CONTINGENCY IN FISHERIES DEVELOPMENT

BY G.L. Kesteven

Summary

Fishing is a high risk industry because of the location and nature of its resources, of the circumstances and character of its operations, and of the perishability of its product. This paper examines the concept of risk, especially in the context of industrial fishing operations, defining a risk outcome of events in the industry, and distinguishing between the probability of each such event and its disutility. An examination is made of the position of a fisheries administrator confronted with the need to assess the risks associated with various proposed courses of action. A classification of risk outcomes and of the consequences of refusing or accepting risks is offered.

INTRODUCTION

The situation I have to examine is that in which an administrator is confronted with a plan for some fishery development project. The administrator has to decide whether to exercise the power and authority reposed in him to permit certain people to do certain things and to direct other people to do other things. His decisions are likely to determine the spending of public money and the use of national resources; they can affect the lives of other people for good or bad, directly and indirectly; they may frustrate honest endeavour and legitimate ambition, and may hinder progress and deny to the nation various economic and other benefits; or they may have converse effects. The administrator has certain choices to make and in general wishes to make decisions which will cause (or assist in various ways to cause) events to move in a direction indicated in his master's policy; that is, his decisions should be such that the actions taken as a result of them will be attended by least risk of having outcome other than that which would be in conformity with the policy he serves. He wishes to minimize his risks and he wishes, in self interest, the risks of the developmental enterprise also to be minimized. In this situation he wishes to know what the risks are and what might be appropriate techniques for their minimization; for this purpose a taxonomy of risk would be of value. This note is directed toward such a taxonomy and its theoretical implications.

Fishery, especially in its primary sector, is a risk industry. Sea conditions can interfere with ordinary travel and operations, with fish searching, and with fishing itself; they may be so severe as to cause complete cessation of operations, and frequently they cause loss of equipment and life. The behaviour and distribution of fish, although falling into discoverable patterns, are often unpredictable at particular times and places, and the concealment of fish within water brings uncertainty to a fisherman's searching for them. As a result of these uncertainties in fishing operations the subsequent operations of transport, storage, processing, and marketing themselves are uncertain. Reciprocally, uncertainties in secondary and tertiary sectors leave the fishermen uncertain of disposing favourably of their catch, and on occasions lead the

fishermen into dangerous courses of action. Finally, the high perishability of fish as a commodity further increases the uncertainty of outcome of any set of operations of the industry.

That current fishery operations are often hazardous and always in some degree uncertain is well known, and is a state of affairs which exercises a considerable influence on the attitude of investors. The uncertainties are so diverse, and the forces of some of them so considerable, that fishery is distinguished by them from most other primary industries. However, it cannot be held that every event in a fishery is of doubtful outcome, or of any fishery event that it will always be hazardous, or that the same kind of uncertainty surrounds all fishery matters whose outcome is in doubt. Moreover, we must note that although certain elements of these situations behave in a chancy way (in respect of which a calculation of probabilities is possible) this chanciness is not the same as risk, for risk comes in only insofar as man is concerned; conversely, and equally, the absence of chanciness in an element does not mean that someone in association with it is under no risk.

A CONCEPT OF RISK

We define risk as the likelihood of a particular, undesirable outcome of a specified event, or set of events. The term risk, thus refers expressly, and entirely, to something conceptual: it is a special view or appraisal of "something happening" and is not the something itself; it is not, for example, a danger. Out of a number of outcomes that there might be to a specified event, one outcome is designated undesirable (hereafter we refer to this particular outcome as the risk-outcome) and its probability is to be estimated: this probability of the designated outcome is the risk inherent in the event.

A risk can be considered great or small as to both the seriousness of the risk-outcome and its probability; the two can in most cases be expressed as a probability-weighted disutility.

The probability of a risk-outcome is a property of the system in which the risk-of-event can occur whereas, in contrast, undesirability is attributed to some outcome (thus making of it a risk-outcome) by some person (or persons) viewing the system. That is to say, the probability of a particular event is an intrinsic property of the system in which it occurs, and this view is unaffected by the fact that calculation of the risk is made independently of the system; conversely, undesirability is extrinsic to the system, and this view is unaffected by the fact that the characteristics of the risk-outcome derive from the system. Modification of probability, therefore, requires modification of the system, whereas modification of undesirability requires modification of the viewer himself, or of his relation with the system.

Since undesirability is attributed by a viewer, in terms of his own position and of how an outcome will affect him, a particular outcome which may be a risk-outcome for one person may be not so for another; moreover, any outcome which is commonly regarded as undesirable may nevertheless vary in its aspect to different people, both in respect of degree of undesirability and in

respect of probability-weighted disutility.

In contrast with its chameleonity as to undesirability, the outcome of a particular system on a particular occasion is immutable as to its probability. The estimates of probability for a particular occasion may differ because of differences in the amount of information concerning the system available to those making the estimates, or simply because of differences in calculations, but the probability itself does not vary. The probability of a particular outcome may appear to be modifiable by modification of the system, but in fact what we have after such modification of the system is another probability. Thus the probability of some particular outcome of rolling a particular pair of dice is unchanging provided no modification of the method of rolling is permitted; the probability will be different if the dice are changed by weighting or the rolling method is changed, but this then is another probability, of a different system. If, in the repetition of some particular kind of event the probability of some particular outcome should be variable, it is because the system in which the event occurs itself varies.

The consequence of this view of probability is that to a viewer (strategist) the probability of suffering a particular outcome can be changed only by either avoiding the event-of-risk (or the situation in which it occurs) or modifying the system in which the event-of-risk occurs. When, therefore, an administrator expresses a wish to "minimize his risks" he is really only using a figure of speech, for he cannot change the risks to which he refers. What he can seek to do is to manipulate affairs so as to be able to deal with a situation with least total probability-weighted disutility. For this purpose he may

(1) avoid situations in which the undesirable outcomes may occur;

(2) change some systems in which occur the kinds of outcomes to which he refers;

(3) where neither of the preceding courses is open to him, take precautionary measures to cope with, or moderate the consequences of, the risk-outcome.

To illustrate this we may make use from decision theory of the concept of many stage lottery, as described for example by Hadley*, and construct a diagram, as in Figure 1. Each of the heavy black circles represents a point at which the play of decisions, actions, and physical and other forces of the system determine which outcome will eventuate. Although this diagram represents that there is opposition between "own decisions and actions" and "other forces" I do not suggest that opposition always exists, much less that the one set of forces is equal and opposite to (and thus cancelling out) the other. On the contrary, the two may act fully in the one direction (and dispose or not toward a particular outcome), or be partly in opposition, partly in conjunction. Insofar as we are here dealing with risk-outcome, we represent the case of lotteries with only two results, the risk-outcome as against all possible other

*Hadley, G. (1967).—"Introduction to Probability and Statistical Decision Theory." (Holden-Bay : San Francisco.)

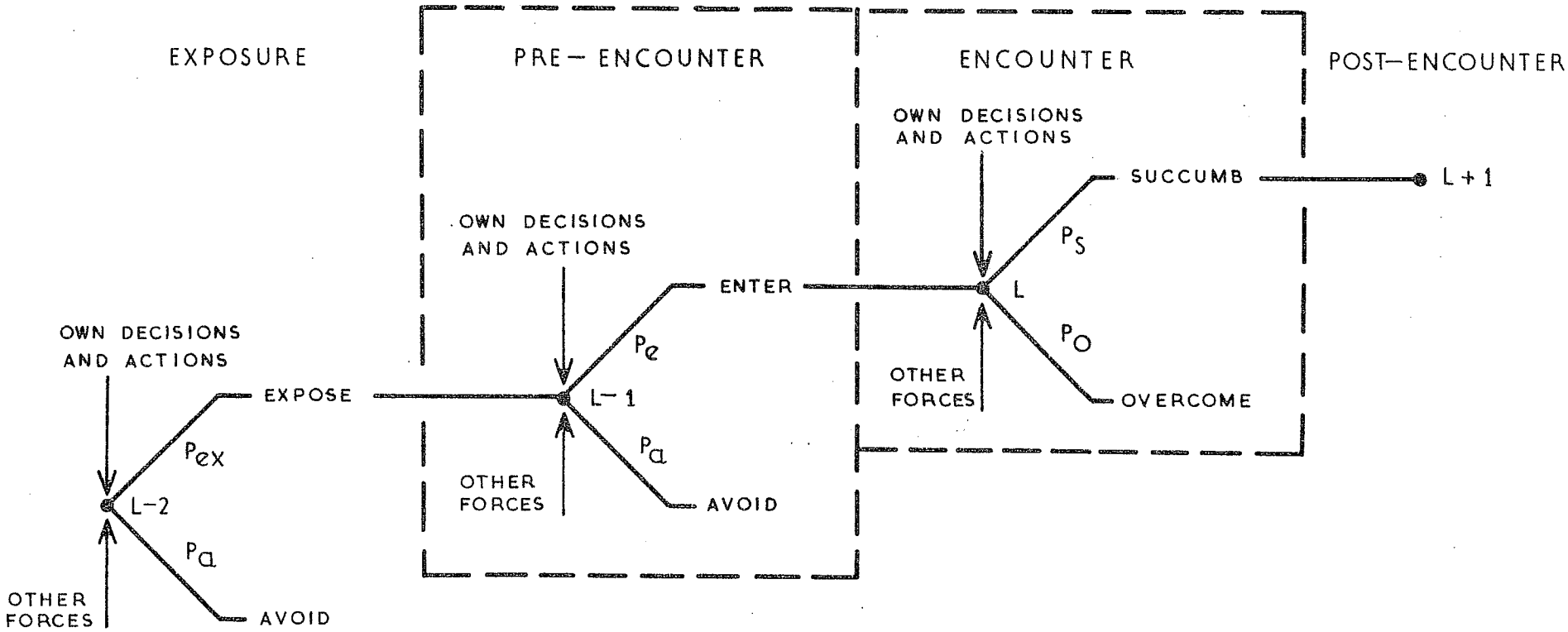


Fig. 1.– Risk situation.

outcomes. On the right of this figure we represent the encounter phase of the risk-outcome; to the left of this we represent that an encounter phase is preceded by one or more identifiable phases in which events determine whether the encounter phase is entered; it is a possibility that decisions will determine the outcome of these phases. To the right of the encounter phase stands, naturally, a post-encounter phase in which there may be further risks. The letters P_{ex}, P_a , etc. on the oblique lines from each L stand for the respective probabilities of the outcomes and in each case, following the convention in probability theory, the sum of the two probabilities is 1.

The methods by which these probabilities are estimated are irrelevant to this note, but we must observe that a figure such as this, while representing a particular sequence, can carry different sets of probabilities, and its outcomes may be assigned different utilities. Primarily a distinction has to be made between the view taken by a person standing outside the situation and that of a person involved in the situation, whose decisions and actions may influence the outcome. To the former the behaviour of the latter is an element of the behaviour of the whole system and is in some way accounted for in the calculation of probabilities; moreover, this external viewer is likely to calculate the probabilities over a wider range of data, and in more general form, then that on which the involved person will decide and act. The involved person will take note of immediate information and the rightness of his decision itself contributes to the probabilities of the situation; in certain cases his decision is final and decisive and the probability is 1 or 0. The outside viewer is most likely to be interested in the total probability, $P_{ex} \times P_e \times P_s$, and this, related to the disutility of the final outcome, will influence his attitude to this situation. There may then be a range of cases between these two encompassing various kinds of action by an outside viewer to influence decisions or even change a situation.

RISK-OUTCOMES

To come closer to a specification of the administrator's position we may now turn to a representative list of the kinds of risk-outcomes in fishery with which we are concerned; such a list is given in the Appendix, and the kinds of situation in which these outcomes can occur are represented in Figures 2, 3 and 4. Although these outcomes are grouped according to the situations in which they occur (and hence to the persons in those situations), an inspection of the list soon discovers alternative ways of classifying them. The first alternative that presents itself lies in the distinction between immediate, first-hand outcomes and those that are consequential. Thus, physical and managerial outcomes have financial consequences which may constitute risk-outcomes, and these in turn may lead to risks at other levels. Another view sees distinction between what may happen to the person, to his position, to his possessions, to that for which he is directly responsible and, finally, what may happen to that for which his responsibility may be in various degrees removed.

Out of this we can see the beginnings of a classification of risk in that we could construct for a particular type of risk situation a table of which the frame would be as follows:

	IMMEDIATE OUTCOME			CONSEQUENTIAL OUTCOME		
	Exposure	Entry	Encounter	Exposure	Entry	Encounter
To:						
Person						
Position						
Possessions						
Matters of direct responsibility						
Matters of less direct responsibility						

Into the body of this table could be entered the risk-outcomes themselves, accompanied by estimates of their probability. This information could be supplemented by disutility evaluations. We must at this point turn to the measurement of disutility.

DISUTILITY

Quantification of the seriousness of any outcome may at first sight appear extremely difficult, especially in the case of an outcome such as loss of life. The problem can be approached, however, in terms of what a rational decision-maker would estimate that he would be willing to do, or to pay, in order to avoid or prevent an outcome, or what he would be willing to forego rather than endure the outcome. Alternatively it can be approached by way of estimates of the costs of making good the result of an outcome should it eventuate. The whole of actuarial practice is available for estimation of costs of insurance against defined outcomes. Finally, there are costs of services and equipment (such as safety at sea, weather information, sea-rescue) to guide decision-makers in their efforts to moderate the effects of certain outcomes, and in some cases to change the system, which can serve as a measure of the disutility of certain outcomes.

The foregoing means of measurement are relevant essentially to the person involved in a situation although the third is of relevance also to a person outside of the situation. The situation is represented in Table 1, from which it will be seen that at each decision point L_{-2} and L_{-1} the decision maker must assess the probability-weighted disutility of refusing the risk against the probability-weighted disutility of accepting it.

Position of the Administrator

We can now see the position of the administrator somewhat more clearly. For the most part, as the Appendix shows, an administrator stands, in the sense of Figure 1, within relatively few of the risk-situations we have in mind. The principal consequence of this condition is that the administrator, as person outside the situation, is concerned with modification of situations in an

TABLE 1

	Involved Person		Person Outside of Situation
	Refuse Risk	Accept Risk	
Exposure	Cost of avoidance *per se** Cost of loss of opportunity	Cost of insurance either as equipment, etc., or as financial arrangement	Cost of warning services
Pre-Encounter	Cost of avoidance *per se* Cost of loss of opportunity+		
Encounter		Cost of damage or loss Cost of loss of opportunity Cost of repairs Cost of loss of opportunity	Cost of rescue services Cost of consequential outcomes

* Cost of avoidance means any operating costs for which there is no return because of adopting the avoidance strategy; it may include costs of drawing on warning services.

\+ Lost opportunity means any opportunity to produce which is lost because of the avoidance strategy.

endeavour to determine outcomes, and therefore, so far as relates to the subject of this note, is engaged chiefly in the calculation of probabilities, utilities and of probability-weighted disutilities. His is an information function directed toward influencing events: he promulgates laws and regulations; he gathers, compiles, analyses, interprets, and disseminates information; he manages various services; he gives advice, relating both to his own activities and to matters such as the granting of financial assistance, the prosecution of research, and the conduct of developmental activities. Therefore, although an administrator stands outside of real situations of the industry, each time he must make a decision he stands at a decision point of Figure 1. His risk-situation is a kind of reflection or projection of the real risk-situation of the industry he administers.

Let us take as example of his problem the case where a proposal for some development project is under consideration. The administrator stands at decision point L_{-1}, and the risk-outcome he contemplates is the consequence to him and his administration of the failure of the project in the case that his administration has supported the project; he also, at L_{-1} must consider risk-outcomes in the event that his administration does not support the project: he may then be blamed if it fails, or criticized if it succeeds. He has then to place disutility values on these various outcomes and to calculate the probability of each. He is principally concerned with the probability-weighted disutility $P_s u_s$ as influenced by the disutilities $P_e u_s$ and $P_a u_a$. That is, he is concerned with the forces operating L (including the influences, positive and negative, he may himself exert) which determine the two probabilities P_s and P_o. The uncertainties with which he has to deal may be summarized as follows:

(1) Uncertainty of an event-of-interest in
   (a) physical system,
   (b) biotic (non-human) system,
   (c) human system,
   (d) system combining these elements.

The behaviour of these systems can be, of course, regular or irregular and the probabilistic approach is concerned with both the reliability of regular patterns and the occurrence of random elements. It is not the purpose of these notes to give any review of the enormous literature dealing with this subject.

(2) Uncertainty which has its origin in the state of knowledge concerning the system in which the event-of-interest occurs:
   (a) Descriptive.— Information as to
      (i) location, structure and dimensions of the system in more or less static sense, and
      (ii) as to its operation (time series).

Predications based on this type of information implicitly assume the continuation of the circumstances prevailing over the period in which the information

has been gathered. In particular such predictions cannot accommodate any changes of the system impelled by the operation of forces external to the system. Furthermore, the estimate of random elements is limited to the range of experience of the period of observation,

> (b) Analytic.— Information as to the processes going on within the system, and between it and its context, and as to the determinants of the behaviour of the system.

Predictive systems based on this type of information have a potential for forecasting events outside the range of experience of the period of observation, provided that observation can be made of all the forces capable of significant influence on the system.

Whilst class (1) indicates the kinds of systems in respect of which there may be uncertainty, and hence the kinds of investigation required to reduce the uncertainty, class (2) relates to reliability of information and in particular to the reliability of predictions. The administrator is especially interested in class (2) since it is through the improvement of the state of his information that he acquires a power to select his risk-situation and to modify situations to states of lower risk.

In the sense of state of information, and administrator's situations fall into three principal classes:

(1) The start of a development, when information concerning the resource to be exploited, the process to be employed, or market to exploit is minimal and little can be said with firmness about the form or magnitude of industry that might be established.

(2) The pilot-operation phase of development, when indications have been obtained as to prospective form and magnitude of industry, and trials must be made of real-situation operations to obtain information on the play of social and economic forces.

(3) The phase of established industry when the task is to maintain the effective operation of the industry in the face of periodic and random changes in various elements.

The flow diagrams, Figures 2 and 3, representing the events and decisions in operations of primary and secondary sectors of a fishery, represent the kind of situation from which an administrator draws information and to which he furnishes information whilst exercising various influences, as a situation of class (3). The kinds of risk-outcome of the industrial situation itself are indicated in the Appendix; these, as noted earlier, have consequential outcomes, including those with which an administrator must deal, but whether these are risk-outcomes depends upon political climate and formulated policy. If, for example, a nation has a completely laissez-faire attitude to industrial activity, a fisherman's failure to make a catch might be a matter of indifference;

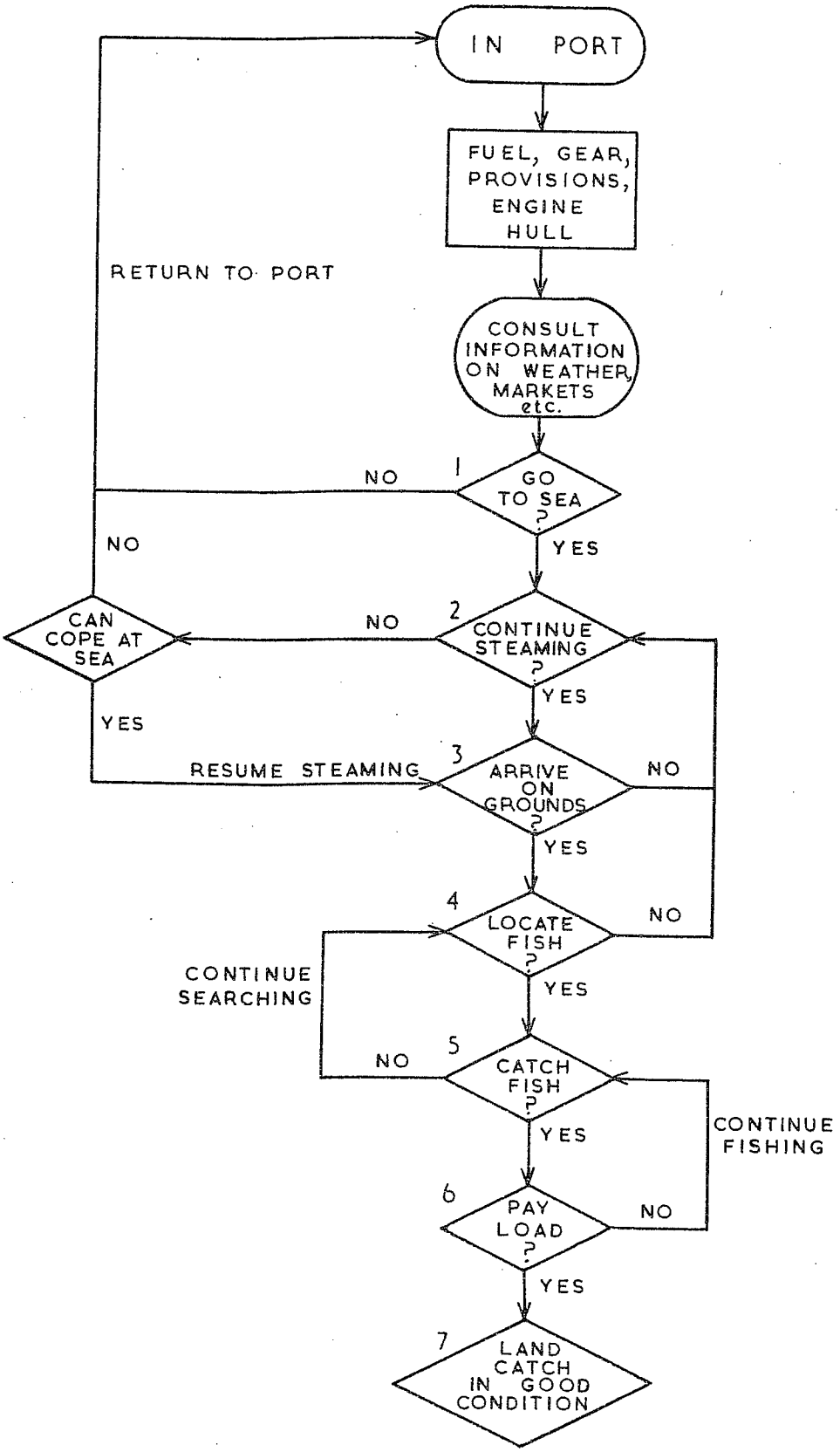


Fig. 2.- Primary sector operation

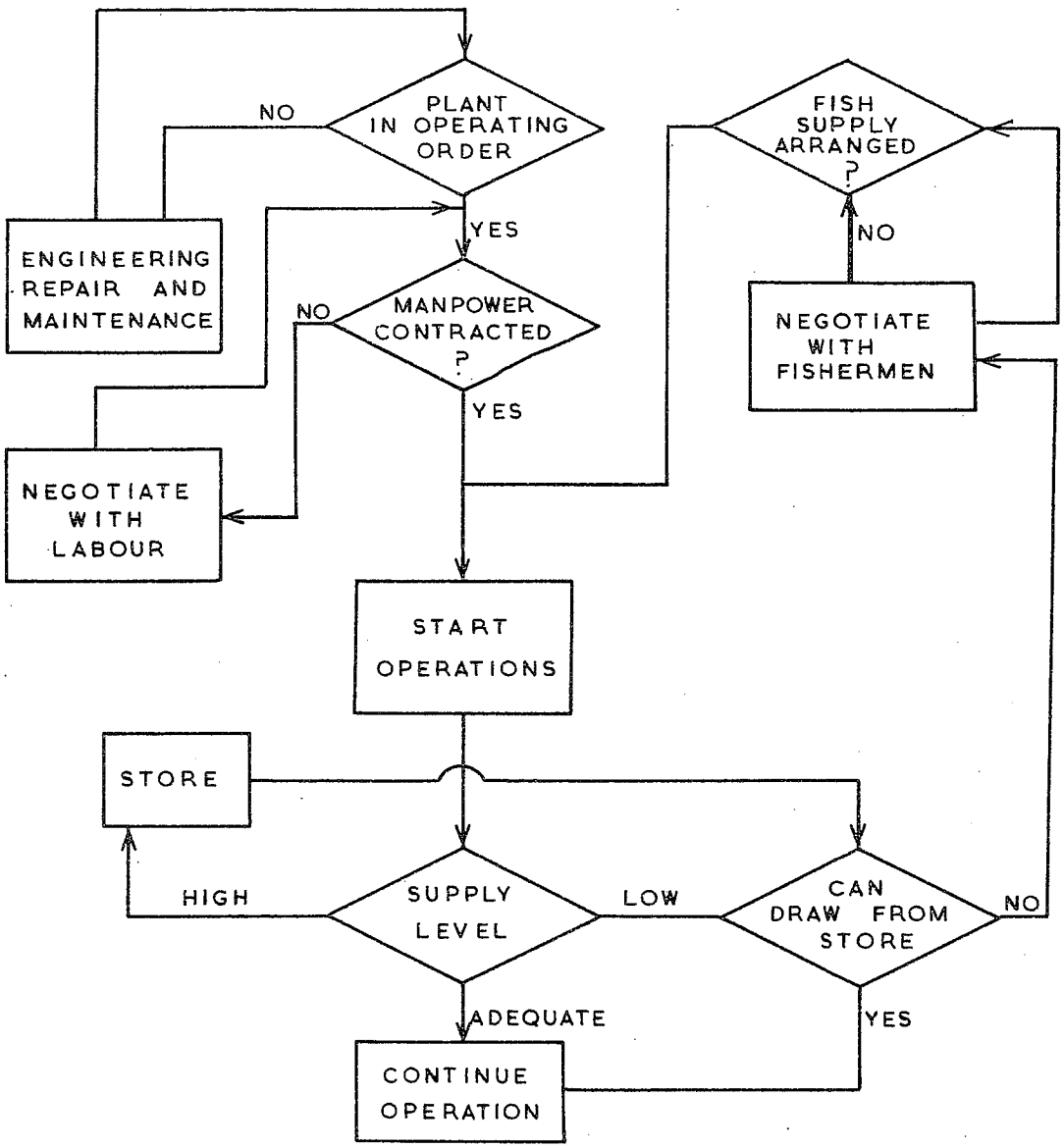


Fig. 3.- Secondary sector operation.

but if official policy is to raise the productivity of the industry, such a failure would be a matter of concern. Here we have an illustration of the origin of "undesirability" and at the same time, further evidence that an administrator speaks only figuratively when he says he wishes to minimize his risks. Everytime an administrator's advice leads to a policy to develop the industry in any sense whatever, there is some identification of new undesirable outcomes and a setting of higher standards; this has the result of increasing the range of risk-outcomes of which note must be taken and may increase the likelihood of occurrence of risk-situations. Formulation of policy to raise productivity, for example means that every opportunity to realise this policy, and every force that might deny it, may present a risk of some kind or another, so far as an administrator's responsibilities are concerned. Thus the effect of part of an administrator's work is to increase the number of his risks.

The flow diagram of Figure 4 is a sketch of events and decisions in development of an industry, and thus represents situations of classes (1) and (2). In steps 1 to 8, information is being obtained about natural systems in which human behaviour as yet plays no part; in steps 9 to 11, the human element is introduced and its behaviour and effects are observed. Therefore the information-gathering strategy in stages 1 to 8 should be of a kind that will most directly and effectively investigate the natural system, whereas in steps 9 to 11, the presence of human element as part of the system is indispensible; that is to say, organized research is required (and is the most economic strategy) for steps 1 to 8, and pilot-scale operations are required in steps 9 to 11. Then in steps 12 to 23 there is continuation of situation (2), leading into situation (3), but with some feed-back demands for situation (1) decisions.

APPENDIX

CATEGORIES OF RISK-OUTCOME

	Risk-situation	Risk-outcome
I. Physical	(a) In fishing	Breakdown of equipment; damage to or loss of equipment, by fire, storm, or other mishap
		Injury to persons, loss of life
		Loss of catch (e.g. by split net)
		Damage to or spoilage of catch
	(b) In handling, storing, transporting, and processing fish and fish products	Breakdown of equipment
		Damage to or loss of equipment by fire, storm, or other mishap
		Injury to persons, loss of life
		Damage to or spoilage of raw material or product
II. Managerial	(a) In fishing	Interruption of or interference with operations (e.g. by weather)
		Failure to find fish
		Failure to catch at desired rate
		Sickness, malperformance, incompetence, or absence of crew
		Deficiency in or failure of services:
		at sea - of weather and market information services
		in port - of unloading, fuelling, provisioning, and other services
		Loss of opportunity to dispose of catch

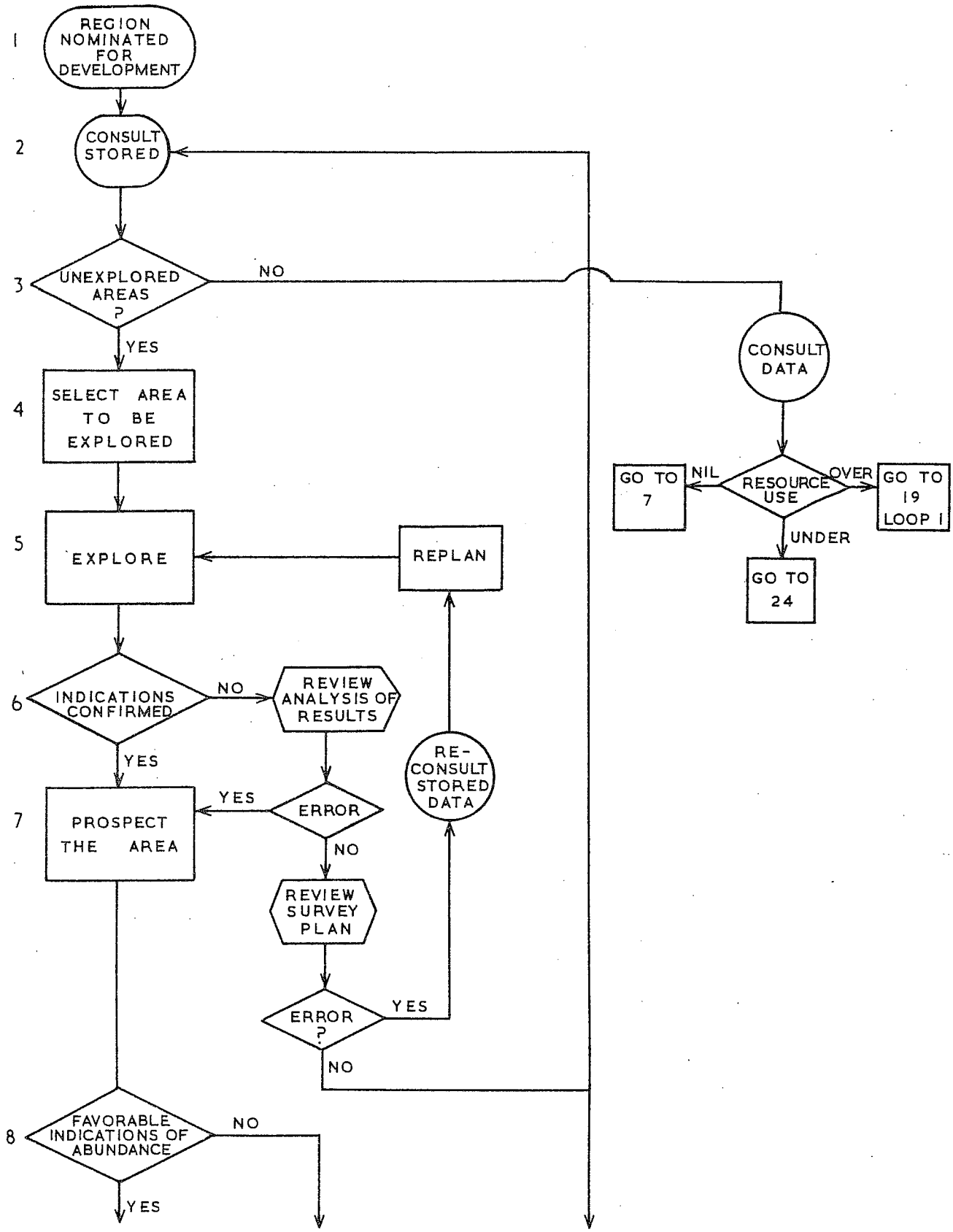
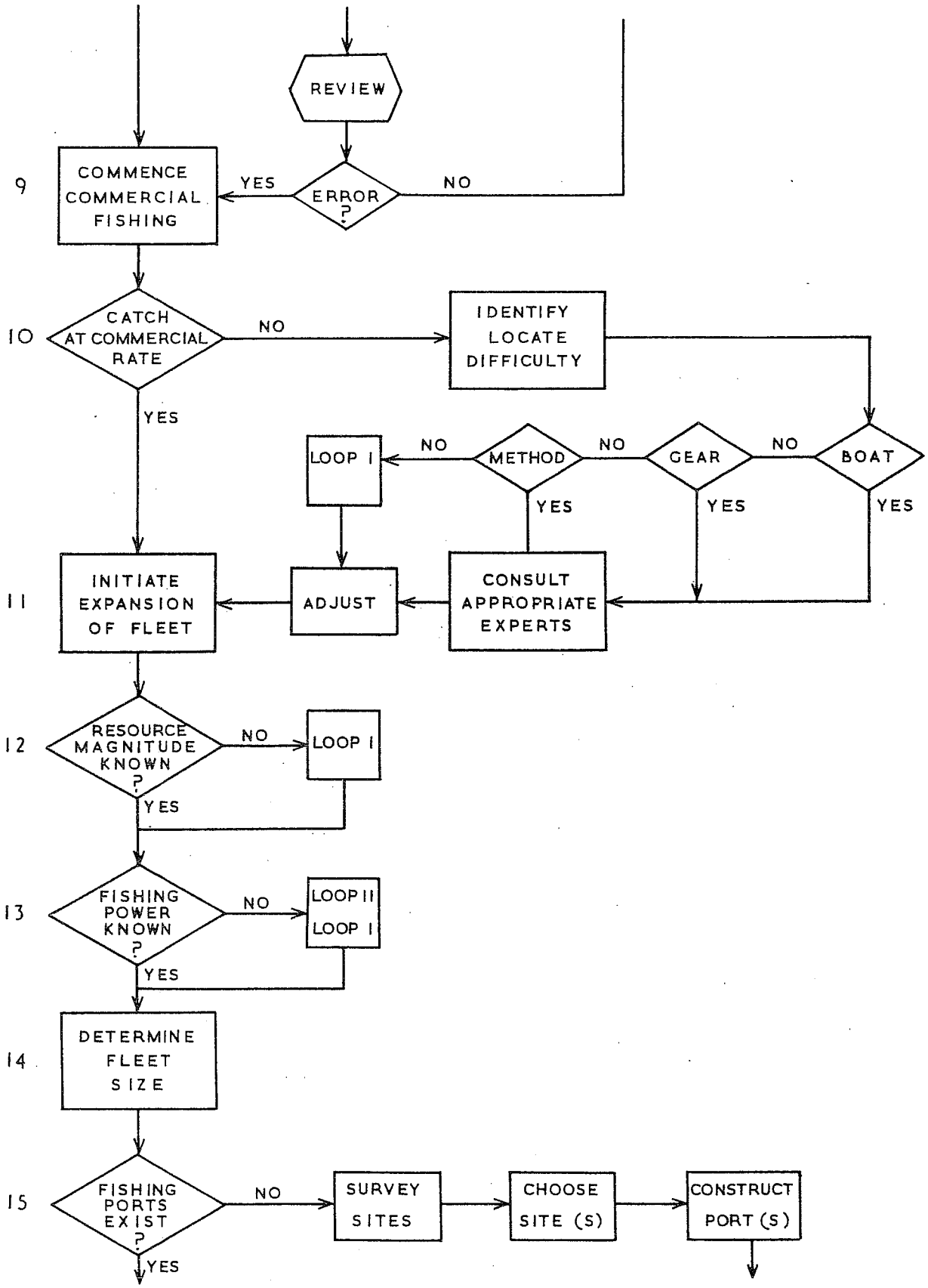
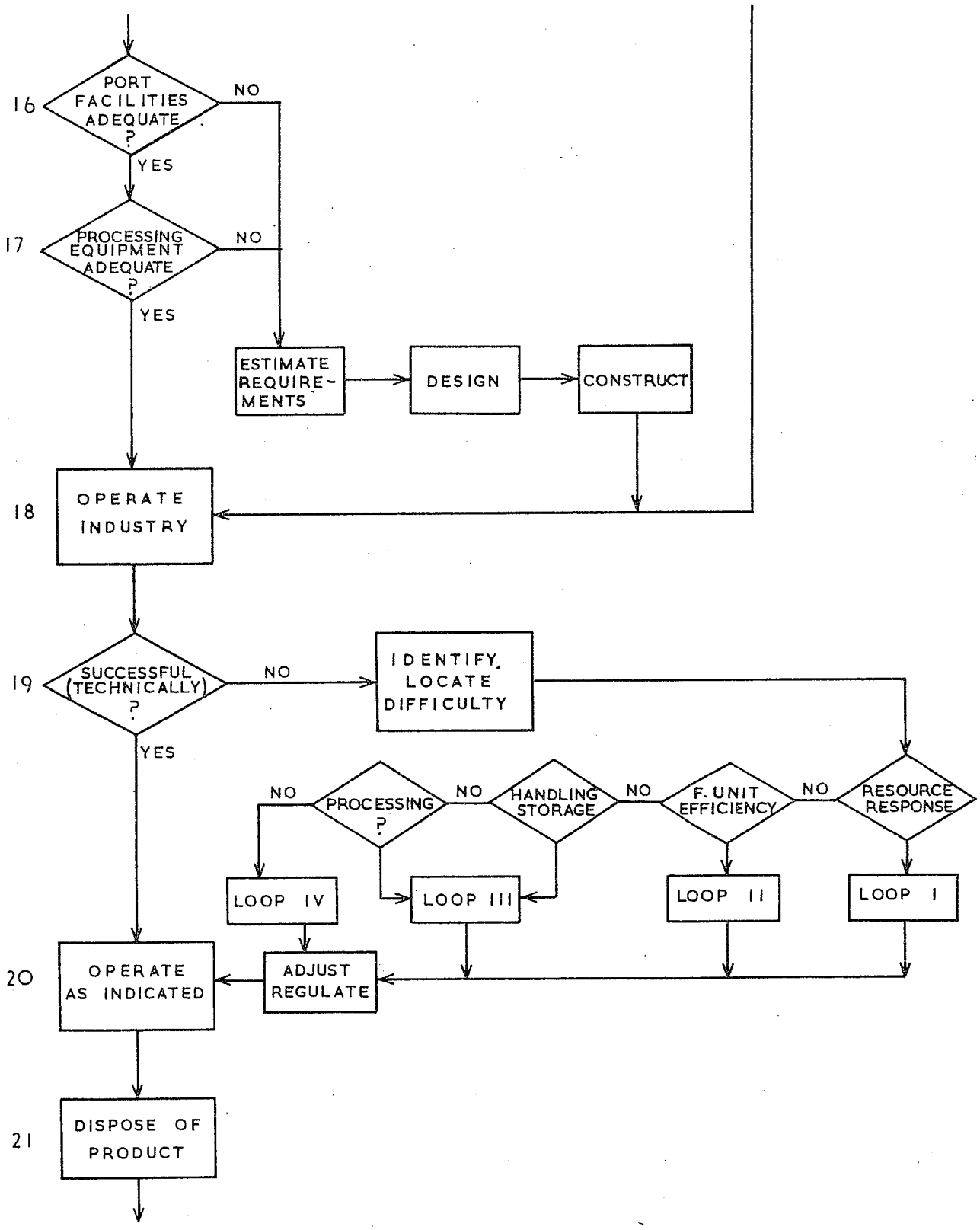
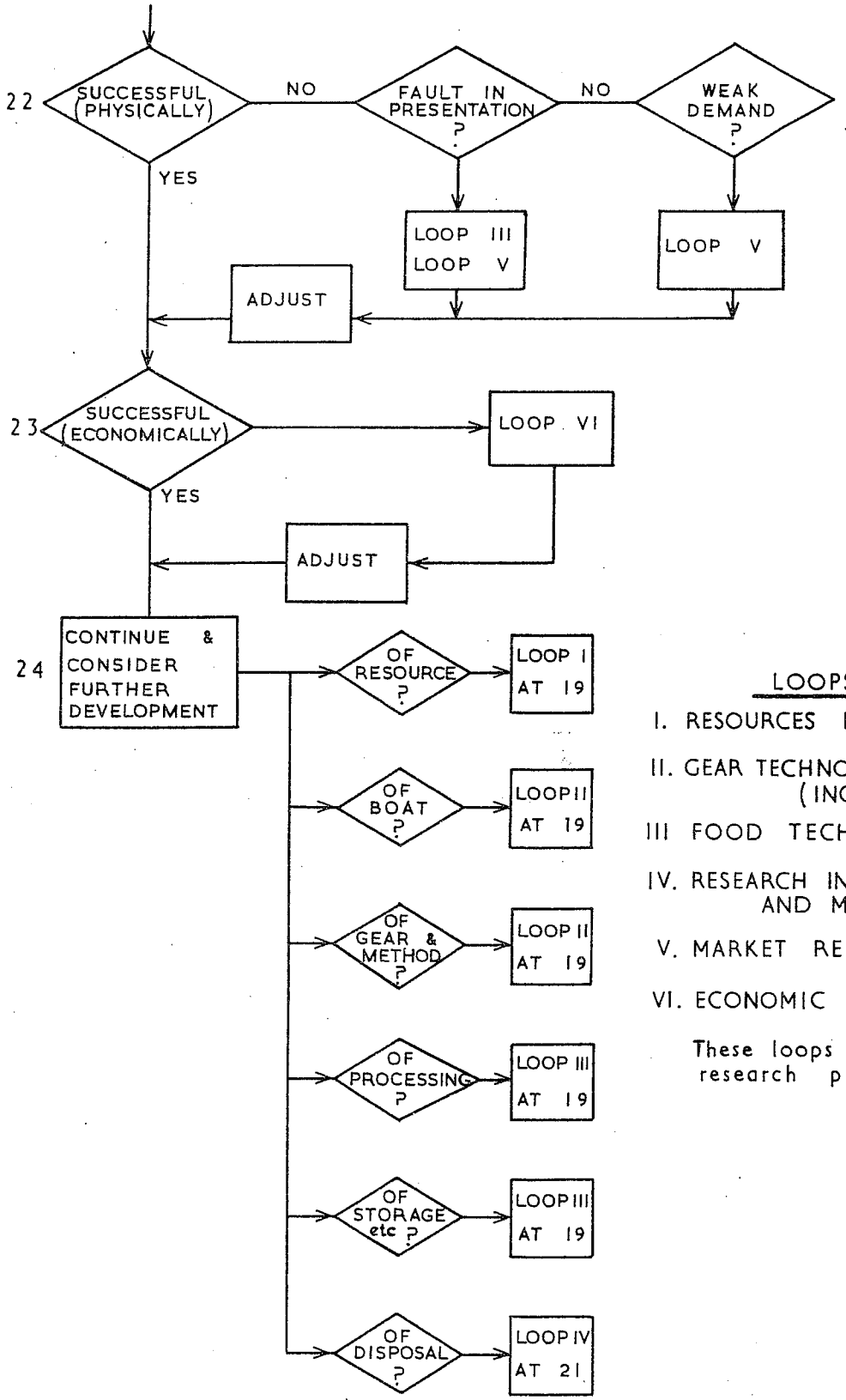


Fig. 4.- Primary sector development


REVIEW
9
COMMENCE COMMERCIAL FISHING
YES
ERROR ?
NO
10
CATCH AT COMMERCIAL RATE
NO
IDENTIFY LOCATE DIFFICULTY
YES
LOOP I
NO
METHOD
NO
GEAR
NO
BOAT
YES
YES
YES
11
INITIATE EXPANSION OF FLEET
ADJUST
CONSULT APPROPRIATE EXPERTS
12
RESOURCE MAGNITUDE KNOWN ?
NO
LOOP I
YES
13
FISHING POWER KNOWN ?
NO
LOOP II
LOOP I
YES
14
DETERMINE FLEET SIZE
15
FISHING PORTS EXIST ?
NO
SURVEY SITES
CHOOSE SITE (S)
CONSTRUCT PORT (S)
YES


16
PORT FACILITIES ADEQUATE ?
NO
YES
17
PROCESSING EQUIPMENT ADEQUATE ?
NO
YES
ESTIMATE REQUIRE-MENTS
DESIGN
CONSTRUCT
18
OPERATE INDUSTRY
19
SUCCESSFUL (TECHNICALLY) ?
NO
YES
IDENTIFY, LOCATE DIFFICULTY
NO
PROCESSING ?
NO
HANDLING STORAGE
NO
F. UNIT EFFICIENCY
NO
RESOURCE RESPONSE
LOOP IV
LOOP III
LOOP II
LOOP I
20
OPERATE AS INDICATED
ADJUST REGULATE
21
DISPOSE OF PRODUCT



LOOPS

I. RESOURCES RESEARCH

II. GEAR TECHNOLOGY (INCL. BOATS)

III FOOD TECHNOLOGY

IV. RESEARCH IN INSTITUTIONS AND MANAGEMENT

V. MARKET RESEARCH

VI. ECONOMIC RESEARCH

These loops are separate research programmes.

APPENDIX (Cont'd)

	Risk-situation	Risk-outcome
	(b) In handling, storing transporting, processing, and selling fish and fish products	Loss of manpower, breakdown in labour relations, deficiencies or breakdown in fuel, water, or power supply, or in supply of materials (e.g. cans)
		Breakdown in supply of raw materials, or product drop in sales, or loss of sales outlet
		Bad acquisition of equipment
		Fault in contracting
III. Financial		Costs (direct and consequential) of outcomes in I and II above
		Rise in operating costs or in costs of supplies
		Fall in selling prices
		Errors or malfeasance in accounting
IV. Entrepreneurial		Debit in profits and loss account
		Inadequate return on, or loss of investment
V. Legal		Infringement of law
		Breach of contract
VI. Administrative (governmental)		Breakdown in communications between departments or failure of co-ordination
		Action on incomplete or bad information
		Action contrary to policy
		Inconsistent policy
		Change in relations with other governments (on world or federal scale)
		Failure of supported project