THE LAKE TANGANYIKA CLUPEID AND LATID FISHERY SYSTEM: INDICATORS AND PROBLEMS INHERENT IN ASSESSMENTS AND MANAGEMENT

Joseph MUNYANDORERO
Department of Biological Sciences, University of Zambia

ABSTRACT The clupeid and latid fisheries of Lake Tanganyika are described. The paper introduces and applies to those fisheries for the first time the two concepts of *métier* and fishery system. The fisheries are space-structured, international, multi-species, multi-*métier* and multi-fleet. The corresponding fishery system consists of the biological, social and economic sub-systems, based on fish populations, *métiers*, and national and regional markets, respectively. Lack of comprehensive qualitative and quantitative economic indicators handicaps the implementation or development of bio-economic fisheries models, and the assessment of markets dynamics. The available information for the biological and social sub-systems is heterogeneous and incomplete. As a result, the population and fleet dynamics cannot be currently assessed for national fisheries altogether. The spatial and temporal distribution of the fishing activities and the nature of the available information suggest that the biological and social dynamics can be assessed nationally or locally. The "spatial" global or analytical models, eventually incorporating the predation interactions, are particularly worth exploring toward achieving a proper management of national/local fisheries.

Key Words: Lake Tanganyika; Clupeids; Latids; Fishery system; Fishery sub-systems; *Métier*; Spatial models.

INTRODUCTION

Fishing in Lake Tanganyika may have been carried out for centuries using primitive gears and methods. The genuine development of the contemporary fishing activities dates as far back as the 1950s-1960s, when they started in the northernmost and south easternmost ends of the lake (Coulter, 1968, 1991; Mann & Ngomirakiza, 1973; Ngomirakiza & Haling, 1973; Herman, 1978; Pearce, 1985). These activities further extended along other coastlines, but they have so far been always unevenly distributed because of the topographical configuration of the lake shoreline and the availability of infrastructures (Herman, 1978; Coulter, 1991).

Fishing in Lake Tanganyika has therefore a relatively long history. Nevertheless, few works (Herman, 1978; Roest, 1978; Turner, 1978; Pearce, 1985; Shirakihara *et al.*, 1992; Mannini *et al.*, 1996; Munyandorero, 2001) have been devoted to the study of the dynamics of interacting factors involved in the exploitation of the resources. Meanwhile, these factors have exhibited marked changes in both time and space.

This contribution has three objectives. First is to provide an overview of the fishing activities targeting the clupeids and latids in Lake Tanganyika, and a short account of the complexity in terms of interactions among components of the corresponding fishery systems. Along with this objective, the concept of *métier*, which is not familiar to the stakeholders of the said system, will be introduced and used as well. Second is to highlight the basic available information as well as gaps that complicate proper studies of the fishery sub-systems dynamics and, consequently, prevent adequate management measures. Third is to suggest, along with the previous objective, the key aspects to be further investigated, and to lay the theoretical foundations of a "suitable" modelling approach for the dynamics of the fishery sub-systems in question. The modelling framework proposed here is not unique in fisheries science, but has never been explored for the Lake Tanganyika clupeid and latid fisheries. This study is a reflection on how the understanding and depiction of the fishery system under consideration could be improved based on the literature and my own observations.

CLUPEID AND LATID STOCKS AND FISHERIES OF LAKE TANGANYIKA

I. Definitions and Characteristics

Out of about 300 fish species recorded in Lake Tanganyika, only six are of commercial importance, contributing to more than 99% of total annual catches in weight. These are the small-sized, short-lived and schooling clupeid sardine species, *Stolothrissa tanganicae* and *Limnothrissa miodon*, and the latid Nile perch species, *Lates angustifrons*, *Lates mariae*, *Lates microlepis* and *Lates stappersii*. The first three latids, also referred to as large *Lates*, are large and long-lived. The last one is mid-sized and is of an "average" longevity. All of these species are endemic to Lake Tanganyika. Table 1 gives their local names.

In general, there is conflicting information regarding stock identity in Lake Tanganyika. The current knowledge indicates that *L. miodon* (Hauser, 1996; Hauser *et al.*, 1998) and *L. stappersii* (Kuusipalo, 1999) belong to single genetic populations on a large geographical scale, suggesting significant exchanges of individuals throughout the lake: hence, they form single stocks. For either species, however, there is evidence of micro-spatial genetic differentiation within bays (at the southern end for *L. miodon*; at Malagarasi bay for *L. stappersii*), suggesting the existence of subpopulations and local stocks, which can be isolated with thorough investigations. The *S. tanganicae*, *L. microlepis* and *L. angustifrons* stock identities have not yet been investigated in terms of population genetics. However, the former two species likely form single stocks, as they exhibit rapid and extensive migrations across the lake, making genetic mixing possible (Chapman & van Well, 1978; Coulter, 1991). *L. angustifrons* probably forms local stocks owing to its demersal and predominantly sedentary life style (Coulter, 1991). *L. mariae* consists of one widespread subpopulation and six local subpopulations that do not show any evidence of total reproduc-

Table 1. Local Names of the Lake Tanganyika Clupeid and Latid Fish Species.

Taxa	Burundi	DRC[1]	Tanzania	Zambia
1. Clupeids				
Together	Ndagala	Ndakala	Dagaa	Kapenta
S. tanganicae			Dagaa	
L. miodon			Lumbo	
2. Latids				
2.1. *L. stappersii*				
Juveniles[2]	Nyamunyamu	Nyamunyamu		
Adults	Mukeke	Mikeke	Mikebuka	Mvolo
		Mvolo		Bukabuka[3]
2.2. Large *Lates*				
Together	Sangala	Nonzi	Nile perch[4]	Nile perch
	Capitaine	Sangala	Sangara	
		Capitaine		
L. angustifrons	Sangala	Capitaine	Sangara	Gomba
				Pamba
				Sikiti
				Chisoso
				Pamba Sikiti[5]
L. mariae	Sangala	Sangala		Pamba
				Ngonzi
				Kalomolomu
				Chisosa
L. microlepis	Nonzi	Nonzi	Nonzi	Nonzi
				Nyumvi

[1] DRC stands for Democratic Republic of Congo.
[2] The commercial name of both clupeid species and juvenile *L. stappersii* is Ndagala in Burundi, Ndakala in DRC.
[3] For Nakaya (1993), "Bukabuka" is a Greek origin name given to *L. stappersii*.
[4] Nile perch is a commercial name.
[5] For Kendall (1973), "Pamba Sikiti" is a single name of *L. angustifrons*; the name "Chimizi" is used to denote large specimens of this species, and the compounded name of "Katala wa Komonga" is employed for darker and deeper-bodied *L. angustifrons*.
Sources: Coenen (Personal communication) for all species in all countries; Bayona (1993) and Katonda (1993) for clupeids in Tanzania; Enoki *et al.* (1987) and Imai (1996) for clupeids, *L. stappersii, L. mariae*, and *L. microlrpis* in the north-western area of Lake Tanganyika; Kiyuku (1993) and Mambona (1995) for large *Lates* altogether in Burundi and DRC, respectively; Kendall (1973) and Nakaya (1993) for *Lates* species in Zambia.

tive isolation (Kuusipalo, 1995).

As for the fisheries of Lake Tanganyika, three types have been routinely distinguished and described from the early 1950s. These are the traditional fishery, the artisanal fishery (that operates with improved devices, such as motor-power, that are more efficient than the traditional methods (Coulter, 1991)) and the semi-industrial fishery, also inappropriately called industrial fishery (Table 2). The latter two fisheries were also referred to as pelagic fisheries, because their target clupeid and latid species partly or totally spend their life cycle in the pelagic zone. As a rule, fishermen operate only in waters of their "home" country (i.e. the country where they are officially registered and/or licensed). Exceptionally, however, this was not always the case for the Burundian fishermen who also operated in the Congolese sector of the lake up to 1960, engaging in the semi-industrial fishery, and up to 1977 in both the traditional and artisanal fisheries (Herman, 1978; Roest, 1988).

The previous typology of fisheries has applied for a long time only to Burundi, the Democratic Republic of Congo (DRC) and Tanzania. In Zambia, reference has often been made to the artisanal and semi-industrial fisheries only (Pearce, 1985, 1992; Mudenda, 1998), the latter being considered, as in Tanzania, the only "commercial fishery" (Katonda & Kalangali, 1994; Mudenda, 1998). In reality, however, the Zambian artisanal fishery of Lake Tanganyika has encompassed both artisanal and traditional activities (Coenen *et al.*, 1998). Furthermore, Pearce (1992) and Lupikisha (1993) consider that the chiromila

Table 2. Main Characteristics of Clupeid and Latid Fisheries of Lake Tanganyika.

Features	Traditional fisheries	Artisanal fisheries	Semi-industrial fisheries
Beginning	From centuries	1957: Bujumbura/Uvira	1953-54: Burundi
Type of exploitation	Small-scale (subsistence)	Small-scale Commercial	Mechanised Commercial Labour and capital intensive
Status of fishermen	Part-time fishermen	Full-time professionals	Full-time professionals
Fishing localities	Inshore waters	Waters further from shore	Pelagic waters
Typical fishing unit			
• Boats	1 dugout/planked canoe	1 catamaran/trimaran 1 fibreglass/planked boat Motorised "tugboats" 2-4 light-boats	1 motorised steel-vessel 1 purse-seine carrying boat 2-5 light-boats.
• Crew size	Variable (2-3 fishermen)*	Variable (4-11 fishermen)*	Variable (20-54 fishermen)
• Fishing gears	Gill nets; hand-line; long-line; traps; scoop-net; traditional beach seines; mosquito nets; poison	1 traditional lift net 1 Apollo lift net 1 Chromila net 1 kapenta seine	1 purse seine/ring net
Fishing time	Dark night/daytime*	Dark night/daytime*	Dark night
Type of lighting	Fire canes; latter 1 pressure lamp	Pressure lamps	Pressure lamps Mercury vapour lights
Target species	Juvenile/mature clupeids Demerso-benthic latids Other fish species	Clupeids of various sizes Young *L. stappersii*	Adult clupeids and latids

* According to *métier*; see text for detail.

nets (Fig. 2d) are semi-industrial fishing devices.

Contrary to the previous classical typology of fisheries, I argue that at a global, national or local scale, the clupeid and latid stocks of Lake Tanganyika are exploited by one single fishery, where three interacting fleets co-occur, namely the traditional fleet, the artisanal fleet and the semi-industrial fleet. Depending on the spatial scale of observation, the fishery in question can therefore be treated as international, national or local. The latter two considerations lead, of course, to the definition of national or local fisheries that, in addition to biological interactions and uncontrollable migrations affecting the species, have a potential to interact technically and/or sequentially between themselves.

Artisanal and semi-industrial fishing units set out to fish in the afternoon of any given day, and land fish the following day at about 5-6 A.M. They operate between 7 P.M. and 4 A.M. (this leads to a maximum of 10 hours of presence at the fishing ground) during moonless nights under good weather conditions. This leads to an annual average of 250 trip-nights of activity per artisanal and semi-industrial units (Bellemans, 1991). For these units, the fishing strategies and materials were designed to primarily attract, concentrate and catch altogether schools of clupeids (70-80% of catch in weight) and *L. stappersii* (5-15% of catch in weight) using artificial light. In such a context, the large *Lates* and other species (cichlids, catfishes, lungfishes, etc.) are by-catches. The reverse is observed for most of the traditional units. It is most likely that the large *Lates* are caught while aggregating upon their clupeid preys (Mann *et al.*, 1975; Coulter, 1991).

II. Typology and Evolution of *Métiers*

Figure 1 depicts the distribution of fishing activities on Lake Tanganyika. Typical fishing units and fishing practices (Fig. 2) have been described extensively (e.g. Hickling, 1961; Coulter & Znamensky, 1971; FAO, 1973; Ngomirakiza & Haling, 1973; Mann *et al.*, 1975; Herman, 1978; Pearce, 1985, 1992; Bellemans, 1991; Coulter, 1991; Hoekstra & Lupikisha, 1992; Leendertse & Horemans, 1991; Katonda & Kalangali, 1994; Imai, 1996). This work attempts to extract from such a literature the main *métiers* and to reconstitute their spatial and temporal succession and occurrence.

It is worth clarifying here the concept of *métier*, which is wrongly synonymized with that of gear or fleet (Ulrich, 2000). This concept, which has had a number of close or equivalent definitions (Laurec & Le Guen, 1981; Biseau & Gondeaux, 1988; Mesnil & Shepherd, 1990; Laurec *et al.*, 1991; Laloë & Samba, 1991; Pelletier & Ferraris, 2000; Ulrich, 2000), is used to categorize typical homogeneous activities of fishing fleets. According to the 1987 EEC Working Groups (Mesnil & Shepherd, 1990), "a *métier* is a coherent functional entity in terms of vessel type and size (within a fleet), gear, target (group of) species, spatial and temporal fishing pattern, which can be summarised by a consistent array of catchabilities by species and age". *In fine*, this definition means that a fleet can practise several *métiers* (Pelletier & Ferraris, 2000;

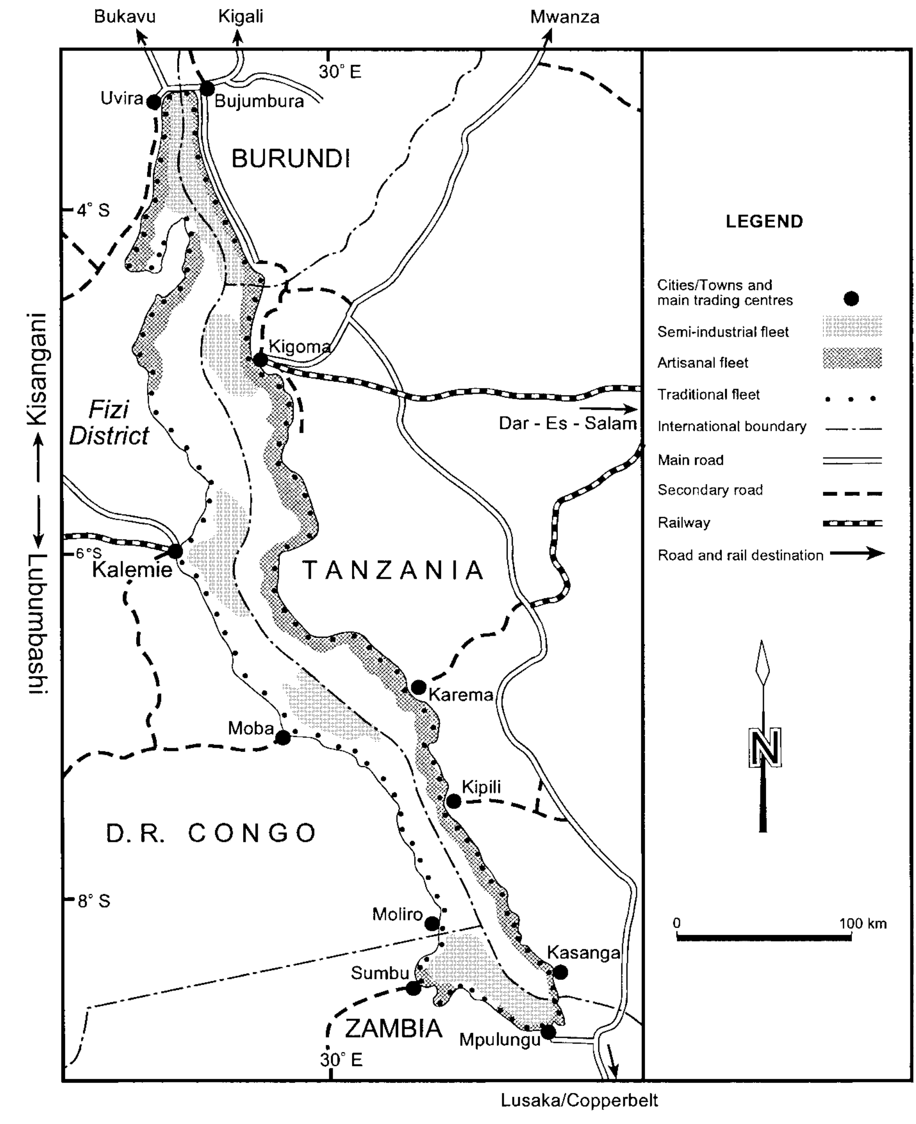

Fig. 1. Distribution of Fishing Activities on Lake Tanganyika [established after Hanek *et al.* (1993); Coenen *et al.* (1998); it has not been static, but dynamic in both space and time].

Ulrich, 2000). In a mixed fishery, it is therefore possible to distinguish various *métiers* with regard to types and sizes of vessels (e.g. dugout canoe, catamaran, purse seiner), gears in use (e.g. gillnets, beach seines, long line, purse seine, etc.), skippers' decision, target species and spatial and temporal strata. Note that, for a particular type of gear, the presence of different dimensions, such as different mesh sizes, lengths and depths of gill nets, and fishing practices, such as set gillnetting, surrounding gillnetting, lead to distinct *métiers* (Laurec & Le

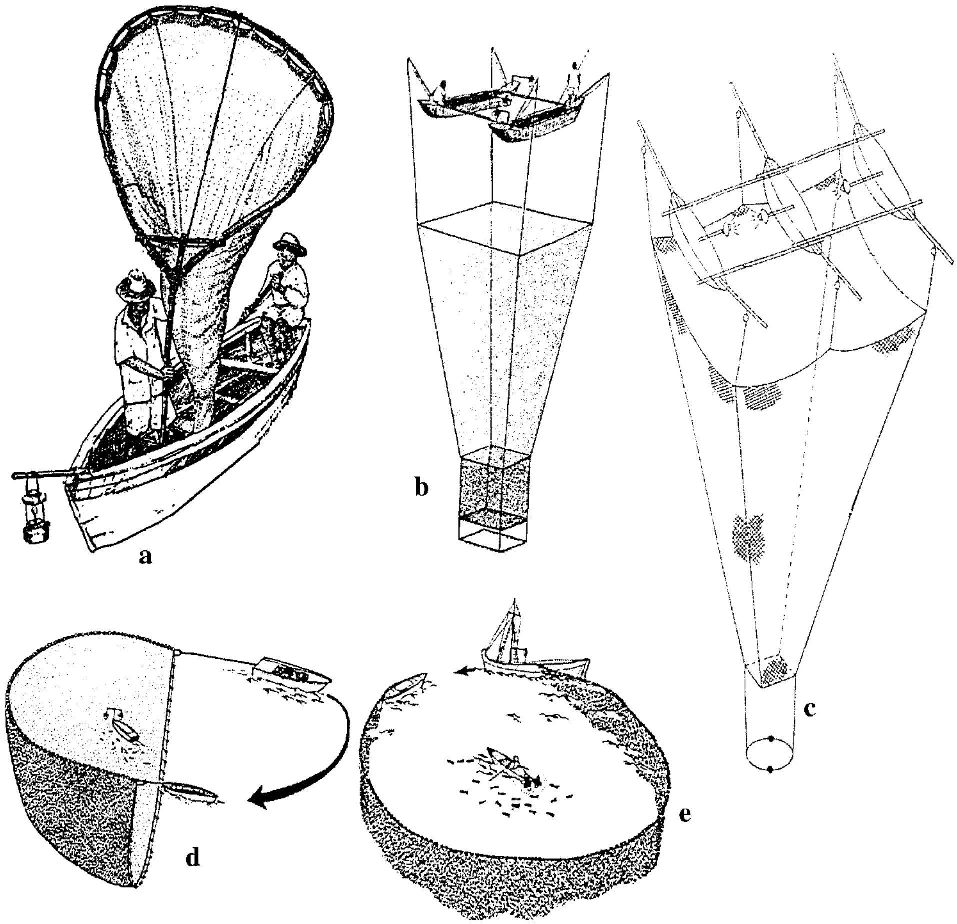

Fig. 2. Important Fishing Practices Targeting the Clupeid and Latid Stocks in Lake Tanganyika [after Coulter (1991) for sketches **a**, **b**, **d** and **e**; Challe & Kihakwi (1994) for sketch **c**)]. **a.** Scoop (lusenga)-netting; **b.** Traditional catamaran-lift netting; **c.** Trimaran-lift netting; **d.** Chiromila-netting; **e.** Purse seining.

Guen, 1981). Changes in *métier* by individual vessels of a fleet can consist of either fishing tactic or fishing strategy, when they are planned for implementation on a fine (i.e. local and seasonal) or global (i.e. wide and long-term) scale, respectively (Millischer, 2000). In which case, they correspond to the transfer of fishing effort from one zone to another and/or from species or age groups to the others (Laloë & Samba, 1991; Gascuel *et al.*, 1993; Gascuel, 1995; Pelletier & Ferraris, 2000). Here, a category of vessels often takes into consideration the environmental factors (e.g. availability of the whole stock or of some age groups, weather conditions, profitability, regulation, etc.) in choosing either type of *métier* to be practised (Garrod, 1973; Hilborn, 1985; Hilborn & Ledbetter, 1985; Allen & McGlade, 1986; Laloë & Samba, 1991; Mesnil & Shepherd, 1990; Gascuel *et al.*, 1993; Gascuel, 1995).

In this study, a *métier* is defined as a combination of "type of vessel, fishing gear and type of lighting/fishing location and period of the year/target (group of) species". Such characteristics are routinely used in describing typical fishing practices in Lake Tanganyika. However, they are emphasized here to show their importance as *métier* attributes, because, instead of fleet or gear, the concept of *métier* is flexible and fundamental in any attempt of accurately assessing and managing the fisheries systems (Mesnil & Shepherd, 1990; Murawski *et al.*, 1991; Pelletier & Ferraris, 2000; Ulrich, 2000). To simplify, the previous definition of *métier* will be further reduced to the name of fishing gear used with a qualifying attribute.

1. *Traditional and artisanal métiers*

The traditional fleet operates with non-motorised small dugout or planked canoes (Fig. 2a) inshore (0-1km from shore). According to *métier*, fishing is conducted in littoral (0-10m deep), sub-littoral (10-40m deep) or demerso-benthic (>40m deep) waters. The inshore area corresponds to the breeding ground for clupeids and nursery one for clupeids and large *Lates*.

The traditional fleet operates along the whole Lake Tanganyika shoreline, mainly at sheltered bays and beaches immediately adjacent to cultivable lands. It involves the use of several *métiers* — hereafter referred to as "traditional *métiers*" — by small-scale farmers that fish part-time in unfavourable farming seasons.

Two *métiers* are the most dominant:

- dugout or planked canoe, scoop net-lusenga and pressure lamp (Fig. 2a); inshore, mainly dry season; juvenile and mature clupeids and juvenile *L. stappersii*
- dugout canoe, beach seine operating during daytime; inshore, mainly dry season; juvenile and mature clupeids, and immature and small-sized inshore fish

The former *métier* currently predominates in the northern half of Lake Tanganyika. The latter, considered by Katonda (1997) and Mölsä *et al.* (1999) as artisanal *métier*, is widespread with a differential popularity according to regions; it is mainly used at the northern and middle parts of the lake (Imai, 1996; Coenen *et al.*, 1998). Other common traditional *métiers* consist of gill-netting, hand-lining, long-lining and fish-trapping. According to the mesh size and/or type of gear, they target a mosaic of demerso-benthic fish, including immature and adult *L. angustifrons* and *L. mariae*. Sometimes, a traditional unit operates with several *métiers* during a fishing trip (Pearce, 1992).

According to basin and weather conditions (either calm or moderate wind), an artisanal fishing unit operates with one of the following types of main boat and gear: planked catamaran/trimaran and lift net (Figs. 2b and 2c), fibreglass/planked boat and chiromila net (Fig. 2d), and planked boat and kapenta (i.e. clupeids) seine. The main boat is equipped with pressure lamps and can be motorised. In order to enhance the fishing efficiency, the main boats work in association with other fishing devices, namely:

- Planked skiffs, equipped each with 3 to 4 fish-attracting lamps. Such light boats are independently used to attract, concentrate and bring schools of fish within reach of the gear in use.
- Auxiliary planked boats, which are powered "tugboats" in lift-netting (Bellemans, 1991) and "shouting boats" in kapenta-seining (Pearce, 1992; Hoekstra & Lupikisha, 1992). Tugboats help non-motorised catamaran units to reach distant fishing grounds and land fish quickly. Fishermen in shouting boats call out instructions to the pullers on the beach as to which direction to draw the seine.

The artisanal fleet operates in grounds generally situated between 1 and 5 km from shore (Mann *et al.*, 1975). These grounds are herein referred to as "semi-pelagic" or "semi-littoral" grounds, if the *métier* considered is practised in zones close to the offshore or inshore, respectively. Thus, the following artisanal *métiers* are distinguished.

- Traditional planked catamaran or trimaran, traditional lift net and pressure lamps; semi-pelagic, throughout the year during dark nights; sub-adult (i.e. intermediate-sized) clupeids and young (≤ 15cm) *L. stappersii*: this is practised in all Lake Tanganyika riparian countries, with high concentrations in the Burundian and Tanzanian waters, and in the north-western waters of DRC of Uvira and Fizi regions, South Kivu.
- Planked catamaran, 'Apollo' lift net and pressure lamps; semi-pelagic and pelagic, throughout the year and during dark nights; sub-adult (i.e. intermediate-sized) clupeids and immature (≤15cm) *L. stappersii*: this is mainly practised in the Burundian and northern Congolese and Tanzanian waters of Lake Tanganyika.
- Fibreglass/planked boats, chiromila net and pressure lamps; semi-pelagic, throughout the year and during dark nights; sub-adult (i.e. intermediate-sized) clupeids and *L. stappersii*: this is practised in the Zambian and southern Tanzanian waters of Lake Tanganyika.
- Planked boats, kapenta seine and pressure lamps; semi-littoral, throughout the year during dark nights or, sometimes, daytime; immature and mature clupeids (mainly *L. miodon*), and juvenile and small-sized cichlids: this is practised in the Zambian waters of Lake Tanganyika. A similar *métier* was described by Imai (1996) in the north-western area of Lake Tanganyika.

In addition to the main *métier*, an artisanal fishing unit can also practise a traditional *métier* during a trip, such as long-lining for catching predators (Mann *et al.*, 1975).

Apart from results obtained from occasional surveys carried out on the activities of traditional and artisanal fleets, there is no information about the com-

Table 3. History of the Artificial Light-based Traditional and Artisanal *Métiers* Targeting the Clupeids and Latids in the Lake Tanganyika Riparian Countries.

Métiers	Burundi	DRC	Tanzania	Zambia
Scoop-netting	? →	? →	? →	?[a, b] → 1976-79
Beach-seining	? →	? →	? →	1964[a, b] →
Kapenta-seining				1970_s[a, b] →
Regular lift-netting*	1957[c, d] →	1957 →	1972[e, f] →	1986[b, g, h] →
Chiromila-netting**				1969[a, b] →
Apollo lift-netting	1990[i] →	?[j] →	?[j] →	

?: Unknown launching year; figure at arrow beginning: launching year; figures at arrow end: year or period of decline or extinction; open arrow end (i.e. without figure at the end): the *métier* is still practised even today.

* Petit (*in* Patterson & Makin, 1998) also mentions the presence in the Burundian artisanal fleet of units operating near shore with "bottom lift nets" (at 20m deep) and "mosquito lift nets" (at 10m deep).

** Coenen *et al.* (1998) reported 13 chiromila units during the 1993 frame survey in the southern waters of Tanzania.

Letters refer to sources: a. Pearce (1985); b. Pearce (1992); c. Ngomirakiza & Haling (1973); d. FAO (1973); e. Katonda & Kalangali (1994); f. Katonda (1997); g. Hoekstra & Lupikisha (1992); h. Mubamba (1992); i. Bellemans (1991); j. Hanek & Reynolds (1999).

Table 4. Some Technical Characteristics of Gears Used to Fish for Clupeids and Latids in Lake Tanganyika.

	SN	BS	KS	TLN	CN	ALN
Circumference (m)	2[a]			55-65[b]		100[b]
				30*[c]		
				24*[d]		
				20*[e]		
				64-85[f]		
Depth (m)	2[a]	(16.7)[g]	10-15[h, i]	8[c]	25-35[h, e]	
	(6.4)[g]		5-15[e]	(17)[i]		
				18-24[f]		
				10[e]		
Longevity (years)	±2[a]					
Mesh size, stretched (mm)	6[j]		6-12[h]	8-12.5[a]	8 & 10[e, h]	
				10[c]		
				5-6[k]		
				6-10[e]		
Length (m)	(8)[g]	18-300[i]	50-80[h, e]	10-180[i]	100 & 160[e, h]	
		(159)[i]	30-450[i]	(80)[i]		
		50-199[g]	(94)[i]	30-70[g]		
		(117)[g]		(64)[g]		
Square area (m^2)				256[g]		
Diameter (m)	1-2[h]					
Material of construction				Nylon [c]		

SN=scoop net; BS=beach seine; KS=Kapenta seine; TLN=traditional lift net; CN=chiromila net; ALN="Apollo" lift net.

* In the 1970s and before, the opening dimension of TLN was 7.5m×7.5m according to Ngomirakiza & Haling (1973), 6m×6m according to Mann *et al.* (1975). The mouth opening of the Zambian TLN is 5m×5m (Mubamba, 1992).

Letters refer to sources: a. Coulter (1991); b. Bellemans (1991); c. Ngomirakiza & Haling (1973); d. Mann *et al.* (1975); e. Mubamba (1992); f. Challe & Kihakwi (1994); g. Leendertse & Horemans (1991); h. Pearce (1992); i. Hoekstra & Lupikisha (1992); j. Hickling (1961); k. Turner (1978). Figures between parentheses refer to averages.

Table 5. Some Technical Characteristics of Boats Used to Fish for Clupeids and Latids in Lake Tanganyika.

	TC/T	AC	FG/PB (chiromila)	PB (kapenta seine)	Canoe
Length (m)	4.5-6[a]	7-9[c]	9 & 13[d]		4-5*[a]
	(5.3)[a]				(4.6)*[a]
	5.5-7[b]				3-7**[a]
	5[e]				(4.1)**[a]
					2-3[e]
Number of lamps	3[f]	14-19[c]	(2)[d]	2-26[i]	1[j]
	2-8[g]			(6.30)[i]	
	2 or 3[h]				
Intensity per lamp	300-400 lm [f]	***	250-1000 Watts [d]	350-500 candle power [d, k]	
Engine HP	9.5[f]		90 & 120[d]		
	15[b]			9[a]	
Crew size (number of men)	4[a, f, i]	8-11[c]		4-25[i]	1.7[c]
	5[c]			(8)[i]	2-3[j]
				8[j]	2[l]
Gross tonnage (t)	1-2[m]				
Presence/number of skiffs	Yes [c]	Yes [c]	Yes/2 or 3 [d, j]	Yes/1-12[i]	
				(2.6)[i]	
Presence of auxiliary boats	Yes [c]	Yes [c]		Yes [c]	Yes [c]

TC/T = Traditional catamaran/trimaran; AC = "Apollo" catamaran; FG/PB = Fibre glass/planked boat; PB = Planked boat.
* Length for planked canoe.
** Length for dugout canoe.
*** Two lamps out of the 14-19 lamps have the same candle power as those used by the semi-industrial fleet. Figures between parentheses refer to averages.
Letters refer to sources: a. Leendertse & Horemans (1991); b. Challe & Kihakwi (1994); c. Bellemans (1991); d. Pearce (1992); e. Enoki *et al.* (1987); f. Ngomirakiza & Haling (1973); g. Coenen *et al.* (1998); h. Herman (1978); i. Hoekstra & Lupikisha (1992); j. Coulter (1991); k. Mubamba (1992); l. Katonda & Kalangali (1994); m. Imai (1996).

plete time series of historical basic data requirements for characterising the typical *métiers*, assessing fleet dynamics and standardising the fishing effort. Those data might include the spatial and temporal distribution of fishing units and effort allocation, and the number and technical characteristics of boats and gears (e.g. material of construction; average individual size, age and expectancy; mesh and hook sizes; types, light intensities and candle power of lamps; crew sizes; engine HP, etc.).

Table 3 is a summary of the history of the artificial light-based traditional and artisanal *métiers* targeting the clupeids and latids in the Lake Tanganyika riparian countries. Tables 4 and 5 give some technical characteristics of related gears and boats, respectively. Those characteristics are particular to national fisheries and surveying years. What is important to mention here is that various national traditional and artisanal fleets which fish for clupeid and latid species in Lake Tanganyika using light attraction, over the years have undergone major changes affecting fishing power, the development, expansion and decline of *métiers* as well as the introduction of the new ones. The following are some examples for the relatively well-known Burundian, Tanzanian and Zambian artificial light-related traditional and artisanal *métiers*.

- The scoop nets, lusenga, have always been mosquito netting or of fine-meshed netting (Hickling, 1961) prior to the 1950s. They were successively made from plant fibres, old tyre casing and cotton mosquito gauze, all of which had different average span depending on the nature of thread (Coulter, 1991). Nylon nets replaced the cotton nets since 1952 (Katonda & Kalangali, 1994). Light in scoop-netting was initially wood fire (Hickling, 1961; Katonda & Kalangali, 1994) or produced by burning bundles of canes, and later by using paraffin pressure lamps (Ngomirakiza & Haling, 1973; Coulter, 1991). These lamps were introduced in the northern part of the lake (Burundi and Uvira) by 1953 (Hickling, 1961), in Tanzania in 1952 (Katonda & Kalangali, 1994) and in Zambia in 1957 (Pearce, 1985). This *métier* has disappeared in the 1970s from the Zambian traditional fleet (Pearce, 1992), but still predominates in the northern half of Lake Tanganyika. In the Burundian sector of the lake, the scoop net units operated in 1990 with either "standard"-type lamps, i.e. lamps with light beam directed downward without an important shadow zone, or "anchor"-type lamps, i.e. ordinary household kerosene pressure lamps (Bellemans, 1991). Finally, it is worth mentioning that the scoop net *métier* used to be the mainstay in the Tanzanian fishery in the early 1970s, contributing well over 80% of the catches up to 1976 (Katonda, 1997).
- In Burundi, catamaran boats were formerly of steel-built material. Later, as in other countries, planked and fibreglass catamarans were introduced (Ngomirakiza & Haling, 1973). In Tanzania, both catamarans and trimarans have co-existed, the latter operating with large nets in large fishing areas. However, the transformation of trimarans into catamarans has been progressive, whereby one boat was suppressed and the distance/surface between the remaining two was increased in order to use large nets and have large fishing area/volume (Katonda & Kalangali, 1994).
- Prior to the 1980s, the Zambian traditional fleet operated mainly with scoop nets and beach seines, and the artisanal fleet relied on chiromila-netting in the 1970s. The chiromila nets and kapenta seines were since then the main fishing devices of the artisanal fleet (Pearce, 1985, 1992).
- Whereas the Burundian artisanal fleet was almost characterised by the same catching power over the years from 1957 to 1986, it underwent marked increase in efficiency after 1987 (Bellemans, 1991). This was reflected in the following:
    (i) the use of larger nets and boats, as well as of skiffs and auxiliary boats.

(ii) the increase of the surface between catamaran boats and of the motorization rate.

(iii) the introduction of the "Apollo" units (i.e. "super" lift net units). These units operate with 14-19 lamps, of which 2 have the same lighting power as those used by the semi-industrial fleet. The "Apollo" lift net *métier* has so far replaced the Burundian semi-industrial *métier*.

2. *Semi-industrial métier*

The semi-industrial fleet operates in the pelagic zone (40m deep), situated at 5km from shore and beyond (Mann *et al.*, 1975; Roest, 1988). A typical semi-industrial fishing unit consists of one purse seine (or ring net), one powered "mother" Greek-type steel vessel (about 40 tons), one purse seine-carrying boat (about 20 tons), two to five light skiffs (1-2 tons), and a crew size of 20 to 54 fishermen. Figure 2e shows a purse seiner in operation. Table 6 indicates some physical attributes of the Burundian, Tanzanian and Zambian semi-industrial units observed in the early 1990s. The light intensity of lamps in skiffs usually ranges between 2000 and 8000 candle-power (Hickling, 1961; Mukirania, 1995). A pairwise comparison of the attributes means (t-test) and variances (F-test) shows that:

- For the Burundian and Zambian fleets, there was significant difference between mean lengths and mean depths of purse seines/ring nets, between mean numbers of vessels' years of activity and between mean numbers of light skiffs. No significant difference was found between the mean lengths and mean engine HP of vessels. Except for the number of light skiffs, the purse seines/ring nets were equally variable in their lengths and depths, and the purse seiners were also equally variable in their lengths, number of years of activity and engine HP.
- For the Burundian and Tanzanian fleets, there was significant difference between mean depths of purse seines and mean widths of purse-seiners, but not between mean lengths of purse seines. Except for the depth of purse seines, the lengths and widths of purse seiners were equally variable.
- There was no significant difference between mean depths of purse seines and mean lengths of vessels for the Tanzanian and Zambian fleets. Likewise, the depths of purse seines and lengths of vessels were equally variable.

The semi-industrial units of the Uvira fishing area, DRC, had, in the early 1980s, physical attributes similar to those indicated in Table 6 (Enoki *et al.*, 1987).

Purse-seining started in Burundi in 1953-54 (Mann & Ngomirakiza, 1973), in DRC in 1955 (Mambona, 1995), in Tanzania by the early 1970s (Katonda & Kalangali, 1994; Katonda, 1997) and in Zambia in 1962 (Coulter, 1968; Pearce, 1985). Between 1954 and 1956 in the Burundian and Congolese waters off Bujumbura and Uvira, this activity operated with two small vessels (7-12m long), 15 fishermen, two or three small lamp boats and two fine-meshed

Table 6. Some Attributes of the Semi-industrial Units of Lake Tanganyika Recorded in 1990.

Attributes	Burundi (1990)	Tanzania (1990)	Zambia (1990)
Purse seine/Ring net			
-Number	17	3	16
-Length (m):			
Range (m)	225-400		200-340
Average±s.d (m)	320.88±43.81		267.5±39.24
-Depth (m)			
Range (m)	80-150	55-110	57-120
Average±s.d (m)	101.82±14.54	76.67±29.30	85.75±20.45
-Circumference			
Range (m)		200-350	
Average±s.d (m)		261.67±78.48	
-Mesh size (mm)	5-7 (poche) 16-22 (exterior)		10 (ring nets) 12 (purse seines)
Purse seiner			
-Length (m)			
Range (m)	13.6-21	12-15.6	13-22
Average±s.d (m)	16.67±1.91	14.27±1.97	16.13±2.60
-Width (m)			
Range (m)	3.3-5.5	3.3-3.65	
Average±s.d (m)	4.95±0.59	3.48±0.18	
-Activity (years)			
Range (years)	4-30		2-28
Average±s.d (years)	16.29±7.89		8.38±7.24
-Engine HP			
Range (HP)	120-355	60-140	140-430
Average±s.d (HP)	205.59±69.68	105±40.93	226.88±73.73
Purse-seine carrying boats			
-Length (m)	7	7	7
Light skiff*			
-Number			
Range	4-5		3-5
Average±s.d	4.94±0.24		4.38±0.96
-Light per skiff*			
Range			2-6
Average±s.d			3.5±3.46
Lights in mother boat*			
Range (number)			0-6
Average±s.d (number)			1.88±2.35

* Some Zambian semi-industrial units used both paraffin lights (2000 candle power) and mercury vapour lights (250-1000 watts). Others used exclusively either paraffin lights or electric lights (mercury vapour lights).
Sources: Bellemans (1991) for Burundi, Challe & Kihakwi (1994) for Tanzania and Pearce (1992) for Zambia.

(≈6mm, stretched) small purse seines (200m long, 30-45m deep) targeting only the clupeids (Hickling, 1961; Roest, 1988). In the same waters from 1956 to 1962-1963, purse-seining especially targeted the latids because of their higher commercial value, and the clupeids were neglected (Herman, 1978; Coulter, 1991). That period was characterised by the increase in size and number of boats and use of large nets. The mesh size was 18mm, stretched. The period 1962-1964 coincided with the introduction of nets combining small meshes on the first 40m (6-8mm, stretched) to catch clupeids, and larger meshes lower down (16-18mm, stretched) to target latids. All fishermen adopted that type of net by 1964. In the three decades since, however, the legal and commonly used mesh size ranged between 10 and 12mm, stretched, leading to a single "semi-industrial *métier*" in all Lake Tanganyika riparian countries, namely the *métier* purse seine of mesh size 10-12mm, stretched, artificial light; offshore, throughout the year during moonless nights; adult clupeids and latids. Figure 1 shows that this *métier* was (and is still being) practised in waters off towns and cities (Bujumbura, Kigoma, Kalemie, Uvira, Moba and Mpulungu) and regions with good infrastructure (roads, railways, water transport facilities, electricity, markets, etc.). A similar spatial occurrence of this *métier* was also observed earlier (Chapman & van Well, 1978; Herman, 1978; Coulter, 1991).

Along with the aforementioned historical modifications of boats and gears' technical characteristics, some fishing practices and innovative equipments may have affected the fishing efficiency of national semi-industrial fleets. They include:

- The adoption of some fishing tactics (Pearce, 1985; Coulter, 1991). Such tactics consist of the following:
    - (i) seasonal alterations of purse seines to fish closer inshore for juvenile clupeids.
    - (ii) seasonal movements of purse seiners, designed to either catch alternatively clupeids and *L. stappersii* as a result of stock density and fish pricing at the market (Burundi), or to suit the changes in weather conditions and fish distribution/abundance (Zambia).
- By the late 1980s, some units of the Zambian semi-industrial fleet embarked on operating with echo-sounders and a new lighting system. The latter innovation was characterised by the use of light boats equipped with mercury vapour lights that run on generators, and of equipping purse seiners with light, so that they were also involved in attracting fish (Pearce, 1992).

III. Components of the Lake Tanganyika Clupeid and Latid Fishery System

1. *Sub-systems and inter-sub-system interactions*

As for other fisheries systems (Hilborn, 1985; Millischer, 2000), the Lake Tanganyika clupeid and latid fishery system is made up of the biological, social and economic sub-systems (Fig. 3). These sub-systems rely on the spatial and temporal dynamics of the clupeid and latid stocks, the traditional, artisanal and

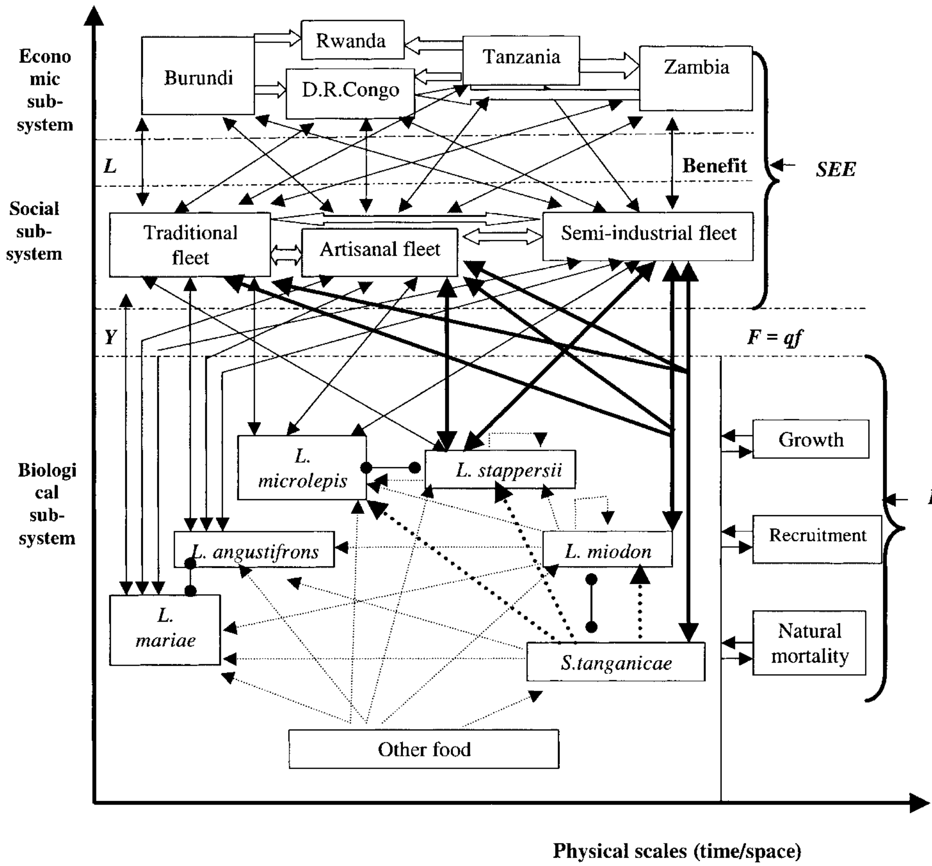

Fig. 3. Modelling Scheme of the Dynamics of the Lake Tanganyika Clupeid and Latid Fishery System.
Y=catches; ***L***=landings (=catches as there are no discards); ***F***=fishing mortality; ***q***=catchability; ***f***=fishing effort; ***PE***=physical environment (e.g. hydro-climate); ***SEE***=social and economic environment (e.g. profitability; regulation). Bold arrows indicate major interactions.
⇨ Exports to; ⇔ Technical interactions; ⇢ is prey of; ↔ Inter-sub-system interactions; → Regulates; •–• Competes with.

semi-industrial fleets, and of the markets (i.e. processing and distributions), respectively. They interact with each other, and interactions do exist within each system's component as well. Note that Figure 3 outlines a broad conceptual schematic model of the fishery system dynamics under consideration, and can be developed/adapted accordingly, i.e. with reference to particular temporal and spatial scales.

Hilborn (1985) and Millischer (2000) provided the interactions between the major components in any fishery system. On Lake Tanganyika, the traditional, artisanal and semi-industrial fleets take catch from clupeid and latid stocks and inflict specific fishing mortality on them. The fleet dynamics therefore act upon the resource dynamics by modifying the fish's fishing mortality. The fish in turn act upon fishermen through their abundance and/or availability. The fleets transfer catch to the market (processing and distributions) in turn for money. Here, the fishermen act upon the market through the nature, volume and regularity of fish production. Finally, the market acts upon the fleet dynamics through the fish demand, reflected in fluctuations of fish pricing, and indirectly upon the stock dynamics via the fishermen.

2. *Intra-sub-system interactions*

The previous account consists of anthropogenic (social and economic) effects on the dynamics of clupeid and latid populations in Lake Tanganyika. However, two other factors regulate those dynamics, namely the specific biological parameters (i.e. recruitment and individual growth in weight as inputs, and the natural mortality as output) and the biological interactions. The latter are dominated by the predation between species at different phases of their life cycles (Matthes, 1968; Mann *et al.*, 1975; Coulter, 1976, 1991; Ellis, 1978). Thus, all large *Lates* are predators; *L. stappersii* and *L. miodon* are both predators and preys, and are even cannibalistic; *S. tanganicae* is preyed upon by all the foregoing species (Fig. 3). Both biological parameters and biological interactions are controlled in complex and non-predictable ways by the dynamics of environmental processes. The most dominant of those processes seem to be the timing and strength of the up-welling generated nutrients and the succession of related plankton in the lake. This results in uneven and ephemeral spatial and temporal distributions of clupeid and latid species in relation to the patchy and ephemeral availability of preys and, consequently, leads to substantial spatial and temporal fluctuations in stocks' levels and yields (Mölsä *et al.*, 1999).

The clupeid and latid species are either main targets or by-catches of either fleet (Fig. 3). Those fleets operate in space-structured fashions (Sub-section II). Some *métiers* co-occur permanently (e.g. scoop-netting and beach-seining, traditional lift-netting and chiromila-netting) or seasonally (e.g. purse-seining and artisanal *métiers* in the Zambian sector). Others operate in overlapping locations (e.g. traditional lift-netting and "Apollo" lift-netting as well as "Apollo" lift-netting and purse-seining in the Burundian sector, various artisanal *métiers* in the Zambian sector) or are potentially sequential (e.g. purse-seining and beach-seining, scoop-netting or kapenta-seining). For a particular species, various *métiers* therefore can target the same or different life stages. Such an activity pattern is indicative of conflicts between users (Mubamba, 1992), as evidenced by the possible existence of technical interactions, of which the most probable seems to be the competition for the same resource and space between *métiers*. Thus, the artisanal *métiers* should be or may have been in competition with the semi-industrial *métier* in semi-littoral/semi-pelagic waters, even in the pelagic zone (as is the case in Burundi), with the traditional *métiers* inshore. On the other hand, the traditional *métiers* potentially harm the viability of the artisanal and semi-industrial ones, since they target the majority of young clupeids and latids before they recruit further from shore. The reverse is likely true for the semi-industrial *métier*, either when practised closer inshore, or, more often, fishing adult clupeids offshore before they migrate onshore for spawning. These potential technical interactions between national offshore and inshore operating *métiers* are likely complicated by the longitudinal seasonal migrations of some target species, which can lead to the problem of sequential national/local fisheries.

Upon landing, fish use and processing depend on the type of fleet. Small-scale subsistence fishermen immediately consume fresh fish caught and/or sell a part of the harvest to generate some cash income. In the small-scale artisanal sector, the fish are sun-dried or smoked before sales. The Burundian semi-industrial fishermen/companies immediately sell fresh fish at the market (Bujumbura), whereas the Zambians usually freeze them before sales. Sun-dried/smoked and frozen fish are usually transported along different marketing channels. The fish marketing process and statistics have not been comprehensively investigated. However, it is well known (Herman, 1978; Imai *et al.*, 1988; Coulter, 1991; Imai, 1996; Mölsä *et al.*, 1999) that fish are transported to and sold in national and regional markets, most of which are situated in large cities and mining regions/towns. Thus, for example, a part of the Burundian harvest has been exported to Rwanda and East DRC Provinces, and that of the Tanzanian harvest to Zambia. Some fishing companies based in Mpulungu, Zambia, have also exported *L. stappersii* from time to time to DRC (Mubamba, 1992).

SOME CONSIDERATIONS FOR ASSESSING THE DYNAMICS OF THE LAKE TANGANYIKA CLUPEID AND LATID FISHERY SUB-SYSTEMS

Donor agencies and public services in charge of the management of the Lake Tanganyika fishery resources have been always concerned by the factors that have a potential to influence the dynamics of the said fishery sub-systems. Among others, the following aspects have so far been given priority: biology and ecology of exploited species, design of appropriate fishing devices and methods, collection of fishing statistics, hydro-dynamism, populations dynamics, and institutional collaboration. Still, prior to the "FAO/FINNIDA Research for the Management of the fisheries on Lake Tanganyika-GCP/RAF/271/FIN" era in the early 1990s, such aspects have been carried out, in most cases, as sparse and discontinuous experiences not embedded in sound long-term and lake-wide programmes properly planned from the statistical and ecosystem standpoints.

This section is a short review of the available basic knowledge/data requirements for the study of the aforementioned sub-systems' dynamics. While the advantage of such information is obvious, I highlight here the related gaps and suggest the key aspects to be further deeply investigated for its refinement. It must be borne in mind that the routine management of fishing activities relies, in most cases, on the population dynamics models. Such models are themselves built by coupling the dynamics of the fishery's biological and social sub-systems. Depending on the analytical or global (i.e. surplus-production) approach used, such models require as inputs biological and ecological parameters, and catch/effort data, respectively.

I. Biology and Ecology of Clupeids and Latids

Biological and ecological studies (e.g. Roest, 1978, 1988; Moreau & Nyakageni, 1988, 1992; Coulter, 1991; Moreau *et al.*, 1991, 1995; Kimura, 1991a, 1991b, 1995; Pakkasmaa & Sarvala, 1995; Mannini *et al.*, 1996; Kawanabe *et al.*, 1997; Mölsä *et al.*, 1999; Phiri & Shirakihara, 1999) have been mostly devoted to clupeid species and *L. stappersii*, because of their commercial importance. The key features to be considered in any attempt of studying analytically the spatial and temporal dynamics of any population include the following.

The feeding is dominated by the predation interactions between species (Fig. 3), where *S. tanganicae* is entirely planktivorous. In particular, there exist marked seasonal and inter-annual alternate fluctuations in the biomass of *S. tanganicae* (the most pelagic and productive clupeid) and *L. stappersii* (the most abundant pelagic predator) because these species exhibit a strong predator-prey relationship (Pearce, 1985, 1988; Roest, 1988; Coulter, 1991; Coenen, 1995). Such information is essentially qualitative and need to be quantified on a spatial and temporal basis to check "who eats whom and how many". Note also that the clupeids are preyed upon by other species of the lake (Matthes, 1968).

The reproduction of clupeid and latid species takes place continuously throughout the year, with main peaks during the rain seasons. Such peaks vary from year to year and following the lake's longitudinal gradient. Moreover, the clupeid species can have the maximum of their reproductive activity twice per year in some localities. The fish are likely multi-spawners. *L. miodon* and (perhaps) *S. tanganicae* spawn inshore, and the other species spawn offshore. Apart from *L. stappersii* whose life cycle is almost entirely pelagic, except for juveniles of 13-27cm-long who migrate onshore to prey upon juvenile *S. tanganicae* (Roest, 1988), the other species have an inshore larvae and juvenile life style and, with regard to a particular *métier*, recruit and become exploitable at variable ages and sizes. The small size of the Lake Tanganyika clupeids and latids eggs suggests high fecundities. However, fish fecundity has never been thoroughly investigated, nor the spawning grounds, the very factors that control the distribution of eggs and larvae, and recruitment. All these aspects are worth investigating.

The clupeids are small-sized (L_∞=9-11cm for *S. tanganicae*, 15.5-17cm for *L. miodon*) and short-lived (average life expectancy, t_{max}=1 year for *S. tanganicae*, 2 years for *L. miodon*) species, characterised by their high growth and natural mortality rates. *L. stappersii* is mid-sized (L_∞=47-52cm) and is of an "average" life expectancy (t_{max}=6-10 years). The other *Lates* are large (L_∞>75cm) and long-lived (t_{max}>10 years). Those parameters were derived using length frequency data, with the exception of the results of Coulter (1976) for *L. mariae*, and Kimura (1991a, 1991b, 1995) and Pakkasmaa & Sarvala (1995) for clupeids, obtained from reading scales and otoliths, respectively. In the long term, the usefulness of results based on length frequency data will be of limited interest, owing to the strong hypothesis of equilibrium that usually underlies the length-based modelling approaches of population dynamics. It is therefore advisable to undertake monitoring studies on individual ages of animals, in order to obtain matrices of catch-at-age data per year or season. This should help in applying modern and robust techniques of stocks assessment (i.e. age-based virtual population analysis, VPA, or cohort analysis). The previous remark especially stands for *L. stappersii* and large *Lates*. For clupeids, catch-at-length data could perhaps be enough, because, on an annual or bi-annual scale, it can be reasonably supposed that the related stocks are in a permanent equilibrium with fishing effort and environmental factors.

L. stappersii and *L. microlepis* undertake extensive horizontal seasonal migrations throughout the lake. Other *Lates* species (which are demerso-benthic) are sedentary and should likely form local stocks. The larvae and adult *S. tanganicae* and *L. miodon* do school together. A number of studies have led to conflicting information about the extent of their horizontal migrations. Even if such migrations take place, they should be localised. Such a situation should be simple and trivial if they occur within the respective national sectors. However, this is unlikely the case, mainly in adjacent national zones, where the fish freely move across the international boundaries, forming shared stocks. Thus, for instance, some fish dispersed on a particular day in the Tanzanian waters of the lake can school and be caught the following nights in the waters of another country and vice versa. It is therefore clear that a sound management of national/local clupeid and latid fisheries in Lake Tanganyika must imperatively take into account the status of stocks (local/global) and the migration rates between the national sectors or reference fishing zones. The genetic status of clupeid and latid populations in Lake Tanganyika, mentioned earlier, need to be studied as well, on the basis of various patterns and causes of migration.

II. Fishing Statistics

Table 7 summarises the periods for which time series of historical catch (Y) and exploitation indices (f) data are available for clupeids and latids from Lake Tanganyika up to 1996 (Pearce, 1992; Bayona, 1993; Lupikisha, 1993; Katonda, 1993; Coenen, 1995; Coenen *et al.*, 1998). The series in question are heterogeneous, incomplete and different from country or region to another. The following are their major features:

- Particular attention was paid more in collecting the statistics of the semi-industrial fleet than in compiling those of other fleets. The historical series of data are relatively more detailed for the Burundian and Zambian fleets, than they are for the Tanzanian and Congolese fleets. The statistics of the Congolese fleets are even largely missing or uncertain, except for some short data series for Uvira, Fizi, Kalemie and Moba fishing localities (Enoki *et al.*, 1987; Mambona, 1987, 1995; Coenen, 1995; Coenen *et al.*, 1998). Yet the Congolese and Tanzanian fleets contribute on average for 75.5% of total annual catches in weight, and operate over a wide area, that can reach 86%

of the total lake surface.

- The catch and fishing efforts were not disaggregated by individual traditional and artisanal *métiers*. Even for the Burundian and Zambian semi-industrial fleets, some fish species and/or fish commercial categories appear together in catch statistics.
- Exploitation indices are unreliable. For fisheries like those of Lake Tanganyika relying on light attraction of fish, a "reliable" fishing effort unit must take into account the following (Gulland, 1983): number of trips, technical characteristics of gears, time spent in effective fishing operations, total lighting intensity, colour of light, and, if possible, weather conditions, moon phase and state (cloudiness, clarity) of the sky.
- The absence of annual data on various forms of capital invested, maintenance repairs, expenditures including salaries, various losses, total revenue and net benefits, pricing and volume of fish sold along various marketing channels, etc.

On the other hand, the log-sheets of Zambian purse seiners, catamarans and chiromola units indicate interesting records on the fishing activity since the period 1983-1986 onwards (Munyandorero, unpublished data). For each fishing unit, these consist of the fishing company, home port, date of fishing trip, statistical square (5km×5km) fished, total weight of (groups of) species caught, number of hauls, crew size, number of light-boats and, sometimes, the technical characteristics of the "mother" boat and purse seine/ring net (e.g. engine HP, mesh size, etc.). Such a recording system is incomprehensive in that it does not include, for instance, the lighting intensity from both light and mother boats, colour of lights, fishing trip duration, distance travelled from home port, volume and cost of fuel used, exact duration of fish attraction and school concentration, duration of individual hauls, moon phase, and weather conditions. However, it provides a useful database for assessing the spatial and temporal dynamics of fishermen movements, fishing activity allocation, and, eventually, the indices of patch, local abundance (density) and local fishing power, and the standardisation of fishing intensity. For a fleet that has operated for a long time in too small an area (perhaps about 300km^2) off Mpulungu, such an information could also enable a fair estimation of the annual rates of lake proportions/sub-areas newly prospected as a result of local over-fishing and local stock depletion. Similar records have also been compiled for the Burundian semi-industrial fleet (Mann *et al.*, 1975; Petit *et al.*, 1990), but have not yet been properly processed as well.

The major recommendation here is to equally pay attention and fairly allocate proportional resources in collecting the temporal (i.e. annual, seasonal) and spatial basic statistics of all types of *métiers*/fisheries. The fishermen should use the Global Positioning System (GPS) to accurately recognize their fishing locations and properly report their catch and effort returns. Since the fleets and *métiers* have been "fairly" defined, it is advisable to further collect all data requirements for characterising and quantifying the pressure they exert indi-

Table 7. Periods for which Time Series of Data on Historical Catch (Y) and Exploitation Indices (f) are Available for Clupeids and Latids from Lake Tanganyika up to 1996, as Recorded by Fleet and Entire National Sector of the Lake.

Fleets and statistics	Burundi	DRC	Tanzania	Zambia
Semi-industrial *Y*				
-Total	1954-1995	MD	1973-1989	1962-1996
-Clupeids*	1956-1995	MD	1974-1987 (1)	1962-1996
-*L. miodon*	MD	MD	1974-1987 (1)	1962-1996 (15)
-*S. tanganicae*	MD	MD	1974-1987 (1)	1963-1996 (15)
-*L. stappersii*	1956-1995	MD	1974-1987 (1)	1963-1996
-Large *Lates*	1956-1995	MD	1974-1987 (1)	1962-1996
-*L. microlepis*	MD	MD	1974-1987 (1)	1963-1996
-*L. mariae/L. angustifrons*	MD	MD	1974-1987 (1)	1963-1996
-Other species	1954-1995	MD	MD	1977-1996
Semi-industriel *f* (number)				
-Fishing units	1954-1996	1955-1995 (22)	1961-1995 (13)	1962-1996
-Trips	1976-1995	MD	1967-1987 (1)	1962-1996
-Hauls	MD	MD	1974-1987 (1)	1963-1996 (7)
-Light-boats	MD	MD	MD	1973-1996 (3)
Artisanal *Y*				
-Total	1959-1995	MD	1964-1992 (1)**	1953-1994 (1)**
-Clupeids	1959-1995	MD	1967-1992 (10)**	1977-1990**
-*L. stappersii*	1974-1995	MD	1966-1992 (16)**	MD
-Large *Lates*	1974-1995	MD	1967-1992 (15)**	MD
-Other species	1959-1995	MD	1967-1992 (9)**	1977-1990**
Artisanal *f* (number)				
-Fishing units	1957-1994	MD	MD	MD
-Trips	1992-1995	MD	MD	MD
Traditional *Y*				
-Total	1950-1995	MD		
-Clupeids	1950-1995	MD		
-Other species	1950-1995	MD		
Traditional *f* (number)				
-Fishing units	1952-1995 (1)	MD	MD	MD
-Trips	1992-1995	MD	MD	MD

MD: Missing or uncertain data (for DRC, the statistics are more detailed at fishing locality level). Figures in parentheses: number of years with missing statistics within the period.
* In Burundi, clupeid catches also include those of young *L. stappersii* (fork length < 15cm).
** Statistics combine records from both traditional and artisanal fleets.

vidually on the said stocks (the temporal and spatial scales are to be chosen accordingly). At the same time, it will be essential to compile the basic data for evaluating the spatial and temporal dynamics of the fishery's social and bio-economic components.

SUMMARY, PROSPECTS AND CONCLUSION

The clupeids and latids form shared stocks in Lake Tanganyika. The related fishery, developed since the 1950s, is space-structured, international, multi-species, multi-*métier* and multi-fleet. Most of the *métiers* practised are unselective vis-à-vis the fish species and sizes because of the small mesh sizes of nets in use. All types of fleets are found in all Lake Tanganyika riparian countries (Fig. 1), but their distribution pattern is differential. Thus, the traditional fleet is omnipresent along the shoreline, but predominates along the Tanzanian shoreline. The artisanal fishing activities have historically developed first in the northern (Burundi and the DRC locality of Uvira) and southern (Zambia) sectors of the lake; they have been recently expanding and becoming increasingly preponderant in the Tanzanian waters (Hanek *et al.*, 1993; Katonda, 1997). The national semi-industrial fleets have always been operating in pelagic waters off towns and cities, and off regions with basic infrastructures. Moreover, the main part of Lake Tanganyika, most of which belong to the DRC and Tanzanian pelagic sectors, is officially less fished in than are the Burundian and Zambian waters. The unexploited or weakly exploited pelagic zone can therefore be considered as a natural reserve that plays two vital roles in relation with the continuous migratory flux of fish into and from it. That is, it can "supply" the national/local sub-stocks with fish when they are depleting as a result of overfishing, on the one hand; on the other, it can serve as "refuge area" of animals from these sub-stocks offering them appropriate niches.

The Lake Tanganyika clupeid and latid fishery system consists of the biological, social and economic sub-systems, based on fish populations, *métiers*, and national and regional markets. The biological interactions, essentially the predation between species, and the potential technical and sequential interactions are among the major determinants of the said system.

The biological, ecological and genetic reviews of exploited species, as well as those of fishing statistics, have partially highlighted some gaps that constitute an obstacle to a proper assessment, at both global and national/local scales, of the dynamics of the foregoing sub-systems. For the assessment of the stock dynamics, the handicap stems from the heterogeneity, insufficiency and even lack of adequate data that relate to the biology (e.g. fecundity, catch-at-age) and ecology (e.g. spatial and temporal structures in size/age of biomass transfer through predation and annual/seasonal migration rates between national sectors or reference geographical zones) of species, the definitive genetic structure of populations, as well as the catch and effort statistics. The standardisation of effort should be particularly difficult, owing to different recording systems and typologies of fishing activities, and the multiplicity of *métiers* for which there is no disaggregated catch and effort records. Moreover, there are no qualitative and quantitative economic indicators (e.g. pricing, volume of fish sold, marketing channels, investment, revenue, expenditures, etc.) allowing implementing or developing the bio-economic models, or assessing the market dynamics. All the previous gaps in data requirements make empirical and uncertain any management measure.

Conversely, the problems alluded to could be reduced if the study conducted is to be confined to a national or local scale. This should be particularly the case for the Burundian and Zambian fisheries (and, by extension, for the fisheries of the northernmost and southernmost sectors of the lake). In fact, despite their insufficiency, the catch, exploitation indices and the spatial and temporal fishing activities of these countries' semi-industrial fleets are more detailed than are those of other countries. The subsequent diagnostics should naturally be improved by the acquisition of reliable catch-at-age/length data, and of proper data on reproduction/fecundity, genetic population structures, migration and predation rates, etc. The spatial, multi-species, global or analytical models could therefore be developed or implemented for a more comprehensive assessment of the dynamics of national/local sub-stocks, and for a relatively sound management of related fisheries sub-systems.

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REFERENCES

Allen, P.M. & J.M. McGlade 1986. Dynamics of discovery and exploitation: the case of the Scotian shelf groundfish fisheries. *Canadian Journal of Fisheries and Aquatic Sciences*, 43: 1187-1200.

Bayona, J.D.R. 1993. Variation in abundance and distribution of *Limnothrissa miodon* in the Tanzanian sector of Lake Tanganyika: The need for continued stock assessment. *FAO, CIFA Occasional Paper*, 19: 121-140.

Bellemans, M. 1991. Structural characteristics of the Burundian fisheries in 1990 and historical review. *UNDP/FAO Regional Project for Inland Fisheries Planning (IFIP)*, RAF/87/099/TD/25, (Unpublished).

Biseau, A. & E. Gondeaux 1988. Apport des méthodes d'ordination en typologie des flotilles. *Journal du Conseil International de l'Exploration de la Mer*, 44: 286-296.

Challe, N.A. & A.D.B. Kihakwi 1994. Tafiri catalogue of fishing gears of the Kigoma and Rukwa regions of Lake Tanganyika (Tanzania): Historical data report 3. *FAO/FINNIDA Research for the Management of the Fisheries on Lake Tanganyika*, GCP/RAF/271/FIN-TD/15 (Unpublished).

Chapman, D.W. & P. van Well 1978. Growth and mortality of *Stolothrissa tanganicae*. *Transactions of the American Fisheries Society*, 107: 26-35.

Coenen, E.J. 1995. LTR's fisheries statistics subcompnents: March 1995 update of results for Lake Tanganyika. *FAO/FINNIDA Research for the Management of the Fisheries on Lake Tanganyika*, GCP/RAF/271/FIN-TD/32 (Unpublished).

Coenen, E.J., P. Paffen & E. Nikomeze 1998. Catch per unit effort (CPUE) study for different areas and fishing gears of Lake Tanganyika. *FAO/FINNIDA Research for the Management of the Fisheries on Lake Tanganyika*, GCP/RAF/271/FIN-TD/80, (Unpublished).

Coulter, G.W. 1968. Changes in the pelagic fish population in the southeast arm of Lake Tanganyika between 1962 and 1966. *Fisheries Research Bulletin of Zambia*, 4: 29-32.

Coulter, G.W. 1976. The biology of *Lates* species (Nile perch) in Lake Tanganyika, and the status of the pelagic fishery for *Lates* species and *Luciolates stappersii* (Blgr.). *Journal of Fish Biology*, 9: 235-259.

Coulter, G.W. (ed.) 1991. *Lake Tanganyika and Its Life*. Natural History Museum Publication, Oxford University Press, London.

Coulter, G.W. & Y.A. Znamensky 1971. The chiromila net: A method for catching light-attracted fish in Lake Tanganyika. *Fisheries Research Bulletin of Zambia*, 5: 215-224.

Ellis, C.M.A. 1978. Biology of *Luciolates stappersii* in Lake Tanganyika (Burundi). *Transactions of the American Fisheries Society*, 107: 557-566.

Enoki, A., W.B. Mambona & M.-S. Mukirania 1987. General survey of fisheries in northwestern part of Lake Tanganyika. *Ecological and Limnological study on Lake Tanganyika and Its Adjacent Regions*, 4: 98-101.

FAO, 1973. A brief review of the current status of the inland fisheries of Africa. *The African Journal of Tropical Hydrobiology and Fisheries (special issue)*, 1: 3-19.

Garrod, D.J. 1973. Management of multiple resources. *Journal of the Fisheries Research Board Canada*, 30: 1977-1985.

Gascuel, D. 1995. Efforts et puissance de pêche: Redéfinition des concepts et exemple d' application. In (D. Gascuel, J.L. Durand & A. Fonteneau, eds.) *Les Recherches Françaises en Évaluation Quantitative et Modélisation des Ressources et des Systèmes Halieutiques*, pp. 159-182. Actes du Premier Forum Halieumétrique, Rennes, 29 juin au 1er juillet 1993, Editions ORSTOM, Collection Colloques et Séminaires, Paris.

Gascuel, D., A. Fonteneau & E. Foucher 1993. Analyse de l'évolution des puissances de pêche par l'analyse des cohortes: Application aux senneurs exploitant l'albacore (*Thunnus albacares*) dans l'Atlantique Est. *Aquatic Living Resources*, 6: 15-30.

Gulland, J.A. 1983. *Fish Stock Assessment: A Manual of Basic Methods*. John Wiley & Sons, Chichester.

Hanek, G. & J.E. Reynolds 1999. *CD-ROM on the Lake Tanganyika Fisheries Research Project (GCP/RAF/271/FIN), 1992-1999*. FAO, Rome.

Hanek, G., E.J. Coenen & P. Kotilainen 1993. Aerial frame survey of Lake Tanganyika fisheries. *FAO/FINNIDA Research for the Management of the Fisheries on Lake Tanganyika*, GCR/RAF/271/FIN-TD/9 (Unpublished).

Hauser, L. 1996. *Genetic and Morphological Differentiation of Native and Introduced Populations of the Lake Tanganyika Sardine,* Limnothrissa miodon. Ph.D. dissertation. University of Wales, Swansea.

Hauser, L., G.R. Carvallo & T.J. Pitcher 1998. Genetic population structure in the Lake Tanganyika sardine *Limnothrissa miodon*. *Journal of Fish Biology*, 53 (Supplement A): 413-429.

Herman, C. 1978. La pêche dans le lac Tanganyika: situation actuelle et perspectives de développement. *FAO, CIFA Technical Paper*, 5: 16-41.

Hickling, C.F. 1961. *Tropical Inland Fisheries*. Longmans, London.

Hilborn, R. 1985. Fleet dynamics and individual variation: Why some people catch more fish than others. *Canadian Journal of Fisheries and Aquatic Sciences*, 42: 2-13.

Hilborn, R. & M. Ledbetter 1985. Determinants of catching power in the British Columbia salmon purse seine fleet. *Canadian Journal of Fisheries and Aquatic Sciences*, 36: 51-56.

Hoekstra, T.M. & J.M. Lupikisha. 1992. The artisanal capture fisheries of Lake Tanganyika, Zambia: major socio-economic characteristics of its fishermen and their fishing units. *UNDP/FAO Regional Project for Inland Fisheries Planning (IFIP)*, RAF/87/099-TD/41/92 (Unpublished).

Imai, I. 1996. Fishing activity and circulation of fish products in the north-western area of Lake Tanganyika. *Studies in the Humanities*, 31(3): 39-61.

Imai, I., W.B. Mambona & M. Mukirania 1988. Circulation of fish products in the northwestern area of Lake Tanganyika, Zone Uvira and Zone Fizi. *Ecological and Limnological Study on Lake Tanganyika and Its Adjacent Regions*, 4: 54.

Katonda, K.I. 1993. The fishery of *Stolothrissa tanganicae*, Regan, 1917, in the Tanzanian waters of Lake Tanganyika. *FAO, CIFA Occasional Paper*, 19: 141-156.

———— 1997. Trends in land and water resource uses likely to influence the fisheries of Lake Tanganyika (Tanzania): Potential conflict areas. In (K. Remane, ed.) *African Fisheries, Aquaculture and the Environment*, pp. 26-32. Fishing News Books, Oxford.

Katonda, K.I. & A.N.M. Kalangali 1994. Historical review of the artisanal and industrial fisheries of Lake Tanganyika in Kigoma and Rukwa regions, Tanzania: Historical data report 1. *FAO/FINNIDA Research for the Management of Fisheries on Lake Tanganyika*, GCP/RAF/271/FIN-TD/15 (Unpublished).

Kawanabe, H., M. Hori & M. Nagoshi (eds.) 1997. *Fish Communities in Lake Tanganyika*. Kyoto University Press, Kyoto.

Kendall, R.L. 1973. The benthic gill net fishery of Lake Tanganyika, Zambia, 1962-1972. Report of the Department of Fisheries (Unpublished).

Kimura, S. 1991a. Growth of *Stolothrissa tanganicae* estimated from daily otolith rings in southern Lake Tanganyika. *Ecological and Limnological Study on Lake Tanganyika and Its Adjacent Regions*, 7: 60-61.

———— 1991b. Growth of *Limnothrissa miodon* estimated from daily otolith rings in southern Lake Tanganyika. *Ecological and Limnological Study on Lake Tanganyika and Its Adjacent Regions*, 7: 62-64.

———— 1995. Growth of the Clupeid fishes, *Stolothrissa tanganicae* and *Limnothrissa miodon*, in the Zambian waters of Lake Tanganyika. *Journal of Fish Biology*, 47: 569-575.

Kiyuku, A. 1993. Situation économique des pêcheries burundaises au cours des douze dernières années. *FAO, CIFA Occasional Paper*, 19: 204-212.

Kuusipalo, L. 1995. Diversification of endemic Nile perch *Lates mariae* (Centropomidae, Pisces) populations in Lake Tanganyika, East Africa, studied with RAPD-PCR. In (H. Mölsä, ed.) *Symposium on Lake Tanganyika Research, September 11-15, 1995, Abstracts*, p. 61. Kuopio.

———— 1999. Genetic differentiation of endemic Nile perch *Lates stappersi* (Centropomidae, Pisces) populations in Lake Tanganyika suggested by RAPD markers. *Hydrobiologia*, 407: 141-148.

Laloë, F. & A. Samba 1991. A simulation model of artisanal fisheries of Senegal. *ICES Marine Science Symposium*, 193: 281-236.

Laurec, A. & J.-C. Le Guen 1981. *Dynamique des Populations Marines Exploitées, Tome 1. Concepts et Modèles, Rapports Scientifiques et Techniques 45*. CNEXO/Centre Océanographique de Bretagne, Brest.

Laurec, A., A. Biseau & A. Charuau 1991. Modelling technical interactions. *ICES Marine Science Symposium*, 193: 225-236.

Leendertse, K. & B. Horemans 1991. Socio-economic characteristics of the artisanal fishery in Kigoma region, Tanzania. *UNDP/FAO Regional Project for Inland Fisheries Planning (IFIP)*, RAF/87/099-TD/22/91 (Unpublished).

Lupikisha, J.M.C. 1993. *The Fisheries Statistics Data Collection System in Zambia and Fisheries Statistics of Lake Tanganyika*. Paper presented to the Workshop on the Coordination and Standardization of Fisheries Statistics for Lake Tanganyika, July 26-30, 1993, Bujumbura, Burundi.

Mambona, W.B. 1987. Statistical analysis of fishery production in the northwest area of Lake Tanganyika. *Ecological and Limnological Study on Lake Tanganyika and Its Adjacent Regions*, 4: 102-104.

——— 1995. Données historiques sur les statistques et économie de pêche de la partie zaïroise du lac Tanganyika: Historical data report 1. *FAO/FINNIDA Research for the Management of the Fisheries on Lake Tanganyika*, GCP/RAF/271/FIN-TD/31, (Unpublished).

Mann, M.J. & N. Ngomirakiza 1973. Evaluation of the pelagic resources in the Burundi waters of Lake Tanganyika and the evolution of the fisheries. *The African Journal of Tropical Hydrobiology and Fisheries (special issue)*, 2: 135-141.

Mann, M.J., F. Bashirwa, C.M.A. Ellis, J.B. Nahabakomeye & H.O. Enderlein 1975. Preliminary report on fish biology and stock assessment in Lake Tanganyika (Burundi). FAO/F/: DP BDI/73/020/5 (Unpublished).

Mannini, P., E. Aro, I. Katonda, B. Kassaka, C. Mambona, G. Milindi, P. Paffen & P. Verbug 1996. Pelagic fish stocks of Lake Tanganyika: biology and exploitation. *FAO/FINNIDA Research for the Management of the Fisheries on Lake Tanganyika*, GCR/RAF/271/FIN-TD/53 (Unpublished).

Matthes, H. 1968. Preliminary investigations into biology of the Lake Tanganyika Clupeidae. *Fisheries Research Bulletin of Zambia*, 4: 39-45.

Mesnil, B. & J.G. Shepherd 1990. A hybrid age- and length-structured model for assessing regulatory measures in multiple-species, multiple-fleet fisheries. *Journal du Conseil International pour l'Exploration de la Mer*, 47: 115-132.

Millischer, L. 2000. *Modélisation Individu centré des Comportements de Recherche des Navires de Pêche. Approche Générique Spatialement Exciplicite par Système Multi-agents. Intérêts pour l'Analyse des Stratégies et des Puissances de Pêche*. Ph.D. dissertation. Ecole Nationale Supérieure Agronomique (ENSA), Rennes.

Mölsä, H., J.E. Reynolds, E.J. Coenen & O.V. Lindquist 1999. Fisheries research towards resource management on Lake Tanganyika. *Hydrobiologia*, 407: 1-24.

Moreau, J. & B. Nyakageni 1988. Les relations trophiques dans la zone pélagique du lac Tanganyika (Secteur Burundi): Essai d'évaluation. *Revue d'Hydrobiologie Tropicale*, 23: 157-164.

Moreau, J. & B. Nyakageni 1992. *Luciolates stappersii* in Lake Tanganyika. Demographical status and possible recent variations assessed by length frequency distributions. *Hydrobiologia*, 232: 57-64.

Moreau, J., J. Munyandorero & B. Nyakageni 1991. Evaluation des paramètres démographiques chez *Stolothrissa tanganicae* et *Limnothrissa miodon* du lac Tanganyika. *Verhandlungen der Internationale Vereingung fur Theortische und Angewandte Limnologie*, 24: 2552-2558.

Moreau, J., M.L.D. Palomares, JR.F.S.B. Torres & D. Pauly 1995. *Atlas Démographique des Populations de Poissons d'Eau Douce d'Afrique. Technical Reports 45*. International Center for Living Aquatic Resources Management (ICLARM) and Agence de Coopération Culturelle et Technique (ACCT), Manilla.

Mubamba, R. 1992. Status of the fishery industry in Zambia. A report submitted to the Foundation of Applied Research of the University of Tromsø, Norway, in fulfilment of a

NORAD/SADCC fellowship for a training course in management for sustainable fisheries (Unpublished).
Mudenda, H.G. 1998. Zambia Biodiversity strategy action plan (BSAP). The biodiversity of fish in Zambia. *A report prepared for the International Union for Conservation of Nature* (IUCN), Zambia (Unpublished).
Mukirania, M.-S. 1995. Données historiques sur la relation entre l'effet de la lumière et les prises au lac Tanganyika: Historical data report 6. *FAO/FINNIDA Research for the Management of the Fisheries on Lake Tanganyika*, GCP/RAF/271/FIN-TD/31 (Unpublished).
Munyandorero, J. 2001. Length-based Beverton and Holt spawning stock biomass per-recruit-models, with application to the *Lates stappersii* (Boulenger) stock in Lake Tanganyika. *Fisheries Management and Ecology*, 8: 1-14.
Murawski, S.A., A.M. Lange & J.S. Idoine 1991. An analysis of technical interactions among Gulf of Maine mixed-species fisheries. *ICES Marine Science Symposium*, 193: 237-252.
Nakaya, K. 1993. Common names of fishes of Lake Tanganyika in Zambia. *Ecological and Limnological Study on Lake Tanganyika and its adjacent Regions*, 8: 66-68.
Ngomirakiza, M. & L. Haling 1973. Développement de la pêche artisanale dans les eaux burundaises du lac Tanganyika. *The African Journal of Tropical Hydrobiology and Fisheries (special issue)*, 1: 53-57.
Pakkasmaa, S. & J. Sarvala 1995. Growth of the pelagic clupeids in Lake Tanganyika estimated from daily otolith increments. In (H. Mölsä, ed.) *Symposium on Lake Tanganyika Research, September 11-15, 1995. Abstracts*, p. 103. Kuopio University Publications C. Natural and Environmental Sciences, Kuopio.
Patterson, G. & L. Makin 1998. *The State of Biodiversity in Lake Tanganyika*. Natural Resource Institute, Chartam.
Pearce, M.J. 1985. A description and stock assessment of the pelagic fishery in the South East arm of the Zambian waters of Lake Tanganyika. Annual Report of the Department of Fisheries (Unpublished).
——— 1988. Some effects of *Lates* species on pelagic and demersal fish in Zambian waters of Lake Tanganyika. *FAO, CIFA Occasional Paper*, 15: 69-87.
——— 1992. The results of a survey of the fisheries of the Zambian waters of Lake Tanganyika. *UNDP/FAO Regional Project for Inland Fisheries Planning (IFIP)*, RAF/87/099/WP/13/92 (Unpublished).
Pelletier, D. & J. Ferraris 2000. A multivariate approach for defining fishing tactics from commercial catch and effort data. *Canadian Journal of Fisheries and Aquatic Sciences*, 57: 51-65.
Petit, P., B. Nyakageni & J. Moreau 1990. La production exploitée au lac Tanganyika (Burundi). Variations des rendements: Essai d'interprétation. In (IAC, ed.) *Fisheries of Great Lakes of Africa*, pp. 5-17. IAC Occasional Paper, Wageningen.
Phiri, H. & K. Shirakihara 1999. Distribution and seasonal movement of pelagic fish in Southern Lake Tanganyika. *Fisheries Research*, 41: 63-71.
Roest, F.C. 1978. *Stolothrissa tanganicae*: Population dynamics, biomass evolution and life history in the Burundi waters of Lake Tanganyika. *FAO, CIFA Technical Paper*, 5: 42-62.
——— 1988. Predator-prey relationships in northern Lake Tanganyika and fluctuations in the pelagic fish stocks. *FAO, CIFA Occasional Paper*, 15: 104-129.
Shirakihara, K., K. Use, S. Kamikawa & W.B. Mambona 1992. Population changes of sardines in northern Lake Tanganyika. *African Study Monographs*, 13: 57-67.
Turner, J.L. 1978. Status of various multi-species fisheries of Lakes Victoria, Tanganyika and Malawi, based on catch and effort data. *FAO, CIFA Technical Paper*, 5: 4-15.

Ulrich, C. 2000. *Modélisation Multi-flotilles et Multi-métiers des Pêcheries Artisanales de la Manche. Evaluation Plurispécifique des Stocks, Étude des Intéractions Techniques et Intégration dans la Modélisation Bioéconomique*. Ph.D. dissertation. Ecole Nationale Supérieure Agronomique (ENSA), Rennes.

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Author's Name and Address: Joseph MUNYANDORERO, *University of Zambia, Department of Biological Sciences, P.O. Box 32379 Lusaka, ZAMBIA.*
E-mail: jmunyandorero@natsci.unza.zm or *jmunyand@yahoo.com*