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CONSIDERATIONS ON THE FEASIBILITY OF A DIRECTED FISHERY FOR PANGA *PTEROGYMNUS LANIARIUS* (PISCES: SPARIDAE)

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Recent assessments of the status of the panga *Pterogymnus laniarius* stock on the Agulhas Bank, South Africa, showed that catches could be sustained at considerably higher levels than those harvested at present. Although the stock could be successfully harvested using available fishing methods, the sympatry of this species with other commercial species, such as shallow-water Cape hake *Merluccius capensis*, Cape horse mackerel *Trachurus trachurus capensis* and other deep-reef species was of concern, because these species would form a significant bycatch in a panga-directed fishery. These findings highlight the problems of bycatch management and emphasize the need for creativity by both scientists and fishers in designing new and improved methods for selectively exploiting bycatch fish resources.

Panga *Pterogymnus laniarius* (Cuvier 1830) is considered to be the most abundant commercial sparid species inhabiting the Agulhas Bank, South Africa (Fig. 1), where it is caught by the offshore linefishery (Smale and Buxton 1985, Hecht and Tilney 1989) and trawlfishery (Booth and Hecht 1998). Panga have been fished commercially since the turn of the century, when the species was one of the most important demersal fish landed in South Africa (Gilchrist 1899, 1900, 1901, 1902, 1903, 1904). From the 1950s to early 1970s it was the third most abundant trawlfish species landed, despite being caught as bycatch (Botha 1970). In recent years, it is numerically the second most important commercial species caught by the South-East Coast offshore linefishery between Kei Mouth and Still Bay (Brouwer 1997). In 1964, a directed fishery for panga was established by Japanese and Taiwanese companies in South African waters, using bobbin trawling gear to fish the hard substrata where the species is considered to be particularly abundant (Japp *et al*. 1994). By 1977, the panga resource was considered overexploited (Sato 1980) and directed fishing was terminated in 1978, with the establishment in 1977 of the South African 200-mile Exclusive Economic Zone (Fig. 2). Foreign fleets were then restricted to a panga quota not exceeding 1 800 tons. By the early 1980s, the foreign fleets were excluded from South African waters. Panga is currently a bycatch in the South African trawlfishery and is targeted by commercial linefishers, with an annual total catch averaging 839 tons over the past decade (Japp *et al*. 1994). There is now considerable interest in re-establishing a directed fishery.

Recent stock assessments have indicated that a four- to fivefold increase in fishing yield may be sustainable (Booth and Buxton 1997a, Booth and Punt 1998). Even at present catch levels, there appears to be evidence of a stock recovery (Booth and Punt 1998). This implies that, if panga were to remain a bycatch of the trawlfishery, no new management strategy would be necessary. Alternatively, were the panga stock to be fished by a new directed fishery, consideration would have to be given to existing catches by the line and trawl fisheries.

Questions obviously arise as to whether or not it is possible to develop a panga-directed fishery to exploit the resource at maximum sustainable levels. If such a fishery were developed, what gear should be used and what areas should be fished? The impact of a panga-directed fishery on sympatric species, particularly those that are part of current directed fisheries and which are subject to quota restrictions, also needs to be assessed. In the event of panga being caught within both a directed fishery and as bycatch in the trawlfishery, similar questions arise regarding possible bycatch problems, gear selection and potentially fishable areas.

Problems are inherent in the development of a new directed fishery, particularly on a resource that has been landed as bycatch in the past. Intuitively, if a species makes up a significant proportion of the bycatch within a multispecies fishery and is developed into a directed fishery, the new fishery will have its own bycatch problems. Therefore, suitable data are needed to address this issue. As there is currently little information regarding panga bycatch and discard rates, other available data on the resource should be used. If a panga-directed fishery were to be developed, esti-

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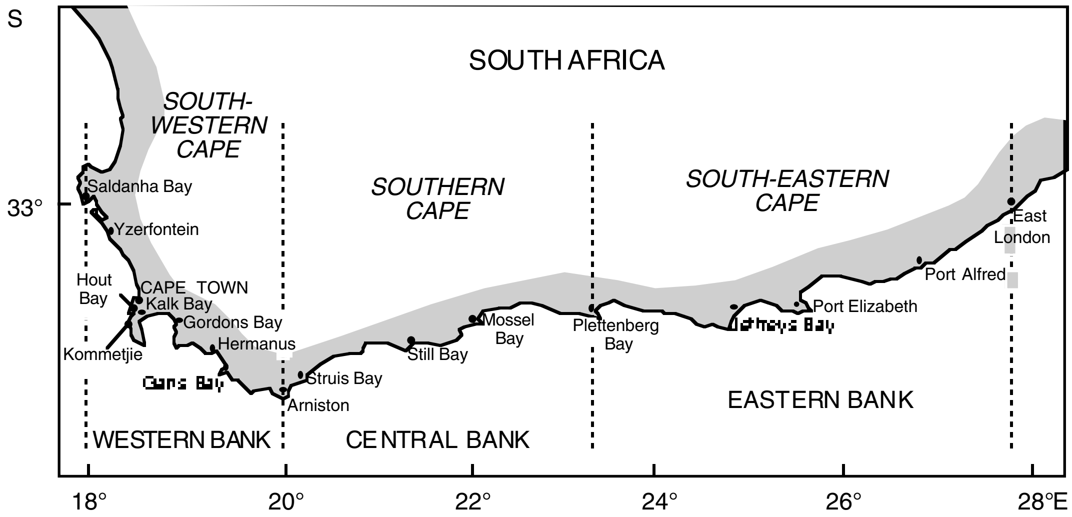

Fig. 1: Map of the Agulhas Bank, showing the localities mentioned in the text

mates of bycatch would need to be ascertained in order to minimize any potential impact that the fishery might have on other sympatric species.

This study examines available information on the past, present and possible future trends within the fisheries where panga are harvested. The gear used is assessed and estimates of bycatch in a directed fishery are provided, particularly with regard to sympatric commercial species. These findings could contribute toward the setting of guidelines for the development of a management strategy for the future sustainable utilization of this resource.

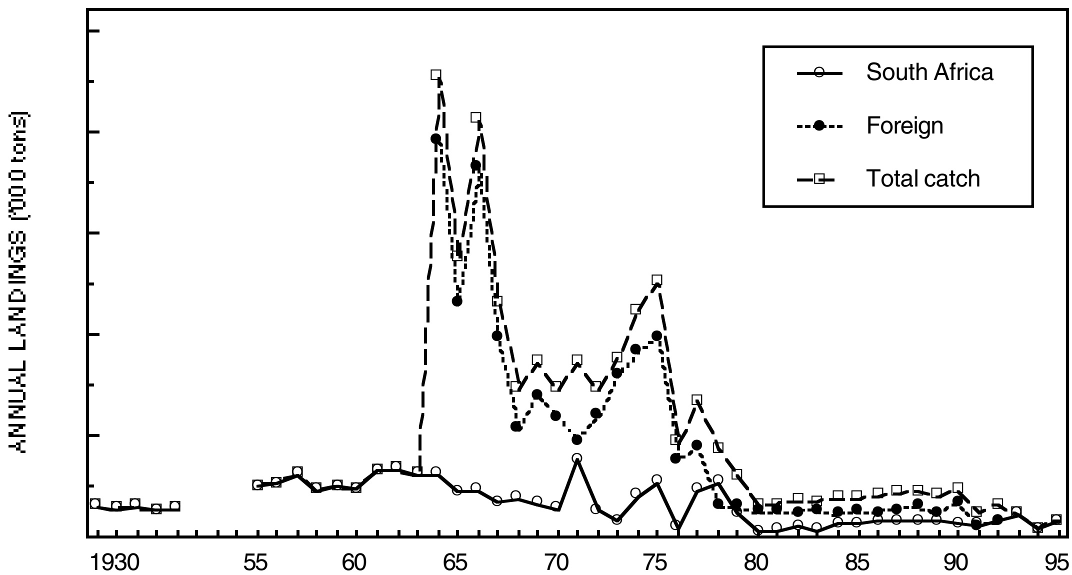

Fig. 2: Annual landings of panga caught by South African and foreign vessels on the Agulhas Bank, 1929–1995 (MCM, unpublished data)

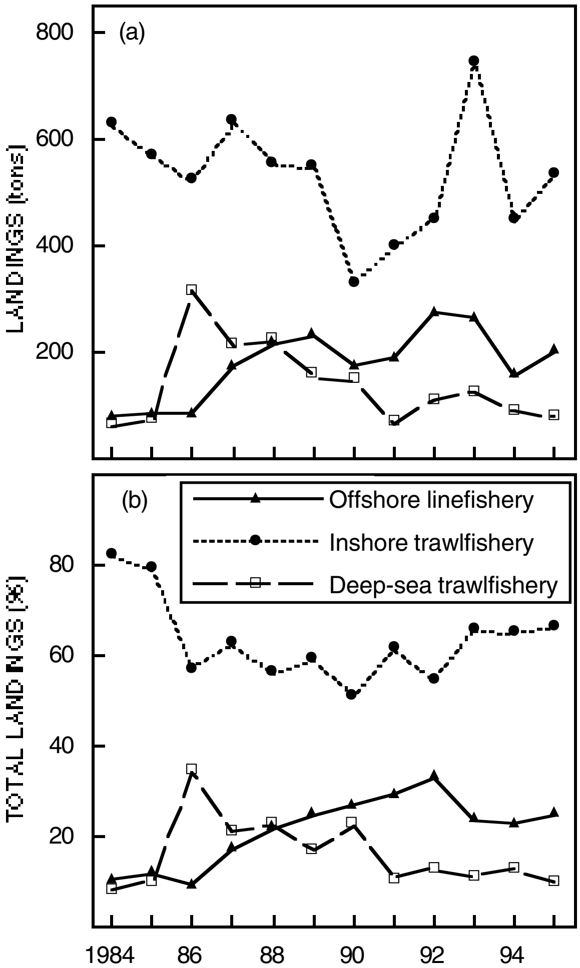

Fig. 3: (a) Annual landings and (b) percentage of landings of panga caught on the Agulhas Bank by the deep-sea trawl, inshore trawl and offshore linefisheries from 1984 to 1995 (MCM, unpublished data)

MATERIAL AND METHODS

A first estimate of the approximate contribution of the various species caught within a panga-directed fishery needs to be determined. The most suitable data are from the research surveys conducted by the joint Japanese/South African biomass surveys (Uozumi *et al*. 1984, 1985, Hatanaka *et al*. 1983) and those from the biannual biomass surveys carried out by Marine and Coastal Management (MCM). Similarly, catch data from linefishers who targeted panga between 1994 and 1996 are available. These data were used to

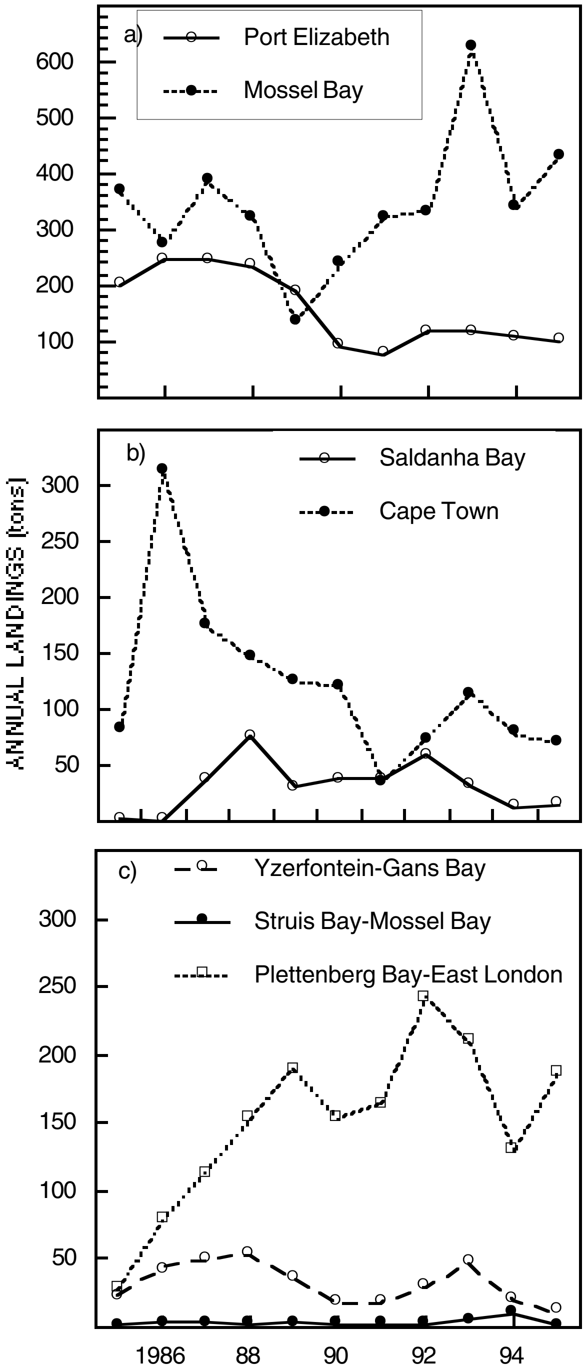

Fig. 4: Annual catches of panga landed at various sites by (a) inshore trawl (b) deepsea trawl and (c) commercial offshore linefisheries from 1985 to 1995 (MCM, unpublished data)

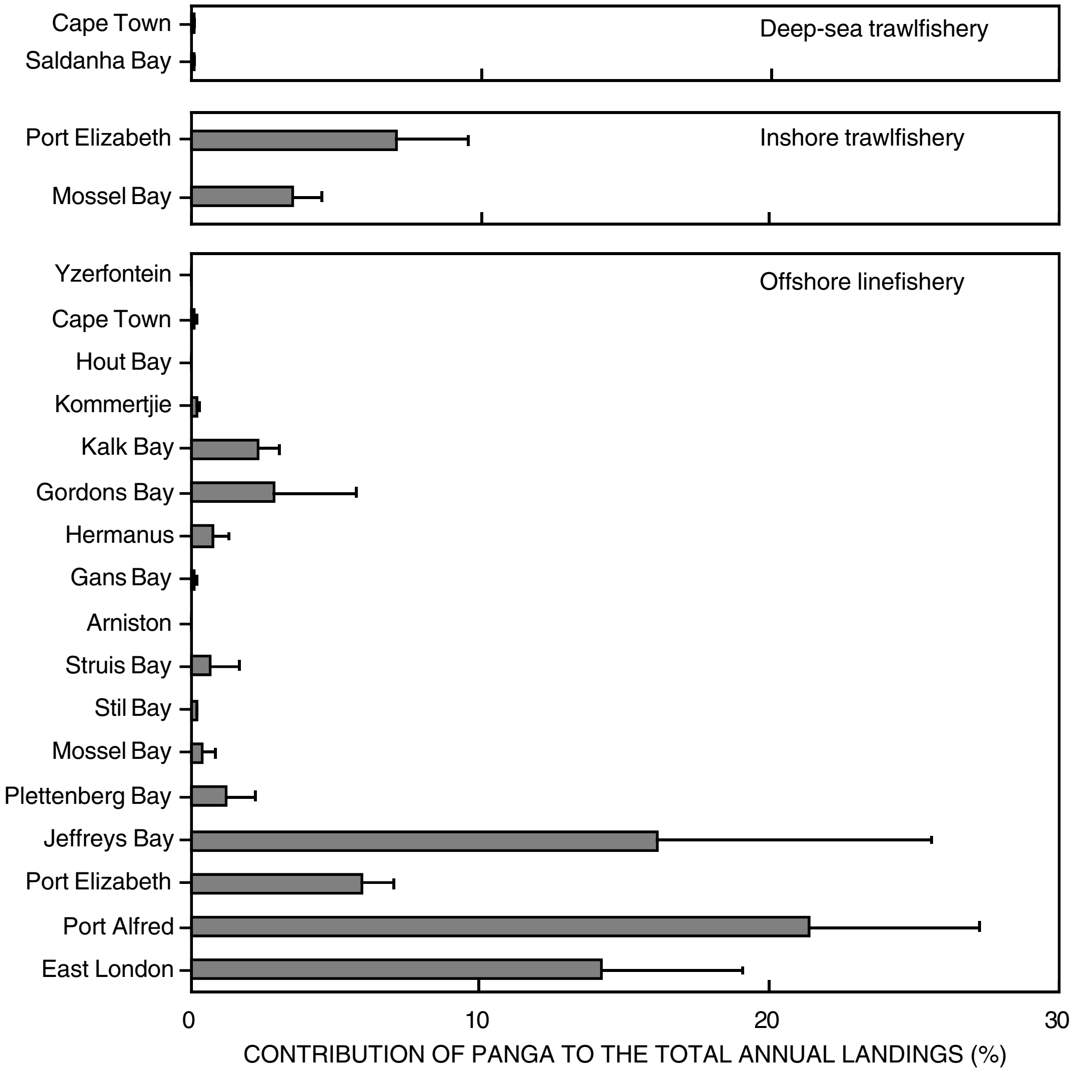

Fig. 5: Percentage contribution of panga (+1 *SD*) by mass to the total annual catch landed at various sites by three South African fishing sectors from 1990 to 1995 (MCM, unpublished data)

elucidate annual and regional catch trends, to establish the importance of panga to the various fisheries and to assess the advantages and disadvantages of the different gear used in each fishery.

An inherent problem in both MCM and the Japanese/South African dataset is that not all possible panga habitats were sampled. Whereas MCM surveys did not cover most of the hard grounds of the Agulhas Bank, the Japanese/South African biomass surveys covered extensive areas, with the exception of high-relief reef which cannot be trawled with bobbin trawl gear. A suitable method is developed here to obtain a first approximation of the fish assemblage associated with areas dominated by panga. Those trawls that were dominated by panga (where panga constituted the greatest relative mass in each trawl) were selected and the percentage mass composition of all species noted. The geographic location of each trawl was also noted. The method was also applied to the commercial and recreational linefish catches where panga is the dominant species. The relative contribution by mass of the various species within the fish assemblage was estimated to provide some

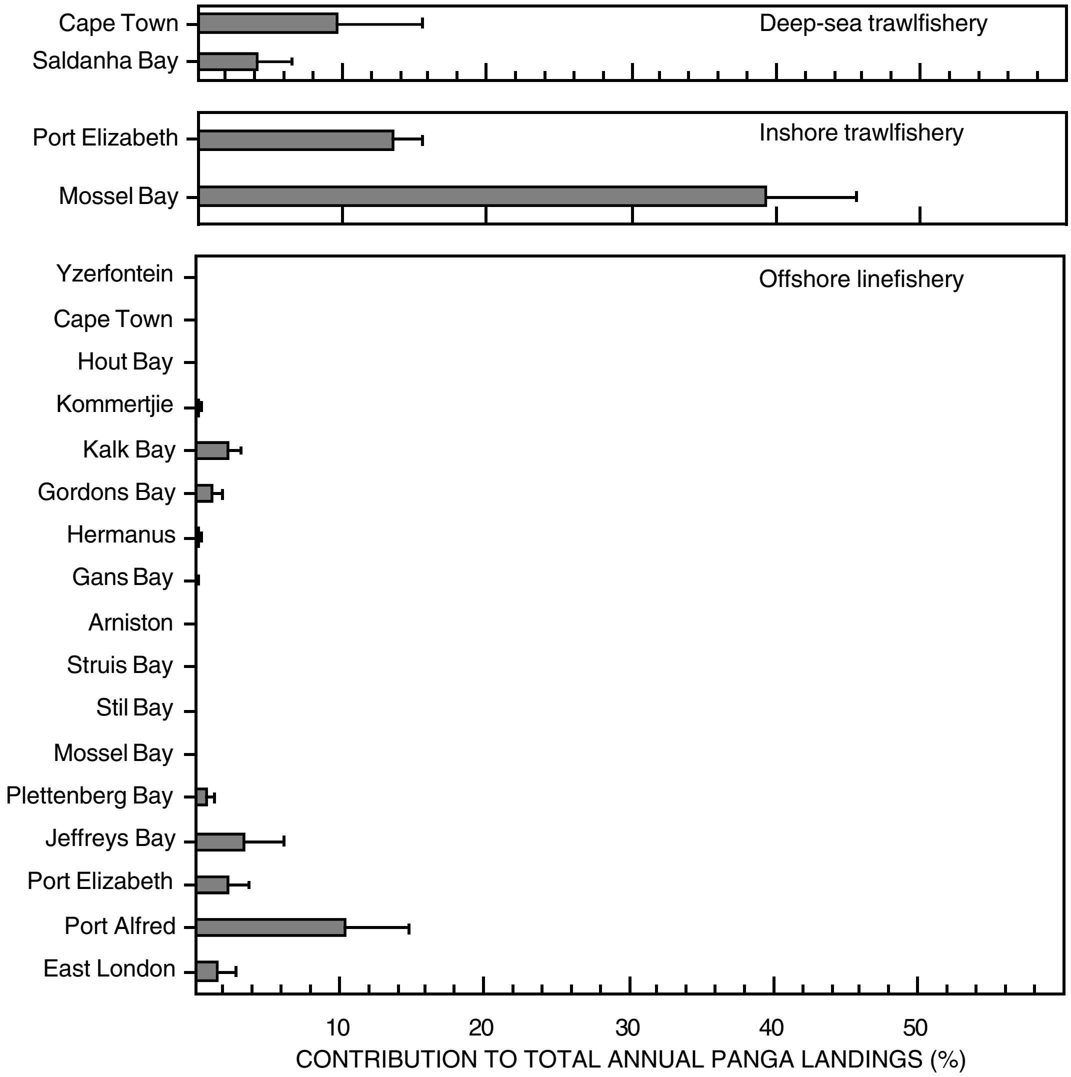

Fig. 6: Percentage contribution of various landing sites to the annual panga catch (+1 *SD*) by three South African fishing sectors from 1985–1995 (MCM, unpublished data)

quantitative indication of whether or not a bycatch problem would emerge in a panga-directed fishery.

RESULTS AND DISCUSSION

Catch trends

The trawlfishery lands approximately 80% of the annual panga catch, predominantly as bycatch (Figs 3, 4). It should also be noted that almost all panga caught by the trawlfishery are landed. The South African deep-sea trawlfishery is restricted to fishing outside the 110-m isobath, where they target the Cape hakes *Merluccius capensis* and *M. paradoxus* to depths of over 500 m. Although the panga catch has never been large in the deep-sea trawlfishery, contributing relatively little to the catches landed in Cape Town and Saldanha Bay, it does land a reasonable portion

Table I: Percentage composition (± standard deviation) of fish species present in trawls either dominated by panga irrespective of mass (n = 126) or where they constituted >40% of the catch by mass (n = 56), and from commercial (n = 11) and recreational (n = 4) offshore linefish catches where panga were dominant by mass. Trawl estimates were obtained using biomass survey data (n = 1 585 trawls) from 1980 to 1995, and only species which contributed >5% by mass were chosen for the analysis. All species within the linefishery were used for analysis. Only those species which were >0.5% of the various catches are shown below

Common name	Species	Fishery	Percentage composition (irrespective of mass)			Percentage composition (>40% by mass)		
			Mean ± *SD*	*CV*(%)	95% *CI*	Mean ± *SD*	*CV*(%)	95% *CI*
Panga	*Pterogymnus laniarius*	Research trawl	40.0 ± 12.6	31	(37.8, 42.2)	50.3 ± 10.0	20	(47.7, 52.9)
		Commercial line	68.6 ± 14.3	450	(40.6, 96.7)			
		Recreational line	73.8 ± 13.9	841	(19.0, 128.6)			
Hake	*Merluccius capensis*	Research trawl	12.4 ± 9.9	80	(10.6, 14.1)	11.2 ± 9.2	82	(8.8, 13.6)
		Commercial line	4.0 ± 6.4	200	(–8.4, 16.5)			
		Recreational line	8.3 ± 16.7	830	(–24.4, 41.1)			
Horse mackerel	*Trachurus trachurus capensis*	Research trawl	6.4 ± 8.4	131	(5.0, 7.9)	6.1 ± 7.5	124	(4.1, 8.0)
Spiny dogfish	*Squalus megalops*	Research trawl	7.0 ± 7.8	112	(5.6, 8.4)	4.4 ± 6.7	153	(2.7, 6.1)
Lesser gurnard	*Chelidonichthys queketti*	Research trawl	1.7 ± 4.7	280	(0.8, 2.5)	0.2 ± 1.0	539	(–0.1, 0.4)
Cape gurnard	*Chelidonichthys capensis*	Commercial line	3.4 ± 4.2	140	(–5.1, 11.9)			
		Recreational line	4.4 ± 7.7	380	(–10.6, 19.4)			
Carpenter	*Argyrozona argyrozona*	Research trawl	1.3 ± 3.9	298	(0.6, 2.0)	1.3 ± 3.6	278	(0.4, 2.2)
		Commercial line	11.8 ± 11.5	360	(–10.6, 34.3)			
		Recreational line	9.0 ± 11.7	590	(–14.0, 32.1)			
Silver kob	*Argyrosomus inodorus*	Commercial line	4.5 ± 10.0	330	(–15.7, 24.6)			
Santer	*Cheimerius nufar*	Commercial line	1.8 ± 2.3	73	(–2.8, 6.3)			
Dageraad	*Chrysoblephus cristiceps*	Commercial line	3.2 ± 9.8	310	(–15.6, 22.4)			
Windtoy	*Spicara auxillaris*	Research trawl	0.9 ± 4.7	499	(0.1, 1.7)	0.5 ± 4.2	768	(–0.5, 1.6)
Beaked sandfish	*Gonorhynchus gonorhynchus*	Research trawl	0.7 ± 3.4	522	(0.1, 0.3)	1.4 ± 5.0	351	(0.1, 2.7)
Jacopever	*Helicolenus dactylopterus*	Research trawl	0.8 ± 3.0	366	(0.3, 1.3)	0.7 ± 2.6	395	(0.0, 1.3)
Joseph shark	*Callorhynchus capensis*	Research trawl	0.5 ± 1.9	350	(0.2, 0.9)	0.3 ± 1.3	444	(0.0, 0.6)

CV = Coefficient of variation
CI = Confidence interval

(15–40%) of the annual panga catch (Figs 3–5). The marked decline in the deep-sea sector's share of the annual panga catch over the past decade reflects changes within the fishery, with effort being directed towards the deeper, hake-dominated grounds where panga density is low. The majority of deep-sea vessels land their catch either at Cape Town or Saldanha Bay, with the panga component taken over the Agulhas Bank. The differences in the contributions of panga at the various landing sites reflect the capacity of the fishing companies.

The inshore trawlfishery catches the largest amount of panga annually, landing >60% of the total annual panga catch (Figs 3–5). Vessels are size- (30 m) and effort- (750 hp) restricted, enabling them to fish effectively up to 150 m. Over the past decade, it appears that the panga catch has been relatively stable. However, when viewed in conjunction with estimates of total hake-directed effort, which are decreasing annually, hake-directed catch per unit effort (*cpue*) estimates for panga show a steady increasing trend of 1.1% per year (Booth and Punt 1998). This is because the panga catches have decreased at a slower rate than the hake *cpue* estimates. The inshore fishery operating from Mossel Bay has always been larger than that from Port Elizabeth, so accounting for the greater portion of the total panga catch landed by the former fishing sector. However, the panga component of the inshore trawl catch was greater at Port Elizabeth than at Mossel Bay (Fig. 5).

Panga are landed between East London and Cape Town, but they only constitute an important component of the commercial offshore linefish catch between Plettenberg Bay and East London (Figs 3–6). They are not considered to be important within the recreational offshore linefishery, where only 5% of the fishers target them and often use small panga as bait (Brouwer 1997). In both sectors, panga are not a preferred species, because they are small and have a low market value. Although targeted by a small proportion of commercial fishers, panga are becoming increasingly important. This is primarily a consequence of the decline in abundance of other large reef fish that have dominated this fishery in the past (Smale and Buxton 1985, Hecht and Tilney 1989). Data from the commercial linefishery reflect the importance of panga along the East Coast, particularly at Jeffreys Bay, Port Alfred and East London (Figs 5, 6).

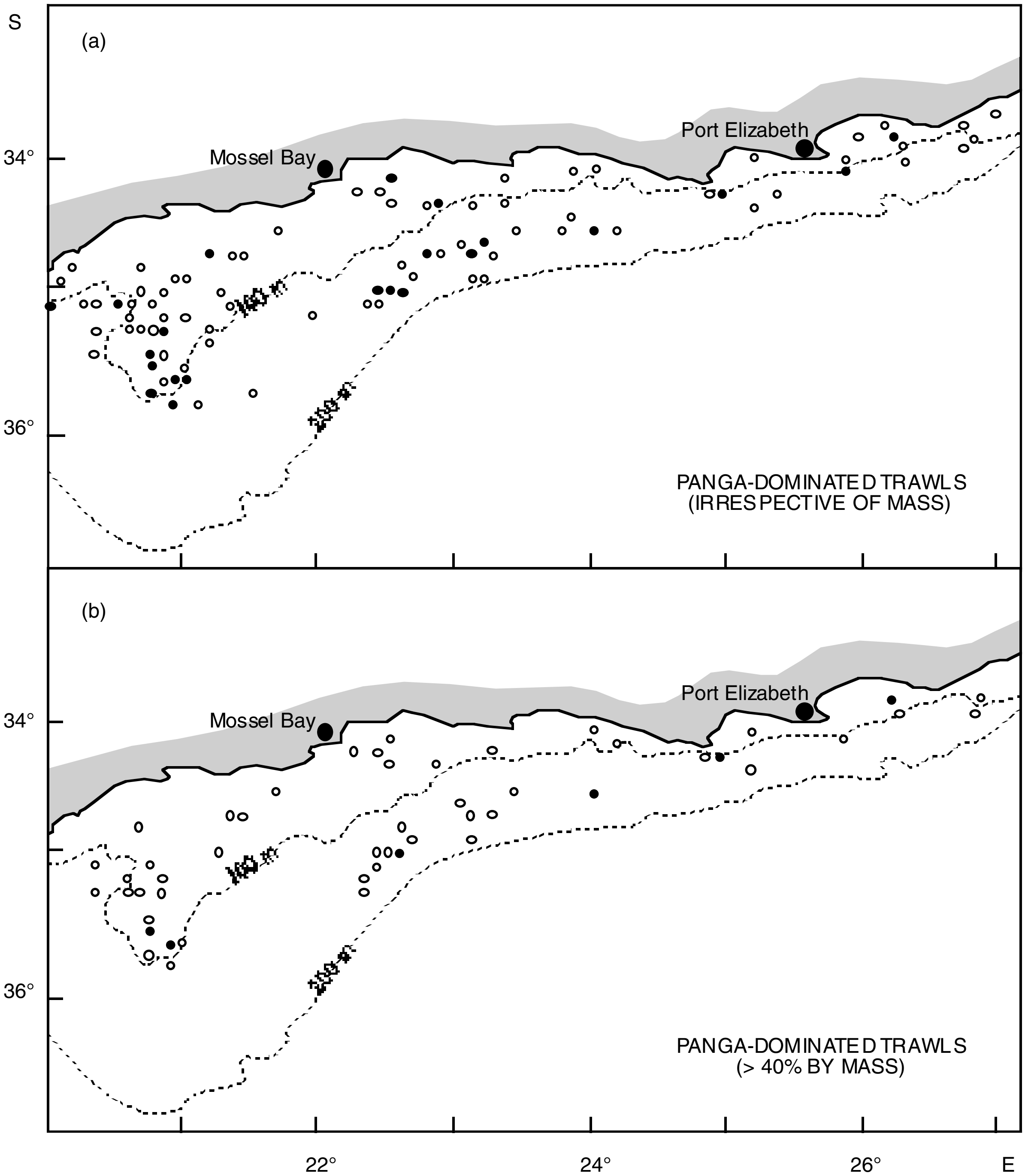

Fig. 7: Survey trawl positions over the Agulhas Bank (between 1980 and 1995 where panga was (a) the dominant species by relative mass (n = 126) and (b) where they represented at least 40% by total trawl mass (n = 59) of each trawl catch. Open and closed dots denote where one or more than one trawl was dominated by panga respectively

Table II: Point estimates of various biological reference points for panga. Catch units are in metric tons

Stock assessment technique	Biological reference point						
	M	F_{MSY}	C_{MSY}	$F_{0.1}$	$C_{0.1}$	F_{SB50}	C_{SB50}
Surplus production model[1]	–	NE	6 800	NE	NE	NE	NE
Yield-per-recruit[1]	0.2	0.28	5 200	0.19	5 000	NE	NE
Yield-per-recruit[2]	0.2	NE	NE	0.25	6 443	0.20	5 707
	0.28	NE	NE	0.39	4 302	0.30	3 924
Age-structured production model[3]	0.2	0.31	5 610	0.17	5 200	0.11	4 470
	0.28	0.47	5 050	0.24	4 640	0.14	3 810

NE denotes that the quantity was not estimated by the study concerned
[1] Sato (1980)
[2] Booth and Buxton (1997a)
[3] Booth and Punt (1998)
M = Natural mortality rate
F_{MSY} = Fully selected fishing mortality at which C_{MSY} occurs
C_{MSY} = Maximum sustainable yield
$F_{0.1}$ = Fully selected fishing mortality at which $C_{0.1}$ occurs
$C_{0.1}$ = Equilibrium catch at which the slope of the yield-fishing mortality curve is 10% of that at the origin
F_{SB50} = Fully selected fishing mortality at which C_{SB50} occurs
C_{SB50} = Equilibrium catch at which the spawning biomass is half that of the pristine level

The foreign trawlfishery landed the most panga in the past (Fig. 2). It provided the only directed trawling effort on the stock, using modified trawling gear that permitting effective exploitation of large areas of hard grounds, consisting of low-profile reef and rocky outcrops (Japp *et al.* 1994). This was accomplished by the addition of steel bobbins (hollow balls), nylon rollers and rock-hoppers on the footrope of the net, allowing for the nets to bounce or roll over rocky substrata. This method prevented tearing and snagging of the net, while allowing for efficient capture of species dwelling on hard ground.

The bycatch problem

Bycatch has been defined by Saila (1983, p. 1) as "... that part of the gross catch which is captured incidentally to the species towards which there is directed effort". In South Africa, where the trawlfishery is directed at hake (and also Agulhas sole *Austroglossus pectoralis* by the inshore sector), 12 other commercially important fish species are landed, constituting 15 and 22% of the inshore and deep-sea trawlfishery catches respectively (Japp *et al.* 1994). If a panga-directed fishery were to be developed, estimates of bycatch would need to be ascertained in order to minimize any potential impact on sympatric species.

Of the 1 585 research trawls analysed in this study, 126 (8%) were dominated by panga, irrespective of its relative mass, and in 56 of those trawls panga constituted at least 40% of the total trawl mass (Table I). The distribution of these trawls and the relative proportions of various size-classes of panga fish are presented in Figure 7. Of the linefish catches dominated by panga, the species averaged 68% of the total catch. Six other sympatric species were present in the catches, each with a contribution of at least 0.5%.

Panga were distributed mainly between 50 and 150 m (Fig. 7), in two principal areas; on the central Agulhas Bank between 50 and 100 m and off Mossel Bay at approximately 100 m depth. Other areas that were dominated by panga, but to a lesser degree, were off Port Elizabeth and Cape St Francis. The proportion of panga within the commercial and recreational linefish catches was significantly higher than in the research trawls. This is a consequence of higher gear selectivity and the discarding of undesirable species. In the research trawls from the two areas, there were up to 20 sympatric species, of which eight constituted >1% by mass (Table I). Hake was the most important of those species, contributing >11% of the trawl biomass. These data suggest that, despite trawling in an area dominated by panga, the fish assemblage is collectively equal to or exceeds the mass of panga. This poses a problem with respect to possible high bycatch rates in a panga-directed trawlfishery. Although the research trawls use a small-mesh (stretched mesh = 25 mm) liner in the cod-end, indications are that fish would be caught in similar proportions with commercial gear, because the selectivities of both gears are similar (Japp *et al.* 1994).

Determining the limits of allowed bycatch within a directed fishery is difficult and is also fishery-specific (Hall 1996). Legislation requiring high gear selectivity with reduced bycatch ratios could possibly result in

Table III: Summary of the advantages and disadvantages of current and potential methods used to catch panga on the Agulhas Bank, South Africa

Method	Advantages	Disadvantages
Inshore otter trawl (standard)	Exploits fish larger than maturity with mesh of 75 mm. No need to change the gear or areas fished	Cannot increase effort without risking high bycatch. Fish quality is poor, because most fish are kept on ice for 7–10 days
Deepsea otter trawl (with bobbins or rock-hoppers)	Highly selective for panga over certain low-profile reef and rocky substrata. Has been shown to be highly efficient in catching panga	Bobbins are suspected of causing extensive damage to hard corals and other sensitive areas of panga habitat. There is a high by-catch problem of incidental species. With good freezing facilities, the fish is generally of good quality
Hooks (offshore linefishery)	Exploits fish larger than maturity; no need to change fishery. The fish is landed fresh and is of good quality. Quality can be improved by proper handling	It is difficult to fish >50 m deep and therefore fishers need high rewards for their effort
Small-hooked longlining	May be possible to target the stock because of the relatively high gear selectivity. Excellent fish quality	High incidence of hake bycatch. Increased seabird mortality
Fish traps	Possible to target the stock effectively to maximize the catch and minimize the bycatch. Excellent fish quality	Possibility of high bycatch. New fishing technique that will need refining

high rates of discarding at sea, which would misrepresent the unselective nature of the fishery. Bycatch ratios need to be maintained at a reasonable level to reduce the catch of non-target species, to provide an accurate reflection of current gear selectivity and to ensure a realistic bycatch estimate for further management purposes.

Potential yield

Panga have been subject to various stock assessments over the past two decades (Table II). The first, by Sato (1980), recommended that a yield of 5 000 tons per year was sustainable and would allow for stock rebuilding. Age-at-50% selectivity was estimated by Sato (1980) to be 2 years (17 cm total length) between 1964 and 1977. During that period, Booth and Hecht (1997) estimated age- and size-at-50% maturity to be 5.2 years and 29 cm total length respectively. The selectivity pattern was a result of the use of small-mesh liners in the cod-end of the nets (P. F. Sims, MCM, pers. comm.). Whereas some sole-directed trawlers still use cod-end liners (illegally), they are generally not used by trawlers targeting hake (AJB, pers. obs.). The current legal stretched mesh size is 75 mm and restricts the capture of most immature panga. Sato's (1980) study provided the first evidence for overfishing of panga, with optimal levels of fishing effort estimated at one-third of the levels during that study.

More recent stock assessments, using yield- and spawner biomass-per-recruit (Booth and Buxton 1997a) and age-structured production models (Booth and Punt 1998), provided a more conservative estimate of sustainable yield of 4 000 tons per year, compared to that of Sato (1980). Panga are now selected at 1.5 years (age-at-50% selection = 5.5 years) after maturity, which occurs at 4 years (Booth and Buxton 1997b). This provides a "refuge" of spawning biomass that is essentially unfishable, contributing towards the viability of supporting a sustainable fishery. An additional risk analysis, although not fully incorporated into a comprehensive operational management procedure (see Butterworth and Bergh 1993, Butterworth *et al*. 1993, Punt 1993), showed that an annual catch of c. 4 000 tons could result in an acceptably low risk of overfishing (Booth and Punt 1998).

Fishing methods

In developing a new directed fishery, it is necessary to consider the various fishing gears that are currently available and to assess their advantages and disadvantages in the light of management objectives. Such objectives would include the ability to fish the targeted species effectively and to limit the bycatch. If current fishing gears are found to be unsuitable, then consideration must be given to the development of alternative gear. The panga stock has been harvested using a variety of gears, each with its own inherent selectivities, efficiencies and limitations (Table III).

It is for this reason that the efficiency of these gear types and their ability to meet defined management objectives needs to be investigated. A preliminary assessment can be made regarding their ability to catch panga and possibly to reduce levels of bycatch. Three gear types have been identified and are discussed below.

NETS

Demersal trawling with otter trawls has been the principal method to catch panga in the past. East of Cape Agulhas, where panga are abundant, minimum stretched-mesh regulations ensure the selection of fish larger than size-at-maturity (Booth and Buxton 1997b).

The foreign fleets that fished panga in the past were large, deep-sea vessels using otter trawling gear with bobbins or rock-hoppers. This gear was found to be unselective (MCM, unpublished data), and during the period 1964–1977, despite panga being one of the targeted species, they only constituted some 14% of the total foreign trawl catch (hake being the most important species at 40% of the catch). This fact re-emphasizes the unselective nature of otter trawling gear and its unsuitability as a method for directed effort. Otter trawling with bobbins is also suspected of damaging the substratum, particularly on hard, low-profile reefs, where hard corals, bryozoans and sponges support large invertebrate communities (Jones 1992). Unfortunately, the impact of bobbin gear on various substrata is not known in South African waters. The possible destruction by such gear of various habitats may lead to areas becoming unsuitable for panga. Since the exclusion of foreign vessels from South African waters in 1972, the panga stock has had some opportunity to rebuild (Booth and Punt 1998). However, it is unlikely that the grounds have had a chance to recover, as evidenced during the past decade by commercial SCUBA dive operators (H. van Niekerk, Port Elizabeth, pers. comm.). Clearly, the impact that bobbins and/or rock-hoppers have on the benthic community in South African waters (they are currently legal up to 375 mm in diameter) needs to be carefully assessed.

HOOKS

The use of small hook longlines or rod/handlines is an alternative fishing method to target panga, which needs to be thoroughly investigated. Preliminary results of experimental small-hook (2/0") longlining showed that panga only constituted 50% of the catch, with hake being the dominant (>40%) bycatch species (M. Craig, Plettenberg Bay, pers. comm.). Despite placing the longlines on the substratum, a commonly used strategy to reduce the selectivity on hake, bycatch rates of hake were not alleviated. This poses a serious problem, because hake are restricted by quota. The use of small hooks could also increase the incidence of juvenile bycatch of many trawl and linefish species and increase seabird mortality.

TRAPS

Fishing traps have not been tested or used for teleosts in South African waters, but they have been used successfully elsewhere. They have both the ability to selectively target a particular species within a preferred size-range, while retaining a high quality product that can be marketed for export (Kailola *et al*. 1993). They are extremely effective for snapper *Pagrus auratus* in Australia (Kailola *et al.* 1993), a larger sparid of similar proportions to panga. Concerning the bycatch problem, three principal quota-restricted species need to be excluded; hake, kingklip *Genypterus capensis* and the South Coast rock lobster *Palinurus gilchristi*. In the past, panga formed a substantial bycatch in the South Coast lobster fishery (C. J. Wilke, MCM, pers. comm.). The bycatch of other sympatric sparids, such as the red stumpnose *Chrysoblephus gibbiceps*, santer *Cheimerius nufar* and blue hottentot *Pachymetopon aeneum*, also needs to be addressed, because these are important components of both the recreational and commercial linefisheries.

In summary, there is currently no gear particularly suitable for a panga-directed fishery. Otter trawling is too non-selective and will possibly have the highest incidence of bycatch, owing to the retainment of juvenile fish as a result of the clogging effect of long or large trawls. It is also considered to have the highest environmental impact, particularly on hard grounds with large invertebrate communities. Rod/handlining or longlining with hooks are two possibilities, because the technology is well developed in South Africa. The problem of high bycatch using hook-and-line methods needs to be carefully addressed before any such fishery is considered.

Nursery areas

Preliminary research has been conducted on the distribution and abundance of panga (Hatanaka *et al*. 1983, Uozumi *et al*. 1981, 1985, Badenhorst and Smale 1991, Smale *et al*. 1993, Booth 1998). These studies have shown that panga have a clearly defined nursery area off Cape Infanta (Booth 1998). In the past, that area was heavily fished by foreign vessels, in what was known as the "foreign triangle" (Crawford *et al*. 1987). At least 95% of immature panga are found there; it is predominantly hard ground and only fishable with bobbin gear or hooks (Booth 1998). If a fishery for panga were to be contemplated, there would have to be no direct fishing effort in that area, essentially forming an offshore marine reserve to provide refuge for juveniles and subadults.

CONCLUSIONS

From the results presented, it appears that panga can be fished effectively using a variety of gear types, including otter trawls with bobbins, handlines and longlines, and traps, enabling fishers to harvest the stock to maximum sustainable levels if necessary. Known areas of high panga abundance, such as the extensive areas of hard ground over the Agulhas Bank, support a large fish assemblage, some of which are subject to quota restrictions (e.g. hake). Gear type is the principle factor reducing possible bycatch, with trawling in all its forms being the least selective. Small-hooked longlining, although superior in its selectivity, would likely have a greater impact on hake bycatch and on the juveniles of other species. Whereas offshore linefishing showed the least bycatch and the greatest annual increase in catch, it is difficult to use because panga are small and found most commonly at depths in excess of 50 m. Creative ways therefore need to be sought in the future so that gear can be designed to selectively target a particular species and reduce the bycatch of incidental species, while still retaining fish quality. Fishing methods should be restricted to those other than trawling (and possibly longlining), on account of their unselective nature and excessive bycatch problem. In addition, directed fishing should also be barred from the nursery area of panga on the central Agulhas Bank. This will remove directed effort and associated mortality from immature fish.

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