insurance market which exists at the present time is relatively sophisticated, both at underwriting the risks to stock and applying the technique of risk management.

(ii) *Technological risks*

Aquaculture is a new technology, and the industry is still emerging. It cannot be assumed that the risks associated with aquaculture production are the same as other advanced and established businesses, such as agriculture, horticulture, or fishing. Comparisons are meaningless. However, it is interesting to compare man's level of knowledge of the natural history and biology of a few key aquatic species produced by aquaculture with those of certain domesticated land animals, cereals, or vegetables. For example, if it is assumed in relative terms that about 75% of the biology of the human is known, then probably about 50-60% of the biology of the major domestic land animals, poultry, and crops is known. But the knowledge of the biology of the aquatic animals and plants probably ranges from 20% (for such as the salmonids, and carps), down to 5%.

Even if this comparative quantification is only indicative of a relationship, it illustrates the lack of information which the farmer has about aquatic crops which are intended to give profits on his investment. His lack of information is compounded further by the dimension of water in which he has to work, and all its physical, chemical, and biological ramifications involved in the production equation.

The inadequacy of aquaculture technology is a significant risk to the industry at the present time. For example, the farmers themselves have the greatest need for information which will improve and guarantee farm production. Technological information is of prime importance to the future of the industry. It is up to the individual farmer to make certain that he is well informed about those technical developments which will help him reduce his risk. Production risks are increased where a high level of biotechnical skill is required, but is not readily available. In Japan, Taiwan Province of China (PC), and the USA, some years ago, it was remarkable to note how many new farms located themselves as close as possible to centers of research and development, thus reducing the risk of technical ignorance.

(iii) *Financial risks*

Many financial risks are common to all business enterprises and therefore might be considered "pure risks" (see Section 2.2). However, there are always some conditions which make them peculiar to the aquaculture industry, and therefore they must be considered by the farmer as factors which can influence the profitability of the enterprise.

Aquaculture farmers, like agricultural farmers, invariably require repeated loans. In addition to loans for capital construction, the farmer usually requires initial operational loans. These may be followed by short-terms loans for annual supplies of seed, feed, new equipment, or expansion. Thus the government monetary policy is important (see Section 5.1). For example, government measures to control inflation or high interest rates on loans obviously have a bearing on the farm's profitability.

The government's policy toward a new industry, such as aquaculture, may include a number of non-fiscal incentives for the farmer. These may include grants for development, development infrastructure (such as industrial zones), government equity shareholding, government insurance, leasing of facilities, and even compensation schemes. There may also be subsidies for construction, equipment, and supplies, labor and manpower schemes, and price support. Finally there may be credit on advantageous terms through quasi-government credit schemes, special loans with deferred repayment schedules, and loan guarantees. One or all of these non-fiscal incentives may be available to the farmer and, where economically sensible, they should be used.

Similarly the government often implements a number of fiscal incentives for a new industry with a special policy toward duties, taxes, and quotas. Typical fiscal incentives include duties on physical inputs, import-export duties of products, corporate taxes and income taxes, including tax exemption on commodities earning foreign exchange, quotas, and levies on sales.

It is important for the farmer to determine continuously the extent to which these non-fiscal and fiscal incentives are making the farm operations profitable, as government incentives are usually removed once the industry is established.

Governments may also support the developing industry through a number of valuable services, such as market services (information, intelligence, promotions, etc.), and technical services (research and development, extension, technical training schemes, etc.). Again, these are to be taken advantage of by the farmer, but with the recognition that these services will not necessarily be there forever. A change of government, or changes in government policy, are risks to the utilization of capital by the farmer.

The farmer has also to be aware of changes in the industries which are peripheral to aquaculture, and which will influence his profitability. For example, changes in the prices of fishmeal, a staple of the majority of animal feeds, will change the price of the feed he purchases. Increases in the price of fuel will increase not only his transportation costs, but also general energy costs for pumping water, and heating water in the hatchery. Changes in salaries and wages obviously alter the monthly balance sheet.

The profitability of any farm is closely tied to the farmer's management of capital and cash flow, but also to his overall financial awareness of other changes going on about him which have a direct or indirect effect on the profitability of the enterprise. The farmer will continue to need short-term credit to maintain the operation, and the lending institutions must make certain that credit is always available.

The lending institutions, to-date, have made little attempt to understand the intricacies of farm operations and their capital cycles, and invariably offer credit with terms they normally apply to land-based farmers, or fishermen. As a result, the lending institutions have made a number of inappropriate investments in the sector because of their conditions for the loans. In most instances these losses could have been avoided by a risk management assessment first. Risk management has a great deal to offer the well-informed farmer and the lending institutions in terms of the utilization and management of investment capital.

(iv) *Social risks*

National goals for the aquaculture sector in many countries, and the individual profitability of many farms, are invariably programmed though a series of development phases. This projected expansion, when considered in its entirety, is making considerable demands on natural resources. As a result, many other industries, equally important to the economies of countries and local areas, now compete openly and vigorously for the same resources.

The principal competitors of the aquaculture industry are those industries which also require water and adjacent space (such as electrical generation, agriculture, forestry). But aquaculture is also facing increasing competition for both inland and coastal waters and space from tourism and recreational industries. Furthermore, all are subject to the increasing demands of the

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