The need for an inland fisheries policy in South Africa: A case study of the North West Province

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Abstract

In contrast to many other African countries, inland fisheries in South Africa are poorly developed and the fish populations in many of the country's 3 000 major dams are under-utilised. While the primary purpose South Africa's dams is to supply water for domestic and agricultural use, there has been an increasing realisation that their fish populations could make a contribution to food security through the establishment of capture fisheries. Historically, the fish in most South African dams have primarily been utilised for recreational fishing purposes, as subsistence use was criminalised by the apartheid regime in all waters except in the former homeland areas. This legacy persists as many of South Africa's rural communities do not have a fishing tradition and there is a lack of an institutional framework to facilitate managed and sustainable access to the fish resource in inland waters. Current utilisation of many inland dams is often complicated by the existence of multiple authorities and interest groups, often with competing agendas. As a result, the economic potential of these water bodies is unknown and often grossly underutilised. Our study outlines a case study of fisheries resources in the North West Province of South Africa that could be used for the creation of income and food security for local communities through the development of subsistence, commercial, and recreational fisheries. The study identifies the lack of guidelines for the development of inland fisheries and the lack of an inland fisheries policy, both at the provincial and national level, as major bottlenecks for the sustainable development of these resources and outlines possible focal areas for intervention.

Keywords: inland fisheries, policy, management, morpho-edaphic index

Introduction

There are more than 3 000 dams, ranging in size from less than 2 ha to more than 300 km^2, in South Africa (DWAF, 1997). While the primary objective for the construction of these dams was the provision of water for agricultural, industrial and domestic use (Andrew, 2001), they have considerable potential for the development of inland fisheries.

Inland fisheries are of importance for the national economy and local food security in a number of African countries (Kapetsky and Petr, 1984; Marshall and Maes, 1994; Van der Knaap, 1994). In South Africa, inland fisheries remain poorly developed despite several attempts to develop subsistence and commercial fisheries dating back to the 1970s (Jackson, 1980; Koch and Schoonbee, 1980; Allanson and Jackson, 1983; Cochrane, 1987; Andrew, 2001). The reasons for the lack of fisheries development are unclear, but in many cases appears to be a result of a lack of historic involvement in fishing, a cultural resistance to fishing, a lack of fishing gear, or a lack of knowledge of the potential of the resource (Andrew, 2001). As a result, traditional harvesting is limited to relatively few systems, such as the Phongola floodplain (Merron and Weldrick, 1995) and the Orange River in the Northern Cape Province (Andrew, 2001) and commercial fishing in the form of single licences is only permitted on a limited scale on a few dams (e.g. the Gariep, Bloemhof and Molatedi Dams). Subsequently, the resource is predominantly utilised by a large recreational angling fraternity.

Given that food security, economic empowerment, tourism development, optimal economic benefit from water, and poverty eradication are major national policy objectives in post-apartheid South Africa (ECA, 1989; NEMA, 1998; NWA, 1998), the under-utilisation and poor management of fish resources in inland water bodies highlights the need to promote inland fishery development. A case study of the potential for fishery development in North West Province (NWP) is used to illustrate the need for an inland fisheries policy and a coordinated institutional approach to inland fisheries development and management.

Howard et al. (2002) listed 28 major dams in the Province, which have a combined surface area of more than 11 000 ha. These are used primarily for the maintenance of water supply to the human population and for irrigation in the agricultural sector. Many of these dams also have a considerable value as tourism venues, particularly in areas where they form part of a nature reserve or game park. In such areas, recreational activities include boating, bird watching and recreational angling. Their existence, therefore, contributes significantly to the R 1.4 bn. annual provincial revenue generated from the tourism sector (Visser et al., 2002). In contrast to the agricultural and tourism sectors in the NWP, the fisheries sector is not considered well developed, and the utilisation of the fishery resource in many of the NWP's dams is entirely recreational (Mangold et al., 2002)

The need for developing fisheries resources in the NWP as alternatives to the more traditional methods of securing food and economic independence for rural communities is recognised by the provincial government (Mangold et al., 2002). At the outset of the study, limited subsistence and commercial fishing was known to occur on some of the dams, but little was known about the extent of exploitation (Mangold et al., 2002; Rouhani, 2004). Where commercial fisheries did exist, they were not operated by local rural communities due to social, economic, and political factors (Mangold et al., 2002). The NWP Department of Agri-

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culture, Conservation and Environment (DACE) recognised that a State-led intervention was required to promote optimal social-economic benefits from the freshwater fisheries under its jurisdiction and commissioned the Rural Fisheries Project of the Department of Ichthyology and Fisheries Science, Rhodes University, to undertake a study of 10 dams in the NWP to develop guidelines for the sustainable development and management of the fisheries resource (Rouhani, 2004). This survey was comprehensive and included assessments of environmental variables which affect biological productivity, test fishing, biological analysis of the main fish species, assessments of current fishing pressure and an intensive stakeholder consultation (Rouhani, 2004). The data collected during the survey is presented as a case-study to highlight the need for an inland fisheries policy and comprehensive guidelines and institutional arrangements to support the development of inland fisheries in South Africa.

Methods

Fisheries assessment

The survey was conducted between April 2002 and February 2003 and focused on 10 dams in the NWP ranging in size from 35 ha to 1 571 ha (Table 1). These were: Taung (27.52°S, 24.85°E), Lotlamoreng (25.87°S, 25.85°E), Ngotwane (25.16°S, 25.80°E), Molatedi (24.87°S, 26.45°E) Madikwe (25.38°S, 26.56°E), Lindleyspoort (25.48°S, 26.68°E), Koster (25.7°S, 26.9°E), Bospoort (25.55°S, 27.35°E), Vaalkop (29.83°S, 30.5°E) and Roodekopjes (25.4°S, 27.58°E). To include seasonal trends, dams were surveyed during April 2002, August 2002, November/December 2002 and February/March 2003. During the initial survey in April 2002, the dam was mapped according to its depth profile, its substrate, aquatic macrophytes, tributaries and any other factors that could influence fish distribution. The reservoir habitats were categorised into sites suitable for experimental fishing and potential sampling sites were chosen at random. Three fishing gears were used during the survey. These were:

- Surface set, multifilament nylon gill-nets consisting of 5 panels (10 m long x 2 m deep) with stretched mesh sizes of 44 mm, 60 mm, 75 mm, 100 mm and 144 mm
- A 30 m long x 2 m deep beach seine net with a stretched mesh size of 10 mm
- Long-lines constructed of 12 mm rope with ten hooks (size 9/0) baited with fish heads and intestines at 2 m intervals.

Depending on the size of the dam, between 3 and 6 gill-net and between 1 and 3 long-line sites were selected, and all gears were set overnight. The number of sites chosen for seine netting ranged from 3 to 16, depending on the size of the reservoir and the number of suitable sites available. At each site, water temperature, turbidity, conductivity and pH were measured directly, using hand-held instruments. All fish caught during experimental fishing were identified to species level, measured to the nearest mm total length (TL) or fork length (FL) depending on species, and weighed to the nearest gram.

For all experimental fishing gear, mean catch per unit effort ($\overline{CPUE}$) was calculated as:

$$\overline{CPUE} = \frac{\sum_{i=1}^{n}\left(C_i / E_i\right)}{n} \quad (1)$$

where:

C_i is the total catch on day i

E_i is fishing effort on day i

In this study, E_i was standardised to kg/experimental fleet night basis for gill-nets or kg/10 hook·night for long-lines.

Potential yield

As a result of the absence of prior biological and fisheries data, direct estimates of fish production in dams could not be determined. In similar instances, first estimates of potential fish yield have often been obtained using empirical approaches such as the morpho-edaphic index MEI (Ryder, 1965; Schlesinger and Regier, 1982; Marshall and Maes, 1994). The MEI was developed by Ryder (1965), to take into account the effect of lake fertility, indicated by TDS or conductivity, as well as the mean depth of the lake, in the prediction of fish yields. It is acknowledged that the estimates of fish yield derived from these MEI models are more than incidental (Ryder et al., 1974), and that these models have some predictive utility on the total annual yield attainable from a dam.

To obtain a first-estimate of the potential fish yield in each dam, two empirical models using a MEI as a predictor of fish yield were applied. These were: the Schlesinger and Regier (1982) global, temperature-adapted MEI model:

$$LogYield(kg/ha \bullet yr) = 0.044T + 0.482 \;\; Log\frac{TDS}{MD} + 0.021 \quad (2)$$

where:

T is temperature in °C

TDS is the total dissolved solids in mg/ℓ

MD is the mean depth of the reservoir in metres

and the Marshall and Maes (1994) model developed for African reservoirs where:

$$Yield(kg/ha \bullet yr) = 23.281 * \left(\frac{MD}{CON}\right)^{0.447} \quad (3)$$

and CON is the mean conductivity measured in $\mu S \cdot m^{-2}$.

Stakeholder consultation

The primary stakeholders for the development of the fishery in the 10 dams were identified as: the North-West Province Department of Agriculture, Conservation and Environment (DACE), tribal authorities, local and district municipalities, local and national recreational angling clubs, the North West Tourism and Parks Board (NWTPB), DWAF, water user associations (WUAs), recreational, subsistence and commercial fishers. Through consultation with the local DACE official, relevant stakeholders were identified and informal, semi-structured interviews were conducted with the various stakeholders to determine the nature of their use of the resource and whether they had any recommendations or suggestions to improve the fishery potential of the dam.

Recommendations for fisheries development

To make preliminary recommendations for fisheries development in the 10 dams we utilised results from the productivity analysis, species composition, stakeholder consultation and personal observations. The recommendations fell into four categories: community-managed subsistence fishery (CMSF); commercial fishery (CF); recreational fishery (RF) or open-access equilibrium (OAE).

Community-managed subsistence fishery (CMSF)

This type of fishery is managed by a local community to maximise sustainable yield, food security and employment. The

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harvest is primarily consumed locally and excess may be sold. The fishery is managed primarily through input controls such as closed seasons, gear limitations and limited access. Allowable gears in this fishery include gill-nets, long lines and hook and line fishing. A CMSF was recommended in areas where:

- MEI models predicted fishery yields of > 50 t/yr
- No IUCN red data book listed species were present and the species composition was dominated by *Clarias gariepinus*, *Oreochromis mossambicus* and *Cyprinus carpio*
- Community land bordered the dam
- There was a pre-existing subsistence fishery
- There were no pre-existing tourist facilities and the dam was not conducive for tourism development for scenic or safety reasons.

Commercial fishery (CF)

A commercial fishery is operated by a private individual who is granted access at provincial level to harvest a pre-determined yield from a dam. The enterprise is profit- oriented, striving to minimise production costs and to maximise efficiency in production. Gears permissible for commercial use include gill-nets, long-lines and beach seine nets and the fishery is managed on maximum yield strategy. A commercial fishery was recommended in areas where:

- MEI models predicted fishery yields > 100 t/yr
- Species composition was dominated by *Clarias gariepinus*, *Oreochromis mossambicus* and *Cyprinus carpio*
- No IUCN red data book listed species were present
- There was limited community access to and use of the resource
- Limited recreational and subsistence use of the fishery was observed.

Recreational fishery (RF)

In a recreational fishery the resource is used exclusively for recreation by anglers using hook and line. Users are neither dependent on the resource for survival, nor for economic gain. These fisheries can be managed for maximum participation through output controls such as daily bag limits and through catch-and-release (where recreational anglers return caught fish to the water alive) fishing. An RF was recommended where:

- MEI models predicted yield lower than those capable of sustaining either a CMF or a CF
- There was a history of recreational use
- The dam was bordered by nature reserve, private land or community land
- Pre-existing tourist facilities were present or showed potential for the development of tourist facilities
- The community expressed an interest in tourism development.

Open access equilibrium (OAE)

In OAE fisheries no management recommendations are set and the dam is maintained as a common, open-access resource. An OAE was recommended in dams where predicted yields were lower than those capable of sustaining either a CMF or a CF and the potential for the establishment of tourist facilities was limited.

Results

Experimental gill-net and long-line catch per unit effort (CPUE) is shown in Fig. 1. Long-line CPUE varied between dams and ranged from 8.8 ± 6.2 kg/10 hook·night at Taung Dam to 20.3 ± 13.9 kg/10 hook·night at Molatedi Dam. Gill-net CPUE also varied between dams and ranged from 1.7 ± 1.4 kg/net·night at Lindleyspoort to 30.5 ± 12.3 kg/net·night at Vaalkop. CPUE at Lindleyspoort and Bospoort Dams was considerably lower than that in any of the other dams (Fig. 1). With the exception of these two dams, CPUE followed a similar pattern to estimated potential yield from MEI models. The low CPUE in these two dams was, therefore, likely to be a result of heavy fishing pressure observed in these dams (Table 1). In terms of mesh size, the 100 mm and 144 mm stretched mesh sizes contributed more than 50% to the total CPUE in all dams (Fig. 2).

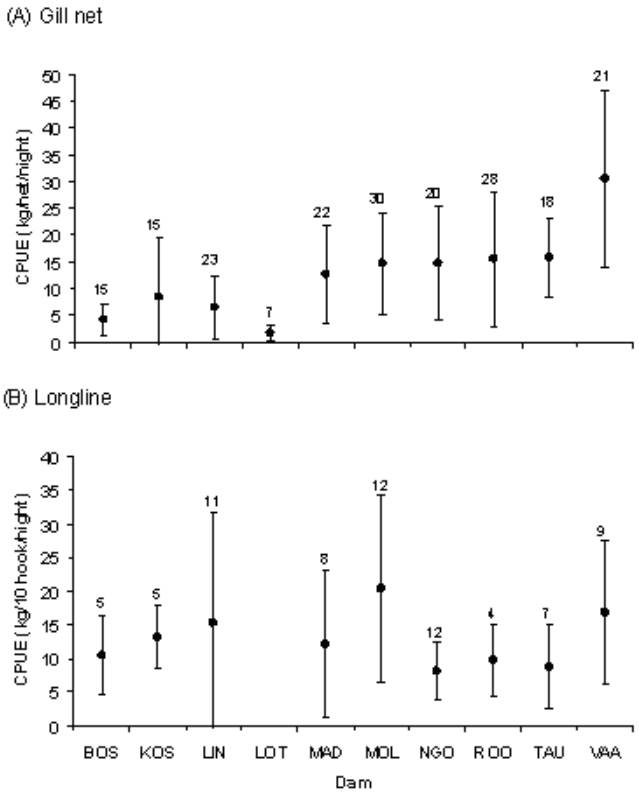

Figure 1

Mean (A) gill-net and (B) long-line catch per unit effort (CPUE) for experimental nets set in 10 dams of the North West Province of South Africa between April 2002 and February 2003. Error bars indicate standard error; numbers above error bars = sample size. Each net consisted of 5 randomly placed panels (3 m deep x 10 m long) with stretched mesh size of 44 mm, 60 mm, 75 mm, 100 mm and 144 mm. BOS = Bospoort, KOS = Koster, LIN = Lindleyspoort, LOT = Lotlamoreng, MAD = Madikwe, MOL = Molatedi, NGO = Ngotwane, ROO = Roodekopjes, TAU = Taung, VAA = Vaalkop.

Species composition

All fish caught on long-lines were the African sharptooth catfish, *C. gariepinus*. In gill-nets, species composition varied between dams and between mesh sizes. The overall species composition in each dam is shown in Table 1. A total of 16 species were sampled with gill-nets during the survey. While species composition differed between dams, the catch composition in most dams was generally dominated by *C. gariepinus*, the Mozambique tilapia, *O. mossambicus* and the common carp *C. carpio*. The exception was Taung Dam, where smallmouth and largemouth yellowfish (*Labeobarbus aeneus* and *Labeobarbus kimberleyensis*) dominated the species composition.

TABLE 1

Summary of physical characteristics of 10 dams in the North West Province of South Africa, and the potential production and annual yield calculated using the Schlesinger and Regier (1982) and the Marshall and Maes (1994) morpho-edaphic models. Ranges in potential yield are the result of either applying the more conservative Schlesinger and Regier (1982) model (lower bound) or the more optimistic Marshall and Maes (1994) model (upper bound).

Dam	Size (ha)	Mean depth (m)	Cond. µS/m²	TDS (mg/ℓ)	Mean temp (°C)	Potential yield	
						kg/ha·yr	t/yr
Bospoort	379	4.7	825	496	22	92-233	35-88
Koster	262	4.9	99	149	21	46-89	12-23
Lindleyspoort	180	7.8	135	127	23	41-83	7-15
Lotlamoreng	35	1.5	642	453	22	151-345	5-12
Madikwe	431	3.3	176	161	25	87-138	37-60
Molatedi	755	30.5	253	191	23	26-60	20-45
Ngotwane	401	4.7	243	203	23	66-135	27-54
Roodekopjes	1 571	6.5	676	622	25	119-186	187-292
Taung	465	12.0	252	182	22	36-91	17-42
Vaalkop	1 111	5.0	545	346	25	101-189	113-210

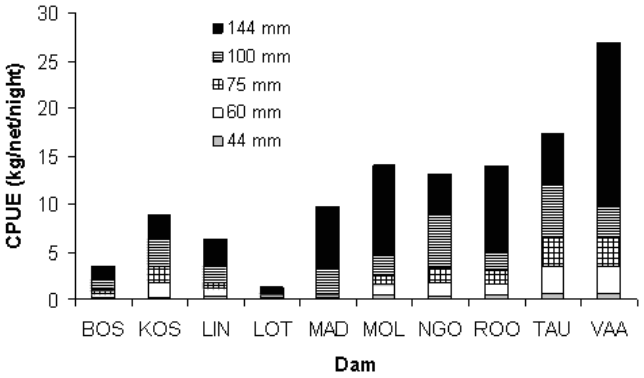

Figure 2

CPUE by mesh size in experimental gill-net fleets set in 10 dams in the North West Province between April 2002 and March 2003 . BOS = Bospoort, KOS = Koster, LIN = Lindleyspoort, LOT = Lotlamoreng, MAD = Madikwe, MOL = Molatedi, NGO = Ngotwane, ROO = Roodekopjes, TAU = Taung, VAA = Vaalkop.

Potential yield

Input parameters for MEI models and the resultant estimated yield and potential total annual yield for each dam are shown in Table 2. Of the two MEI models chosen, the Schlesinger and Regier (1982) model was the more conservative. Since MEI based models are only an indication of the total productivity of a dam, the results from both models are indicative of the range of potential yields attainable from the dam under 'best-case' conditions (Table 2). The MEI model estimates of potential fishery yield for the 10 dams investigated ranged between 36 (Taung) and 345 (Lotlamoreng) kg/ha·yr as the 'best-case' scenario (Table 3). This translates to a total annual potential fish yield of between 460 t/yr and 840 t/yr) from the 10 dams (Table 3). Due to their shallow depth, high conductivity and TDS most dams were highly productive, with a possible annual yield exceeding 100 kg/ha·yr for either the Schlesinger and Regier (1982) or the Marshall and Maes (1994) models. The exceptions were Koster, Lindleyspoort, Molatedi and Taung Dams which, as a result of their relatively lower TDS and greater mean depth, were less productive.

Stakeholder consultation

The results from stakeholder consultations and personal observations by the survey team are summarised in Table 3. The pattern of utilisation of the 10 dams was diverse and ranged from almost no utilisation (Taung) to high levels of utilisation through the establishment of large, uncontrolled gill-net fisheries (Table 3). Many of the dams are currently used for recreational activities such as angling and boating.

In all dams accessible by local communities, an interest was expressed to develop both a capture fishery and tourist facilities and plans to do so were in various states of development.

Fishery management arrangements

On all of the dams surveyed, the only form of formal fishery management being applied was the control of recreational fishing by means of individual permit and a single commercial permit issued for Molatedi Dam by the North West Province Department of Agriculture, Conservation and Environment. Compliance actions against illegal gill-nets were reported to be occasionally undertaken, but a blind eye was turned towards most subsistence fishing activity. There was no attempt at effort limitation in any of the fisheries despite evidence of over-fishing in some cases. Access to the dams surveyed was either open or controlled by various private and public bodies responsible for the land use adjacent to the water bodies.

Recommendations for fishery development

By considering the summarised key biological and social survey data presented in Table 3, recommendations were made for the type(s) of fishery development activity most appropriate for each dam (Table 3).

Community-managed subsistence fisheries were recommended for Bospoort, Madikwe and Ngotwane due to their relatively high productivity, low tourism potential, presence of subsistence fishers and a community interest to develop a capture fishery.

Recreational fisheries were suggested for dams (Koster, Lindleyspoort, Molatedi, Roodekopjes, Taung and Vaalkop) which had combinations of the following characteristics: tourist facilities, recreational boating, adjacent nature reserves, private

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TABLE 2

Per cent (%) species composition by weight of experimental gill-net catches in 10 dams in the North West Province of South Africa. The overall resource status, expressed as conservation status (CS) of each species, whether the species is considered a harvestable resource (HR), and the potential use (PU) of each species is indicated. Conservation status (CS) is either: (C) common; (T) threatened; or (P) pest. Whether the resource is harvestable is indicated as either: (y) yes; or (n) no. Potential utilisation of each species is either for (S) subsistence; (C) commercial; or (R) recreational use. Dams are indicated by: BO = Bospoort, KO = Koster, LI = Lindleyspoort, LO = Lotlamoreng, MA = Madikwe, MO = Molatedi, NG = Ngotwane, RO = Roodekopjes, TA = Taung, VA = Vaalkop.

Species name	Resource status			Dam (%)									
	CS	HR	PU	BO	KO	LI	LO	MA	MO	NG	RO	TA	VA
Barbus mattozi	C	y	SR			20		8	19		7		5
Chetia flaviventris	C	n	S										<1
Clarias gariepinus	C	y	SCR	47	75	72	4	90	57	86	48	26	42
Cyprinus carpio	P	y	SCR	17	3	1	58		<1		2	2	<1
Labeo capensis	C	n	SR									6	
Labeo molybdinus	C	n	S			<1		1	4	14	<1		4
Labeo umbratus	C	y	S									2	
Labeobabus marequensis	C	n	R		8	1			<1		4		1
Labeobarbus aneus	C	n	R									45	
Labeobarbus kimberleyensis	T	n	R									20	
Marcusenius macrolepidotus	C	y	S			2							
Micropterus salmoides	P	n	R								<1		
Oreochromis mossambicus	C	y	SCR	36	14	4	38	2	20	<1	12	<1	20
Schilbe intermedius	C	y	S								27		28
Tilapia sparrmanii	C	y	S	<1			<1	<1				<1	
Unidentified *Barbus* spp.	C	y	S		<1								

TABLE 3

Summary of productivity analysis, species composition, stakeholder consultation and personal observations leading to recommendations for potential use of each of 10 dams surveyed in the North West Province of South Africa. BOS = Bospoort, KOS = Koster, LIN = Lindleyspoort, LOT = Lotlamoreng, MAD = Madikwe, MOL = Molatedi, NGO = Ngotwane, ROO = Roodekopjes, TAU = Taung, VAA = Vaalkop.

Characteristics	Impoundment									
	BOS	KOS	LIN	LOT	MAD	MOL	NGO	ROO	TAU	VAA
Size	379	262	180	35	432	755	401	1571	465	1110
MEI Yield (kg/ha·yr)	92-233	46-89	41-83	151-345	87-138	26-60	66-135	119-186	36-90	101-189
Potential Yield (t/yr)	35-88	12-23	7-15	5-12	37-60	20-45	27-54	187-291	17-42	113-210
Commercial species (%)	100	92	77	99	91	77	86	62	27	62
Red list species	no	no	no	no	no	no	no	no	yes	no
Nature Reserve	no	no	no	no	no	no[1]	no	no	no	yes[2]
Private land shoreline	no	yes	yes[3]	no	yes	yes	no	yes	yes	no
Community land shoreline	yes	no	no	yes	yes	yes	yes	yes	yes	no
Tourist facilities (yes/no)	no	yes	yes	yes	no	yes	no	yes	no	yes
Recreational boating	no	yes	no	no	no	yes	no	yes	no	no
Recreational angling	no	large	medium	no	small	large	no	large[2]	no	large[2]
Subsistence angling	large	no	small[4]	large	small[4]	large	small	large	small	small[1]
Commercial fishing	no	no	no	no	no	yes	no	no	no	no
Illegal gill-netting	large	no	no	large	no	yes	no	large	no	Large
Mining	granite	none	none	none	none	none	none	none	diamond	none
Tourist value	minimal[6]	medium	high[3]	medium[7]	minimal[7]	high	medium	high	high	high
Local interest to develop capture fishery	yes	no	no	yes	no	yes	yes	yes	yes	n/a
Community interest to develop tourism	yes	no	no	yes	no	yes	yes	yes	yes	n/a
Recommendation	MCF	RF	RF	OAE	MCF	MCF/RF	MCF	RF/CF	RF[8]	RF

1 While nature conservation areas do not border Molatedi impoundment there are major reserves in close vicinity; 2 Vaalkop impoundment is surrounded by nature reserve; 3 At Lindleyspoort all land adjacent to the dam is private; 4 mainly by labourers from adjacent private farms; 5 regular local, national and international angling competitions take place; 6 security problems; major development is planned on the dam including tourist lodges, 7 dam is not aesthetically appealing, 8 this fishery has potential for up-market utilisation. MCF = managed community fishery, RF = recreational fishery, OAE = open access equilibrium, CF = commercial fishery

land, or red data fish species.

On Molatedi and Roodekopjes, where tourism, recreational fishing and in the case of Molatedi, commercial fishing existed side-by-side with subsistence fishing and illegal gill-netting, it was recommended that existing activities be formalised into legal, managed fisheries. Due to the low potential yield of Molatedi, a community-managed subsistence fishery was recommended, whereas on the highly productive Roodekopjes Dam potential exists to support either a community-managed subsistence fishery or a commercial fishery alongside a recreational fishery.

On Lotlamoreng Dam, where potential yield was low, a high level of subsistence fishing and illegal gill-netting was occurring, it was concluded that the chances of any management intervention succeeding were low and that an 'open access equilibrium' fishery on the dam should be allowed.

Discussion

Fisheries development is particularly relevant to the livelihoods of rural communities in the North West Province, where food security is a major problem and fishing has, until recently, been largely out of reach of rural communities (Mangold et al., 2002). With the democratic political dispensation in South Africa and the decentralisation of authority, local communities have been given far greater control over, and access to, resources within their areas (Mangold et al., 2002). Subsequently, the fisheries resources in some of the NWP dams are already utilised by informal subsistence anglers, illegal gill-net fishers, and by community initiatives operating unregulated formal gill-net fisheries (Rouhani et al., 2004). Evidence from the present study, however, suggests that the utilisation of the fisheries resources in many of the NWP dams is still likely to be below the potential optimal yield and that there is considerable potential to develop permanent recreational, subsistence or commercial fisheries. The survey however revealed that institutional arrangements governing the use of freshwater fish resources are rudimentary and inappropriate for the establishment of managed, and possibly co-existent, subsistence, commercial and recreational fisheries. If fishery development in the North West Province is to be biologically sustainable, and conflict between user groups avoided, a state led intervention to establish appropriate fishery management institutions will be required.

Fisheries development

The principles of fishery development are well established and applicable to the resources present in the North West Province. It is widely recognised that the long-term sustainable use of fish resources, which promotes the economic and social well being of the fishers, is the overriding objective of fisheries management (Charles, 2001). Consequently, the development of new fisheries must be guided by policy, management protocols and an institutional environment that ensures biological sustainability and optimises the economic benefits for the surrounding communities.

Biological sustainability

The biological sustainability of a fish resource is achieved if biodiversity is conserved, endangered species are protected and harvest levels for exploitable species are within pre-determined sustainable levels (Charles, 2001).

As a result, the potential for commercial and subsistence fisheries development was excluded at Taung Dam due to the presence of the vulnerable largemouth yellowfish, *L. kimberleyensis* (IUCN 2003) and *L. aeneus*. These species, which dominated the experimental gill-net catch composition, undertake spawning migrations (Tomasson et al., 1984) which make them vulnerable to overexploitation. All other dams, where exploitable indigenous (*C. gariepinus* and *O. mossambicus*) and exotic (common carp *C. carpio*) species dominated, were considered likely to sustain commercial, recreational or subsistence fisheries.

In the NWP, as in all South African inland fisheries, commercial fishing was already access limited (De Villiers, 2004) while subsistence and recreational fishing were not. The resultant unregulated entry into the fishery by subsistence and recreational users in conjunction with the use of illegal gill-nets indicates that the fishery in all NWP dams approximates an open-access system which, in the long-term, compromises sustainable utilisation (Hardin, 1968; Charles, 2001). Long-term development strategies will therefore need to align fish harvest to sustainable levels of yield through access limitation.

Optimal economic benefits

Given the finite nature of fisheries resources, decisions on the best use of a fishery will have to take into account the potential of each sector to address major national policy objectives including food security; economic empowerment; tourism development; optimal economic benefit from water, and poverty eradication (ECA, 1989; NEMA, 1998; NWA, 1998).

The allocation of the resource to profit-oriented commercial users, for example, would create economic independence for a limited number of participants at each dam but will not maximise employment or local fish supply. In the NWP, this was a feasible option in Roodekopjes Dam where high-potential fish yields were likely to support such a fishery. Alternatively, the development of a subsistence fishery would not lead to significant economic empowerment but would maximise food security and contribute to poverty eradication at a local level.

While the link between subsistence fishing and food-security is clear, the potential contribution to poverty reduction requires explanation. A guiding principle for any subsistence enterprise is the minimum rural wage (BCEA, 1997). While the economics

TABLE 4
Estimated annual yield in tons, based on the Marshall and Maes (1994) morpho-edaphic index, estimated total value of the fish assuming a price of R6/kg and the total number of people that could be employed at minimum rural wage of R 10 440 per year in 10 dams of the North West Province.

Dam	Yield (t)	Value (R '000s)	Employment (No. of persons)
Bospoort	88	531	51
Koster	23	140	13
Lindleyspoort	15	90	9
Lotlamoreng	12	72	7
Madikwe	60	358	34
Molatedi	45	272	26
Ngotwane	54	326	31
Roodekopjes	292	1 750	168
Taung	42	253	24
Vaalkop	210	1 258	121
Total	842	5 051	484

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of a small-scale inland fishing operation have not been evaluated in detail, a good indication is the gross value of the estimated yield. Table 4 shows the number of fishers that could be employed at the BCEA (1997) recommended minimum rural wage (R10 440/yr) in each of the 10 dams investigated, assuming annual yield from the 'optimistic' Marshall and Maes (1994) MEI model, and an average fish price of R 6/kg (2004 fish price from subsistence fishers at Lake Gariep, Weyl personal observation). Since this is a 'best-case' scenario, the fisheries of the 10 dams investigated would support, at most, 484 full-time subsistence fishers. Utilisation above this level would result either in over-utilisation of the resource or in diminishing economic returns per fisher.

Recreational anglers are neither dependent on the resource for survival nor for economic gain but probably have the potential to maximise economic independence through the creation of employment in associated industries. In dams such as Taung Dam where the fish species composition is unlikely to sustain commercial or subsistence fisheries, recreational fishing is the only viable resource use option. The activity of anglers and boaters observed on some the dams investigated (Table 3), illustrates that the North West Province dams have a significant recreational fishing and associated tourism potential. Foremost were Roodekopjes and Vaalkop Dams where local, national and international angling competitions have been held. No direct estimates are available of the total expenditure by recreational fishers in the NWP, but Visser et al. (2002) indicate that in 1999, the average expenditure by an international tourist in the NWP was in excess of R900/night. Hence the value of the tourism activities associated with recreational fishing, such as accommodation, craft sales, guiding, gear, and other recreational activities, is potentially much greater than the direct value of fish caught if properly developed.

While there is potential for the 10 dams in the NWP to make a much greater contribution to the provincial economy, the development of inland fisheries, and associated allocation of access rights, will require trade-offs between sectors, such as the potential revenue generated by recreational users vs. the food security and economic empowerment value to subsistence or commercial fishers. The results of the stakeholder consultation revealed that the further development of the fishery on the dams was constrained by the lack of appropriate management structures, the absence of an inland fisheries policy, and the fragmented institutional responsibility for management of the water bodies. Therefore a coordinated public sector institutional intervention, guided by a policy, will be required if optimal economic, social and biological outcomes from the development of NWP fisheries are to be achieved.

Legislation governing inland fisheries

The legislative situation governing water use in the NWP is similar to that in South Africa as a whole. All water is held in trust by the State which, through its implementing agency, the Department of Water Affairs and Forestry (DWAF), is responsible for administering rights to the use of that water (NWA, 1998). In addition, the DWAF may also control or prohibit access to any Government waterworks; and make reasonable charges for the use of, or entry into any water surface or land associated with, any Government waterworks (NWA, 1998). Biological resources including fish, on the other hand, are governed by the Provincial Governments through guidance by the National Environmental Management Act (NEMA, 1998), which emphasises issues of sustainability, biological diversity, ecosystem integrity, the precautionary principle and the use of natural resources for the national good.

While the principles of the act are currently applied through the Provincial Nature Conservation bodies, which are empowered to allocate licences for subsistence, commercial and recreational fishing (Mangold et al., 2002), there appears to be no overall policy for the allocation of access rights to a particular dam. This has resulted in fairly informal management arrangements which do not necessarily lead to optimal socio-economic outcomes or sustainable fishing practises.

Inland fisheries policy and a coordinated institutional approach

Responsibility for access to dams and their fishery resources is currently fragmented between government departments and is not directed by a coherent policy. This lack of a national policy hinders the development of inland fisheries. This is particularly evident in the National Water Act (NWA, 1998), which doesn't specifically mention fisheries, although fishing is probably a 'beneficial use' of water.

The NWP nature conservation authority residing under the Department of Agriculture, Conservation and Environment (DACE) has taken an initiative in developing the fisheries sector, but it is unlikely that they have the manpower or capacity to allocate rights and manage the fisheries in the dams that are widely spread. It is also questionable whether fisheries development is in line with the DACE's legislated mandate, given that: fisheries are really a 'developmental' activity aimed at creating a socio-economic benefit. Government has legislated that local authorities (municipalities) should be the vehicles for promoting local economic development in South Africa and each has an integrated development plan with funding and posts. For this reason, local municipalities could be capacitated to promote fishery development, but DWAF and provincial nature conservation authorities would need to align and adapt their policies to support fishery development in so far as their mandate dictates. The current situation whereby inland fisheries management is shouldered by provincial nature conservation authorities is anomalous as these authorities are not 'development'-orientated. For this reason, the role of NGOs and universities could be very important in supporting local authorities in developing projects and capacity. Alternatively, Provincial Departments of Agriculture have a development and food-security mandate and the national Department of Agriculture could be designated as the lead national Department to develop policy and lead a process of institutional alignment to support fishery development. It must be recognised that currently the Department of Agriculture probably lacks the human capacity to develop and manage fisheries resources and that the development of rural fisheries in South Africa will require considerable institutional capacity building.

Towards an inland fisheries policy for South Africa

The present case study highlights the need for a national policy on inland fisheries and provides some insights into the required objectives of such a policy. Ideally a policy should be short, give direction, but avoid prescriptive approaches and keep options open with regard to practically achieving policy objectives. (Munkejord, 2005) Based on our analysis we therefore identify the general purpose and objectives of a possible inland fisheries policy.

Based on the potential for development highlighted in our study, we suggest that the general purpose of an inland fisher-

ies policy should be to develop ecologically sustainable inland fisheries which would provide economic opportunity and food security through managed subsistence, commercial and recreational fishing.

The policy objectives should:

- Identify a national lead agent to develop inland fisheries. It is our opinion that the National Department of Agriculture is best positioned to play this role due to its 'development' mandate.
- Require the drafting of management plans for local fisheries, in particular the implementation of a 'co-management' approach which includes relevant stakeholders and resource users
- Be aligned with existing national policies and legislation on biodiversity, environmental management, water utilisation, economic development, poverty alleviation, etc.
- Recognise and give substance to South Africa's commitment to relevant international agreements and conventions such the FAO Code of Conduct on Responsible Fisheries, the SADC Protocol on Fisheries and NEPAD Abuja Agreement on Fisheries and Aquaculture
- Identify local communities as the primary economic beneficiaries of inland fishery development, while recognising that tourism and other forms of development usually require partnerships with the private sector and other stakeholders
- Recognise the need to formalise and manage fishing rights more efficiently for the various sectors
- Make provision for the development of cooperative governance arrangements and provide the provincial and local authorities as well as all user groups with the capacity to effectively co-manage inland fisheries
- Promote the harmonisation of provincial ordinances governing inland fishing.

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