Inland Fisheries and Aquaculture: A Synergy for Sustainable Food Fish Production[1]

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Introduction

Inland capture fisheries and aquaculture have a number of divergent as well as overlapping relationships. In general, fishers are hunter/gatherers and socio-culturally quite distinct from fish farmers. The essential components of these cultures influence the way they view their respective environments and its resources. Institutionally, fisheries output is often controlled by managing the fishers, directly (via numbers of fishers, size of boats, etc.) and/or indirectly (via total permissible catch, etc), while aquaculture output is likely to be controlled by managing the aquatic environment. Within this concept, an important difference between inland capture fisheries and aquaculture is the question of ownership, official or customary. Aquaculture involves an acceptance of ownership of products and often, production facilities, while capture fisheries exploit common property. Typically, capture fisheries utilize open access resources in which the only human intervention is the harvesting of wild fish stocks. Aquaculture, on the other hand, involves systems where the grower exerts control over both the cultured organism and the culturing environment. Cutting across the disciplines of capture fisheries and aquaculture are practices known as culture-based and enhanced fisheries.

Culture-based fisheries refers to fisheries which are maintained by stocking with material (postlarvae, fry, fingerlings, etc.) originating from aquaculture installations, i.e., hatcheries and/or nurseries, into water bodies that hitherto did not support fishery activities. Enhanced fisheries refers to activities aimed at supplementing or sustaining the recruitment of one or more aquatic organisms and raising the total production or the production of selected elements of an existing fishery to or beyond a level which is normally sustainable by natural processes.

Culture-based and enhanced fisheries are existing components of aquatic production systems in many parts of the world. Traditional knowledge and practices of enhanced fisheries, such as the brush parks or *Acadja* systems, have existed for a long time (Welcomme, 2002). Many of these practices are complex, involving different forms of resource access and allocation, and are characteristically based on established and accepted values and beliefs. Culture-based and enhanced fisheries are regarded as aquaculture if the stocked material is accepted as owned by an individual or a group (i.e., the "growers") throughout the grow-out period until harvested.

[1] This chapter also draws information and data from the paper entitled "Interactions between inland capture fisheries and aquaculture and their contribution to food security and poverty alleviation in sub-saharan Africa", prepared for the Twelfth Session of the Committee for Inland Fisheries for Africa (CIFA), held in Yaounde, Cameroon, from 2-5 December 2002.

Commonalties and Synergies

The common denominator between inland fisheries and aquaculture is food fish production. Institutionally, in most cases this translates into both activities being overseen by the same government agency (e.g., Departments of Fisheries). However, the dissimilarities between the two interventions have led to institutional segregation in some cases where, for example, aquaculture is linked to animal husbandry and inland fisheries to forestry and wildlife. Fishers and fish farmers often require different forms of technical support. Moreover, whereas fishers are more-or-less concentrated along the margins of surface waters, fish farmers can be widely scattered and difficult to reach. Where inland fisheries officers are occupied with regulation and control, there is an added dimension whereby government staff are seen as constabulary and not as development assistants. Institutional complexity can, at times, be simplified and monitoring improved through co-management strategies for inland fisheries management which are becoming an increasingly preferred option, particularly in Asia (Amarasinghe and De Silva, 1999; Middendorp *et al.*, 1999; Sverdrup-Jensen, 2002), as well as in Africa[2].

Culture-based fisheries can offer advantages over other forms of traditional aquaculture practices. The most obvious advantages are:

- Culture-based fisheries are a non-consumptive water user, as opposed to some semi-intensive or intensive culture systems which require fresh supplies of water at regular intervals in order to maintain the growth and well being of the stock.
- Culture-based fisheries are a secondary user of existing water resources, natural and/or quasi natural, and will rarely have to compete with the primary users of the water resource, as opposed to water reserves which are established specifically for aquaculture production and may compete for water with other potential users e.g., agriculturists, horticulturists, etc.
- Culture-based fisheries activities require minimal skill levels and minimal capital investment in contrast to those required in intensive and/or semi-intensive culture practices, and as such, the dissemination of the former is easier and is often attractive, even to the poorer sectors of a community.
- The types of water bodies suitable for culture-based fisheries are often located in rural areas and are often common property resources. Utilization of these water bodies for culture-based fisheries development, therefore, has to be carried out at a community level, through appropriate institutions, and will have a direct influence on poverty reduction.
- In general, culture-based fisheries will not involve external feed inputs, except for grass if grass carp is stocked, thereby making it a totally 'non-polluting' activity, the stocked fish being dependent on the natural food production in the water body.

The culture-based fisheries also have some disadvantages:

- Culture-based fishery practices are totally climate dependent and often have no discretion on the water management schedules, and therefore, aquaculturists generally have less control on production, and consequently production can vary widely from year to year, making it difficult to develop marketing strategies.
- In culture-based fisheries, harvesting of several water bodies in a given area or region may need to be done within a narrow time frame (because of climatic factors and similar hydrological regimes). This could result in an over supply of fish, creating marketing problems and reducing the return to the producer.
- Culture-based fisheries are generally practiced in communal water bodies, often with free access. As such, adequate and effective community management structures and institutions have to be in put in place prior to embarking on the aquaculture activity.

[2] The Sustainable Fisheries Livelihood programme funded by the Department of Interntional Development of the United Kingdom and executed by FAO in 25 West African Countries is presently undertaiking pilot projects on inland fisheries co-management in Burkina Faso, Côte d'Ivoire, Ghana, and Mali.

Interactions

Worldwide, water is becoming a limited resource, and activities that rely on aquatic environments have the potential to develop competition as the resource base shrinks and/or demand expands. Hence, both inland fisheries and aquaculture are competing for scarce resources, sometimes at the same place and same time. Competition can take several forms in addition to competition for water; inland fisheries and aquaculture share government coffers for their support, along with sharing users' time and consumers' capital. These various interactions can be synergistic, antagonistic or neutral.

Inland fisheries and aquaculture also have the potential to impact each other at the resource level in a number of ways. Farmed fish may either purposefully or accidentally enter natural water bodies and compete with, prey on, or disturb the habitat of local fishery resources. In the case of enhanced fisheries or culture-based fisheries, the enhanced fishery may promote additional fishing pressure that could impact non-enhanced fisheries. Disease transmission from farmed to wild fish may also occur. The reverse contamination is possible when wild fry (early life history stages) are collected for on-growing in aquaculture facilities. Wild and domestic stocks have further interactions, as the former provide the basic genetic diversity that is necessary for genetic improvement programmes, while aquaculture facilities may be used to increase numbers of rare or threatened wild aquatic species. The use of introduced or alien species, including alien genotypes, i.e., genetically altered fish, has the additional potential to impact fisheries.

Both inland capture fisheries and aquaculture require environments conducive to the well being of the stocks, although interactions between fisheries and aquaculture appear different with respect to land and water use. Changes in use patterns can have long-term effects on primary resources. By converting mangrove areas to ponds, shrimp farmers have reduced the ecosystem services that many users rely upon, especially coastal fisheries. Such changes to natural habitats may cause changes to the diversity of aquatic life that depends on the mangroves and other habitats as breeding and nursery areas. These ecological changes can be accompanied by equally significant, or even more serious, socio-economic changes. Changing livelihoods through a shift in resource use can have important ramifications which, if unheeded, can result in serious conflicts and even exacerbate the conditions of those already disadvantaged.

There are many facets to the relationships at the resource level. In the past five decades, the inland aquatic environment has been subjected to far reaching changes arising from human activities, particularly damming and wetland reclamation for agriculture. These interventions may result in interactions between inland capture fisheries and aquaculture. The primary objectives for damming have been hydroelectric power generation and the promotion of irrigation agriculture. The conversion of river fisheries into reservoir fisheries generally results in changes in catch composition and diversity. To compensate for the loss (under certain conditions) and to take advantage of a lacustrine habitat, as well as to provide alternative livelihoods for persons displaced by impoundment of agricultural land, aquaculture is often established. In addition to large dams, impoundments and small reservoirs cumulatively accounting for a large surface area have been created in many countries, primarily for small-scale irrigational purposes (FAO, 1999).

Spatial interactions can be more direct in both influence and competition. Aquaculture facilities can compete directly with those of fisheries. In some instances shore-based fish farms can compete with fishing communities and fishing grounds. In more obvious cases, cage-culture operations can be found in water bodies with important inland fisheries. In this latter case, there may well be positive interactions on one front where wild fish populations may benefit from feed intended for the cultured species. However, on another front, accumulation of feed below cages could have an overall negative environmental impact, in extreme instances resulting in regular fish kills of both the cultured and naturally recruited stocks. Pond construction close to rivers and lakes may alter aquatic habitats in profound ways. Clearance of terrestrial and littoral plants to

open up pond areas may have consequences on local biodiversity; diversion of water by damming or through channels alters hydrological patterns in ways that may have consequences for the surrounding natural environment and the fisheries that depend on it. Besides physical changes in habitat, aquaculture may discharge effluents that may include metabolic wastes, unconsumed feed, pathogens and even alien species (escapees) that could impact the chemical and biological nature of the ecosystem.

Inland fisheries and aquaculture also interact at the social and economic levels. In response to decreased catch and income from capture fisheries, governments are turning to aquaculture as a source of livelihood. In many instances, high value aquaculture products are targeted and regarded as export commodities. This has led to formerly open-access fishing grounds that satisfied many customary needs being owned or controlled by commercial producers or corporations which may be from outside of the local area, i.e., groups of absentee fish farmers. This shift can be further complicated by the aforementioned socio-cultural elements where different segments of society catch and raise fish. As catch declines and governments look to aquaculture to fill the gap, aquaculture may be seen as a means of livelihood for former fishers who can no longer be supported by the fishery. However, if these individuals cannot adapt socio-culturally from hunting to growing, they will not successfully make the transition. There are notable illustrations of fishers not satisfactorily converting to fish farmers. Over the last three decades, for example, governments have been encouraged to provide initial support for establishment of aquaculture practices (cage culture) as an alternate livelihood for persons displaced from impoundment of reservoirs. However, the relatively high capital and recurrent costs for inputs needed for aquaculture often tempt these persons to sell their "leases" to commercial producers and/or corporations, opening another avenue for absentee fish farmers.

The subsectors furthermore interact in regards to price and marketability of fish. In areas where capture fisheries are prominent, consumers may prefer wild to farmed fish, and the price of wild fish is often lower. In areas away from established capture fisheries where farmed products would be more competitive, there may not be the tradition of eating fish and therefore, fishery products are not well received. Additionally, surplus catch from especially good fishing years can find its way into local markets quite remote from the capture fishery and may further depress market price for farmed fish. In the reverse scenario, a case in point is the salmon industry in Europe and North America, where increased production efficiency has lead to inexpensive farmed fish lowering the price of wild fish. Although this is good for the consumer, fishers suffer financially. Thus there is potential for conflict among stakeholders who must compete for land and water and in the market place. In developing countries in the tropics, however, most inland fisheries in lacustrine waters are artisanal, and cater to the daily needs of the communities that live within a narrow radius of the water body (Murray, *et al*., 2001'). Fish originating from such inland fisheries generally do not compete with cultured products, which tend to be centrally marketed for an entirely different clientele, including export.

The development aspects of inland capture fisheries/aquaculture interactions are considerable. This often leads to commercial aquaculture being proposed as a development strategy. However, this development scenario, which is based on theoretical economic gains and experiences in other parts of the world, often has not adequately considered the contribution that inland fisheries makes to food security and rural livelihoods. Often the value of ecosystem services provided by many inland water bodies has not considered and resource issues have not been adequately addressed.

In the tropics, there are large numbers of small-sized water bodies (< 100 ha), natural (e.g. oxbow lakes in Bangladesh) or man-made, for various purposes, primarily for small-scale irrigation. These water bodies are mostly non-perennial, retaining water only 6-10 months of the year, and the natural recruitment of fish species into these waters is limited and often inadequate to support even subsistence capture fisheries. On the other hand, such water bodies are ideally suited for development of culture-based fisheries. The choice of species for such

fisheries is based on market demand and socio-cultural preferences, and complementarity between food habits of the individual species, when a mix of species that feed on different food types that are naturally produced in the water body is utilized. The yields, by and large, are a result of the quality and quantity of seed stocked and the natural productivity of the water body.

Contribution to Food Fish Production

The relative contribution of inland capture fisheries to world inland fish production over the last 20 or so years has remained relatively static (Fig. 1; FAO, 2001). The increase in world inland fish production over these two decades is primarily a reflection of the increased inland aquaculture production. This trend is most clearly evident when inland fish production in Asia, the mainstay of world aquaculture, is taken into consideration (Subasinghe *et al*., 2001). In Asia, there had been a paucity in inland capture fisheries, and its relative contribution to inland fish production has been decreasing, as opposed to that of inland aquaculture production (Fig. 2). This lack of a significant increase in inland capture fisheries production is probably due to such reasons as: (a) a decline in riverine fish stocks due to various causes, such as damming which had effected several fisheries (E.g. hilsa - *Tenualosa* spp.), pollution, etc.; (b) the reported catch data being lower than the actual in major river systems (e.g., Sverdrup-Jensen, 2002); (c) the lack of commercial fisheries for food-fish species as opposed to recreational fisheries in

Figure 1. Total world inland capture fisheries prduction, and contribution of the latter to the total (based on FAO statistics, 2002).

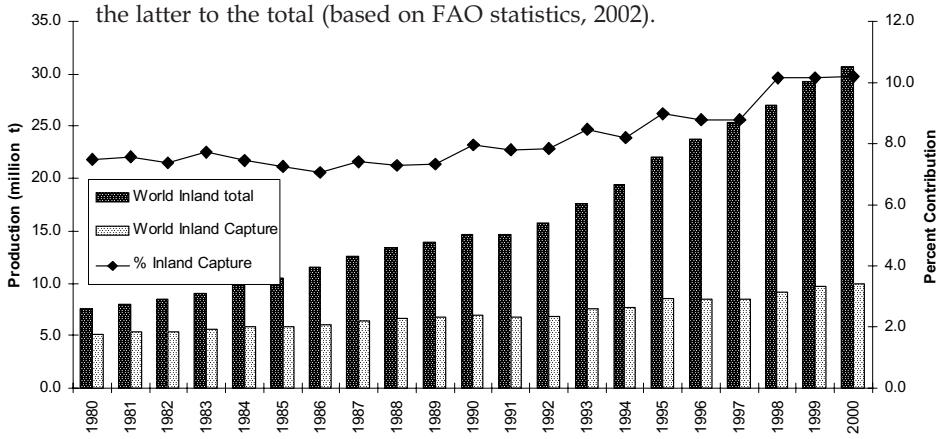
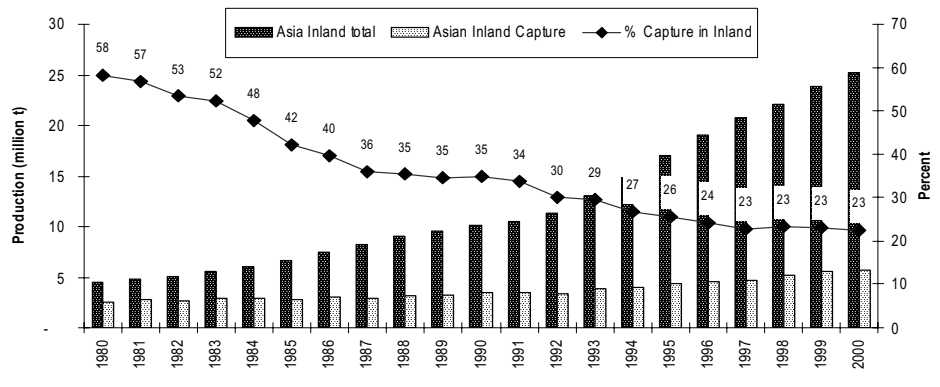


Figure 2. The total inland fish production, and the inland capture fishery production in Asia, and the per cent contribution of the latter to the total (based on FAO statistics, 2002).

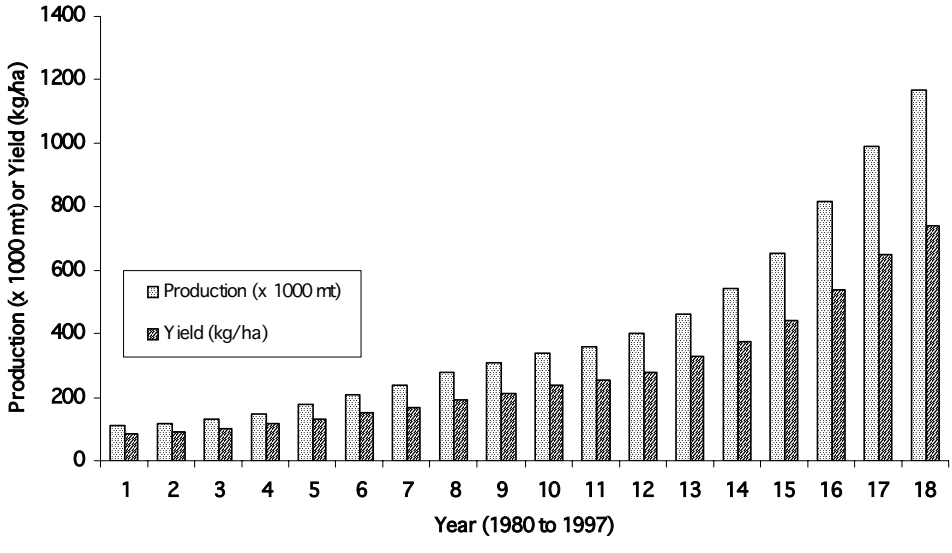


lacustrine waters in most developed countries (Welcomme and Bartley, 1998; Miranda, 1999); and (d) development of fisheries in large, inland, lacustrine waters in developing countries being relatively more recent (Huang *et al*., 2001), and management of such fisheries not being optimal in most instances (De Silva, 2001).

Inland cultured finfish production in developing nations is dominated by cyprinids and tilapias, approximately in the ratio of 25:1 (FAO, 2001). Chinese and Indian major carps are indigenous to China, and India and Bangladesh, respectively. These two groups of carps, stocked individually or in various combinations, and at times augmented with tilapias, are known to give the highest production in culture-based fisheries (Thayaparan, 1982; Middendorp *et al*., 1999; Quiros and Mari, 1999). All other countries which plan to develop culture-based fisheries may have to depend on selected species from these two groups of carps, and some tilapia species augmented by a very few indigenous species, if available. As such, in a global perspective, culture-based fisheries can be considered to be relatively more dependent on exotic than indigenous species.

In most developing countries, culture-based fisheries are in an early developmental phase, although its potential as a major strategy for food fish production was recognized almost two decades ago in some countries, such as Sri Lanka (Thayaparan, 1982; De Silva, 1988). Currently, culture-based fisheries are most developed in PR China, where an estimated production of over a million MT was achieved in 1997, with a mean yield of 743 kg ha^{-1} yr^{-1} (Fig. 3). The Chinese culture-based fisheries practices are also exceptional, in that China is one nation where the fisheries are based entirely on indigenous species, the Chinese carps and Wuchang fish.

Figure 3. Yearly (1980 to 1997) fish production in thousands of tons from the culture-based fishery and the mean yield per ha (in kg) in reservoirs in China (based on data from Song, 1999)



The recent developments in oxbow lakes in Bangladesh (Middendorp *et al.*, 1999) and small water bodies in Cuba (Quiros, and Mari, 1999), Laos PDR (Lorenzen *et al*., 1998a), Sri Lanka (Pushpalatha, 2001), Thailand (Lorenzen *et al*., 1998b) and Vietnam (Nguyen *et al*., 2001) are very encouraging. In most countries, the developments are community based; groups of individuals leasing (from relevant governmental authorities) and/or managing individual water bodies for fishery activities. It has been emphasized that a key to the development of culture-based fisheries is community organization resulting in the establishment of relevant institutional structures. Establishment of appropriate harvesting and marketing strategies is also crucial to

the long-term sustainability of culture-based fisheries, to ensure reasonable returns to the producers and avoid over supplies within a narrow time frame.

It is estimated that in Asia alone there are about 66 million ha of water bodies suitable for culture-based fisheries (FAO, 1999). De Silva (2003) estimated that a 5% usage of this acreage for culture-based fisheries development, in the ensuing ten years, at a production level comparable to that obtained in China (Song, 1999) should yield 2.5 million MT, providing a significant boost to inland aquaculture production. It is also foreseeable that in most countries, corresponding seed supply facilities, operated privately, would develop as culture-based fisheries activities intensify, adding an extra dimension to rural development.

Challenges and Prospects

The synergies and interactions described above include institutional, social, economic, environmental and bio-technological aspects - areas for complementarity and areas of possible competition. The crosscutting issue is one of finite resource availability in a world of increasing population and declining environmental quality. The challenge today is how to balance these factors to optimize the synergistic interactions while minimizing the potentially antagonistic ones. Acknowledgement of these interactions offers opportunities for sectoral development for increasing food security, reducing poverty and improving rural livelihoods. The challenge is to find ways to ensure that the mutual benefits to inland fisheries and aquaculture accrue within common aquatic environments. The two subsectors need to form partnerships, as both depend on healthy aquatic environments and both are impacted by other development activities. This is a multifaceted task. It involves appropriate selection of natural species and their responsible adaptation to culture conditions.

Joint use of the environment and sustainable sharing of resources to the ultimate benefit of communities require that individual action not be treated in isolation, but as part of a much larger entire hydrological system. This approach necessitates an understanding of the larger system, including an intimate awareness of the intricate interactions that make it sustainable. For many inland fisheries and aquaculture systems, this dictates a watershed approach to development; charting the detailed webs of these biospheres. In some cases, for large inland waters it may be more effective to take an integrated shoreline approach, particularly where there are urban centres competing for resource use. Although catching and farming fish produce a similar end product, the process and activities reaching that end are different. Women and children have important roles to play as harvesters, processors and distributors of fish. As many areas promote aquaculture as an alternative to fishing, the roles of all stakeholders need to be considered to avoid displacing certain members of society and to ensure that new opportunities can be realized.

To meet the challenge, governments, in collaboration with stakeholders, must have a clear and comprehensive strategy for the development of their aquatic resources. This should take a holistic approach, given the multifaceted nature of resource use and the potential for conflict and competition. This strategic framework is all the more important as fiscal and human resources for many countries are becoming more and more limited and the public sector is asked to do more with less, frequently in close collaboration with the private sector. This strategy must unambiguously identify the roles of all stakeholders, assigning responsibilities and benefits. It should take an ecosystem approach, in most cases revolving around the watershed as the geographic area of delimitation. Governments, development agencies and other stakeholders should accept that there could be merit in incorporating traditional knowledge within fisheries and aquaculture development programmes. Thus, studies should be undertaken to expand the knowledge base of existing traditional knowledge in fisheries and fishery enhancements, to improve understanding of the complexities of resource utilization. Efforts should be made to build on existing enhancement practices or to merge them with modern know-how and technology.

Through these processes there is an inherent dependence on information. Effective and current information channels are necessary for the full spectrum of players involved in aquatic resource management to be able to make meaningful decisions and fully appreciate the involvedness of the aquatic systems in question. Information technology has rapidly developed globally, but there are still real and apparent difficulties in information flow from rural areas and rural communities. This implies that continuing research needs to be done to understand the dynamics and limitations of any ecosystem intervention that originates from inland fisheries and aquaculture. There is a need to better understand, for example, effects of escapees and biodiversity changes, and the consequences of pollution and habitat degradation on local ecosystems. Governments should implement Environmental Impact Assessment (EIA) prior to embarking on activities that impact aquatic environments and should continue to monitor the ecosystem changes.

States and other stakeholders should work to effectively implement the provisions of the Code of Conduct for Responsible Fisheries and to apply, as appropriate, the elements in the Guidelines for Inland Fisheries and Aquaculture. The contribution of inland fisheries and aquaculture to food security and poverty alleviation has to be made more visible and stakeholder participation improved. The potential role of inland fisheries and aquaculture in the economy should be stressed to promote cooperation of private and public interests. Capture fisheries and aquaculture development have to be seen and approached as an integral part of rural development using the Code of Conduct for Responsible Fisheries and, as appropriate, the Sustainable Livelihoods Approach, as useful tools.

The increasing importance of aquaculture in the fish food supplies is widely acknowledged. Further improvements in aquaculture practices and new developments have to confront a different set of problems to those encountered in the second half of the last century or so, foremost of these being the increasing competition for primary resources such as land and water. The situation is further exacerbated as the bulk of aquaculture production occurs in the developing world, and in some of the most populous nations in the world such as China, India, etc., where land and water are at a premium. In such a context, the utilization of the vast acreage of water bodies available in the developing world, for fish production, through the development of culture-based fishery activities has considerable potential. Development efforts should give careful consideration to the subtle interactions, commonalties, differences, and synergies that exist between aquaculture and culture-based fisheries.

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