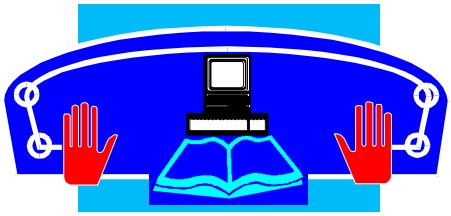

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ECOLOGICAL ADAPTATIONS IN SUBSISTENCE FISHING: THEIR IMPLICATIONS FOR STABLE COMMERCIAL FISHERIES DEVELOPMENT

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ABSTRACT

Subsistence fisheries often display technologies and methods closely adapted to local ecological conditions. Some of the cultural factors which can contribute to these adaptations are briefly discussed A number of subsistence fisheries in tropical freshwaters are then examined with particular reference not only to their specific ecological adaptations but also to their total yields.

For stable development, a fishery's biological resources should be classified according to their ability to sustain various degrees of exploitation by man. The efficiency of small-scale flexible equipment, such as that used by subsistence fishermen, in situations where a commercial fishery's resources are particularly fragile or patchily distributed in space and time is discussed. There then follows an examination of the role of large-scale intensive technology in the harvesting of more resilient fishery resources, especially during those periods when such resources are locally super-abundant. The importance of recognizing the highly diverse and often unstable nature of tropical fisheries when planning strategies for their development, is emphasized throughout.

It is concluded that subsistence fishing should not be considered merely as a 'primitive' stage in fisheries development to be inevitably replaced by the more progressive and intensive techniques of commercial fishing, but rather as a resource in itself which can yield much valuable ecological information about local environments and fauna and which in certain situations can be incorporated profitably into a developing commercial fisheries programme.

INTRODUCTION

Aboriginal subsistence systems are adaptive in that they provide a sustained yield of resources from the natural environment. The highly diverse and flexible technology used in the aboriginal fisheries of the Amazon basin, for example, is well adapted to

Amazonian aquatic environments and fish fauna which are both spatially and temporally extremely heterogeneous, (Chapman, 1977). These adaptations in conjunction with other factors such as a detailed knowledge of local aquatic ecosystems, high degree of fishing skill, and certain cultural checks on over-exploitation of resources (Reichel-Dolmaroff, 1976), have allowed aboriginal fishermen in the Amazon to realize high yields/fishing effort ratios (Bergman, 1974) while at the same time maintaining a stable and permanent relationship with the fishery ecosystem.

By contrast, the commercial fisheries in the same region, with their increasing reliance upon imported large-scale neo-technology and high market demands unchecked by adequate legislated controls, are becoming more intensive and unstable, particularly in terms of declining yields/fishing efforts ratios (Chapman, 1977). In nearly every aspect of their operation, the 'principles of permanence' observed by Clarke (1977) are characteristic of 'paleotechnic' consnercial fisheries.

Clearly for socio-economic reasons, it is impossible for modern commercial fisheries to adopt paleotechnic methods of exploitation, no matter how well-adapted to the environment, in order to achieve ecological stability. And yet, if the decline in the commercial fisheries of this region is to be halted, some means must be found of incorporating into their development the stability characteristic of aboriginal fisheries. Odum (1969) has devised a model fOr stable ecosystem development in Which lard-use management strategies are implemented to achieve either a 'compromise' between moderate yields and moderate quality on all the landscape, or a 'compartmentalization' of the environment to form a balanced mosaic of 'productive', 'protective', 'intermediate', and 'urban-industrial' areas. The question here is, how could this model be applied to the stable development of the aquatic ecosystems of the Amazon basin and what role would the aboriginal fisheries play in such a plan?

APPLICATION OF ODUM'S MODEL TO THE STABLE DEVELOPMENT OF THE AMAZONIAN FISHERIES

Odum's compartmentalization strategy for ecosystem development seems a particularly appropriate one for the highly heterogeneous Amazonian aquatic environment. Here the first division could be drawn between the productive varzea or Amazon floodplain (Lathrap, 1970) and the relatively unproductive interfluvial areas or terra firme. Within the varzea 'compartment', a further sub-compartmentalization is possible of the different floodplain features such as ox-bow lakes, backswamps, streams, and main rivers, which vary significantly as favourable for fish production (Fig. 1) (Marlier, 1967; Sioli, 1968; Junk, 1970 & 1973; Geisler et al., 1971; Fittkau et al., 1975). This compartmentalization can be temporal as well as spatial, for many Amazonian fish species show migratory patterns strongly correlated to

seasonal fluctuations in water level (Lowe-McConnell, 1975) which affect their availability to fishermen and hence seasonal productivity of fishing (Fig. 1). Since the productivity of varzea ecosystems is closely linked to the stability of nearby terra firme watersheds (Sioli, 1975a & 1975b) the latter should be set aside as 'protective' compartments (national parks, *reserves)* where *no* exploitation, or only strictly controlled exploitation, of natural resources is allowed.

Deciding whether to apply a 'compartmentalization or 'compromise' type of development strategy to the *Amazonian* fisheries will depend not only upon ecological factors but also upon socio-economic factors. For example, a form of Odum's 'compromise' strategy already exists in Amazonian aboriginal fishing where with its small-scale, highly diverse and flexible technology, moderate yields can be obtained from almost all the available environments throughout the year without reducing their'protective' qualities or stability (Bergman, 1974). On the other hand, the inflexible nature of the large equipment used in the commercial fisheries makes it physically impossible to use in certain habitats or during particular seasons. Also the use of this large-scale equipment is economical only where large quantities of fish can be harvested in a short-time such as might occur during migratory runs or when many fish become trapped in temporary dry season pools (Chapman, 1977). Thus for the commercial fisheries, the Amazonian aquatic environment is one of clearly defined spatial and temporal 'compartments', some highly productive and amenable to intensive exploitation and others in which fishing is totally unproductive. In between these two extremes exists a whole range of 'intermediate' aquatic ecosystems which are perhaps too fragile or physically or economically not well-suited to highly intensive fisheries exploitation, but which would be under-utilized if set aside for fully 'protective' purpcses. Here the use of smaller-scaled 'intermediate' technology, including modified versions of the highly adapted aboriginal fishing equipment, would allow an extensive or 'compromise' type of fisheries exploitation in which moderate yields could still be realized without threatening ecosystem stability.

Besides purely extractive activities such as fishing. fisheries development also includes the production. or rulture of fish protein. In fish culture, the quantity of the yields obtained is strongly dependent upon the amount of energy input in the form of capital and labour which can be provided by man (Ortega, H. pers. com.). The intensive culture of fish in artificial ponds requires high capital investments whereas more extensive forms of fish culture similar tothe 'whedo' systems of West Africa (Welcomme, 1972) derive much of their required 'input' from the natural energy fluxes associated with river flood regimes (Penaherrera et al., 1967). Such extensive methods of fish production provide a further example of Odum's compensative strategy which man, by manipulating rather than totally transforming natural energy cycles, retains ecological stability in his subsistence system.

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ROLE OF ABORIGINAL FISHING IN THE STARLE DEVELOPMENT OF AMAZONIAN FISHERIES

One of the most important roles of the aboriginal fisheries, in the development of the coucnercial fisheries of the Amazon, is to provide blueprints for the design of small-scale, highly adapted technology fOr fishing in 'intermediate' environments. A long period of cultural residence in the region (Meggers, 1971) has given Amazonian aboriginal groups the experience necessary to develop a fishing technology extremely well-designed for the exploitation of local aquatic ecosystems and which, aside from possible improvements in the durability of its component materials, requires few modifications to increase its efficiency.

The aboriginal fisheries are important in another respect. The ability to draw up an ecological management plan for the fisheries of the type outlined in Odum's model as well as deciding which controls to impose on the fisheries, will require a great deal of knowledge of the fish fauna and aquatic environments of this region. Unfortunately, it is precisely this knowledge which is lacking in the Amazon except, that is, among the aboriginal. fishermen who by necessity are intimately acquainted with the fisheries ecosytem. This point is emphasized by , Goodland and Irwin (1974) who state that the

'Amerindians are the only *societies* with the necessary knowledge, expertise and tradition to prosper in the Amazon jungle. Amerindians not only profoundly appreciate what exists, but also understand ecological interrelations of the various components of the Amazonian ecosystem better than do modern ecologists. Indians perceive specific relationships which biologists are only now discovering to be accurate. And since the Amazon jungle is the most complex, richest and least understood ecosystem in the world, the Amerindians' knowIedge of it is of inestimable value. (p. 184)'.

Indeed the accumulated wisdom of native fishermen about their environment is a 'resource' in itself which has hardly been exploited yet by planners and developers in tropical fisheries. Thus, rather than being merely a 'primitive' stage in fishery development, native subsistence fisheries by providing the basis for a highly adapted fishing technology as well as much needed ecological intonation about local environments and fauna, have a key role to play in any plan seeking a balanced development of fishery resources.

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COMMENTS

Petr, T.: Is there any incentive, eg. nutritional improvement or an increased population pressure, for the aboriginal fishermen to intensify their fishing activity?

Chapman, M.: For the purely subsistence aboriginal fishermen, there is little incentive for increasing their fishing activity. For example, the Conibo fishermen of the Upper Amazon obtain all the fiah for their protein subsistence within an hour of fishing per day. However, those aboriginal fishermen who are moving into towns and entering the market-system are no longer self-sufficient. Thus they have the incentive to intensify fishing activities to increase their outcome to meet their non-proteinous requirements.

Tan, E.: How important are the osteoglossids as food fish in the Amazon?

Chapman, ?1.: In the Amazon, the osteoglossids, particularly Arapaima gigas, are extremely important as focal fish, especially in the Manaus area. But due to increasing commercial exploitation, there is a danger that Arapaima gigas may disappear from certain regions of the Amazon.

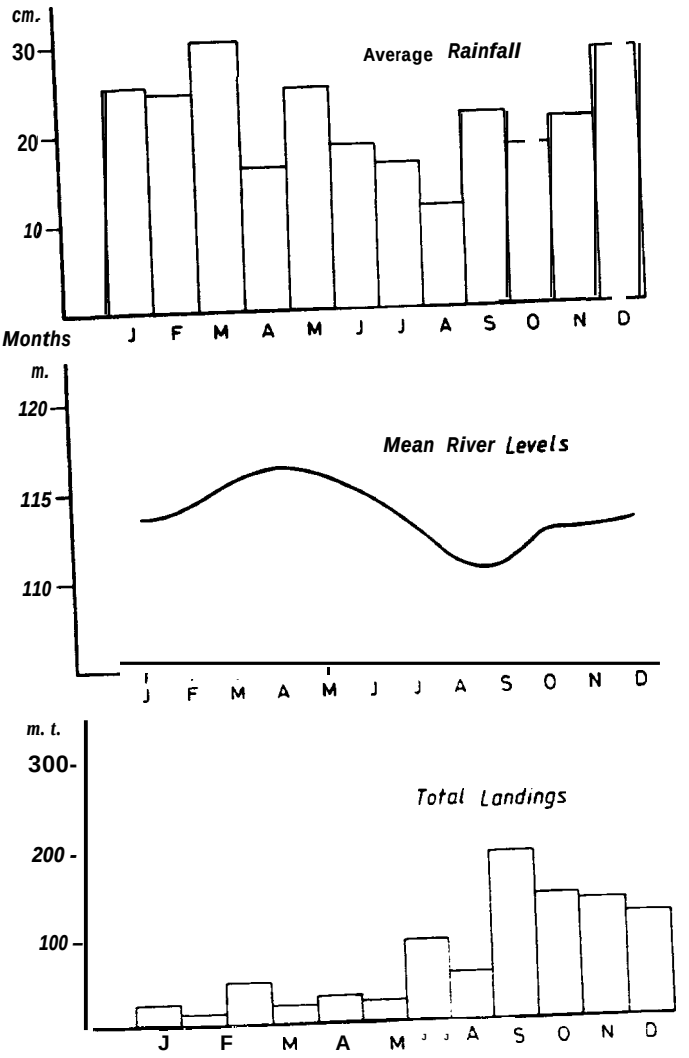

Fig. 1 : Seasonal variations in annual rainfall, mean river level, and total landings of fresh fish at Iquitos, Perú[71].