Sardine catch from a liftnet, Lake Kariba. Photo: Brian Marshall.

Pelagic Fish and Fisheries of Tropical and Subtropical Natural Lakes and Reservoirs

T. PETR AND J.M. KAPETSKY
Fishery Resource Officers (Inland Fisheries)
Inland Water Resources and
Aquaculture Service
Fishery Resources and Environment Division
FAO, Rome, Italy

Where pelagic fisheries have developed on large inland lakes and reservoirs of the tropics and subtropics they are usually based on small clupeids or cyprinids, but atherinids and characids also have openwater forms which can be exploited. The bycatch, which may be significant, is made up of their large predators. One of the oldest pelagic fisheries known is for the small cyprinid *Mirogrex terraesanctae terraesanctae* on Lake Kinneret in Israel which dates from biblical times. This fish provides from 43 to 65% of the lake's total catch, equivalent to 27 to 41 kg/ha.

The best known and the most successful pelagic fishery on a natural lake is the Lake Tanganyika fishery, which is based on the clupeids *Stolothrissa tanganicae* and *Limnothrissa miodon.* The first species dominates the industrial ringnet and traditional fisheries in most years. The annual recorded catch from Lake Tanganyika is about 73,000 t or 22.5 kg/ha, with a potentially harvestable clupeid stock of 350 kg/ha/yr. The associated pelagic predators are mostly represented by the freshwater perches: three *Lates* species and *Luciolates stappersii,* which in the Burundi sector of this lake make about one-third of the total openwater catch.

In Lake Victoria, Africa's largest lake, the small cyprinid *Engraulicypris (Rastrineobola) argenteus* supports a fishery of some 11,000 t/yr of which about 9,500 t/yr equivalent to 23 kg/ha (in 1979) are caught in Kenyan waters. There has been a sharp increase in the catches of this pelagic fish recently due to considerable pressure by the traditional fishery on inshore stocks. The underexploited *Engraulicypris,* together with the pelagic *Haplochromis,* represent the only known reserves for further development and expansion of the traditional fishery.

Contrary to the situation on Lake Victoria, a pelagic fishery on Lake Malawi for the related *Engraulicypris sardella* has not yet developed except in the shallow southern end of the lake where purse seining can reach the bottom. Two biological factors contribute to the difficulty of establishing a pelagic fishery. First, *E. sardella* is difficult to concentrate by light attraction and it is a fish easily disturbed by noises. Secondly, compared with the sardines of Lake Tanganyika, *E. sardella* is relatively low in biomass in Lake Malawi. This is because most of the zooplankton production of Lake Malawi is eaten by the lake fly, *Chaoborus,* and, in turn, the lake fly larvae are only poorly utilized by fishes. In Lake Tanganyika most zooplankton is directly preyed on by the sardines. Thus, for the present, despite a pelagic potential estimated at 30-40 kg/ha (about 100,000 t when extrapolated to the whole lake surface), fishing methods are not yet adequate to concentrate and catch the Lake Malawi cyprinid in sufficient quantities so that an open-water fishery would be economically viable.

Introductions to African Lakes

A general increase in the demand for fish along with heavy pressure on littoral stocks has focused attention on introductions of pelagic species as a means of better utilization of available water resources in those African lakes and reservoirs which are without indigenous pelagic stocks. The first such introduction

Purse seiner towing auxiliary boats including one for light attraction of sardines, Lake Kariba. Photo: Brian Marshall.

was the transplant of Lake Tanganyika sardines into Lake Kivu in 1958-60. Lake Kivu is a young African lake which was formed when a river naturally dammed a valley. Thus, much like in some reservoirs, its original riverine fauna did not include a species adapted to life in deep open waters. Of the two species introduced *Limnothrissa* "took" well and now it is established throughout the lake area. A minimum estimate of sustainable yield is about 40 kg/ha. The pelagic fishery has been slow to develop on the lake for a number of reasons: the lake-shore populace has no tradition of fishing, fish is not a common food, and fishing materials have to be imported at great cost.

Another introduction of a Lake Tanganyika sardine, this time into Kariba reservoir in Zambia/Zimbabwe in 1967-69, has resulted in a rather spectacular pelagic fishery development. But at first, when no explosive increase in sardines was detected within 2 to 3 years, the introduction was judged to be a wasted effort. However, from 1975 when commercial fishing for *Limnothrissa* really began, the offshore clupeid fishery grew to about 12,000 t/yr in 1981 in the Zimbabwean sector, or 22 kg/ha when taken over the whole reservoir surface. The sardine bycatch, represented by the predatory tigerfish *Hydrocynus,* is caught in sufficient quantity to support a small canning operation. In contrast to the pelagic fishery, the littoral fishery of larger fishes contributes only about 2,000 t/yr. It appears that in the Zimbabwean sector both the pelagic and inshore fisheries have reached their upper limits. In a reservoir situation in which the annual biological production potential is heavily dependent on nutrients carried in by flood waters, sardine fishery catches may vary considerably from year to year, as in Kariba (see Fig. 1), and thus control of effort becomes an important management decision.

Following the filling of the Cahora Bassa reservoir in Mozambique in 1974, *Limnothrissa* from the upstream Kariba Lake invaded via the Zambezi River. Recent periodic sampling supported by preliminary results from acoustic surveys in the eastern portion of the reservoir indicate that *Limnothrissa* is well established. A potential yield of about 8,000 t/yr (30 kg/ha) has been estimated. However, because of difficulty of communication with population centers and economic problems, a pelagic fishery has not yet been established.

Pelagic fish are indigenous to two other large African reservoirs. Kainji Lake in Nigeria has an estimated 3,140 t average biomass of the clupeids *Pellonula afzeliusi* and *Sierrathrissa leonensis,* and Lake Volta in Ghana has *P. afzeliusi, Cynothrissa mento* and *S. leonensis,* of which the first two clupeid species contribute 23% by weight to experimental gill-net catches. There are no accurate statistical data on catches of the pelagic fish for either of these man-made lakes, although the fish are caught in some periods of the year in large quantities. In Lake Volta, the catch per fisherman/night reaches 30 kg, and in experimental mid-water trawling in Lake Kainji the maximum catch was 102 kg/hr.

Other Tropical Lakes

Elsewhere in the tropics, clupeids have successfully established themselves in Ubolratana reservoir in Thailand, where the clupeid *Corica goniognathus* has been reported to occur in large quantities. This fish contributed increasingly to the catches up to 1973 when 760 t (36% of the total landings) were harvested. Thereafter, there was a decline in the catches of this species and during 1974-78 the catches fluctuated from 300 to 450 t/yr, which represents 15 to 22% of the total landings from this reservoir. In Mexico, small atherinids of the genus *Chirostoma* are the mainstay of nearshore and offshore fisheries of several of the largest natural lakes. Yields have ranged as high as 40-50 kg/ha. In the Brokopondo reservoir in Surinam, there is evidence that a small characid, *Creatochanes melanurus,* has become the dominant openwater fish and the main prey species.

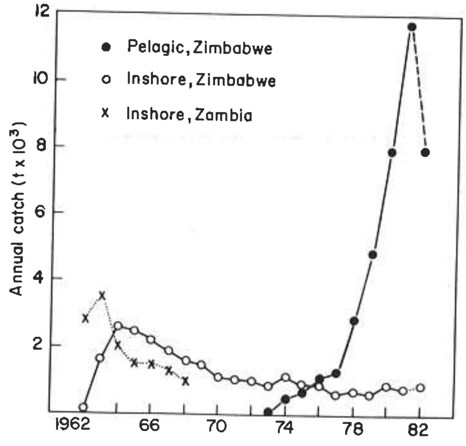

Fig. 1. Fish landings on Kariba reservoir.

Characteristics

The biological characteristics of clupeids and of some other small pelagic fish have made them eminently suited for the relatively unstable aquatic environment of new reservoirs, and for natural lakes with a vacant pelagic niche. As their spawning takes place in the pelagic zone, their eggs and young are not threatened by the instability of rapid water level fluctuations to which the littoral fishes are exposed. The large number of eggs laid, the short life cycle of the small pelagic fish, and their adaptability to various types of food allow for successful colonization of offshore waters. Another attractive feature of small pelagic fishes is that they can be relatively easily and economically processed and transported. This is an important advantage where more sophisticated means of preservation are lacking or are undependable. For example, *Limnothrissa* can be air/sun dried whole on simple chicken-wire racks (or on a sandy beach) in about three days. It is then placed in conveniently-sized plastic bags for transport and later sale.

Pelagic fishes also form a reliable food base for predatory fish which are known to rapidly increase in numbers when clupeids become established. The easy availability of sardines in Lake Kariba and Lake Volta has led to a tremendous increase of tigerfish (*Hydrocynus* spp.) in Lake Kariba and Nile perch *(Lates niloticus)* in Lake Volta. Finally, in addition to supporting offshore industrial-scale fisheries, many freshwater pelagic fishes also provide nearshore artisanal fisheries. Such is the case on Lake Tanganyika, Volta reservoir, Lake Malawi and Mexican lakes, to mention a few.

Currently, pelagic fisheries are best developed in Lake Tanganyika, Lake Kariba and Lake Kinneret, with the pelagic stocks of the two last lakes being exploited to their full capacity. In Lake Victoria, the stock of pelagic fish in Nyanza Gulf forms the dominant fishery, while there are indications that considerable stocks may await exploitation in the rest of the lake. Purse seining with light attraction is the major fishing technique used for catching *Stolothrissa* and *Limnothrissa.* Developed originally for Lake Tanganyika, this type of fishing represents the largest units applied on Lake Kivu and Lake Kariba as well, on the latter lake with catches averaging 100 to 800 kg/haul, with about six hauls per night. In Lake Kariba, chilamila and liftnets are also used. In Lake Kinneret, purse seines are the major gear for catching the pelagic cyprinid. The Lake Volta fishery uses scoopnets, but light attraction has not been very successful in concentrating the indigenous pelagic clupeids. In Lake Kainji mid-water trawls have been used experimentally. On both reservoirs, a large-scale pelagic fishery is still awaiting development.

Development Prospects

What are the prospects for pelagic fisheries development on inland tropical and subtropical waters, and especially on the new large reservoirs? In terms of fishery yield it seems reasonable to expect from 20 to 40 kg/ha/yr from small pelagic fishes and their bycatch based on statistics already available (Table 1). However, experience has shown that unless there is an indigenous stock of clupeids in the river system concerned, establishment of pelagic fishery based on clupeids could require a period of as much as 8 to 10 years after their introduction. Experience with other pelagic species is not available, as no other pelagic fish have been transferred to be tested for their suitability, especially for new reservoirs. Reservoirs of considerable retention time seem to be more suitable for the clupeids than those with a fast flushing rate.

An additional factor affecting reservoir clupeid production appears to be the river input, with the fish population being strongest in the year following floods, and weakest in the year following low flows.

Planning Necessary

Establishment of pelagic stocks can enhance fish productivity in natural lakes and reservoirs. However, before such an introduction is undertaken, there are several questions which must be addressed and much detailed planning must precede the decision. Experience in Africa and elsewhere dictates that these questions should include the following: are small pelagic fish acceptable in the market place or can they be made so? Can they be fished efficiently and economically? What amounts of capital investment and human resources are required to develop the fishery?

Where important fisheries already exist it is also important to question what direct or indirect effect the exotic might have on the indigenous fishes and fisheries. *Limnothrissa,* for example, in various ecosystems, at various life stages and in differing seasons is known to be phytoplanktivorous, zooplanktivorous, a periphyton/aufwuchs grazer, an insectivore and a cannibal.

A related consideration is whether a suitable fish is available locally, or in the region, rather than seeking one from afar. If so, much time and expense might be saved in evaluating the ecological, technological, and economic consequences of an introduction. For example, the mass occurrence of *Corica goniognathus* in Ubolratana reservoir indicates that a suitable Asian pelagic fish may already be available in that region. However, in spite of its eminent ecological importance and its present impact on the subsistence economy and nutrition of lakeside inhabitants, this small pelagic fish is still considered economically valueless by entrepreneurs and fish traders whose aim is to market highly priced species in urban markets. This, and the other questions raised above, are to be kept in mind when considering future pelagic fisheries development on new inland water bodies in tropical and subtropical countries. ●

Further Reading

FAO. 1982. Bibliography of fisheries and limnology for Tanganyika. CIFA Occas. Pap. 6. Rev. 1. 45 p.

1983. Selected bibliography on major African reservoirs. CIFA Occas. Pap. 10.

Marshall, B.E. Kariba (Zimbabwe/Zambia). *In* J.M. Kapetsky and T. Petr (eds.) Status of African reservoir fisheries. CIFA Tech. Pap. (In press).

Table 1. Characteristics of pelagic fisheries of some natural lakes and reservoirs in Africa.

Water body	Surface area (km²)	Main pelagic species	Pelagic yield (kg/ha) a = actual p = predicted	Type of fishery
Lakes				
Tanganyika	32,900	*Stolothrissa tanganicae* *Limnothrissa miodon*	a = 22.5; p = 350 (without predators)	commercial; artisanal
Malawi	30,800	*Engraulicypris sardella*	a = slight; p = 30-40	commercial
Victoria	68,800	*Engraulicypris argenteus*	a = 23 (1979; Kenya)	commercial; artisanal
Kivu	2,699	*Limnothrissa miodon*	a = slight; p = 40	artisanal
Kinneret	168	*Microgrex terraesanctae*	a = 27-41 (1970-80)	commercial
Reservoirs				
Kariba	5,364	*Limnothrissa miodon*	a = 22 (1981)	commercial
Cahora Bassa	2,665	*Limnothrissa miodon*	a = nil; p = 30	not yet developed
Kainji	1,270	*Pellonula afzeliusi* *Sierrathrissa leonensis*	a = small; p = ?	littoral artisanal only
Volta	8,482	same as Kainji plus *Cynothrissa mento*	a = moderate; p = ?	littoral artisanal only