Extensive culture of two mullet species in freshwater impoundments in the eastern Cape

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The feasibility of using freshwater mullet *Myxus capensis* and flathead mullet *Mugil cephalus* to increase the fisheries potential of freshwater impoundments was investigated. The recruitment periods of fry of both species into the upper reaches of a number of eastern Cape estuaries were established. Techniques used to minimize mortalities during the capture, transportation and stocking of the fry are described. Data on growth and mortality of both species of mullet fry stocked into a variety of impoundments are discussed with regard to their potential for extensive aquaculture and angling purposes.

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Die gebruik van die varswaterharder *Myxus capensis* en die platkopharder *Mugil cephalus* om die visserypotensiaal van varswaterdamme te verhoog, is ondersoek om die uitvoerbaarheid daarvan te bepaal. Die aanwas van jong vissies van albei spesies in die boonste gedeeltes van sekere Oos-Kaap riviermondings is bepaal. Tegnieke om die mortaliteit onder jong harders van albei spesies tydens die vang, vervoer en uitplasing te verminder, word beskryf. Groeitempos en mortaliteitsyfers vir albei spesies in verskillende opgaardamme, met betrekking tot hul potensiaal vir ekstensiewe akwakultuur en hengel, word bespreek.

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The culture of mullet in brackish and freshwater ponds has been practised for many years in the Indo-Pacific region and Mediterranean countries (Bardach, Ryther & McLarney 1972). Faced with the increasing world-wide shortage of animal protein, the large-scale culture of fish of the family Mugilidae could play an important part in increasing the quantity of culture fish needed to relieve this shortage, particularly in the third world (Oren 1981; Nash & Koningsberger 1981). Stimulated by programmes such as the International Biological/Marine Production (IBP/PM) 'Mullet Project', research and development of mullet culture has increased dramatically over the last decade (Liao 1981; Oren 1981).

A number of countries have increased the fisheries potential of their inland waters through large-scale mullet stockings. Millions of mullet fry (including *Mugil cephalus*) have been stocked into Lake Mariut and Lake Quarun in Egypt (El-Zarka & Kamel 1965) and into Lake Kinneret (Sea of Galilee) in Israel (Bar-Ilan 1975). Mullet catches today form an important component of the extensive fisheries in these waters. Such extensive mullet culture could have special significance for South Africa where intensive warm-water fish culture is virtually nonexistent and harvesting of fish from large man-made impoundments appears to have commercial possibilities.

As techniques for the large-scale propagation of mullet have not yet been perfected (Nash & Kuo 1975; Nash & Koningsberger 1981), the culture of these species relies on the capture of wild fry (Bardach *et al.* 1972; Chen 1976; Ben-Yami 1981). However, since fry are extremely sensitive to handling, special attention has to be given to the high mortalities incurred during their capture, transportation and stocking. This presently aggravates the increasing difficulty in obtaining fry for stocking purposes (Tang 1975; Ben-Yami 1981).

Significant differences occur in the temporal recruitment of fry of various mugilid species into estuaries along the South African east coast (Wallace & van der Elst 1975) and elsewhere (Bograd 1961; El-Maghraby, Hashem & El-Sedfy 1974; Kurian 1975). Bok (1979) showed that only *Mugil cephalus* and *Myxus capensis* enter completely fresh water in the Kowie River in the eastern Cape in large numbers.

The main objectives of this study were to (i) establish the periods of recruitment of *Mugil cephalus* and *Myxus capensis* fry into eastern Cape rivers; (ii) develop efficient techniques for the capture, transportation and stocking of large numbers of fry without incurring high mortalities; (iii) determine the growth rate of these two mullet species in various water bodies and (iv) estimate the potential of the two species for extensive fish farming as well as for angling.

During an eight-year period (1975 – 1982) over 130 000 *Mugil cephalus* and 50 000 *Myxus capensis* fry were captured, transported and stocked into a variety of water bodies in the eastern Cape Province.

Study area

Netting for mullet fry took place in a number of rivers along the eastern Cape coast (Figures 1 & 2). The Kowie, Swartkops and Fish Rivers were more intensively netted, with the majority of mullet fry used for stocking purposes coming from the latter two rivers. Netting operations were restricted to the heads of the estuaries in either completely fresh or occasionally slightly brackish (< 5‰ salinity) water. The capture of fry in these areas has a number of advantages: (i) there is no need to acclimatize the fry to fresh water when stocking into dams — this is a distinct advantage as abrupt salinity changes are often a major source of mortality (Mires, Shilo & Shak 1975); (ii) large numbers of fry (15 – 40 mm FL) often accumulate in these usually shallow areas where partial barriers to fish movement such as rapids, causeways or even weirs are commonly found and (iii) fry of only *Mugil cephalus* and *Myxus capensis* are usually present in these areas.

Materials and Methods

Capture

A variety of 2 – 5 mm (stretched mesh) seine and dip-nets were used to capture mullet fry. A sample of at least 10, usually more than 30, was preserved in 5% formalin for later identification and measurement. With experience it was found that even small fry of *Mugil cephalus* and *Myxus capensis* could be distinguished with the naked eye in the field. In this study, only mullet smaller than 50 mm FL were classified as fry.

As mullet fry are very sensitive to handling, special techniques were developed for their capture. The most successful net, causing least injury to the fry, proved to be a short seine-net (2 – 4 mm mesh) approximately 5 m long by 1,5 m deep with a shallow bag incorporating a cod-end consisting of a canvas bag with a volume of about 20 l. Each end of the net was attached to a 2-m pole and could be operated by two people. Seining was usually carried out in shallow water (< 1 m). After each haul, the fry were concentrated in the water of the canvas bag and then poured into a suitable container. By keeping the fry immersed in water virtually all the time, these capture methods minimized skin abrasion and scale loss, which is considered to be a major cause of subsequent mortalities (Ben-Yami 1981 and personal observations).

Transportation of fry

The fry were transported in plastic drums (100 and 200 l capacity) in water from the capture site made up to 5‰ salinity by adding coarse 'rock' salt (NaCl). Transporting freshwater fish in a weak salt solution has been shown to alleviate osmotic breakdown caused by stress and scale damage (Hattingh, Le Roux Fourie & Van Vuren 1975) and to reduce the chances of subsequent fungal (*Saprolegnia*) infections (Yashouv & Ben-Schachar 1967). The transportation water was continuously oxygenated. Densities of 120 fry l^{-1} during transportation were not exceeded in this study, but far greater densities are theoretically possible (Ben-Yami 1981; Hamman 1981). Mullet fry have been held for over 18 h and successfully transported over 1 000 km using the above techniques.

Stocking of fry and monitoring of growth

Before the fry were released, water from their new environment was mixed with the transportation water to enhance acclimatization of the fry. Mullet fry were stocked into a variety of freshwater impoundments in the eastern Cape (Table 1). Fry were captured and stocked in winter and spring and sampled for growth in late autumn or winter. In this way growth over the summer season could be determined. Both seine and gill-nets covering a wide range of mesh sizes were used to obtain unbiased samples for growth determinations.

Results and Discussion

Recruitment of fry

Peak recruitment of *Mugil cephalus* fry into the upper reaches of the Kowie estuary takes place during July to October, with smaller numbers in May, June and November (Bok 1979). Similar recruitment periods were evident in other eastern Cape rivers sampled during this study (Figure 1).

Table 1 Details of dams into which mullet fry were stocked to determine growth rates

Dam no.	Locality of dam	Name of farm or dam	Approx. area (ha)		Approx. stocking density (fish/ha) *Mugil cephalus*	*Myxus capensis*	Water quality pH	Secchi disc (cm)	Alkalinity (ppm $CaCO_3$
1	33°43′S/25°30′E	Amanzi Estates	8,0	a	500	300	8,3 –	60 – 100	111 – 115
				b	700		8,6		
2	33°27′S/25°07′E	Morgenpracht	1,0	a	200	1 000	8,2 –	*ca* 50	115 – 179
				b	1 500		8,4		
3	33°18′S/26°28′E	Strowan	0,5		200	800	7,6 –	25 – 60	55 – 92
							9,0		
4	33°08′S/26°43′E	Grasslands	0,5	a	1 000	200	8,2 –	12	300 – 436
				b	1 500		8,5		
5	33°28′S/26°30′E	Avondale	0,3		–	500			
6	33°19′S/26°31′E	Hamilton Dam	0,5		–	5 000	7,9	70	95
7	32°59′S/27°51′E	Amalinda	8 × 0,02		10 000	1 000 –	8,1 –	25 – 45	120 – 145
						10 000	8,4		
8	33°26′S/27°04′E	Crossroads	3,0		1 000	–	8,6	*ca* 20	310
9	33°29′S/26°20′E	Mountain View	0,4		400	–	8,1	7	135
10	33°19′S/26°32′E	Douglas Reserv.	0,5		1 200	1 000	7,0	150	42
11	33°28′S/26°31′E	Avondale	0,04		2 000	–			

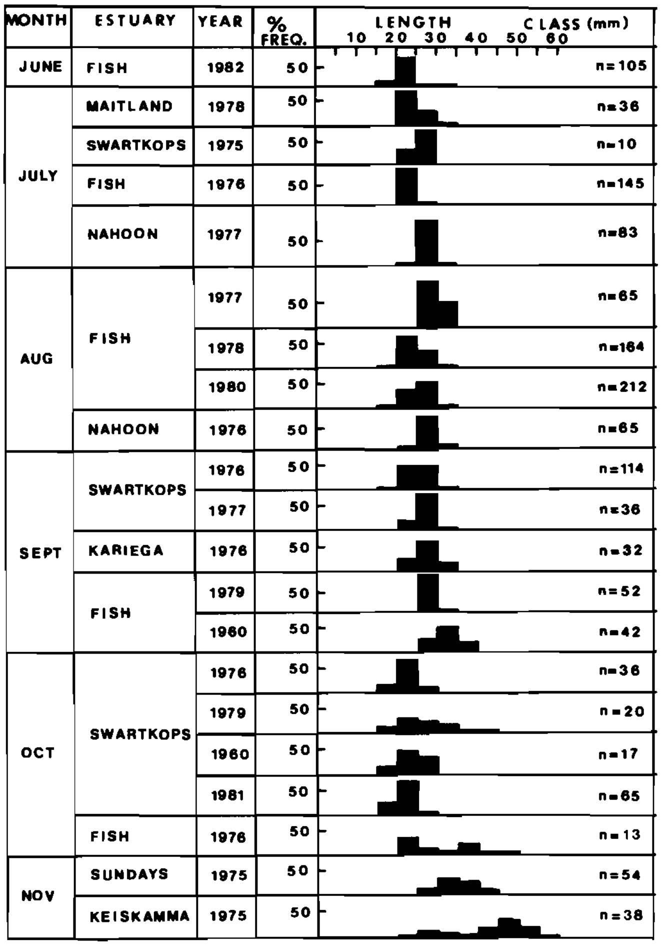

Figure 1 The length-frequency distribution of *Mugil cephalus* fry caught at the heads of various eastern Cape estuaries during 1975 – 1982.

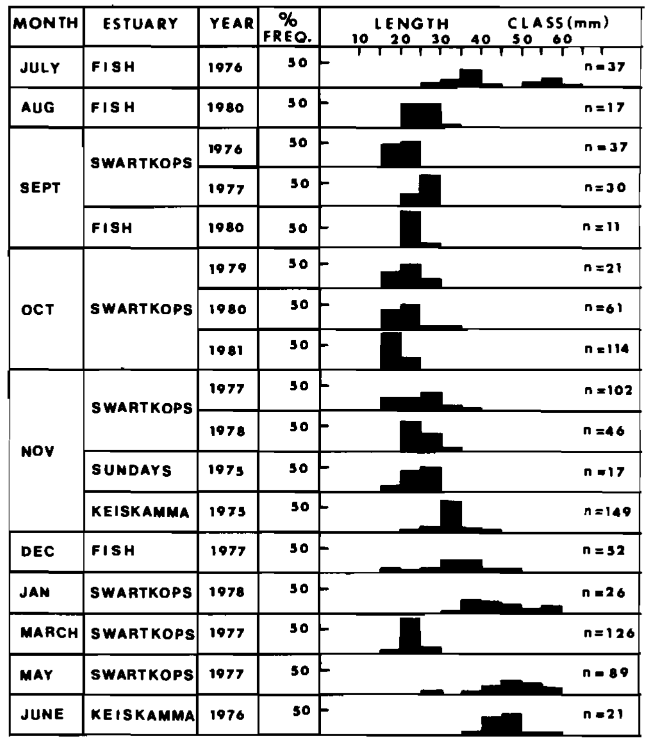

Figure 2 The length-frequency distribution of *Myxus capensis* fry caught at the heads of various eastern Cape estuaries during 1975 – 1981.

Recruitment of *Mugil cephalus* fry into the Fish River occurred mainly from July to September, while lower numbers of larger fry were captured in October. In the Swartkops River, peak recruitment of *Mugil cephalus* fry occurs during September and October. Small (<35 mm FL) *Mugil cephalus* fry were present in all rivers sampled during the period July to October. Recruitment tapered off in November and no *Mugil cephalus* fry were captured from December to May (Figure 1).

Myxus capensis fry were found to recruit into the upper reaches of the rivers during most months of the year (Figure 2). More intensive recruitment of small fry (<30 mm FL) is, however, apparent in spring and early summer. These findings agree with recruitment data reported for the Kowie River (Bok 1979). Apart from a sample of small *Myxus capensis* fry netted in March 1977 in the Swartkops River, most fish caught from January to July had widely ranging length distributions, with most fish being larger than 35 mm FL. This may reflect limited spawning during the period.

Predominantly monospecific shoals of *Mugil cephalus* were caught during the initial phase of this species' recruitment period (June, July and August), with increasing numbers of *Myxus capensis* appearing in the catches later in the recruitment period. By October or November, pure *Myxus capensis* shoals were often encountered. Therefore, although the recruitment periods of the two species overlap, the peak recruitment of *Myxus capensis* appears to be one to three months later than *Mugil cephalus.*

Mortalities

Mortalities observed during transportation were usually less than 2% and appeared to result mainly from mechanical damage incurred during netting. Additional mortalities did occur within a week or so after stocking, but were usually difficult to estimate. 'Stocking mortality' was estimated from fry stocked into glass aquaria and cement tanks and was found to be less than 10% within the first 10 days after capture and transportation. These mortalities were mainly due to secondary infection of damaged areas of the skin and fins by *Saprolegnia* sp.

The above mortalities compare favourably with those reported for mullet fry in the literature. Liao (1981) reports the handling mortality of *Mugil cephalus* fry collected from the sea in Taiwan as 70%. Handling and transportation mortality of *Liza aurata* and *Liza saliens* fry (30 – 40 mm) transported from the Caspian to the Aral Sea (quoted in Ben-Yami 1981) was 14%, which did not include stocking mortality. The mortality of *Mugil cephalus* fry during acclimatization (7 – 10 days) in nursery ponds in Taiwan (i.e. stocking mortality) ranges between 5 – 15% and is thought to be mainly due to the delayed effects of 'mechanical injury during catching and handling' (Tang 1975).

As shown in Table 2, the total mortalities (i.e. stocking mortality plus 'natural' long-term mortality) of *Mugil cephalus* fry (<30 mm FL) stocked directly into 0,02-ha earth ponds, which were drained over 200 days later, were substantial (mean = 44%), but were comparable to a mortality of 54% for larger fry which were nursed for three months prior to stocking. *Myxus capensis* fry stocked into the above ponds showed similar mortalities (mean 47%) while larger yearling fish generally showed lower mortalities (Table 3). The high total mortalities of mullet fry found in this study are similar to mortalities in fish-ponds reported in the literature (Table 4).

Long-term mortality of mullet fry stocked directly into large

Table 2 The stocking details and mortality of *Mugil cephalus* fry grown in 0,02-ha earth ponds at Amalinda Fish Station, East London

Date stocked	Growth period (days)	Stocking density no./ha	Mean length at stocking (mm)	% Mortality
16-8-76	202	1 500	29	63
16-8-76	202	4 000	29	54
16-8-76	202	800	29	38
16-8-76	202	300	29	50
16-8-76	202	400	29	25
16-8-76	202	200	29	0
22-8-80	248	10 000	20-30	49[a]
22-8-80	248	5 000	20-30	55[a]
22-8-80	248	10 000	20-30	65[a]
4-12-79	154	10 000	63	54[b]

[a]mean of 3 ponds; [b]mean of 2 ponds

Table 3 The stocking details and mortality of *Myxus capensis* fry and yearlings grown in 0,02-ha earth ponds at Amalinda Fish Station, East London

Date stocked	Growth period (days)	Stocking density no./ha	Mean length at stocking (mm)	% Mortality
16-9-76	134	1 000	31	55
16-9-76	134	2 000	31	35
22-8-80	248	10 000	20-25	50[a]
16-9-76	134	1 000	145	10
16-9-76	134	2 000	136	15
16-9-76	134	300	106	17
16-9-76	134	400	124	50

[a]mean of 3 ponds

Table 4 The total mortality of mullet fry stocked into fish ponds in various countries

Species	Mortality (%)	Country	Authors
Mugil cephalus	66	Egypt	El-Zarka & Fahmy 1966
Mullet fry	95	India	Thomson 1966 from Ben-Yami 1981
Mugil cephalus	50	Israel	Mires 1970
Liza ramada	50	Israel	Mires 1970
Mugil cephalus	88	Egypt	Eisawy *et al.* 1974
Mugil capito	75	Egypt	Eisawy *et al.* 1974
Liza aurata	68	Israel	Chervinski 1976
Mugil cephalus	50	Taiwan	Liao 1981

dams was difficult to gauge and would be expected to vary greatly depending upon factors such as predation pressure, availability of suitable food, water quality etc. When stocking into large impoundments there seems to be little benefit in applying nursery procedures as practised when stocking fry into smaller fish-ponds. In Taiwan (Tang 1975), newly caught fry are held in acclimatization ponds and artificially fed for 7 – 10 days before being stocked into larger growing ponds and in Israel, mullet fry are initially stocked into nursery ponds at high densities (30 000 per ha) for 60 – 100 days before being moved to production ponds (Pruginin, Shilo & Mires 1975). Unless there is a danger that the fry would be subject to heavy predation if stocked into an impoundment at a small size, the increased risk of mortality due to the additional handling and transportation during a nursery period would minimize any such advantage.

Growth rates of stocked fry

Growth rates of *Myxus capensis* and *Mugil cephalus* fry stocked into a variety of dams in spring and subsequently sampled in autumn or winter are presented in Tables 5 and 6. Research on ageing natural populations of both mullet species in this area (Bok in prep.), has shown that scale annuli are deposited in spring and for practical purposes early spring can be taken as the 'birth date' of both species. The growth data of mullet stocked into artificial impoundments can therefore be compared to corresponding length-at-age data of mullet from natural systems.

The mean growth of *Myxus capensis* stocked into the various dams was found to be very similar to that found under natural conditions in the Kowie, Swartkops and Fish River systems (Bok in prep.). For example, three-year-old dam-grown *Myxus capensis* did not differ on average by more than 8 mm FL or 34 g from similar-aged mullet from the natural riverine populations. The largest sizes reached by *Myxus capensis* after one, two and three years' growth in the various dams (Table 5) were 31 g (139 mm FL), 175 g (238 mm FL) and 506 g (331 mm FL), respectively. Therefore a period of at least three years is needed before a marketable size is reached.

Female *Myxus capensis* were found to grow markedly faster than male fish after the third year. In dam No. 6, stocked at 5 000/ha, the modal lengths of female and male fish were 345 – 360 and 315 – 320 mm FL respectively, after four growing seasons (Figure 3).

Unlike *Myxus capensis*, the growth rate of *Mugil cephalus* stocked into the various dams was found to be markedly higher than in natural riverine populations (Bok in prep.). For example, the *Mugil cephalus* in the dams were 200 – 500 g heavier than the riverine mullet after two years' growth. The largest

Table 5 Growth of *Myxus capensis* stocked as small fry (initial mean fork length range 23 – 28 mm) into various dams in spring (October and November) (For details of dams see Table 1)

Dam	Mean fork length (mm) after number of growing seasons: 1	2	3
1	106[a]	238	331
2	139	193	277
3a	100		
3b	111		
4			267
5		202	
7	105[b] (101 – 108)		
10	116		
Mean length	113	211	292
Calc. mass[c] (g)	16	119	338

[a]First season's growth occurred in a small dam adjacent to No. 1 (supplied by the same water source) at a stocking density of 10 000/ha.
[b]Value is mean of eight ponds with range given in brackets.
[c]Calculated from the Kowie River length : mass ratio (mass = 0,000004 $FL^{3,2153}$)

Table 6 Growth of *Mugil cephalus* stocked as fry (initial mean fork length range 22 – 28 mm) into various earth dams in spring. (For details of dams see Table 1)

Dam number	Mean fork length (mm) after number of growing seasons 1	2	♂ 3	3 ♀	♂ 4	4 ♀
1a[a]	218	372	435	480	475	545
1b[a]	225					
2a		331				
2b	236					
3	165					
4a	201	332				
4b	238					
7	180[b] (164 – 191)					
8	185	366				
9		342				
10	191					
11	185					
Mean FL	202	349	435	480	475	545
Calc. mass	114[c]	688[c]	1501[d]	2018	1955[d]	2956

[a]a and b values indicate that these dams were stocked on two separate occasions (see Table 1).
[b]Value given is mean (range in brackets) of nine experimental ponds.
[c]Calculated using length: mass relationship for Swartkops River *Mugil cephalus* (mass = 0,000018 $FL^{3,0059}$).
[d]Calculated using length : mass relationship determined from *Mugil cephalus* of 400 – 564 mm fork length from Amanzi dam (Dam 1) (mass = 0,000003 $FL^{3,2879}$).

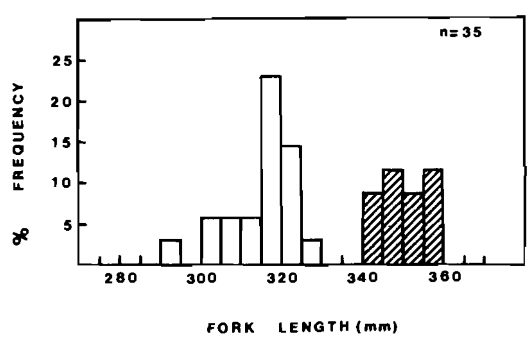

Figure 3 The length attained by male (open histograms) and female (cross-hatched histograms) *Myxus capensis* after five growing seasons in dam No. 6 (see Table 1).

sizes reached by *Mugil cephalus* after the first and second years' growth in the various dams were 244 g (236 mm FL) and 960 g (372 mm FL) respectively (Table 6). After three years' growth, male fish averaged 1 501 g (435 mm FL) and females 2 018 g (480 mm FL). When the mean mass of the two mullet species in all the dams is compared after two years' growth, the mean mass of *Mugil cephalus* (688 g) is almost six times that of *Myxus capensis* (119 g).

The markedly faster growth of female compared to male *Mugil cephalus* after the second year, is clearly shown in the growth data of fish stocked into dam No. 1 (Table 6). The larger size of the females becomes apparent during the third growth season and is very pronounced at the end of the fourth growth season, when females were on average 70 mm longer and 1 000 g heavier than the males. The largest fish caught in this dam after four growing seasons was a female of 564 mm FL weighing 3 600 g.

Mugil cephalus trapped in freshwater impoundments in the eastern Cape are known to live to an age of least eight years and show rapid growth, reaching lengths of well over 600 mm. A major flood of the Fish River in early March 1974 allowed *Mugil cephalus* to enter a natural freshwater vlei (about 5 ha) adjacent to the estuary. When sampled in May 1980 (i.e. over six years later), five fish (all females) of over 600 mm FL were captured, the largest with a FL of 675 mm and weighing 5 585 g. The ages of these fish were estimated (using scale analysis) to be seven to eight years.

Fish farming and angling potential

Both mullet species have been shown to flourish when stocked as fry into freshwater impoundments. The considerably faster growth rate of *Mugil cephalus*, however, makes it the obvious choice for extensive fish farming. The high growth rates of this species were recorded in 'average' farm dams without the benefit of additional food or fertilization. The stocking densities per unit surface area in these dams were, however, relatively low. A major consideration when stocking this species is that mature fish (after about two years of age) tend to move down-river out of an impoundment if given the opportunity. The overflow will therefore have to be screened to prevent the escape of the larger fish. Therefore irrigation storage dams which seldom overflow are well suited for extensive mullet culture.

The considerable production potential of these two species under extensive culture conditions was clearly demonstrated from the results obtained from dam No. 1 on Amanzi Estates. A total of approximately 8 700 *Mugil cephalus* and 5 800 *Myxus capensis* were stocked into this about 8-ha dam during the period November 1978 to October 1981. The dam was harvested sporadically from April 1980 to April 1982 and during low water-level conditions in March 1983 when approximately 95% of the remaining mullet were netted. Details of the mullet harvested are given in Table 7. Even if taken over a four-year period, the production of over 500 kg per ha clearly shows the potential of these extensive culture techniques. The survival rates of 29 and 18% for *Mugil cephalus* and *Myxus capensis* respectively, were achieved in spite of the presence of predatory large-mouth black bass (*Micropterus salmoides*) in the dam.

The results obtained at Amanzi Estates compare favourably with those reported elsewhere. Using the total numbers of mullet caught, Ben-Yami (1981) estimated that survival of mullet fry stocked into Lake Kinneret in Israel was about 10%. The total catch of mullet from this lake up to 1973 was 1 800 tons, with an average fish mass of about 1 kg. Each fingerling

Table 7 Details of mullet harvested from dam No. 1 on Amanzi Estates (see text)

	Mullet species *Mugil cephalus*	*Myxus capensis*
Number stocked	8 700	5 800
Number harvested	2 554	1 041
Survival (%)	29,4	18,0
Total mass harvested (kg)	3 520	582
Mean individual mass harvested (g)	1 378	559
Maximum individual mass harvested (g)	3 992	948
Production obtained per individual fish stocked (g)	405	100

stocked had therefore produced 100 g of fish. The nearly 20 million mullet fry (mainly *Mugil cephalus* and *Liza ramada*) stocked into Lake Kinneret from 1958 to 1973 initiated the development of a lucrative fishery, resulting in revenue of well over three million US dollars (Bar-Ilan 1975).

While the lower growth rates and smaller maximum size of *Myxus capensis* make it comparatively less suitable for extensive fish culture, this species has potential for stocking into dams for angling purposes. In most coastal rivers in the eastern Cape *Myxus capensis* is the largest indigenous angling fish present (apart from eels) and good catches of this sought-after table fish are often made by 'springer' fishermen. The popular bait consists of small, soft-bodied insects such as termites or flying ants (order Isoptera) fished 0,5 – 2 m below the surface using a float. A trout fly rubbed with the above insects and drawn slowly through the water is also used. Besides being a high-quality eating fish, this mullet is also a powerful swimmer and has excellent angling properties. A dam on the outskirts of Grahamstown (No. 6, Table 1) stocked with *Myxus capensis* fry in 1977 has provided good angling and has proved so popular among 'springer' fishermen that a notice enforcing a daily bag limit of four fish per person per day has now been erected. There are no records of *Mugil cephalus* being caught with a baited hook and line in freshwater areas in the eastern Cape.

Conclusion

The work described above has shown the feasibility and potential benefits derived from stocking these euryhaline mullet species into freshwater impoundments. Both species were found to tolerate low winter temperatures of 6 – 8 °C and would therefore be suitable for stocking into large inland impoundments in the Cape Province (and elsewhere in southern Africa) where a lack of high-quality indigenous fish species often exists. These mullet feed largely on algae, diatoms and detritus and are unable to reproduce in fresh water. Therefore little ecological damage from such stockings is possible.

In the long term, the supply of adequate numbers of mullet fry for stocking purposes still remains a constraint to the development of mullet farming in this country. In addition, large-scale netting of natural populations of mullet fry could be detrimental to mullet stocks. The large research effort directed towards perfecting techniques for the artificial propagation of mullet in various countries should ensure that the technology will soon be available for the large-scale propagation of fry. Only when these techniques are implemented will the full angling and aquaculture potential of both mullet species be realized.

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References

BARDACH, J.E., RYTHER, J.H. & McLARNEY, W.D. 1972. *Aquaculture*. Wiley-Interscience, New York.

BAR-ILAN, M. 1975. Stocking of *Mugil capito* and *Mugil cephalus* and their commercial catch in Lake Kinneret. *Aquaculture* 5: 85 – 89.

BEN-YAMI, M. 1981. Handling, transportation and stocking of fry. In: Aquaculture of grey mullet. International Biological Programme 26, ed. Oren, O.H. Cambridge University Press, Cambridge.

BOGRAD, L. 1961. Occurrence of *Mugil* in the rivers of Israel. *Bull. Res. Counc. Isr.* 93: 169 – 190.

BOK, A.H. 1979. The distribution and ecology of two mullet species in some freshwater rivers in the eastern Cape, South Africa. *J. Limnol. Soc. sth. Afr.* 5: 97 – 102.

CHEN, T.P. 1976. Aquacultural practices in Taiwan. Fishing News Books Limited, England.

CHERVINSKI, J. 1976. Growth of the golden grey mullet (*Liza aurata* (Risso)) in saltwater ponds during 1974. *Aquaculture* 7: 51 – 57.

EISAWY, A.M., ISHAK, M.M. & HAMZA, A. 1974. Experimental rearing of two mullet species *Mugil cephalus* and *Mugil capito* in Egyptian fish farms. *Bull. Inst. Ocean. Fish. A.R.E.* 4: 57 – 96.

EL-MAGHRABY, A.M., HASHEM, M.T. & EL-SEDFY, H.M. 1974. Species composition and distribution of the mullet fry in Lake Borollus. *Bull. Inst. Ocean. Fish. A.R.E.* 4: 3 – 31.

EL-ZARKA, S. & FAHMY, F.K. 1966. Experiments on the culture of the grey mullet, *Mugil cephalus*, in brackish water ponds in the United Arab Republic. *FAO Fisheries Reports* 44(5): 255 – 266.

EL-ZARKA, S. & KAMEL, F. 1965. Mullet fry transportation and its contribution to the fisheries of inland brackish lakes in the United Arab Republic. *Proc. gen. Fish. Coun. Medit.* 8: 209 – 226.

HAMMAN, R.L. 1981. Transporting endangered fish species in plastic bags. *Prog. Fish-Cult.* 43(4): 212 – 213.

HATTINGH, J., LE ROUX FOURIE, F. & VAN VUREN, J.H. 1975. The transport of freshwater fish. *J. Fish. Biol.* 7: 447 – 449.

KURIAN, C.V. 1975. Mullets and mullet fisheries of India. *Aquaculture* 5: 114.

LIAO, I.-C. 1981. Cultivation methods. In: Aquaculture of grey mullets. International Biological Programme 26, ed. Oren, O.H. Cambridge University Press, Cambridge.

MIRES, D. 1970. Preliminary observations on the effects of salinity and temperature changes in *Mugil capito* fry. *Bamidgeh* 22: 19 – 24.

MIRES, D., SHILO, S. & SHAK, Y. 1975. Further observations on the effects of salinity and temperature changes on *Mugil cephalus* fry. *Aquaculture* 5: 110.

NASH, C.E. & KUO, C.M. 1975. Hypotheses for problems impeding the mass propagation of grey mullet and other finfish. *Aquaculture* 5: 119 – 134.

NASH, C.E. & KONINGSBERGER, R.S. 1981. Artificial propagation. In: Aquaculture of grey mullets. International Biological Programme 26, ed. Oren, O.H. Cambridge University Press, Cambridge.

OREN, O.H. 1981 (Ed.). Aquaculture of grey mullets. International Biological Programme 26. Cambridge University Press, Cambridge.

PRUGININ, Y., SHILO, S. & MIRES, D. 1975. Grey mullet: a component in polyculture in Israel. *Aquacuture* 5: 291 – 298.

TANG, Y.A. 1975. Collection, handling and distribution of grey mullet fingerlings in Taiwan. *Aquaculture* 5: 81 – 84.

WALLACE, J.N. & VAN DER ELST, R.P. 1975. The estuarine fishes of the East Coast of South Africa. Part IV. Occurrence of juveniles in estuaries. Part V. Biology, estuarine dependence and status. *Investl Rep. Oceangr. Res. Inst.* 32: 1 – 63.

YASHOUV, A. & BEN SHACHAR, A. 1967. Breeding and growth of Mugilidae. II. Feeding experiments under laboratory conditions with *Mugil cephalus* L. and *Mugil capito* Cuvier. *Bamidgeh* 19: 50 – 66.