STATUS OF THE SOUTH AFRICAN MARINE FISHERY RESOURCES 2010

Compiled by Chief Directorate: Fisheries Research,
Fisheries Branch,
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Foreword

South Africa is about to enter a new era in fisheries, one that aims to take a multi-faceted developmental approach to the management of this sector. At the heart of development planning is making sure that the goose that lays the golden egg remains healthy, otherwise there will not be real and meaningful development but only fleeting short-term gains. In the case of fisheries, the golden goose is the fish resources that supply the fisheries, be they subsistence, recreational, semi-commercial or commercial in nature.

The Department of Agriculture, Forestry and Fisheries is therefore strongly cognizant of the importance of ensuring that South Africa's fish resources are used in a manner that keeps the golden goose alive and is sustainable in the long-term, and even in a manner that can improve their supply over time and thereby increase the benefits that the country and its people derive from fishing.

A crucial part of ensuring sustainability is continuous monitoring of catches and fish stocks, and feeding this information back into adaptive management systems. To this end, information on fish catches is collected through co-operation with fishers, and stock status information is collected by conducting regular surveys either by shore-based operations or with the use of the Department's research vessels. This information is used to track trends in the status of fish resources over time and these trends are fed into forward-looking projections of future resource status under different harvesting scenarios. This forms the basis for annual sustainable catch limits and guides the development of stock recovery plans.

Essentially, the status of a fish resource can be seen as capital in the bank, and catches as the interest that accrues on this. Thus, the better the current status of a particular fish resource the greater the amount of fish that may be safely caught (up to a limit, however, because, unlike a bank account, there is a natural upper limit to how many fish there may be). South Africa's fishery resources, like those in other parts of the world, have suffered in the past from overfishing, illegal fishing, and environmental changes. For this reason, the status of certain fish resources are lower than that which would result in the highest possible catches, and therefore be considered overexploited. This does not mean, however, that the resource is doomed – in most cases, investing in recovery plans that trade-off short-term reductions in catches for longer-term improvements in the resource status pays dividends in increased catches, reduced risk of damage to the resource from fishing, and greater resilience to natural and environmental changes.

This report presents and summarises the current status of South Africa's fishery resources. The report has been made possible through the collection of many years of work by dedicated scientists and technicians, and I would like to take the opportunity to thank them all (both past and present) for their contributions to this important work. I thank the authors of the various chapters for compiling this vast amount of information into an understandable form.

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Acronyms and abbreviations

CCAMLR	Commission for the Conservation of Antarctic Marine Living Resources
CCSBT	Commission for the Conservation of Southern Bluefin Tuna
CPUE	Catch per unit effort
DAFF	Department of Agriculture, Forestry and Fisheries
EEZ	Exclusive Economic Zone
FIAS	Fishery-independent abalone survey
FIMS	Fisheries-Independent Monitoring Survey
GIS	Geographical Information System
ICCAT	International Commission for the Conservation of Atlantic Tunas
IUCN	International Union for Conservation of Nature
IOTC	Indian Ocean Tuna Commission
IUU	Illegal, unreported, unregulated (fishery)
KZN	KwaZulu-Natal
MCM	Marine and Coastal Management
MLRA	Marine Living Resources Act
MPA	Marine protected area
MSY	Maximum sustainable yield
NLS	National linefish survey
NMLS	National marine linefish system
OMP	Operational Management Procedure
PMCL	Precautionary management catch limit
PUCL	Precautionary upper catch limit
RFMO	Regional Fisheries Management Organisation
TAB	Total allowable bycatch
TAC	Total allowable catch
TAE	Total allowable effort
TURF	Territorial User Rights in Fisheries
WWF	World WildLife Fund

Executive summary

- This report presents the most up-to-date information and analyses of the status of the marine living resources in 17 fishery sectors in South Africa.
- There is a general trend of deteriorating status with accessibility, such that resources that are more accessible from the shore are under greater pressure and more likely to be overexploited than resources farther offshore.
- Abalone resources continue to decline in response to unsustainable levels of poaching. Resource recovery in some areas is unlikely due to environmental changes.
- Declines in catches of Agulhas sole in recent years, and undercatching of the total allowable catch (TAC), are attributed to decreases in fishing effort on this resource rather than to a decline in its status.
- The shallow-water hake resource is considered to be relatively healthy, although the deep-water hake is heavily depleted. There is evidence that the resource is responding positively in response to the recovery plan.
- The status of the horse mackerel resource appears to be stable, and the precautionary upper catch limit continues to remain constant.
- Linefish resources are considered overexploited or collapsed, with no improvement evident since the declaration of a 'state of emergency' in this fishery in 2000. The current TAC remains too high to ensure the sustainability of these resources, but even if this is reduced, the slow-growing, long-lived nature of most of the species in this fishery is likely to make recovery very slow.
- Harders, the primary target fish of the beach-seine and gillnet fisheries, are considered overexploited. Of concern is the considerable bycatch of overexploited or collapsed linefish species, and rising levels of illegal fishing.
- Oyster resources in the Southern Cape continue to be considered overexploited, whereas those in KwaZulu-Natal are considered optimally exploited.
- The status of Patagonian toothfish remains uncertain due to conflicting assessment results. It is expected that data from the tagging programme will assist to resolve this conflict.
- Shallow-water prawn resources are generally highly variable from year to year, but are currently low due to droughts and the closure of the mouth of the St Lucia Estuary. Deep-water prawn resources, although also variable, appear to be stable. The fishery has a high bycatch and the discard rate can be up to 75%. The environmental effects of the bycatch are under investigation.
- The current harvesting levels of kelps are considered sustainable; other seaweed resources are considered underexploited.
- The status of many shark resources is largely uncertain on account of the paucity of catch and other data available. Recent assessments of a number of shark species indicate, however, that these resources are overexploited.
- Sardine resources continue to be low due to successive years of poor recruitment and an eastward shift in distribution of the adult stock. Undercatches of anchovy are thought to be related more to operational issues than to resource abundance, because there has been continued strong recruitment in the anchovy resource in recent years.
- The outlook for the South Coast rock lobster resource is positive, the previously declining catch rates having been arrested through a number of management interventions that were implemented in 2000/2001.
- Catches of squid are variable from year to year but stable, and the current level of effort in this fishery appears sustainable.
- Swordfish and southern bluefin tuna resources were assessed by the regional fisheries management organisations during 2009. Swordfish were considered to be underexploited in the Atlantic Ocean but overexploited in the Indian Ocean. Southern bluefin tuna resources are considered to be overexploited.
- After severe depletion of the West Coast rock lobster resource, as a result of overfishing and reduced growth rates, it is beginning to show signs of recovery under the current operational management procedure.
- White mussel resources are considered to be underexploited. Research is underway to address the paucity of information on this and other small invertebrate resources.

Underexploited	Optimally Exploited	Overexploited, threatened, endangered or collapsed	Status uncertain
Swordfish Round herring Seaweeds	Shallow-water hake Anchovy Sardine Albacore Yellowfin tuna Bigeye tuna Squid South Coast rock lobster Prawns Oysters (KZN) Kelps	Deep-water hake Southern bluefin tuna Linefish (not individually listed) Netfish Abalone West Coast rock lobster Oysters (South Coast)	Agulhas sole Cape horse mackerel Patagonian toothfish Sharks Some linefish White mussel Other invertebrates

About the report

The purpose of this report is to make available information related to the current status of South Africa's major fish stocks. This report largely reflects the work of the Scientific Working Groups of the former Marine and Coastal Management (now Fisheries Research) up to and including 2009. Scientific Working Groups consisting of both internal and external parties are appointed biannually to evaluate available data and to assess the status of the fish stocks. The primary role of these groups is to advise on the status of marine living resources and on the level at which the resource can be exploited sustainably (the total allowable catch or total allowable effort). The Scientific Working Groups also provide advice on improving the accuracy of the status assessments and the research required to affect this, and on other scientific aspects pertaining to the resources.

Information presented in the report

The report is organised on a resource-by-resource basis. For each resource, the following information is provided:

- *Quick-view assessment* — This appears at the beginning of each section, and is colour-coded for ease of reference.
- *Introduction* — A brief introduction of the resource.
- *History and management* — The history and management of the fishery or resource.
- *Research and monitoring* — Provides background as to what data collection procedures are in place for that resource, and what information is used to assess the status of the resource. Information on future planned research may also be included.
- *Current status* — This highlights the status of the resource as currently assessed and, where available, includes the projections for the future of the fishery or resource.

Abalone

Underexploited	Optimally exploited	Overexploited, threatened, endangered or collapsed	Status uncertain

Introduction

Abalone *Haliotis midae*, locally called 'perlemoen', is a large marine snail that is a highly prized seafood delicacy in the Far East. Abalone are slow-growing, reaching sexual maturity at around seven years of age, and take approximately 8–9 years to reach the minimum legal size of 11.4 cm shell breadth (SB). They reach a maximum size of 18 cm SB, and are believed to live to an age of greater than 30 years. They occur in shallow waters <20 m depth, but the highest densities occur in waters <5 m depth.

Abalone are widely distributed around the South African coastline, from St Helena Bay on the West Coast to just north of Port St Johns along the East Coast. Historically, the resource was most abundant in the region between Cape Columbine and Quoin Point, where it supported a commercial fishery for almost 60 years. Along the East Coast, the resource was considered to be discontinuous and sparsely distributed and as a result no commercial fishery for abalone was implemented there. However, harvesting of abalone along the East Coast was allowed for a number of years through the allocation of experimental permits and subsistence exemptions. The recreational sector also targeted abalone for many years, but due to the decline in the resource, this component of the fishery was suspended in 2003/2004.

Once a lucrative commercial fishery, earning up to approximately R100 million annually at the turn of the century, rampant illegal harvesting and continued declines in the abundance of the resource resulted in a total closure of the fishery in February 2008. The resource has also been heavily impacted by an ecosystem shift that was brought about by the migration of West Coast rock lobster into two of the main (most productive) fishing areas.

History and management

The fishery for abalone started in the late 1940s. During the early phase, the fishery was dominated by five large abalone processing plants. Initially, catches were unregulated, and reached a peak of almost 3 000 tonnes (t) in 1965 (Figure 1). By 1970, catches had declined rapidly, although the fishery remained stable with a total annual catch of around 600–700 t

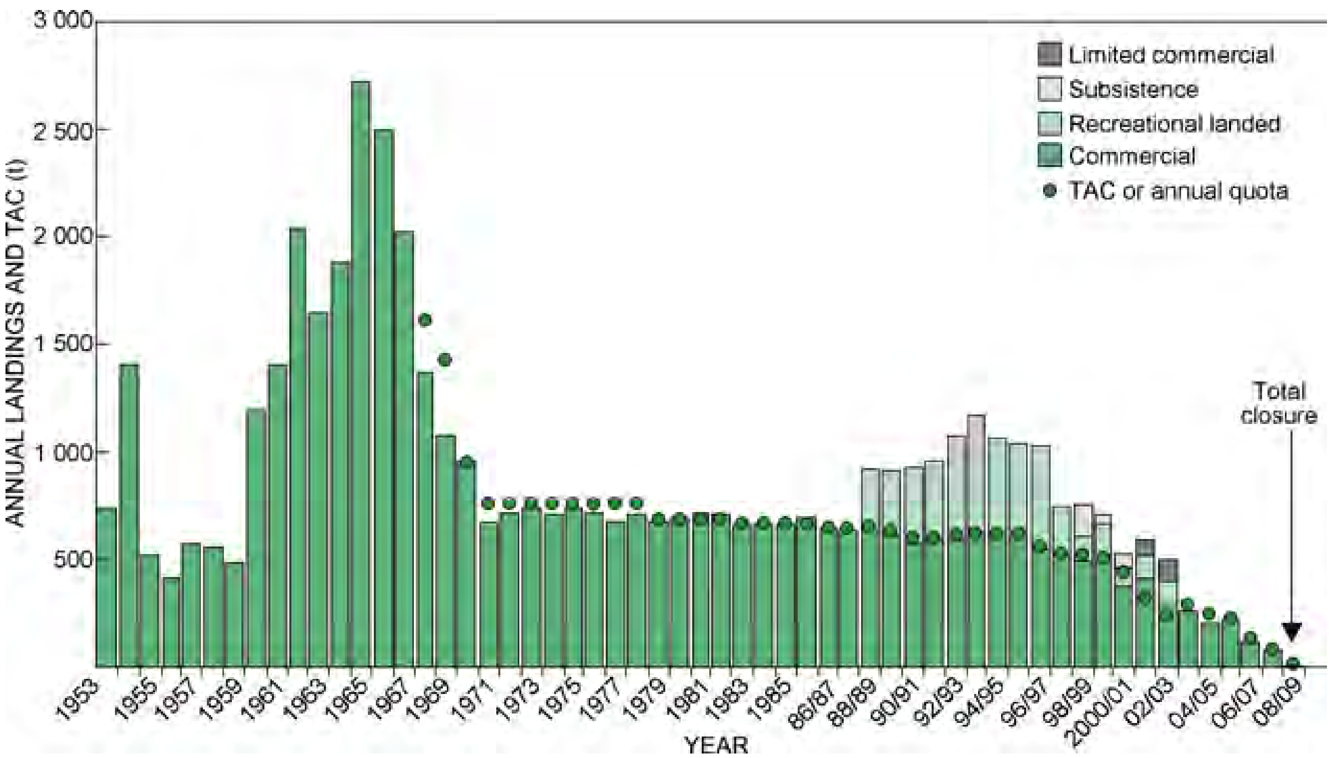

Figure 1: Total allowable catch (TAC) and recorded (legal) annual landings for the abalone fishery from 1953 to 2008/2009. Landings for the recreational sector are only available since 1988/1989. Note that the substantial recent illegal catches are not shown

until the mid-1990s, after which there were continuous declines in catches.

The early 1990s saw the booming of the recreational fishery, and a significant increase in illegal fishing activities. Continued high levels of illegal fishing and declines in the resource led to a closure of the recreational fishery in 2003/2004.

Transformation of the fishery in post-apartheid years sought to increase participation in the fishery, particularly by people who had been previously marginalised. Subsistence rights were introduced in 1998/1999, and were replaced by two-year medium-term rights. In 2003/2004, 10-year long-term rights were allocated, broadening participation in the fishery to some 300 right-holders. At this time, the previous management zones were replaced with Territorial User Rights in Fisheries (TURFs), aimed at developing a sense of ownership of the resource by the new right-holders and, in so doing, introduce co-management of the resource and improve compliance with regard to illegal fishing activities.

Illegal fishing, however, remained high despite the introduction of TURFs and increased compliance effort, including strengthening of the compliance fleet, introduction of stricter penalties for offenders, and controls on international trade through listing of South African abalone on the Convention on International Trade in Endangered Species (CITES).

Confiscations of illegally caught abalone increased rapidly from the turn of the century, with a record high of more than one million abalone being confiscated in 2006 (Figure 2). It is estimated that an average of 14% of all poached abalone are confiscated, and this can be used to estimate the total number of abalone caught illegally. It is thus estimated that the illegal catch of abalone far exceeded the commercial catch (by as much as 10 times) over the past decade.

Although illegal fishing of abalone occurs in all areas, its concentration has shifted from one area to another over the years in response to resource abundance and law enforcement presence. Illegal fishing is not selective with regard to the size of abalone taken, and almost two-thirds of confiscated abalone is below the minimum legal size of 11.4 cm SB. Therefore, most of the illegally caught abalone are taken before having had the opportunity to reproduce.

The continued high levels of illegal fishing and declines in the resource prompted the total closure of the fishery in February 2008. Therefore, most of the illegally caught abalone are then taken before having the opportunity to produce.

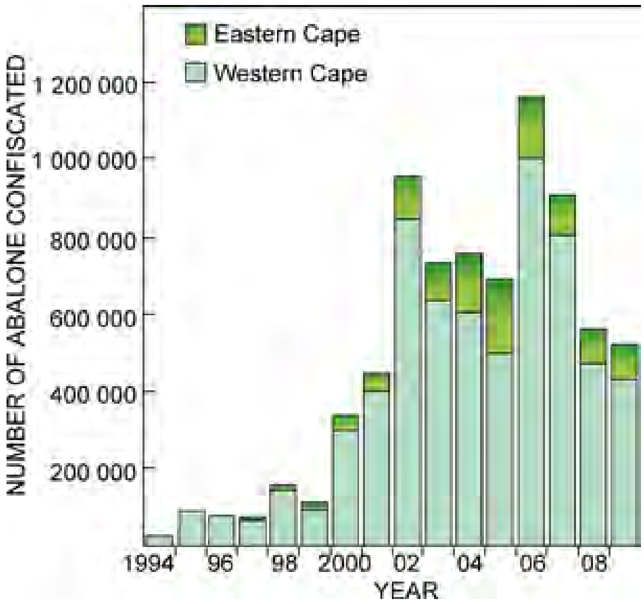

Figure 2: Number of abalone confiscated annually from 1994 to 2009

Research and monitoring

Data from both the fishery and research surveys are used to assess the abalone resource. The commercial fishery was monitored by recording landings at slipways, catch returns by right-holders and monitoring of the size of abalone caught. Commercial catch data are available from 1953, and catch per unit effort (CPUE) data from 1980.

Data on the recreational fishery were collected by means of telephone surveys and validated by recording the details of catch and effort at dive sites from 1992 to 2002. These data provided estimates of total catch, CPUE and trends in the size of abalone harvested.

Data on abalone abundance has been derived from fishery-independent abalone surveys (FIASs) since 1995. Twenty fixed lines are surveyed annually by scuba. The number and size of all abalone >100 mm in length are recorded to provide an index of abundance. Recruitment surveys were undertaken annually from 1988 to 1993 and provided evidence of an ecosystem shift, with a decline in sea urchins and juvenile abalone in some

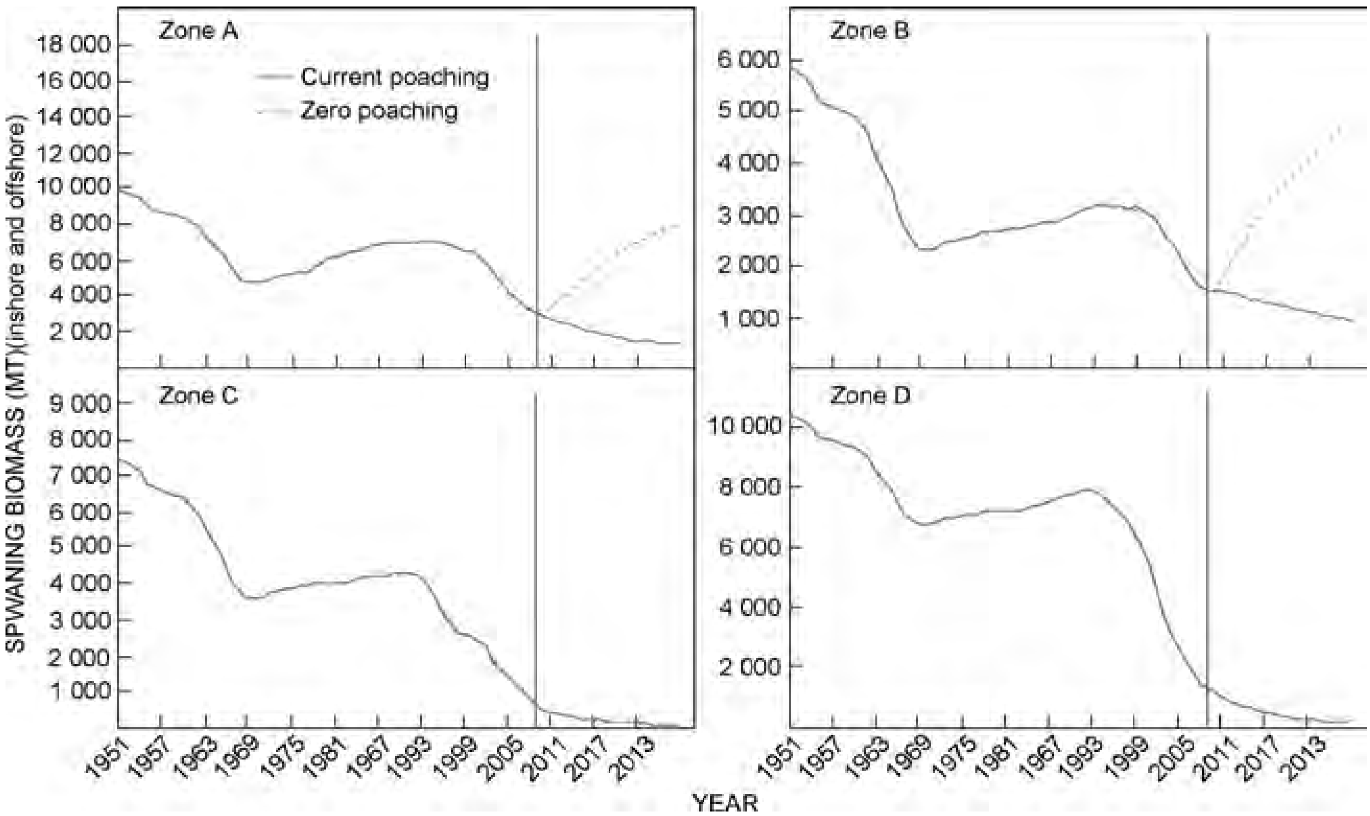

Figure 3: Model spawner biomass estimates for Zones A-D. The 20-year future projections (shown to the right of the vertical bar) assume that poaching catches will remain constant at the current estimated level (average of 2008 and 2009) and future commercial catches are set to zero (solid line). An illustrative scenario of future poaching and commercial catches both set to zero (the dashed line) is also indicated. Results for Zones C and D are indistinguishable from the projections that include poaching

areas, and a simultaneous increase in the abundance of West Coast rock lobster. This ecosystem shift remains unexplained, although research is currently underway to investigate the possible causes.

The illegal sector is monitored by sampling confiscated abalone to obtain estimates of poaching trends and total illegal catch per zone.

In the main fishing areas on the South Coast, the resource is assessed by means of a spatially explicit age-structured production model using commercial CPUE, FIAS, and catch-at-age information inferred from catch-at-length data. The model also estimates the illegal catch and the reduction in recruitment of juvenile abalone due to ecosystem changes. Since 2006, a simple version of a discrete Schaefer model has been used in the assessment of the abalone resource on the West Coast. The biomass dynamics model is fitted to catch and CPUE data in order to predict future trends in abalone abundance. Robben Island is not subject to such model analyses because of data limitations, and advice for this zone is based on inspection of trends in CPUE, FIASs and size composition data.

Priority research areas for the future include extending the population surveys geographically and with depth, studies on abalone aggregation dynamics, and the extent to which the potential of abalone to reproduce could be affected by the density of abalone in an area, as well as further studies on recruitment.

Current status

The latest assessment, conducted in 2009, estimates that the abalone resource along the South Coast is currently at 19% of the pre-exploitation spawner biomass level. This varies between areas from 31% to only 8%. This also varies by depth, from 20% to <1% in the shallower waters (<5 m) and from 58% to 25% in the deeper waters (<10 m). The shallow-water estimates are considered to be more reliable due to the quality of data available. Estimates indicate declines in spawner biomass in all areas during the past year. Model projections of spawner biomass for the South Coast indicate that further declines in spawner biomass are likely in all four zones if the current levels of illegal catch continue (Figure 3). At low levels of abundance, the possibility of an 'Allee effect' (reduced reproductive efficiency) needs to be considered.

Although there are indications of a declining trend in illegal catch from 2002 to 2009, the levels are still high and unsustainable. Of the 940 t estimated to have been caught illegally on the South Coast in 2009, 793 t (84%) is estimated to have been caught in the area between Gansbaai and Cape Agulhas (Zones A and B). Note that models of the resource in this area show that if future poaching could be eliminated, the spawner biomass would be likely to increase quite rapidly, indicating the potential for resource growth in these zones (Figure 3). Similar upward trends are not evident in the area between Cape Hangklip and Gansbaai (Zones C and D), because of the ecosystem shift and the incursion of West Coast rock lobsters into this area, which inhibits the re-establishment of abalone there.

The total biomass estimates for the West Coast (west of Cape Point to Saldanha Bay) are much lower than the previous years' model estimates. The last assessment indicated a slight decline in biomass in the area between Cape Point and Cape Town Breakwater, and a slight increase in biomass in the area north of Cape Town to St Helena Bay over a 10-year projection, if the current estimated levels of illegal catch continue. At Robben Island, a substantial decline in the CPUE has been observed over the past two years, although this period is not long enough to confirm whether this is indeed a negative trend in the abundance of the resource. There was also a decline in the mean size of the commercial catch over the past two years of the fishery. However, the latest surveys around Robben Island indicated a high average density of abalone. The CPUE, size trends and densities thus require continued monitoring.

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Agulhas sole

Underexploited	Optimally exploited	Overexploited, threatened, endangered or collapsed	Status uncertain

Introduction

Agulhas or East Coast sole *Austroglossus pectoralis* are referred to as flatfish because they lie on the seabed on their sides. During larval settlement, both eyes migrate to one side of the head, and well-developed fins encircle the body. They are bottom-dwelling, in sand or silt, and feed on small crustaceans, molluscs, worms and brittlestars in water between 10 m and 120 m depth. They are, however, occasionally also caught in deeper water during research surveys conducted in April and September (Figure 4). Although maximum total length is documented as 58 cm, the average size caught in research surveys (1984–2010) is 25 cm.

Agulhas sole are a small – but commercially important – component of the mixed-species inshore trawl fishery on the South-East Coast, the other target species being hake and horse mackerel. The annual TAC is worth approximately R30 million in 2009, but landings totalled approximately R12 million a year, and in 2010 there were four (excluding one that was lost in a storm in 2009) small inshore vessels dedicated to catching sole and another four vessels that catch mainly hake and some sole.

History and management

Agulhas sole have been fished since the beginning of the last century and was one of the first fish stocks to be managed in South Africa. Exploitation of Agulhas sole formed the economic base for the fishery on the Cape South Coast and was the driving force for the development of the coastal fishing fleet.

The first concerted attempt at managing the Agulhas sole fishery was made in 1935, with the introduction of a 75-mm minimum mesh size for bottom trawl nets. A TAC of 700 t was first introduced in 1978, and individual quotas were introduced

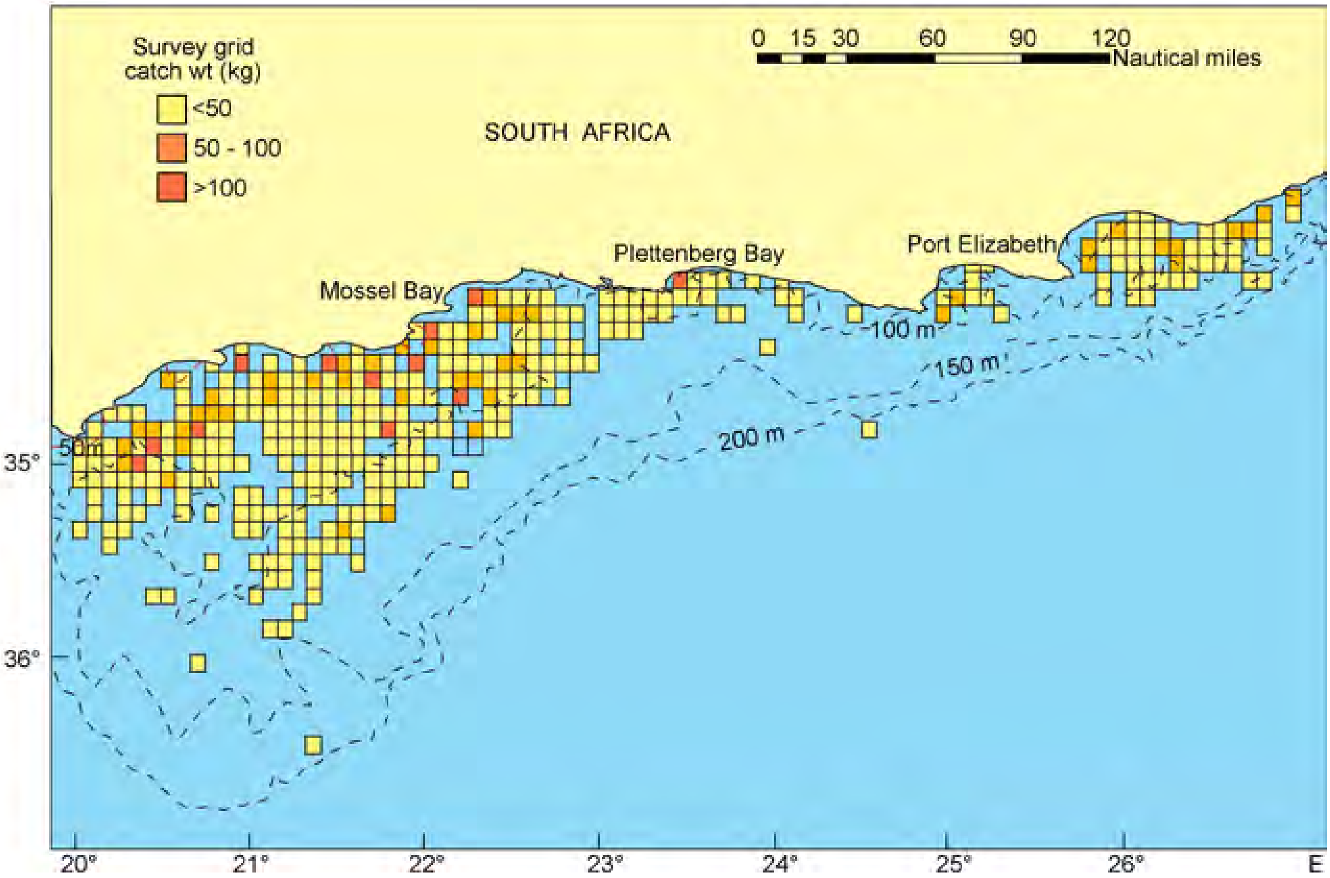

Figure 4: Distribution of Agulhas sole catches during research surveys conducted since 1985

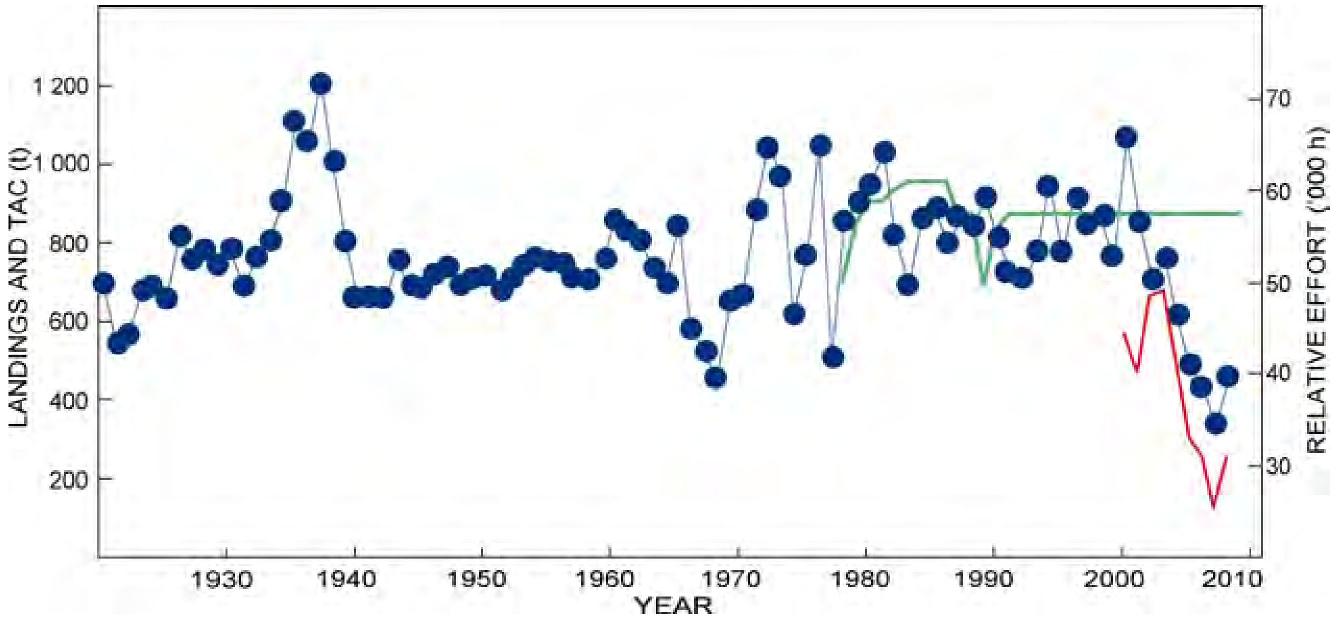

Figure 5: Annual landings and TAC for Agulhas sole on the south-east coast of South Africa, 1920–2009

in 1982. The TAC remained fairly stable thereafter, varying between 700 t and 950 t (Figure 5). From 1989 to 1999, the resource was assessed annually through a modelling approach. Since 1992, however, due to doubts regarding the reliability of the model, the fishery has been managed on a constant TAC of 872 t.

Several factors have influenced the performance of the inshore trawl fishery over the years: including a change from a fishery targeting Agulhas sole in the 1930s to one targeting several species in the late 1970s; management interventions such as the introduction of a global quota system in 1978; individual quotas in 1982; stricter enforcement of the mesh size regulation; boat limitation; fleet rationalisation; closure of certain (nursery) areas to fishing to protect juvenile Agulhas sole; and, more recently, the prevention of within-season trading in quotas.

The objectives for the fishery are to maintain a stable TAC, provided that there is no indication that this is depleting the resource, and to develop a refined assessment to determine whether this TAC might be increased while still remaining sustainable.

Research and monitoring

Abundance estimates are derived from direct surveys using the swept area method. Surveys to estimate abundance were conducted annually from 1986 to 1989, and thereafter biannually (Figure 6). However, for technical reasons, only one survey per year was completed in 1996, 1997, 1999, 2001 and 2005, and none in 1998, 2000 and 2002. The trawl gear on the FRS *Africana* was changed in May 2003 and indices from surveys using the new gear are not directly comparable to those from surveys using the old gear. An Agulhas sole-directed survey was put in place, and four surveys have been successfully completed since September 2006.

There are large within-year differences between survey abundance indices. In some years these fluctuations are too large to be attributed to changes in absolute abundance of the resource, and environmentally induced changes are considered the primary driver of Agulhas sole availability during surveys.

Current status

The decline in annual sole catch since 2000, and apparent undercatching relative to the annual TAC (Figure 5), was initially due to management interventions to compensate for earlier overcatches and were well within the historic interannual variation. The sole catch rate for five small (engine power <250 kW) specialist vessels fishing on the sole grounds has essentially been constant since 2002, indicating that the decline in catches is probably not caused by a reduction in either the abundance or availability of soles on the sole grounds. Instead,

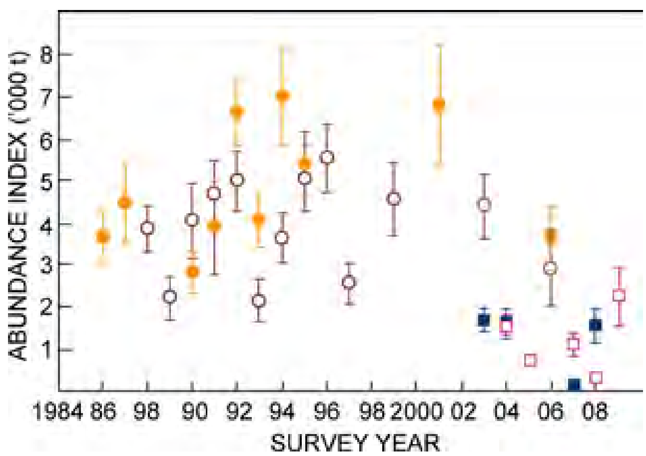

Figure 6: Spring (solid symbol) and autumn (open symbol) survey biomass estimates with 95% confidence intervals for the Agulhas sole resource on the south-east coast of South Africa, 1984-2009. Old trawl gear (circles) and new gear (squares)

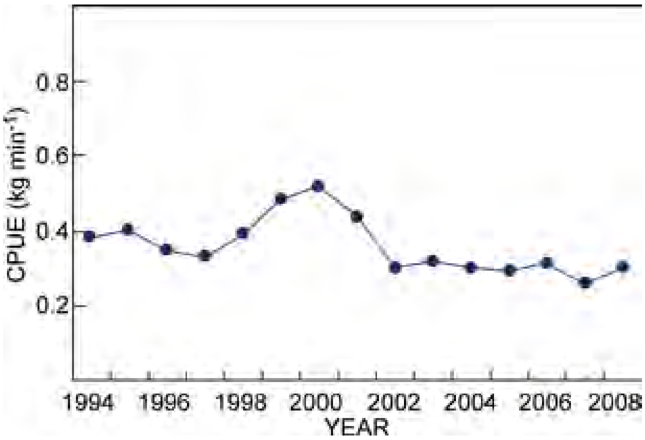

Figure 7: Standardised CPUE for five small Agulhas sole specialist vessels on the Agulhas sole grounds, 1994–2009

the undercatches since 2004 are considered to be caused by operational and economic constraints.

Right-holders in the inshore trawl sector require both hake and sole allocations as the two species are generally caught together. However, the ratio of hake to sole in the catches on and off the sole grounds fluctuates. Historically, within-season trading of hake and sole quota was used by right-holders to adjust their hake and sole allocations to the fluctuations in the hake:sole ratio. Since the introduction of medium- and long-term rights, within-season trading of quota is no longer permitted and it is very difficult for right-holders to balance their hake and sole allocations.

Catches per calendar year (since 1920) and TAC (since 1978) are illustrated in Figure 5. It is important to draw a distinction between calendar–year catch (as used in the assessment models) and quota–year catches (used for resource management purposes), as a quota year does not coincide with a calendar year. Therefore, where the catch in a calendar year is above or below the TAC in Figure 5, it does not necessarily reflect over- or undercatch of the TAC. For example, the fleet was tied up for five months in 1999 and was subsequently allowed to hold catches taken before March 2000 against their 1999 allocations, resulting in the catch in the 1999 calendar year being below the TAC and the catch in 2000 above it. Similarly, management action in response to an overcatch of the 2001 allocation resulted in 37 t of the TAC being withheld and contributing to the apparent undercatch in 2002.

There is substantial interannual variability in the time-series of annual catches (Figure 5) and catch rates. Again, this variability is thought to be driven primarily by environmentally induced fluctuations in sole availability linked to strong north-west fronts, although the decline over the period 2003-2007 was attributed to operational and economic constraints.

In years of depressed sole availability, the situation is sometimes exacerbated by hake moving off the traditional sole grounds, which results in a reduction in the associated hake catch. This situation renders sole-directed fishing less profitable, and consequently some vessels (particularly the larger vessels) concentrate more on hake and some sole allocations are not fully utilised. The CPUE series based on five specialist vessels operating in the fishery is shown in Figure 7, which suggests little recent change in abundance.

In summary, both survey abundance and CPUE trend indications do not suggest any negative impact of the fishery on the stock.

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Cape hakes

Underexploited	Optimally exploited	Overexploited, threatened, endangered or collapsed	Status uncertain

Introduction

The demersal fishery off southern Africa started with the arrival to the Cape of a purpose-built research vessel, *Pieter Faure*, in 1897 and the first commercial trawler, *Undine*, in 1899. Initially, Agulhas sole and West Coast sole *Austroglossus microlepis* were the primary target species, but this changed with the discovery of the vast hake resource off the West Coast. From these humble beginnings, the demersal fishery, based on the Cape hakes, has developed into the most important fishery in the region.

The Cape hakes are distributed on the continental shelf and upper slope off southern Africa from southern Angola to southern Mozambique. The fishery is based on two species, the deep-water *Merluccius paradoxus* and shallow-water hakes *M. capensis*. The resource supports four fishery sectors: off-shore trawl, inshore trawl, hake longline, and hake handline. In addition, hake are taken as bycatch in the horse mackerel and demersal shark longline fisheries, and to a small extent in the recreational sector. As the names suggest, the distributions of the two hake species differ with depth, but there is substantial overlap in their distributions. On the West Coast, the continental shelf is fairly narrow so trawling is in deep water beyond the shelf edge, and as much as 90% to the hake catch in this region is deep-water hake. In contrast, most trawling on the South Coast is on the wide continental shelf, the Agulhas Bank, and as much as 70% of hake catches on this coast are shallow-water hake. However, as it is difficult to distinguish between the two hakes, they are processed and marketed as a single commodity.

The income from hake alone is roughly equal to the total gross income from all other South African fishery resources combined.

History and management

The hake fishery began at the turn of the 19th century. The incursion of foreign fleets during the 1960s resulted in a massive

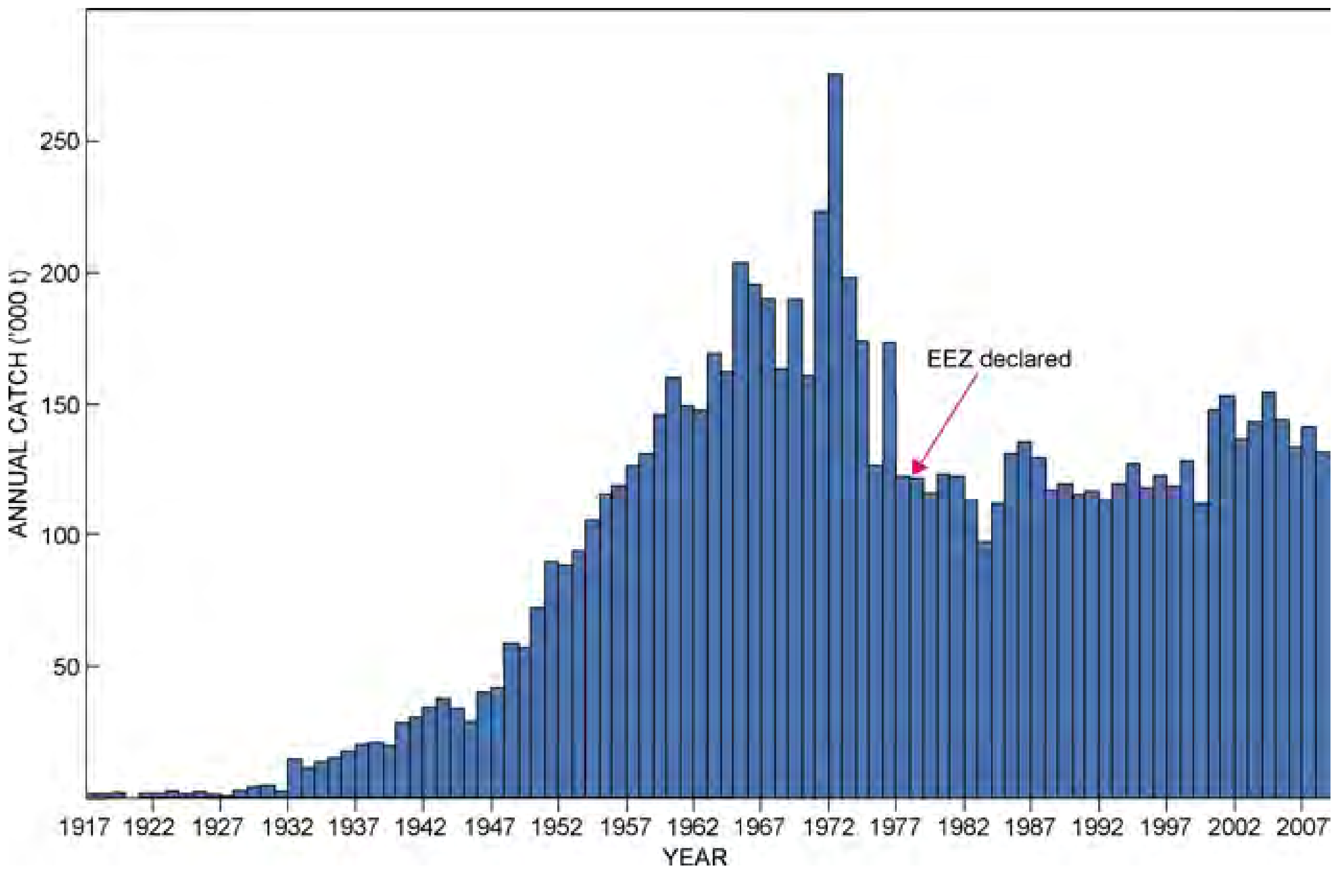

Figure 8: Annual catch of Cape hakes off South Africa, 1917–2008

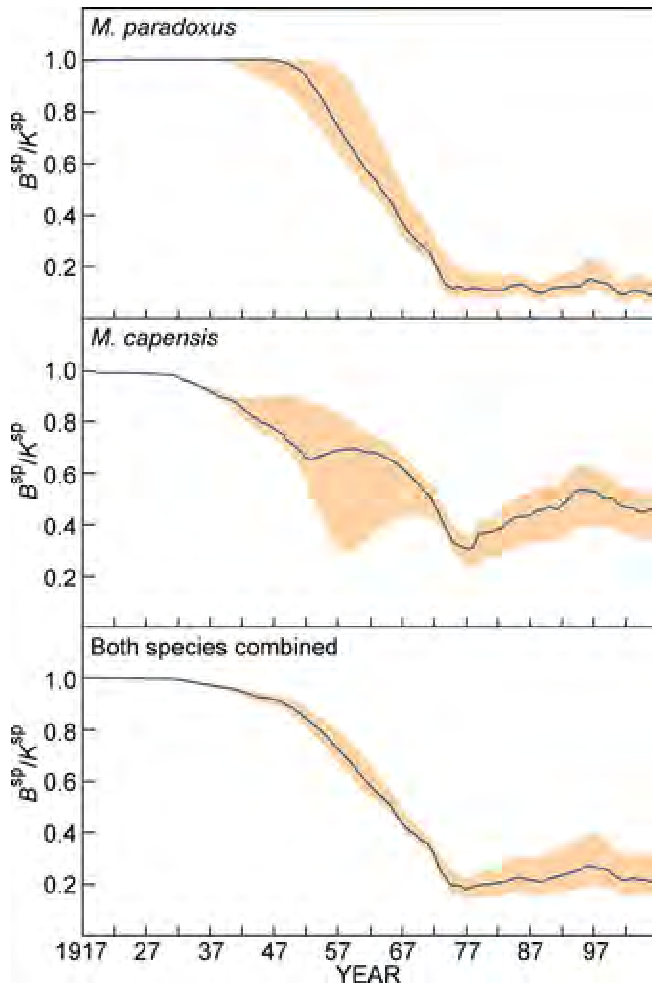

Figure 9: Estimated status (current biomass as a proportion of pristine biomass) for (a) deep-water hake *M. paradoxus*, (b) shallow-water hake *M. capensis* and (c) both species combined. The solid line represents the median value and the shaded area the full range around the median, 1917–1999

increase in effort and catches (Figure 8). Prior to 1950, catches seldom exceeded 50 000 t, but by 1972 annual catches off southern Africa were in excess of 1.1 million tonnes. In 1972, the International Commission for the South-East Atlantic Fisheries (ICSEAF) was formed to control the fishery. In 1977, the declaration of a 200 nautical mile Exclusive Economic Zone (EEZ) by South Africa, together with the introduction of other management measures,resulted in some recovery in the hake fishery (Figure 9).

Because of the substantial overlap in distribution and the difficulty of distinguishing between the two hake species, species-specific catch-and-effort data are not available from the commercial fishery, and the two species have traditionally been assessed and managed as a single resource. Although not ideal, this approach was adequate as long as the relative contribution by each species to the commercial catch remained more or less constant over time. However, the development of a longline fishery, which mainly targetted shallow-water hake, and of the premium market for large hake, resulted in a substantial change in the relative contribution by each species to the commercial catch. This has necessitated the development of species-specific assessment models, although the two species are still managed as a single resource.

The hake resource is currently assessed using species-specific age-structured models, which, in 2006, indicated that the shallow-water hake resource was underutilised whereas the deep-water hake resource was severely depleted. However, because it is not possible to harvest the two hake species separately, species-specific management is not practical and hake resources (both species combined) is managed under an Operational Management Procedure (OMP), implemented in 2006 and aims to recover the deep-water hake resource to 20% of its pre-exploitation levels over a 20-year period. In addition, the OMP restricts fluctuations in the TAC to a maximum of 10% between years in order to provide stability to the industry.

Implementation of this OMP led to reductions in the TAC from 2007 until 2009. Projections indicated that TACs would increase slowly thereafter. In response, it was predicted that the commercial fishery would experience an increase in catch rate (measured as CPUE) of approximately 50% by 2017, and that this increase in CPUE would be evident before increases in the TAC were affected.

Uncertainty remains as to the extent to which the deep-water hake resource is shared between South Africa and Namibia, and the influence of catches by the two fisheries on the resource as a whole. At present, the two fisheries are managed independently, although the established Benguela Current Commission aims to work towards joint management of this resource.

Research and monitoring

Data are collected from both the commercial fishery and fishery-independent surveys. Catch and landings data are submitted by the industry, and on-board scientific observers are deployed on commercial vessels in order to collect scientific information. One of the uses of these data is the estimation of a standardised catch rate (CPUE) time-series using general linear modelling techniques (Figure 10).

Fisheries-independent abundance indices are determined from research trawl surveys conducted by the FRS *Africana* on the West (summer and winter) and South (spring and autumn) coasts (Figure 11). In all, 100 target stations are selected per survey using a pseudo-random stratified survey design, with

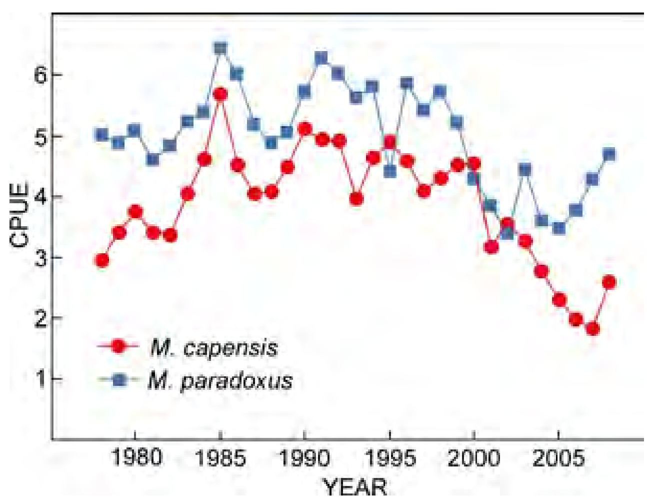

Figure 10: Standardised CPUE for the Cape hakes, 1978–2008

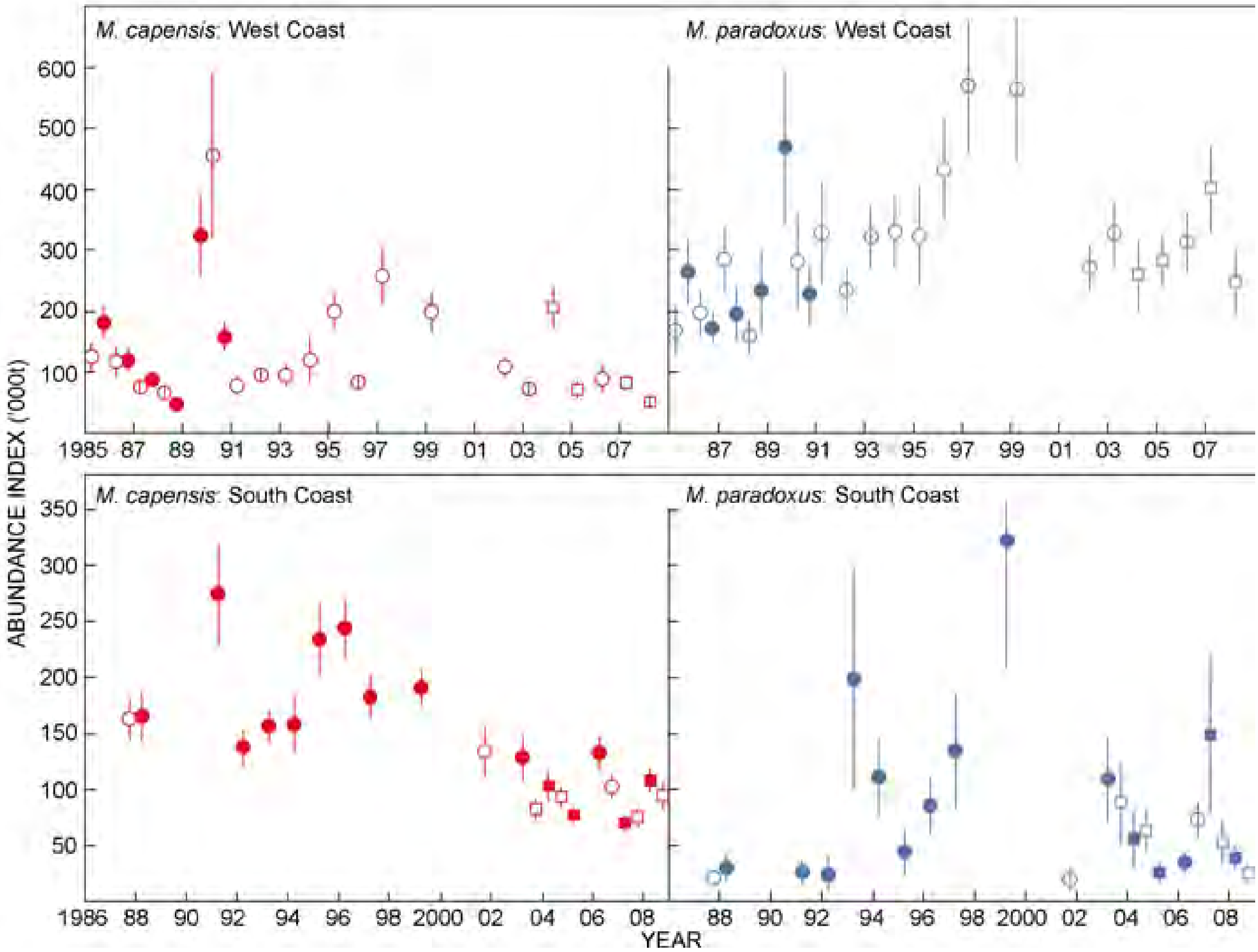

Figure 11: Survey abundance indices with 95% confidence intervals for the two species of Cape hakes on the slope and upper shelf (0–500 m) on the West Coast (1985–2008) and South Coast (1986–2009). Note that the trawl gear was changed in May 2003 and the time-series using the old trawl gear (circles) is not comparable to that using the new gear (squares). See text for further details

the number of stations per stratum proportional to the area of the stratum. Untrawlable areas are avoided and therefore excluded from the surveys. Trawling is conducted during the day only, because of the possibility of hake moving off the bottom and into the water column during the night. Abundance indices are calculated using the swept-area method, which relies on fishing methods and gear remaining constant between surveys. The necessity to change the trawl gear configuration on the FRS *Africana* during 2003 resulted in a break in the time-series.

Research is underway to investigate the stock structure of the Cape hakes using DNA and microsatellites to determine if there are genetically discrete stocks off southern Africa, and, importantly, the extent to which the deep-water hake resource is shared between South Africa and Namibia.

Current status

In line with the guidelines for OMP implementation, an in-depth stock assessment is conducted every two years. The most recent assessment, conducted during 2008, indicated that the status of the hake resource (Figure 10) was still within the applicable range. Consequently, only a routine update was conducted in 2009.

As noted above, it was expected that the TAC would be reduced annually until 2009, followed by a slow, increasing trend. While these expected reductions did occur, they were not as severe as expected (Figure 11) and the recommended TAC for 2010 is slightly higher than that for 2009, indicating that the resource may be responding positively to the recovery plan. The expected increasing trend in CPUE for deep-water hake in response to the reduced catches is evident in Figure 10.

Two associated issues need to be noted. Firstly, model testing assumed that the proportional allocation of the TAC across sectors would remain constant. Therefore, if the proportional allocation among sectors is changed, then the test results and associated projection results for the OMP may not be appropriate. Thus, it is important that adjustments of the TAC be applied evenly across sectors. Secondly, it should be noted that there is substantial overcapacity in the hake fishery. In 2006, it was estimated that the available effort should be

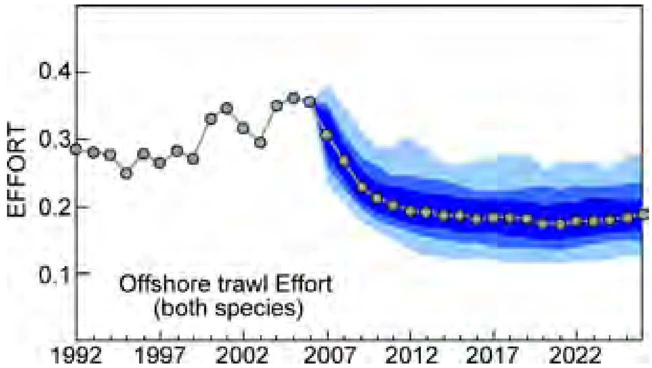

Figure 12: Projected future effort required by the deep sea fleet to catch the projected future allocations to the Deep Sea trawl sector. The shaded areas show the probability envelopes at the 50th (darkest), 75th and 95th (lightest) percentiles

reduced by at least one-third by 2011 (Figure 12). A policy aimed at matching vessel capacity to allocations as a basis for reducing capacity in the deep-sea and inshore trawl sectors has been developed and was implemented in 2008. A similar policy for the hake longline sector was developed during 2008.

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Cape horse mackerel

Underexploited	Optimally exploited	Overexploited, threatened, endangered or collapsed	Status uncertain

Introduction

Cape horse mackerel *Trachurus capensis* are semi-pelagic shoaling fish that occur on the continental shelf off southern Africa from southern Angola to the Wild Coast. They are replaced by the very similar Cunene horse mackerel *T. tracea* and African horse mackerel *T. delagoa* to the north and east respectively.

Horse mackerel as a group are easily recognised by a distinct dark spot on the gill cover and a row of scutes (spiny scales) along the lateral line. However, it is not easy to distinguish between the three species that occur in southern Africa. Cape horse mackerel generally reach 40–50 cm total length and become sexually mature at around three years of age when they are about 20 cm long. They feed primarily on small crustaceans, which they filter from the water using gillrakers that are modified for this purpose.

Historically, large surface schools of adult Cape horse mackerel occurred on the West Coast and supported a purse-seine fishery that made substantial catches. These large schools have since disappeared from the South African west coast, but still occur off Namibia where horse mackerel are the most abundant harvested fish. Off South Africa, adult horse mackerel are currently more abundant off the South Coast than the West Coast.

Adult Cape horse mackerel are taken as a bycatch by the demersal trawl fleet, and as a targeted catch by the midwater trawl fleet, mainly on the South Coast. In addition, the pelagic purse-seine fleet on the West Coast takes juveniles as a by-catch. Cape horse mackerel yield a low value product and are a source of cheap protein.

History and management

Purse-seine catches of adult Cape horse mackerel on the West Coast peaked at 118 000 t in the early 1950s and declined to negligible levels by the late 1960s (Figure 13). In the 1990s, purse-seine catches of juvenile Cape horse mackerel again

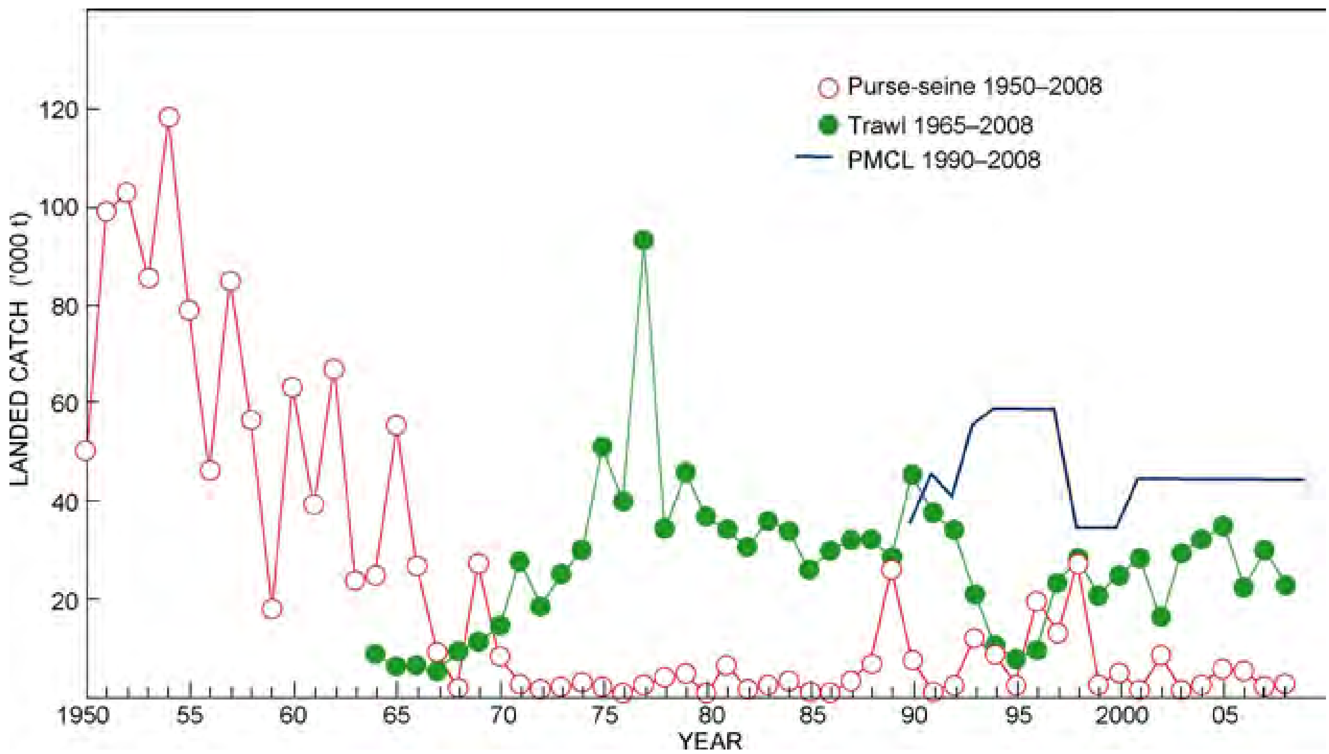

Figure 13: Annual Cape horse mackerel catches by the purse-seine and trawl fisheries, 1950–2008. The thicker line indicates the TAC/PMCL set for the trawl fishery since 1991. Note that 'Trawl' includes both bottom and midwater trawls

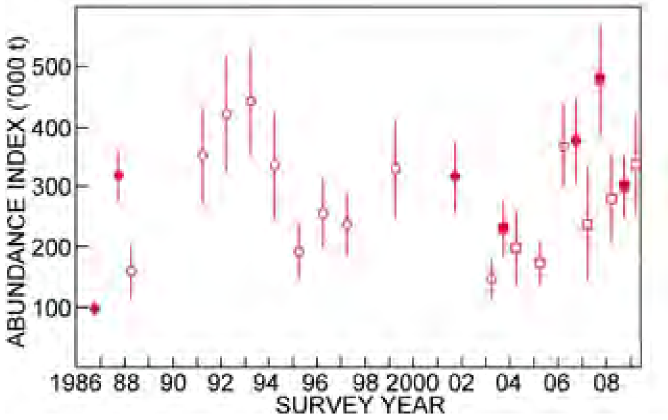

Figure 14: Spring (solid symbol) and autumn (open symbol) survey abundance indices and 95% confidence intervals for the Cape horse mackerel resource on the south-east coast of South Africa from the coast to the 500 m isobath, 1986–2009. Note that the trawl gear was changed in July 2003 and the time-series using the old trawl gear (circles) is not directly comparable to that using the new gear (squares)

showed an increasing trend, reaching 26 000 t in 1998. Although this catch level appears low compared to historic levels, the number of fish per tonne of catch in the 1990s is much greater than was the case during the 1950s. The increasing pelagic catches prompted modelling of the likely effects of large catches of pelagic juvenile Cape horse mackerel on the trawl fishery of 5 000 t for adults, resulting in the introduction of an upper limit for purse-seine catches. Since 1999, the annual purse-seine catch has averaged 3 400 t.

Trawl catches occur primarily on the South Coast and commenced in the mid-1960s, peaking in 1977 (at 93 000 t). Following the declaration of the EEZ in 1977, catches leveled off at between 25 000 t and 40 000 t. When foreign fleets were-finally phased out in the mid-1990s, annual catches (now by South African vessels only) declined to below 10 000 t between 1994 and 1997. Whereas demersal trawl catches have remained low, the re-establishment of a midwater fishery for Cape horse mackerel in 1997 has resulted in an increase in the annual catch (Figure 13).

Biomass has not been determined with a high degree of confidence and the accuracy of resource assessments is such that only precautionary management catch limits (PMCL) have been set for the demersal trawl fishery since 1992 (Figure 13). A portion of the PMLC is allocated for directed midwater trawl and the remainder (28%) is held as a bycatch reserve for the demersal trawl sector. The pelagic fishery for sardine and anchovy is also subject to a bycatch limit for juvenile Cape horse mackerel. At present, the PMCL in the demersal fishery is 44 000 t, and bycatch of Cape horse mackerel in the pelagic fishery is limited at 5 000 t.

Research and monitoring

Cape horse mackerel are semi-pelagic, i.e. they range throughout the water column from the surface to close to the seabed.

When they are close to the seabed (normally during the daytime) they are available to demersal trawls, but cannot be detected by acoustic methods. In contrast, at night when they are off the bottom, they can be detected acoustically, but cannot be sampled by demersal trawls. Thus, neither demersal trawl nor acoustic survey methods are capable of accurately estimating horse mackerel abundance. Furthermore, as the proportion of the resource detectable by either demersal trawl or acoustic methods is highly variable, there are substantial variations in abundance estimates between surveys. In an attempt to resolve this problem, a number of joint demersal trawl/acoustic surveys have been conducted over the past 15 years, the last in 2006. Further surveys have not been conducted due to budget and ships' time constraints.

These surveys have met with variable success, but despite these limitations, the time-series of abundance indices from the demersal trawl surveys (Figure 14) are the best available fishery-independent abundance indices.

Current status

In 2007, a routine update of the existing assessment model was carried out, taking account of updated catch data (Figure 13) and further demersal trawl survey swept-area estimates of abundance (Figure 14). The results and projections under current catch levels were very similar to those obtained previously, upon which past recommendations have been based. Thus, no negative impacts from recent levels of catch were detected, and maintenance of the current levels of catch limitation is considered appropriate. An update of the model was not carried out during 2009 as there were very little new data available, and it was clear that these would not have changed the results to the extent that would have necessitated a change in management advice.

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Linefish

Underexploited	Optimally exploited	Overexploited, threatened, endangered or collapsed	Status uncertain

Introduction

Linefishing in South Africa is defined as the capture of fish with hook-and-line, but excludes the use of longlines. Together, the three sectors of the linefishery (commercial, recreational and subsistence) target between 95 and 200 of the South Africa's 2 200 marine fish species.

Linefish species are predatory and include a number of apex predators such as sharks, groupers, tunas, red steenbras, etc. Most linefish are not exclusively targeted by this fishery but form important components of the catch or the bycatch of other fisheries.

The commercial sector is exclusively boat-based. The total number of registered vessels operating in the commercial linefishing sector was estimated at 700 in the late 1990s, which accounted for 37% of all boats operating in marine fisheries in South Africa. Currently, 455 boats are in operation. Commercial linefishing is a low-earning, labour-intensive industry, important from a human livelihood point of view. Employing an estimated 27% of all fishers, it has the lowest average employment income compared to all South African fisheries. Although the commercial linefishery has the largest fleet, because of a low vessel market value it contributes only 6% of the total estimated value of R2 billion for all marine fisheries.

The recreational boat-based sector expanded rapidly after the introduction of the trailable skiboat in the 1970s, with an estimated minimum of 4 000 vessels.

The subsistence category was legally created in 2000 to recognise those fishers who depend on the resource for food directly – usually poor communities or those using traditional methods. There are almost 30 000 subsistence fishers active along the South African coastline, and 85% of them harvest linefish.

History and management

The origins of linefishing in South Africa can be traced back to the fishing activities of indigenous Khoi people and European seafarers in the 1500s. Despite an abundance of fish, the fishery was slow to develop in the 1700s due to various restrictions implemented by the Dutch administration. These fishing restrictions were removed when the British captured the Cape Colony in 1795 and during the 1800s boat-based linefishing developed into a thriving industry.

Fishing effort in the Cape at the turn of the 19^{th} century was already quite considerable (between 0.12 and 0.37 boats per kilometre of coastline). This increased dramatically during the 20^{th} century and peaked in the 1980s and 1990s (>3 boats per kilometre of coastline). The sharp increase of fishing effort, together with the increase in operational range through the introduction of motorised skiboats on trailers, and the rapid development in fishing technology (echosounders, nylon line, etc.), lead to overfishing of most of the linefish re-sources around the coast during the last quarter of the 20^{th} century.

Despite its long history, the first comprehensive management framework for the linefishery was introduced in 1985. However, successive research surveys indicated continuing declines In December 2000, the Minister of Environmental Affairs and Tourism, taking cognicance of the critical status of many linefish stocks, declared the linefish resource to be in a State of Emergency, as provided for in the Marine Living Resources Act (MLRA, Act 18 of 1998). To rebuild collapsed stocks and to achieve a sustainable level of utilization, a Linefish Management Protocol was developed in 1999 in order to base regulations in the linefishery on quantifiable reference points.

A number of regulations were put in place to manage fishing pressure on linefish resources. Due to the large number of users, launch sites, species targeted and flexibility of the operational range, the commercial linefishery is currently managed through a total allowable effort (TAE) allocation. The recreational fishery is managed by a number of measures, such as size and bag limits, closed areas and seasons, etc. The subsistence fishery is managed through a combination of these.

The level of commercial effort was dramatically reduced when linefish rights were allocated in 2003 for the medium-term and in 2005 for the long-term fishing rights. TAE was set to reduce the total catch by at least 70%, a reduction that was deemed necessary to rebuild the linefish stocks. There has been a reduction in fishing pressure through the implementation of more realistic species-specific daily bag and size limits since 2005.

Although there appears to be a substantial reduction in the linefish effort, it must be noted that trends in the catch information derived from the historic commercial landings for the period 1985–1998 indicate that a relatively small number (20%) of the vessels in the fishery accounted for the majority (80%) of the reported catches, and these highly efficient vessels have remained in the fishery. Moreover, the actual effort has consistently exceeded the TAE recommended for resource recovery due to high levels of illegal activity, effort creep through crew exemptions, 'interim relief' measures, and uncontrolled subsistence fishing in sensitive estuarine and nearshore habitats.

Research and monitoring

Monitoring of the boat-based linefishery in the Cape was introduced by Dr JDF Gilchrist in 1897, in the form of a shore-

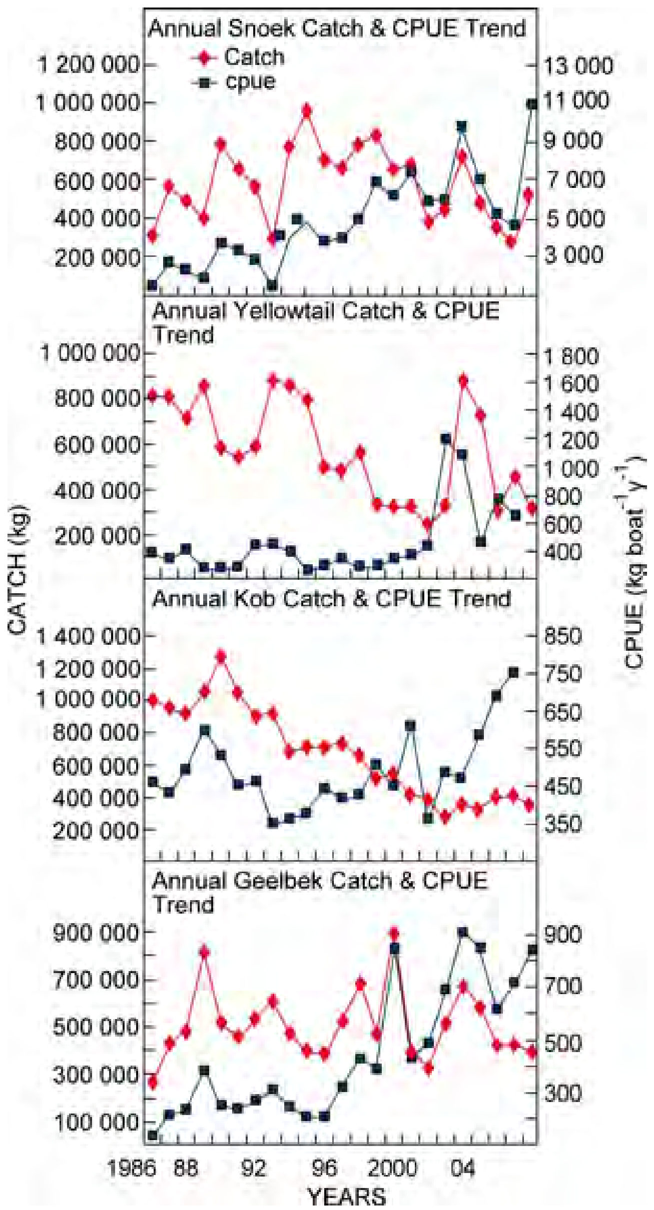


Figure 15: Commercial boat catch (diamonds) and CPUE (squares) trends for the four most important linefish species, presented since the inception of the National Marine Linefish System in 1985, 1986–2009

based observer programme that aimed to record statistics on catch and effort at all the fishing centres. Comprehensive per-species catch-and-effort data on the boat-based commercial fishery have been collected since 1985 and stored in the National Marine Linefish System (NMLS). Although these data are insufficient to determine total catch, because they are based on skipper estimates and are subject to fluctuations in reporting accuracy, they have been shown to provide reliable trends for resource abundance for many species.

A national observer programme was initiated in 2008, in which shore-based observers confirm recorded catch-and-effort data and collect size frequencies per species from the boat-based fishery at fishing hotspots around the country. These data will be vital in the stock assessment for many of the commercially important species.

In 2008, the catch location information for the commercial linefishing fleet has been converted to grid data with a 5×5 nautical mile resolution, for the first time permitting spatial analysis of the commercial linefishing effort and catch. Since then, Geographical Information System (GIS) layers based on these data have been developed for inshore and offshore marine protected area planning.

On account of the enormous numbers of recreational shore-anglers (estimated to be in excess of half a million), comprehensive monitoring of the recreational fishery on a national basis is not feasible. However, regional programmes in KwaZulu-Natal (KZN), and the Eastern and Western Cape monitor shore- and boat-based recreational effort at selected locations.

During the 1980s and 1990s, research focused on the life history and biology of the linefish species. The 21st century saw more research on movement patterns of linefish species and on the effectiveness of marine protected areas (MPAs) in linefish management. The results of a recent study in the Goukamma MPA suggest that if properly placed, MPAs not only provide protection for the breeding stocks of resident linefish, but they are also responsible for an increased catch of these species in adjacent fishing grounds. Research into the movements of linefish within the West Coast National Park suggests that even small MPAs can be beneficial in protecting and rebuilding stocks of mobile coastal shoaling species such as white stumpnose *Rhabdosargus globiceps*.

Whereas previous studies were mostly confined to coastal

Table 1: Stock status of some commercially important linefish species. Life-history pattern and maximum age and of the species are reflected. SB/R = spawner biomass per recruit; VPA = virtual population analysis; CPUE = catch per unit effort (a stock status indicator)

Species	Maximum age (years)	Stock status	Assessment method	Date of last comprehensive assessment	SB/R (% of pristine)	CPUE decline (%)
Snoek	12	Optimally exploited	CPUE	1999	?	42.4
Yellowtail	12	Optimally exploited	VPA	2001	?	40.2
Silver kob	25	Collapsed	SB/R + CPUE	1997/1999	10	93.0
Dusky kob	42	Collapsed	SB/R	1997	2.3	
Geelbek	9	Collapsed	SB/R + VPA +CPUE	1997/1999	5	97.2
Dageraad	23	Collapsed	SB/R	1992	5	
Seventy-four	20	Collapsed	SB/R + CPUE	2006	<5	99.9
Red steenbras	33	Collapsed	SB/R +CPUE	1991	0.2	99.8
White steenbras	25	Collapsed	SB/R + CPUE	1993	6	90.0
Yellowbelly rockcod	24	Collapsed	SB/R	1998	19	Red
Stumpnose	?	Collapsed	CPUE	1999	?	96.6
Roman	17	Collapsed	CPUE	1992	15	88.4
Scotsman	13	Collapsed	SB/R + CPUE	2005	21	65.0
Englishman	17	Collapsed	SB/R + CPUE	2005	17	90.0
White stumpnose	25	Under review	CPUE	2002	?	73.2
Carpenter	33	Collapsed	SB/R	1999	18	88.7
Elf/shad	10	Overexploited	SB/R	1996	34	
Smoothhound shark	25	Overexploited	SB/R	2007	21	
Soupfin shark	25	Optimally exploited	SB/R	2005	34	

areas, the new research ship RV *Ellen Khuzwayo* has permitted the inception of new fishery-independent research aimed at assessment of offshore linefish resources. Based on standardised fish-trap surveys, standardised angling and underwater visual census, this research will provide fishery-independent information on species composition and population structure of demersal species such as red steenbras *Petrus rupestris*, carpenter *Argyrozona Argyrozona*, blue hottentot *Pachymetopon aeneum* and panga *Pterogymnus laniarus* on offshore hard grounds on the Agulhas Bank.

Current status

If the linefishery is carefully managed to return to sustainable levels, it has the potential to become one of the most ecologically and economically viable fisheries in South Africa, because of the following facts: (i) the fishing method can be highly selective and bycatch of undersized fish and unwanted species can be avoided; (ii) the labour-intensive, low-technology, low-investment method maximises employment opportunities; (iii) the product is potentially of high quality and many species command a high price on local and international markets; and (iv) linefishing inflicts minimal physical damage to the ecosystem.

Comprehensive annual assessments of the status of linefish species are not feasible due to the large number of species and their different life histories, and on account of the heterogeneity of the different fisheries impacting on these resources. Because the majority of linefish are long-lived and management changes will take considerable time to have an impact on the stock, it is sufficient to assess individual species at half of their maximum lifespan. Nevertheless, other stock status indicators such as a change in CPUE, or in the proportion of a particular species in the catch, and even the concern of the majority of stakeholders about the status of a particular species, can inform annual management recommendations. These indicators need to be considered in conjunction with the latest stock assessments available.

Overall, there are few signs of a positive response of the linefish stocks to the emergency measures, and catch rates of many linefish stocks continue to decline (Table 1). This can be attributed to several factors, such as the impact of other fisheries, effort-creep and compliance with the regulations.

Snoek Thyrsites atun

This nomadic shoaling predator is the staple of the linefishery in the Western Cape and represents the bulk of the commercial linefish catch. Catches of this species are subject to seasonal and interannual variability and depend strongly on environmental parameters. In recent years, catches have been relatively low, but there was a turnaround in 2008 with a strong increase in both catch and CPUE (Figure 15).

Yellowtail Seriola lalandi

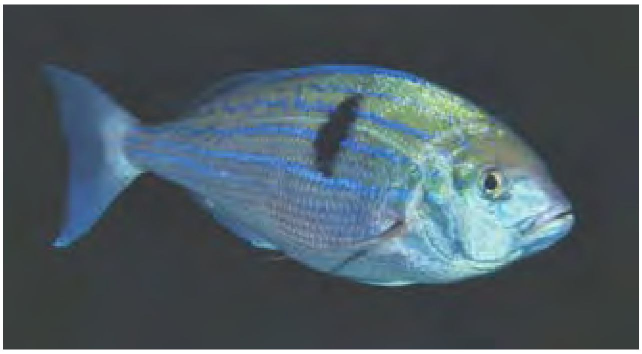
Unlike snoek, yellowtail catches and CPUE have declined steadily over the past five years (Figure 15), but similar to snoek, this species is nomadic and its availability is subject to changes in environmental conditions.

Kob Argyrosomus spp and geelbek Atractoscion aequidens

After snoek and yellowtail, kob (both dusky and silver kob) and geelbek make up for a large percentage of the national linefish catch. CPUE indicates a positive trend for kob and geelbek (Figure 15) as a result of the dramatic effort reduction after the declaration of the State of Emergency in 2000. This is in agreement with reports from the fishery. Putting this into a historical context, however, the current CPUE level is still below 20% of that of the far less technologically advanced fleet that was operational in the early 1960s, indicating that the stocks remain far from recovery.

Seventy-four Polysteganus undulosus

The re-assessment of seventy-four, once one of the most important linefish resources, has not shown significant signs of recovery in the resource after a 10-year moratorium on fishing. The fate of the seventy-four is representative of many other endemic seabream species, being long-lived and with life-history strategies such as sex change and late age of maturity, these species are particularly vulnerable to overexploitation. As many of these fish are resident in a very small area, either year-round or at least during spawning, an effective, well-enforced network of protected areas might be the only viable option to ensure the recovery of these valuable resources.



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Netfish

Underexploited	Optimally exploited	Overexploited, threatened, endangered or collapsed	Status uncertain

Introduction

There are a number of active beach-seine and gillnet fisheries throughout South Africa. By far the biggest are for harders, or mullet *Liza richardsonii* with 28 beach-seine and 162 gillnet fisheries right-holders from False Bay to Port Nolloth on the West Coast. This fishery is managed on a TAE basis with a fixed number of operators in each of 15 defined areas. Permits are issued solely for the capture of harders, St Joseph shark *Callorhynchus capensis* and species that appear on the 'bait list'. The exception is False Bay where right-holders are allowed to target linefish species that they traditionally exploited. All evidence points towards the harder resource being overexploited, and sector conflict arises due to real and perceived impacts on linefish resources from associated bycatch. A substantial illegal component, which may in some years equal or exceed legal catches of harders and bycatch, results in negative perceptions of management and negates most attempts to rebuild these stocks.

History and management

Beach-seine nets were introduced into the Cape during the mid-1600s and gillnets in the late 1800s. Then, the main targets were large linefish species, in particular white steenbras *Lithognathus lithognathus*, white stumpnose *Rhabdosargus globiceps* and geelbek *Atractoscion aequidens*, with reports of nets being strung between Robben Island and the mainland to intercept shoals of these fish moving along the West Coast. Harders were largely used for fertiliser.

Until 2001, some 450 licensed permit-holders used about 1 350 nets, and an unknown number (perhaps a further 100), used another 400 nets illegally. The vast majority of these fishers were not reliant on netfishing, but were occupied with this activity for a short period over the summer and autumn months, and either had other occupations such as teaching or farming, or spent the rest of the year in other branches of the fishing industry, such as the pelagic, rock lobster and linefish (snoek and hottentot seabream) fisheries. Many of the participants (including crew members) were retired from fishing activities and participated in the netfishery to supplement incomes and food supplies. A lot of them, both historically advantaged and disadvantaged, were desperately poor and employed seasonally as crew or factory workers. Overall, there was excess effort in the fishery. Many only went to sea a few times each year, catching small quantities of fish.

They only went to sea when they heard about harders being plentiful from the active participants. They then flooded the few small factories with fish, which maintained the price but refused to take any more fish than could be processed or sold fresh. This extra effort interfered considerably with the viability of the regular fulltime fishers.

During this time, approximately 6 000 t were landed per annum by the beach-seine and gillnet fisheries. The latter accounted for, on average, 3 250 t of harders, 650 t of St Joseph shark, and 130 t of bycatch consisting of at least 27 species. Illegal gillnetting landed approximately 100 t of houndshark *Mustelus mustelus* and 50 t of linefish (mostly galjoen *Dichistius capensis*. Beach-seine permit-holders landed approximately 1 950 t of harders, and in excess of 200 t of bycatch, also predominantly linefish.

It is unlikely that the beach-seine and gillnet fisheries were generating more than R20 million annually. Most of the operators were running at a loss (20–60%), especially in oversubscribed areas. The loss experienced by most fishers also indicated the 'recreational' nature of many of the participants. Indeed, in the Berg River Estuary, <4% of original permit-holders who were interviewed regarded themselves as netfishers and were either retired or employed elsewhere in other fishing sectors and various jobs.

It was evident that the beach-seine and gillnet fisheries were operating at a loss, brought about by effort subsidisation, unfair competition between part-timers and *bona fide* fishers, and declining catches due to overfishing. Consequently, from 2001 onwards, rights were allocated to those reliant on the fishery, and the numbers of legal beach-seine operations were reduced from around 200 to 28 and gillnet operations from about 1 500 to 162.

Prior to this reduction in effort, size frequency distributions of the harders caught suggested that the stock was overexploited on a local and national scale, with a strong negative correlation between effort (number of nets) and the size of fish caught. The medium- and long-term rights allocation saw the removal of part-timers from the beach-seine and gillnet fisheries. The 80% reduction in the number of net permits amounted to an effective 40% reduction in fishing effort, the target set by the Minister in 2001 to facilitate rebuilding of the harder stock.

Also relevant was the linefish bycatch, most of which composed of species regarded as overexploited or collapsed. In turn, most of the catches of overexploited or collapsed species were juveniles below minimum legal size – before they were recruited into the linefishery and before they were able to reproduce – thus considerably compromising replenishment of linefish stocks. Recognising that estuarine gillnetting was severely comprising the nursery function of estuaries and having a negative effect on the fisheries for many other species, the management policy was to phase out all estuarine gillnets in the long-term.

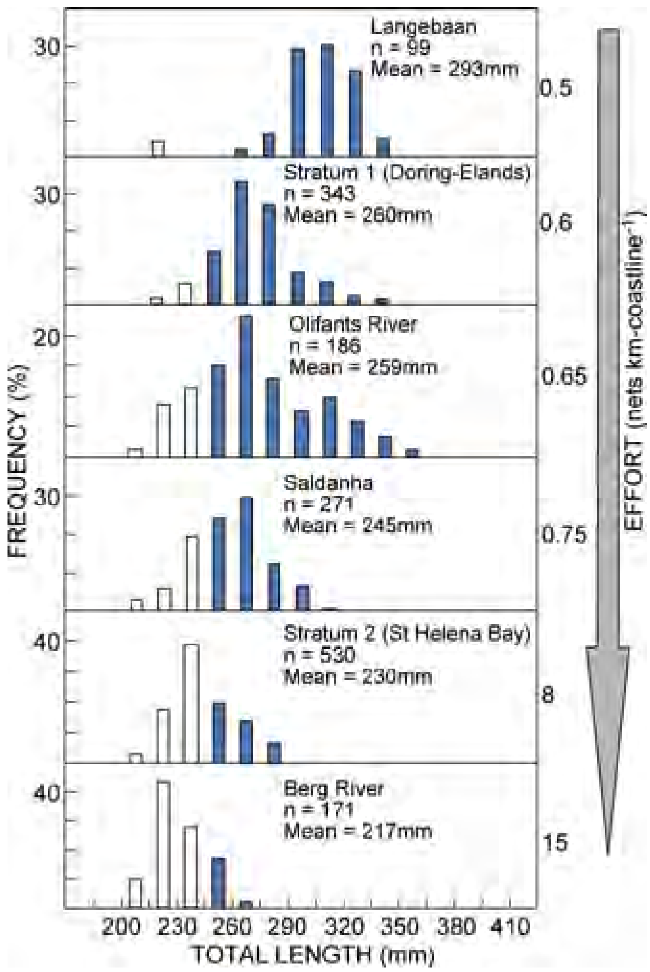

Figure 16: Length frequency distributions of harders landed by commercial gillnetters in different regions. Potential effort levels (nets.km-coastline^{-1}) are included for illustration. Immature fish are depicted. Note, however, that the nets also tend to select for the onset of early maturity which means that age-at-maturity also tends to vary according to the nature and magnitude of effort

Research and monitoring

Fishery-dependent data sources consist of ongoing length-frequency measurements, observer data, compulsory monthly catch returns by right-holders and the National Linefish Survey. (NLS). The most important of the fishery-dependent data sources has been the NLS as this provides comparable and combined catch, effort, compliance and socio-economic information for the beach-seine and gillnet fisheries, as well as the commercial, recreational and subsistence linefisheries. However, the NLS has not been able to be repeated since 1995.

Fishery-independent data is currently collected through sampling estuarine and surf-zone fish assemblages to ascertain the links between environmental and fishery variables and juvenile recruitment. Sample fish densities are compared across estuaries and surf-zones in relation to the different levels of fishing and other variables such as freshwater flow into each of these systems. From these data, a predictive capability that can be incorporated into existing linefish stock assessment models will be developed. This is a relatively novel approach, because the existing assessments are largely based on adults caught by the fishery and often ignore the anthropogenic and environmental influences experienced by fish in their earlier life-history stages. In all, 16 estuaries have been monitored twice annually from 2001 until the end of 2009.

Fishery-dependent size-frequency information allows comparison between areas with different levels of fishing effort and is validated by size frequency distributions from fishery-independent sampling. Past work has shown that this approach provides a good indication of the status of local populations and the stock as a whole as there is a strong negative correlation between the level of netfishing effort and average fish size.

Current status

Prior to the reduction in effort implemented after 2001, size frequency distributions of the harders caught suggested that the stock was overexploited on a local and national scale. There was a strong negative correlation between effort (number of nets) and the size of fish caught. This was not surprising considering that effort ranged from 0.5 nets per kilometre of coastline in Langebaan to 15 nets per kilometre in St Helena Bay (Figure 16). Also relevant was the linefish bycatch, most of which comprised species regarded as overexploited or collapsed. In turn, most of this catch comprised juveniles below the minimum legal size before they were recruited into the linefishery and before they were able to reproduce and thus contribute to replenishment of the linefish stocks.

There is some evidence for recovery of the harder stock in some areas. For example, in the Berg River Estuary, continued monitoring before and after the effort reduction has indicated a recovery in the numbers and size of harders and bycatch species such as elf *Pomatomus saltatrix*. An increase in the numbers and mean size of harders caught in St Helena Bay has also been reported by fishers.

This success may, however, be short-lived as observer data suggest that the illegal gillnet fishery in the Berg River Estuary has escalated recently. These data suggest that at least 300 t are poached from this estuary alone each year. A total of 500 t reduction in reported catches strengthens the veracity of this estimate of biomass poached and highlights the predicted impact on the legal fishery.

Exacerbating the problem has been an anomalous series of 1-in-50 year floods in quick succession on the South Coast, which have considerably reduced juvenile recruitment over the last three years. This will have a negative impact on the adult stocks of many species, including harders and various linefish. Ultimately, the impact on the netfisheries will depend on the linkages between the South and West coasts populations of these species.

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Oysters

Underexploited	Optimally exploited KwaZulu-Natal	Overexploited,threatened, endangered or collapsed Southern Cape	Status uncertain

Introduction

The Cape rock oyster *Striostrea margaritacea*, which is targeted in this fishery, has an extensive geographic distribution, occurring on rocky reefs from Cape Agulhas to Mozambique. They are found in the intertidal zone down to about 6 m deep. They occur naturally and are sold in South African restaurants. A cheaper oyster is the Pacific oyster, which is imported and widely used in marine aquaculture. Oysters along the KZN coast take almost three years to reach marketable size (60 mm right valve length). Oysters are broadcast spawners and along the KZN coast they spawn throughout the year, with peaks during spring and summer.

Harvesting takes place during spring low tides and has traditionally been restricted to the intertidal zone. However, in recent years, there has been a gradual expansion of harvesting depth towards the fringes of the subtidal zone. This is due to a decline in oyster density in the intertidal zone and a gradual increase in gear efficiency. Oysters are dislodged from rocks by means of a pointed steel crowbar. Harvesters are allowed to wear a mask, snorkel and weight-belt and commonly use an oyster pick (crowbar) to dislodge oysters from the rocks. The use of fins and scuba are not allowed. No harvesting is permitted from the subtidal beds, which are considered to seed the intertidal oyster reefs.

History and management

The commercial fishery for oysters dates back to the late 19th century. Prior to 1998, a small number of individuals (<8 people) held concessions to harvest oysters. They in turn employed large numbers of 'pickers' to assist with collections. In 2002, rights were redistributed and medium-term (four-year) rights were allocated to 34 right-holders, the majority of which held limited commercial rights and were allowed to work with up to three pickers each. A few right-holders held full commercial rights and were allocated a maximum of 10 pickers each. In total, 114 pickers were permitted to harvest oysters during this period.

In the 2006 allocation process, the sector was further transformed and three-year commercial rights were allocated to 121 individuals. A large number of pickers were accommodated in this process, the idea being that pickers were granted rights as a means of empowering those who were dependent on

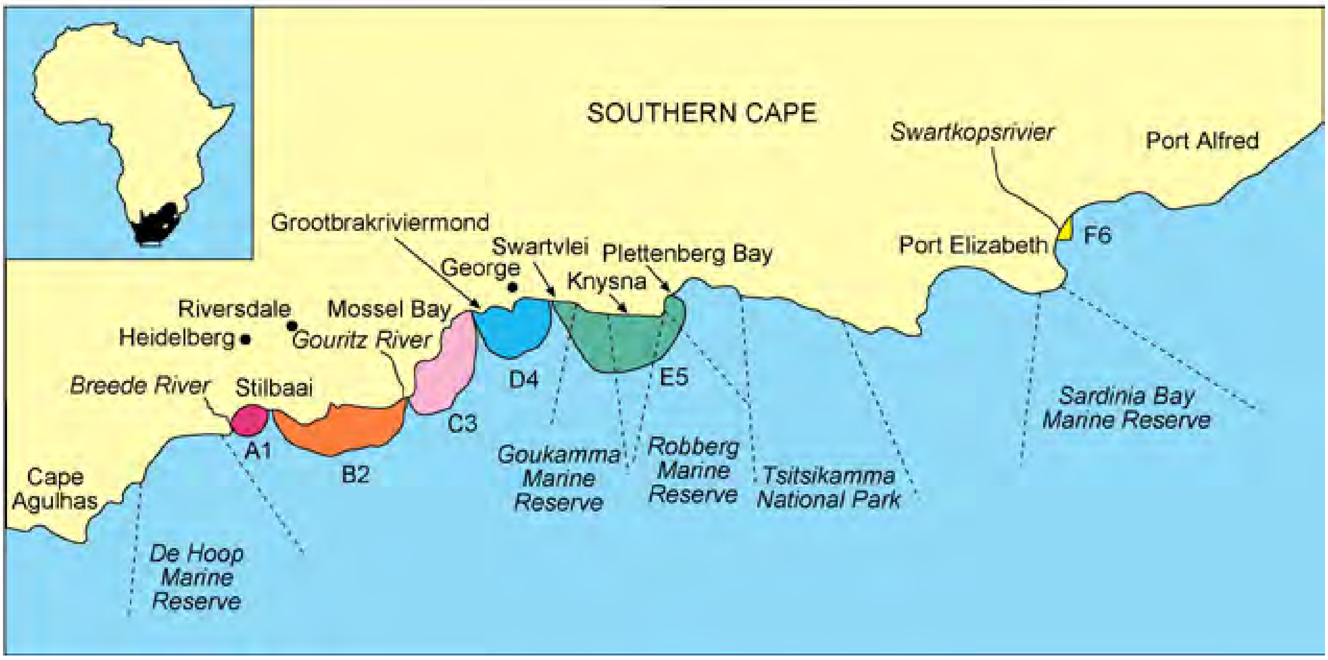

Figure 17: The oyster fishery along the southern Cape showing the different harvesting zones (A1–F6)

oyster harvesting for their livelihood. In the new system, right-holders are required to harvest the oysters themselves and are no longer allocated additional effort (pickers) to assist with harvesting.

The oyster fishery was previously managed as two separate fisheries that were related to their areas of operation, namely the KZN coast and the Southern Cape coast. Since 2002, the oyster fishery has been managed as a national fishery. Under the new management system, four commercial oyster-harvesting areas were officially recognized: KZN North, KZN South, Port Elizabeth, and the Southern Cape (Figures 17 and 18). Regional differences regarding regulations and harvesting patterns have been retained.

For KZN (North and South coasts), the fishery is managed by means of effort limitation, whereby the number of pickers are restricted to a daily bag limit of 190 oysters per picker per day. The oyster fishery in KZN is further managed by a system of rotational harvesting, whereby the coast is divided into zones, and each zone is harvested on a rotational basis (Figure 18). This system accommodates both the commercial and recreational sectors. It requires that each zone remains fallow for at least three years (the optimal length of time required for oyster recruits to reach marketable sizes), thereby allowing for recovery of the oyster stock.

An OMP for the KZN North coast oyster shery is under development. This OMP will form the basis of future TAE recommendations for the resource in this province. The commercial industry in KZN hasrequested consideration of re-zoning for both the South andNorth coasts on the basis of resource distribution and abundance across the zones. Re-zoning of the North Coast was implemented in 2007, and five zones were consolidated into four. There was insufficient information on which to base re-zoning on the KZN South Coast, and five zones remain in that region.

The oyster fishery along the Southern Cape coast is managed by means of limiting effort, by regulating the number of pickers. This effort is split across five subareas according to the extent of accessible oyster reef. The fishery in this region is not managed by means of rotational harvesting and there is no daily bag limit.

In Port Elizabeth, only washed-up oysters are collected. No harvesting of the oyster beds is undertaken.

Traditionally, commercial harvesting was restricted to the intertidal zone. However, in recent years, the area harvested has extended offshore to include the fringes of the subtidal zone. This shift in harvesting depth is attributed to a decline in the number of oysters in the intertidal zone and/or to a gradual increase in gear efficiency.

Research and monitoring

Research on the oyster resource has only begun recently. Because oysters are of relatively low value in comparison to the other commercially exploited species, the fishery has, until recently, not been prioritised in terms of research effort and management attention. The consequence is that the TAE for

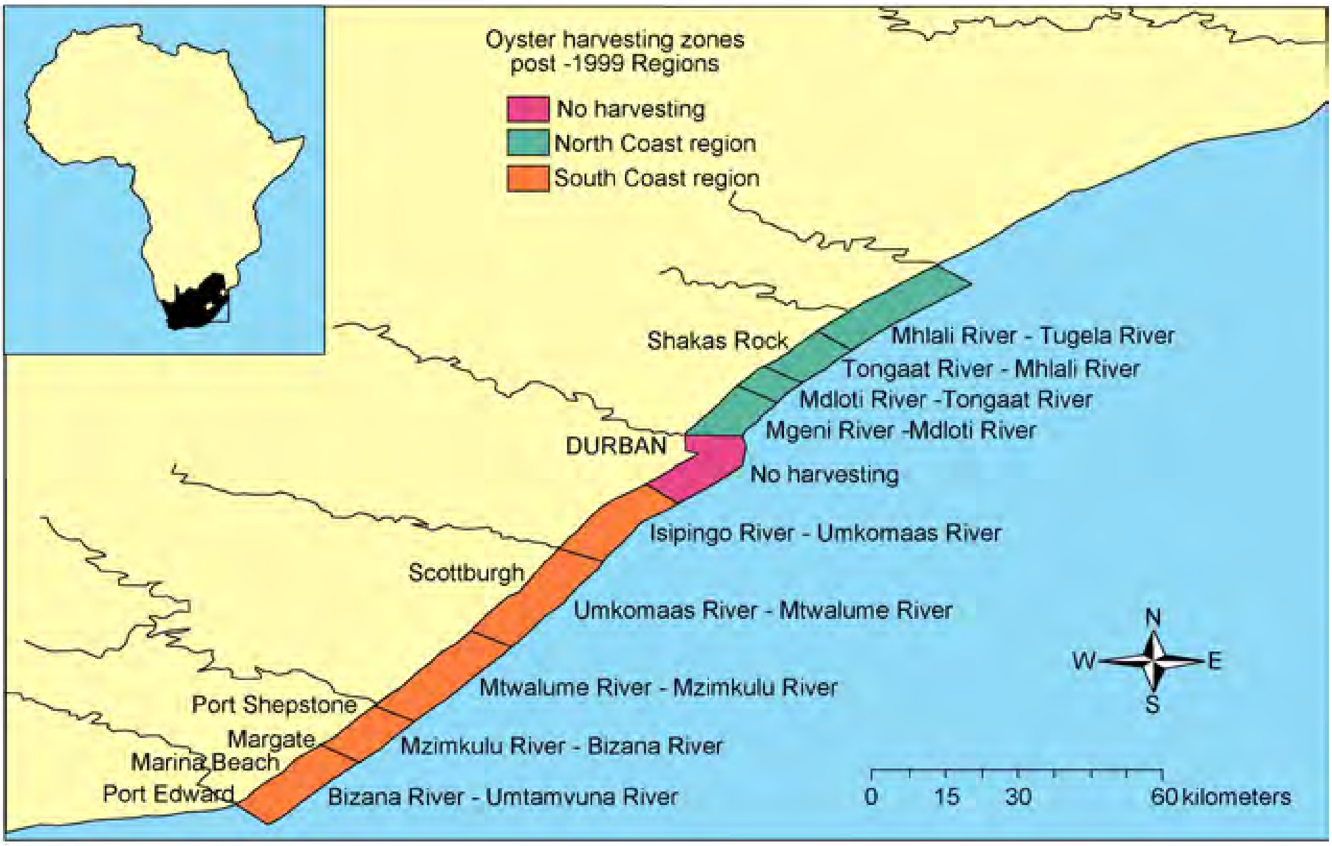

Figure 18: The oyster fishery in KwaZulu-Natal showing the rotational harvesting zones

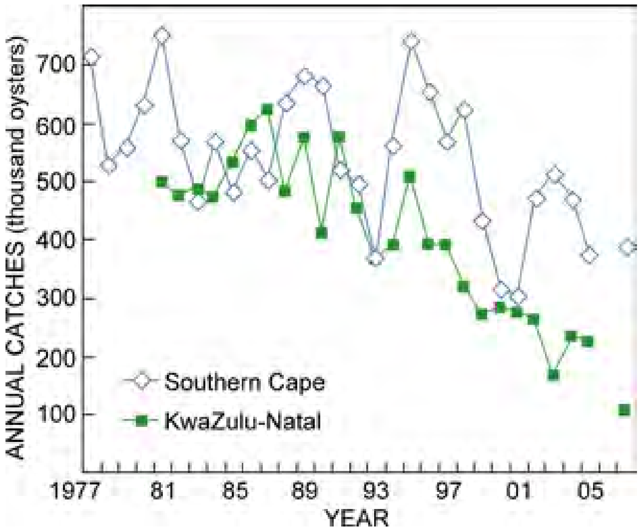

Figure 19: Total number of oysters harvested for Southern Cape and KwaZulu-Natal, 1997–2007

the oyster fishery is currently determined according to historical effort levels and not on the basis of the assessed stock or status of the resource.

Initiatives are underway to improve the quality of catch-and-effort data, and towards undertaking resource assessments. Current research on oysters is therefore focused on developing appropriate methods for assessing the oyster resource, but the patchy distribution and cryptic nature of oysters make accurate sampling of this resource in the intertidal zone very difficult.

Because of the uncertain status of the resource, and evidence of overexploitation, the Southern Cape Coast has been prioritised for research efforts aimed at establishing indices of abundance, estimating density and population size structure, and determining a more accurate TAE.

Furthermore, attempts at establishing a collaborative working relationship with the commercial oyster industry have proven to be very difficult and problematic. Once the method is refined, and a reliable index of oyster abundance is obtained, researchers will be better equipped to provide improved scientific advice on sustainable harvesting levels. Research in the KZN South Coast is carried out by the Oceanographic Research Institute under contract to the Department Agriculture, Forestry and Fisheries with the purpose of providing the TAE recommendation for the entire KZN coast.

Current status

The overall TAE of 145 pickers has remained stable since 2002, based on the total number of pickers active at that time. The status quo is being maintained until further data become available.

On average, 588 087 oysters were harvested per year between 2002 and 2005, 389 286 from the Southern Cape and 198 793 from KZN (Figure 19). Data for 2006 are not available because catch reporting was poor on account of the new rights allocation and the change of right-holders. On average, 493 383 oysters were harvested in 2007, 387 831 from the Southern Cape and 10 552 from KZN. There are no data for 2007 from the KZN South Coast because right-holders failed to activate their permits due to a low density of oysters available, which rendered the activity economically unviable.

The oyster resource along the KZN coast is considered to be optimally exploited. Preliminary resource assessments undertaken during 2006 indicate that, although the oyster stocks have declined since 1980, they have been stable for about the past 20 years, suggesting that current harvesting levels are sustainable.

There is concern that the intertidal zone in the Southern Cape is being denuded of oysters as a result of overharvesting. Recent surveys that measured oyster density and size composition suggest that the intertidal component of the oyster stock along the South Coast appears to be overexploited. Moreover, there have been increasing reports of divers illegally harvesting oysters from subtidal 'mother beds'.

CPUE data for the Southern Cape oyster fishery are unsuitable for the purposes of stock assessment, and the status of this resource remains uncertain.

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Patagonian toothfish

Underexploited	Optimally exploited	Overexploited, threatened, endangered or collapsed	Status uncertain

Introduction

Patagonian toothfish *Dissostichus eleginoides* are slow-growing, reaching sexual maturity at about 90–100 cm total length (TL) (9–10 years old) and attain a maximum size of over 200 cm TL. They occur at depths between 70 m and 1 600 m around sub-Antarctic Islands and seamounts, mainly between 40º and 55ºS. They are replaced by Antarctic toothfish in the colder Antarctic waters. Two small Patagonian toothfish have been caught by bottom trawl on the continental shelf of South Africa.

Patagonian toothfish is a high-price product in the United States and Japan. Although most of the Patagonian toothfish distribution is in waters under national jurisdiction or in the area managed by the Commission for the Conservation of Antarctic Living Marine Resources (CCAMLR), they are on remote seamounts and islands. Therefore they have been, and remain, subject to substantial poaching, so called illegal, unreported, unregulated catches (IUU). They have traditionally been caught by longline, but the IUU vessels are now reportedly changing to deep-set gillnets.

History and management

In 1996, an experimental fishery for Patagonian toothfish in the Prince Edward Islands EEZ was initiated. Five permit-holders participated in the experimental fishery from its inception until 30 November 2005. In 2006, the experimental fishery was translated to a commercial fishery through the allocation of five long-term fishing rights. Because of the small allocations and the high cost of undertaking a fishery in such a remote locality, the five rights-holders have consolidated their allocations onto two vessels. Prior to the start of the experimental fishery there were extremely high levels of IUU fishing, which likely had an adverse impact on the resource (Table 2). The fishery is further characterised by possibly substantial losses through marine mammals (mostly Orca) taking fish off the lines. This 'depredation' by marine mammals can be over 80% of the catch on a single day and 30–50% over a trip.

Only one vessel has operated in the fishery since 2006. (Table 2). The second vessel that participated in the experimental fishery was larger, with consequently higher operating costs, and is not commercially viable given the high level of depredation. A more appropriate replacement vessel is expected to enter the fishery in the 2009/2010 season.

The standardised CPUE of Patagonian toothfish in the Prince Edward Islands EEZ has shown a steady decline due to the earlier substantial levels of IUU fishing, with a leveling-off in recent years (Figure 20), suggesting a substantial fishing impact on the resource.

In contrast, the average size of fish caught in the legal fishery has shown relatively little change (Figure 21), suggesting minimal impact – high fishing pressure results in a decline in the average size in the catch as the older, larger individuals get fished out. Between November 2004 and April 2005, one vessel in the Patagonian toothfish fishery used pots in an attempt to overcome the problem of marine mammals 'stealing' fish off longlines. Although the pots prevented the loss of catch to marine mammals, and caught larger fish on average than the longline fishery, they were difficult to handle. This vessel has since left the fishery and no further pot-fishing has been undertaken.

Table 2: Annual catches of Patagonian toothfish estimated to have been taken from the Prince Edward Islands EEZ

Season	Annual catch (t)			
	Legal fishery		Estimated illegal (IUU) catch	Total
	Longline	Pot		
1996/97	2 921.2		21 350	24 271.2
1997/98	1 010.9		1 808	2 818.9
1998/99	956.4		1 014	1 970.4
1999/00	1 558.7		1 210	2 771.6
2000/01	351.9		352	703.9
2001/02	200.2		306	506.2
2002/03	312.9		256	568.9
2003/04	194.9	72.6	156	423.6
2004/05	131.2	103.5	156	390.7
2005/06	169.0		156	325.0
2006/07[1]	238.0		156	394.0
2007/08[1]	133.0		156	289.0
2008/09[1]	70.0			

[1]Only one vessel

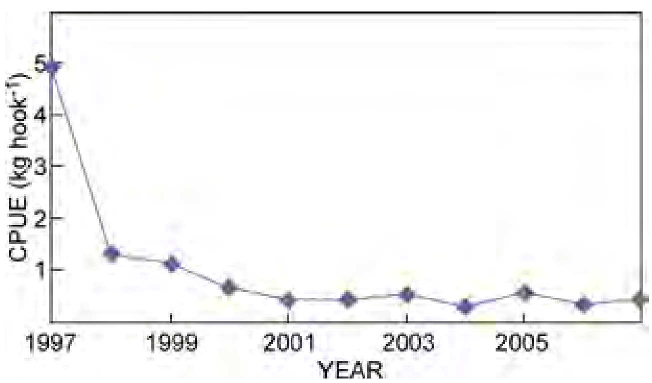

Figure 20: Standardised commercial CPUE for the Patagonian toothfish longline fishery in the Prince Edward Islands EEZ, 1996/97–2006/07

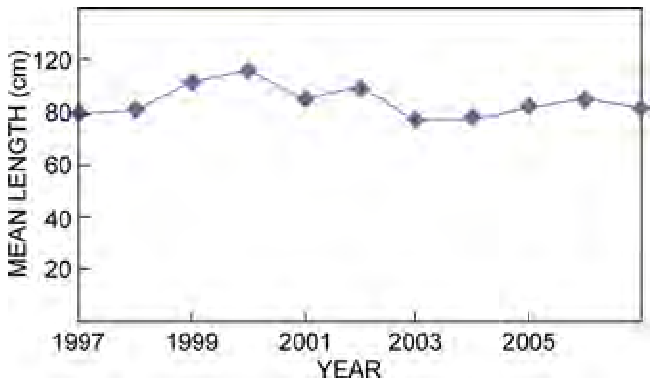

Figure 21: Mean length of Patagonian toothfish caught by the longline fishery in the Prince Edward Islands EEZ, 1996/97–2006/07

As an original CCAMLR member, South Africa remains committed to the commission's objectives, and voluntarily applies the CCAMLR conservation measures within the Prince Edward Islands EEZ. According to CCAMLR Conservation Measure 32-01, 'the fishing season for all Convention Area species is 1 December to 30 November the following year'; thus, a split-year fishing season applies.

A proposed marine protected area (MPA) in the Prince Edward Islands EEZ is under consideration. The proposal is for a zoned MPA that contains 'no-take' and limited access areas and is primarily aimed at the protection of biodiversity, although there may be some benefits to fishing. Fishing is currently not allowed within 12 nautical miles of the islands.

Research and monitoring

Catch-and-effort data are reported by the fishing vessels on a set-by-set basis. In compliance with CCAMLR conservation measures, there is 100% observer coverage in this fishery. Catch-and-effort records and observer reports are submitted to CCAMLR.

From 2001, the status of the Patagonian toothfish resource has been assessed using an age-structured production model based on CPUE and catch data only. The model was extended in 2003 to incorporate information on the size distribution of the fish in the catch and the catch-at-length data. As noted above, the trends in the CPUE data and in the average size of the fish caught are somewhat contrary, and this contrast is highlighted in the model. When a high–weight is placed on the CPUE data, the model output indicates that the resource is heavily depleted, whereas assessments in which high-weight is placed on the catch-at-age data suggest that the situation is not as serious. Several variants of the model have been considered in an attempt to reconcile the CPUE and catch-at-age data, but without success. These circumstances have lead to major difficulties in making scientific recommendations for appropriate catch limits for this resource.

Some toothfish were tagged during 2005 as a trial, and a tagging programme was initiated in 2006 (Table 3). Vessels are required to tag and release one fish per tonne of catch. Fish should be selected at random for tagging (every 50th fish caught regardless of its size) so that a range of sizes are tagged. Unfortunately, fishers tend to select the smaller fish to tag because they are less valuable and are easier to handle – it is difficult to bring a large (70 kg) fish onboard without using a gaff and thereby injuring the fish. The size range of tagged fish has improved in recent years. To date, 556 fish have been tagged and 13 have been recaptured (Table 3).

Table 3: Number of Patagonian toothfish tagged and released per year in the Prince Edward Islands-EEZ, and the number of recaptures per year

Year	Number tagged	Number recaptured
2005	94	1
2006	128	1
2007	120	4
2008	140	0
2009	74	7
Total	556	13

Assessment models incorporating tag data have been developed for many of the Antarctic and Patagonian toothfish stocks in the CCAMLR region. The development of a model for the Prince Edward Islands stock incorporating tag/recapture data will be attempted when sufficient tags have been returned. It is hoped that the model will help resolve the conflicting results from the current models.

In 2009, tagging of skate bycatch was initiated in compliance with CCAMLR's 'Year of the Skate' programme. A total of 43 skates was tagged and one was recaptured. Skate tagging will continue in 2010.

Current status

Different assessments agree that the resource is overexploited. However, they disagree as to the extent of overexploitation. The assessments that place a heavy reliance on CPUE information indicate that the resource is heavily depleted, whereas those that rely on catch-at-length data present a more optimistic outlook.

The impact of the assessment on the TAC is complicated by the high losses of fish to marine mammals. It is estimated that 30-50% of the catch is lost to depredation by Orcas. Thus, the TAC for the fishery (in terms of retained catch) has to be reduced so that the total removals (i.e. retained by the fishery and 'stolen' by marine mammals) is within safe limits.

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Prawns

Underexploited	Optimally exploited	Overexploited, threatened, endangered or collapsed	Status uncertain

Introduction

The KZN prawn trawl fishery consists of two components: a shallow-water (5–40 m) fishery on the Thukela Bank and at St Lucia, in an area of roughly 500 km², and a deep-water fishery (100–600 m) between Cape Vidal in the north and Amanzimtoti in the south, covering an area of about 1 700 km² along the edge of the continental shelf. Species captured in the shallow-water trawlfishing include white prawns *Fenneropenaeus indicus* (80% of the prawn catch), brown prawns *Metapenaeus monoceros* and tiger prawns *Penaeus monodon*. The abundance of shallow-water prawns on the fishing grounds is highly variable between years, depending on recruitment. Shallow-water prawns have a one-year lifespan and the juvenile stages are spent in estuaries; recruitment therefore depends on rainfall and river run-off.

Species captured in the deep-water sector include pink and red prawns *Haliporoides triarthrus* and *Aristaeomorpha foliacea* respectively, langoustines *Metanephrops mozambicus* and *Nephropsis stewarti*, deep-water rock lobster *Palinurus delagoae* and red crab *Chaceon macphersoni*. These deep-water species are longer-lived than those found in the shallow-water component and do not depend on an estuarine juvenile stage.

History and management

Management of the fishery is controlled by effort, which is effected by limiting the number of vessels allowed to operate in the two sectors of the fishery. The two major management challenges facing the fishery are mitigation of bycatch and setting TAE levels that reflect the high interannual variability of the shallow-water resource. Closed shallow-water fishing seasons are used to reduce bycatches of juvenile linefish. It is important to note that many vessels only fish in KZN when prawns are abundant, but then relocate to other areas (such as Mozambique) in periods when yields in KZN decline and the operation becomes uneconomical. Historically, the nominal fishing effort in the KZN prawn trawl fishery has remained virtually unchanged since 1993, although many of the vessels operate in KZN waters only occasionally. More recently, however, the effort has been low with only three vessels operating in 2008. Recruitment failure on the Thukela Bank as a result of inadequate river run-off has severely impacted on the shallow-water fishery.

Research and monitoring

There is ongoing research on the bycatch of the prawn fishery, which is monitored by observers from the former Marine and Coastal Management (MCM); now the Fisheries Branch of the Department of Agriculture, Forestry and Fisheries (DAFF). The collection of data is, however, patchy and not comprehensive. In the absence of suitable biological data (e.g. growth rate, size at sexual maturity, etc.) on the various species targeted by this fishery, annual catch-and-effort data were used as input to a Schaefer surplus production model in order to produce a preliminary stock assessment for this fishery. Initially, the landing (discharge) data were examined for suitability, but these were excluded because, based on the information recorded in the landing records, it was not possible to split the effort data (number of trawling days based on dates of the trip) into shallow- and deep-water sectors. There were also anomalous catch values, which may have resulted from the possible inclusion of landing data based on fishing in Mozambique. There were also numerous trips for which no dates are available. The catch-and-effort data that were eventually used were those provided by skippers on the daily trawl drag sheets, which are captured by MCM, and span the period 1990–2006. Annual estimates of

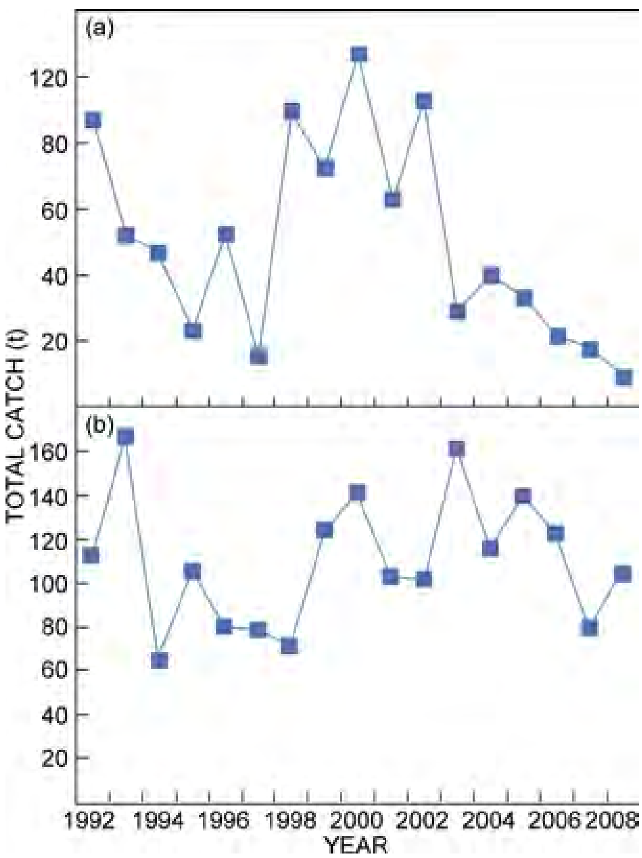

Figure 22: Total annual catches of (a) shallow-water prawns and (b) deep-water prawns in KZN waters, 1992–2008

Table 4: Total catches of the KZN prawn trawl fishery in the various species groups

	Total catch (t)						
	Inshore fishery	Offshore fishery				Both fisheries	
Year	Shallow-water (all prawns)	Deep-water (all prawns)	Langoustine	Red crab	Rock lobster	Landed bycatch	Total catch
1992	87	112	70	187	31		
1993	52	166	83	138	33		
1994	47	65	46	79	10		
1995	23	106	60	108	11	34	342
1996	53	80	58	82	10	24	307
1997	15	79	78	114	10	21	317
1998	90	72	49	100	6	22	338
1999	72	124	49	73	8	28	354
2000	107	142	76	53	10	34	422
2001	63	103	80	54	8	4	313
2002	93	102	56	28	9	10	298
2003	29	162	60	40	5	91	387
2004	40	116	42	24	4	82	308
2005	33	140	42	31	4	88	339
2006	21	123	49	31	5	47	276
2007	18	79	53	24	5	47	226
2008	9	105	31	17	5	35	202

total catch were based on the annual sum of the total combined catch per trawl of four deep-water target species (pink prawn, langoustine, deep-water crab and deep-water rock lobster).

A range of surplus production models were therefore applied to the catch and CPUE data for the KZN crustacean trawl fishery in 2009. This included a simple equilibrium model, fitting data separately to the Schaefer and Fox equations (on all four deep-water species combined and then individually). Unrealistically high levels of both maximum sustainable yield (MSY) and the fishing mortality that would produce this yield (F_{MSY}) were obtained. Data were therefore fitted to both simple and complex non-equilibrium surplus production models (Schaefer, Fox and Pella-Tomlinson), which also resulted in unrealistic estimates of MSY and F_{MSY}. The inability of the models to produce reasonable estimates of MSY and F_{MSY} is probably a consequence of the time-series of data only commencing several years after the fishery began. Consideration will be given to utilising alternative methods of stock assessment for this fishery in future.

Current status

The fishery is regarded as optimally exploited, although there is a need for more and better data collection and systematic research on the biology of the various prawn species and bycatches. The fishing effort in the KZN prawn trawl fishery has remained virtually unchanged since 1993, although many of the vessels operate in KZN waters only occasionally (only three vessels were active in the KZN fishery in 2008/2009).

Catches of shallow-water prawns strongly reflect annual recruitment from estuaries, and a predictive equation relating historical river flows to shallow-water prawn catch on the Thukela Bank has been developed for the period 1988–2000 by the then Department of Water Affairs and Forestry. Very low catches in recent years (Figure 22) are attributed to drought conditions and the closure of the mouth of the St Lucia Estuary by a sandbar – recruitment of juvenile prawns from the estuary to the Thukela Bank is therefore blocked, leading to recruitment failure on the Thukela Bank in the past six years. This has severely impacted on the shallow-water fishery and resulted in the catch reaching a historic low of 9.2 t in 2008 compared with, for example, a catch of 107 t in 2000 (Figure 22, Table 4). As a consequence, it has been recommended that the exploitation levels be retained at the current level, but that fishing on the Thukela Bank be restricted to between March and August.

Trends in catches in the deep-water fishery relate both to abundance and targeting practices, where specific depths or sub-stratum types are selected to achieve a desired species mix or highest economic value. Landings of deep-water prawns increased from 79.2 t in 2007 to 104.6 t in 2008, remaining in this range of catches during the past 15 years (Figure 22). Langoustine bycatch dropped from 53.2 t in 2007 to 31.4 t in 2008, whereas catch of rock lobster remained stable at the low level reached in 2003. Catches of red crab decreased from 24.1 t in 2007 to 17 t in 2008, continuing the decline from the 31 t landed in 2005 (Table 4).

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Seaweeds

Underexploited	Optimally exploited	Overexploited, threatened, endangered or collapsed	Status uncertain

Introduction

The South African seaweed industry is based on the commercial collection of kelps and the red seaweeds *Gelidium* and *Gracilaria*, as well as small quantities of several other species. All commercially exploited seaweeds are found between the Orange and Mtamvuna rivers. In the Western Cape and Northern Cape, the South African seaweed industry is currently based on the collection of beach-cast kelps and harvesting of fresh kelps. Collection of beach-cast Gracilarioids is localised in Saldanha Bay and St Helena Bay. *Gelidium* species are harvested in the Eastern Cape.

The sector is small compared to many other fisheries, but is estimated to be worth at least R35 million annually and to provide between 300 and 400 jobs. Much of the harvest is exported for the extraction of gums. The international seaweed industry is controlled mainly by large international companies that can manipulate prices. Marketing of these raw materials is complicated and requires overseas contacts to sell seaweed or to obtain a good price. As a result, returns for South African companies that do not process locally may be marginal, and they are often forced to stockpile material for many months while negotiating acceptable prices.

Collection and drying of seaweed is a low-tech activity, whereas secondary processing is more technical. Extraction and manufacture of end-products (e.g. plant-growth stimulants, alginate, agar, or carrageenan) is technical and expensive, but although only plant-growth stimulants are currently produced (from kelp) in South Africa, production of other extracts should be encouraged because of potentially higher earnings.

Fresh kelp is now harvested in large quantities (about 5 000 t fresh weight per annum) in the Western Cape as feed for farmed abalone. This resource, with a market value of over R6 million, is critically important to local abalone farmers. Fresh kelp is also harvested for a high-value, plant-growth stimulant that is marketed internationally.

History and management

Commercial interest in South African seaweeds began during World War II, when supplies of agar from Japan became unavailable. Various potential resources were identified, but commercial exploitation only began in the early 1950s.

The South African industry is based almost entirely on three groups of seaweeds: the kelps *Ecklonia maxima* and *Laminaria pallida*, several species of the red seaweed *Gelidium*, and the red seaweeds *Gracilaria* and *Gracilariopsis* (together referred to as 'gracilarioids').

The coastline between the Orange and Mtamvuna rivers is divided into 23 seaweed rights areas (Figure 23). In each area, the rights to each group of seaweeds (e.g. kelp, *Gelidium* or gracilarioids) can be held by only one company, to prevent competitive overexploitation of these resources. Different companies may hold the rights to different resources in the same area.

Management of most seaweed resources is based on TAE, except for fresh kelp, for which a MSY is set in annual permit conditions.

Kelps

Until the mid-1990s, kelp use in South Africa was restricted to the collection, drying and export of beach-cast for the extraction of alginate, a colloid used in the food and chemical industries. Annual yields varied with international market demands, but peaked in the mid-1970s, with maxima of around 5 000 t dry weight (Table 5). Since then, yields of <1 000 t dry weight per annum have been more usual.

Since the early 1980s, a local company has been producing a liquid extract (plant-growth stimulant) from *Ecklonia maxima* and marketing this internationally. A second local company is now producing a similar extract that is used in South Africa.

The growth of abalone farming in South Africa since the early 1990s has led to increasing demands for fresh kelp as feed. In 2009, a total of 6 109 t of fresh kelp fronds was supplied to farmers. Demand for kelp as feed is currently centred around the two nodes of abalone farming activity at Cape Columbine and the area between Danger Point and Hermanus. Kelp harvesters are supplied with a 'Kelp Harvesting Manual', which sets out best practices to ensure sustainability.

Figure 23: Map of seaweed right-areas in South Africa

Table 5: Annual yields of commercial seaweeds in South Africa, 1999–2009. 'Kelp beach cast' (column 4) refers to material that is collected in a semi-dry state, whereas 'kelp fresh beach cast' (column 6) refers to clean wet kelp fronds that, together with 'kelp fronds harvest', are supplied as abalone feed. 'Kelp fresh beach cast' was only recorded separately since 2003

Year	*Gelidium* (kg dry weight)	*Gracilaria* (kg dry weight)	Kelp beach cast (kg dry weight)	Kelp fronds harvest (kg fresh weight)	Kelp fresh beach (cast kg fresh weight)	Kelpak (kg fresh weight)
1999	147 927	269 819	1 443 178	1 501 680	0	273 030
2000	124 614	264 300	759 242	2 784 391	0	608 900
2001	144 997	247 900	845 233	5 924 489	0	641 375
2002	137 766	65 461	745 773	5 334 474	0	701 270
2003	113 869	92 215	1 102 384	4 050 654	1 866 344	957 063
2004	119 143	157 161	1 874 654	3 119 579	1 235 153	1 168 703
2005	84 885	19 382	590 691	3 508 269	126 894	1 089 565
2006	104 456	50 370	440 632	3 602 410	242 798	918 365
2007	95 606	600	580 806	4 795 381	510 326	1 224 310
2008	120 247	0	550 496	5 060 148	369 131	809 862
2009	115 502	0	606 709	4 762 626	346 685	1 232 760

Gelidium

Gelidium species contain agar, a commercially valuable colloid with many food and cosmetic uses, and the only medium for cultivating bacteria in medical pathology. The *Gelidium* resource in South Africa comprises *G. pristiodes*, *G. pteridifolium* and *G. abbottiorum*, all most abundant in the Eastern Cape (Seaweed Rights Areas 1, 20, 21, 22 and 23; Figure 23), where they have been harvested from intertidal area since the mid-1950s. Yields vary with demand from a few to about 120 t dry weight annually.

Gracilarioids

Gracilarioids produce agar of a slightly lower quality to that of *Gelidium*. Only the sheltered waters of Saldanha Bay (Seaweed Rights Area 17) and St Helena Bay (Areas 11 and 12 in part) contain commercially viable amounts of these seaweeds. Only beach-cast material may be collected commercially, because harvesting of the living beds is not sustainable. In Saldanha Bay, large yields (up to 2 000 t dry weight in 1967) were obtained until the construction of the ore jetty and breakwater in 1974, after which yields fell dramatically. Occasional small wash-ups are obtained in St Helena Bay. In the past decade, total annual yields of gracilarioids ranged from zero to a few hundred tonnes dry weight, and the resource is regarded as unreliable.

Other resources

Other seaweeds have been harvested commercially on occasion, including *Porphyra*, *Ulva*, *Gigartina* spp. and *Mazzaella*. However, local resources of these species are small by international standards, and harvesting has not been economically viable. Nevertheless, there is potential for local use of some species, for example in food products.

Research and monitoring

It is not practical to monitor the amounts of kelp cast up on beaches along the approximately 1 000 km of the West Coast where they occur. Collection of beach-cast kelp has no impact on the living resource and is driven by market demands. Monthly returns are, however, submitted and monitored.

Estimates of kelp biomass are based on infrared aerial imagery and GIS mapping, and diver-based sampling. Monthly harvest of fresh kelp is checked against the prescribed MSY as set in annual permit conditions. Since 2008, kelp beds in the two main nodes of harvesting (Gansbaai and Jacobsbaai) are monitored each year, when densities of kelps are determined during diving surveys at each of two permanent locations in each area. Every two years, the same methods are used to monitor kelp beds at Port Nolloth. Values are compared with baseline data from previous surveys. In addition, periodic inspections of selected kelp beds are made from the surface and by divers. Current research aims to improve our understanding of kelp biology in order to manage the resource better. Included in this is a study of the relative distributions of our two main kelp species in shallow water (0–5 m) on the West Coast, in order to improve biomass estimates and to document their relative distributions in the event of possible climate changes in the future.

Assessment of the *Gracilaria* resource is performed on an *ad hoc* basis, because only beach-cast is collected and there is therefore no direct effect on the living resource.

Harvesting of *Gelidium* in the Eastern Cape and the biology of *G. pristoides* was comprehensively researched in the 1980s. Current monitoring is by annual inspections of several randomly chosen harvested and non-harvested shores along the approximately 400 km of Eastern Cape coast where harvesting is done, and annual biomass and density measurements at a permanent study site in Port Alfred, which lies in the centre of Area 1 and is the most intensively harvested. Catch returns are also monitored to ensure that yields do not exceed historical levels: if they did, further inspections and monitoring would be necessary.

Other seaweed resources are assessed on an *ad hoc* basis as the need arises.

Current status

Kelps

There are 14 areas in which kelp rights are held in 2009. No collections were made in three of these areas: in two of them, right-holders could not access the resource.

Yields of dry beach-cast kelp totalled 607 t in 2009 (Table 5). A further 347 t wet weight of fresh beach-cast was supplied to abalone farms, together with 4 763 t wet weight harvested directly as abalone feed. These yields have remained fairly

Table 6: Maximum sustainable yield of harvested kelp for all areas for 2009

Area number	Whole kelp (t fresh weight)	Kelp fronds (t fresh weight)
5	2 840	1 420
6*	0*	4 592
7	1 421	710
8	2 048	1 024
9	2 060	1 030
10	188	94
11	3 085	1 543
12	50	25
13	113	57
14	620	310
15	2 200	1 100
16	620	310
18	2 928	1 464
19	765	383
Total	18 938	14 062

*Note: In Area 6, only non-lethal harvesting of fronds is allowed

steady over the past three years. Substantial harvests for abalone feed were obtained in Areas 5, 6, 7 and 11. Although,there are more than five abalone farms in the Gansbaai–Hermanus area, they are supplied by three rights areas (Area 5,6,7 and normally a fourth – Area 8), with a substantial potential MSY between them. The fact that there is still substantial potential harvestable biomass ('spare' MSY) there bodes well for abalone farms that intend to expand.

In some areas, harvests were well below MSY (Table 6). The underharvest is a result of lower demand for kelp in some areas and/or the use of alternative abalone feeds, and is not a reflection of the state of the resource in those areas. In Area 9, the production of Kelpak (plant-growth stimulant) used almost 1 233 t of fresh kelp stipes (60% of MSY). In all rights areas except 11, the fresh kelp resource can be regarded either as well (but incompletely) exploited or underexploited.

Visual inspections and reports from right-holders show that the kelp resource is stable and healthy.

Gracilarioids

This variable and unreliable resource maintained an apparently very low biomass during 2009. Populations had almost disappeared and wash-ups were reportedly minimal. These periodic occurrences appear to have natural causes and have been recorded before. The resource must at present be regarded as commercially unreliable, although occasional large wash-ups do still occur.

Gelidium

In 2009, *Gelidium* was only collected from Area 1, where *G. pristoides* comprises more than 90% of the harvest. The other species, which make up most of the harvest in Areas 20–23, were reportedly not worth collecting because of prevailing low prices on Asian markets. In Area 3, exploratory collecting by the right-holder produced a very low yield, and no further collecting was done. Catch returns from Area 1 (915.5 t dry weight) were similiar to those for the previous year. Inspections and measurements done in April and July 2009 indicate very healthy *G. pristoides* populations with density and biomass values well within normal limits.

Other seaweed resources

Harvestable *Ulva* and *Porphyra* in Area 12 was surveyed in spring 2008 and again in autumn 2009 in response to commercial interest in these resources. These surveys indicate that a small but sustainable harvest is possible.

Seaweed resources in general, with the exception of gracilarioids, are in a good state. None are overexploited, some (kelp in a few rights areas) are close to optimal exploitation, and many are underexploited.

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Sharks

Underexploited	Optimally exploited	Overexploited, threatened, endangered or collapsed Oceanic whitetip Soupfin shark Longfin mako shark Spiny dogfish Great hammerhead	Status uncertain

Introduction

Global fish stock declines have led to a shift in targeting to elasmobranch and other previously low-value species. It has been argued extensively that elasmobranch stocks offer very limited opportunity for sustainable long-term fisheries due to life-history traits such as slow growth, long lifespans, late age-at-maturity and low fecundity. It is well known that the biggest threats to gobal fisheries resources are multispecies, multisector and multigear fisheries. This is due to the economic support provided by higher-value target species whereas those with lower rebound potential are driven to stock collapse, including the spiny dogfish *Squalus acanthias* off Scotland and Norway, the soupfin shark *Galeorhinus galeus* off California and the basking shark *Cetorhinus maximus* of the Irish Sea.

History and management

Seven fisheries (both pelagic and demersal) in South Africa either directly target or take sharks and other cartilaginous fish such as skates and rays as bycatch. Both the commercial linefish and demersal longline fisheries target the following sharks: smoothhound *Mustelus mustelus* and *M. palumbes*, soupfin *Galeorhinus galeus*, bronze whaler *Carcharhinus*. *brachyurus*, dusky *Carcharhinus obscurus*, hammerhead *Sphyrna* spp., gully *Triakis megalopterus*, cow *Notorhynchus cepedianus* and St Josephs *Callorhynchus capensis*.

The gillnet fishery mainly targets demersal species such as smoothhound, soupfin and cow sharks. A directed pelagic longline targets pelagic sharks such as blue *Prionace glauca*, mako *Isurus oxyrhinchus* and thresher sharks *Alopias* spp. to Japan. The offshore and inshore trawl fisheries catch similar species to those taken by the commercial linefish and demersal longline fisheries as bycatch. The quantity of demersal sharks caught as bycatch in inshore trawl fisheries is higher than sharks caught by the directed demersal shark longline fishery.

The bulk of soupfin and smoothhound shark trunks and fins are exported to Australia for use as fillets. The value of demersal shark fillets is restricted by the mercury content of larger animals, with greater economic incentives to target sharks between 2 and 8 kg. Any larger sharks are purely targeted for the value of their fins. Fin prices of up up to R2 500 per kg per set of fins are the main incentives driving the targeting of larger sharks such as carcharhinid and cow sharks.

The inshore trawl fishery, concentrated around Mossel Bay and Port Elizabeth, is responsible for the greatest catches of demersal shark and other cartilaginous fish species. Cartilaginous fish landed by inshore trawlers include biscuit skate *Raja straeleni*, smoothhound, soupfin and St Joseph sharks. The most common shark caught in trawl fisheries on the Agulhas Bank is the shortspine spurdog *Squalus megalops*, although they are considered too small for processing, they are sometimes landed.

Between 1979 and 1991, sharks comprised 0.3% of South Africa's total commercial landings by mass. Annual shark catches in 1990 were estimated at 606 t. Owing to a high level of discarding and non-reporting, the actual number of cartilaginous fish caught in the trawl fisheries is difficult to quantify. The incentives for trawlers to target sharks and other cartilaginous species have increased because of their increasing market value.

The commercial linefishery is the oldest fishery to have targeted sharks in South Africa. Shark catches by this fishery have fluctuated markedly in response to market forces. Since 1991, however, there has been a steady increase in catches because of a decrease in the availability of valuable linefish species.

Initially, the shark longline fishery was composed of both demersal and pelagic longline vessels. This was later divided into the distinct demersal and pelagic longline fisheries. The pelagic longline fleet targets pelagic sharks using offshore pelagic drifting gear, whereas the demersal fishery targets demersal sharks using bottom-set gear in inshore waters (<100 m).

The domestic pelagic longline fishery originally only targeted tuna and swordfish, although shark bycatch was also taken. Foreign pelagic tuna-directed fisheries are mostly comprised of Japanese and Chinese vessels targeting offshore oceanic species such as mako and blue sharks, carcharhinid sharks such as silky sharks *Carcharhinus falciformes*, oceanic whitetip *C. longimanus*, and porbeagle sharks *Lamna nasus*. Total catches of pelagic sharks have increased sharply since 2006, from 247 t to over 825 t in 2009, because of high market values and the export markets to Europe and Asia. On account of concerns of high pelagic shark catches in the developing domestic swordfish and tuna longline sectors, targeting of pelagic sharks is being phased out by transferring this fishing effort to the large pelagic longline fishery. Under current management, the bycatch limit is set at 2 000 t. Fishing is supposed to stop once this limit is reached.

The demersal longline fishery targets smoothhound and

Table 7: Catches in tons, and Catch Per Unit Effort (CPUE) of demersal shark species from 2006 to 2008 (not scaled up by reporting rate)

	Catch (number)			CPUE (kg hook^{-1})		
Species	2006	2007	2008	2006	2007	2008
Soupfin shark (*Galeorhinus galeus*)	6.90	8.39	29.80	1.11	0.72	0.22
Smoothhound shark (*Mustelus mustelus*)	17.11	38.40	17.00	2.56	3.62	0.13
Gully shark (*Triakis megalopterus*)	0.93	1.05	0.00	0.15	0.10	0.00
Copper sharks (*Carcharhinidae*)	8.14	13.80	2.80	1.19	1.35	0.02
Cow sharks (*Notorynchus cepedianus*)	0.05	0.25	1.80	0.01	0.02	0.01
Skates	0.58	5.06	1.70	0.13	0.5	0.01

soupfin sharks in coastal waters. Permits for the directed catching of sharks using demersal longlines were first issued in 1991. Prior to 1998, over 30 permits were issued to target demersal sharks. Owing to poor fishery performance, these were reduced to 23 permits and then 11 in 2004. Since 2008, only six permits have remained.

Research and monitoring

Historically, there has been little co-ordinated research relating to the biology and stock assessment of commercially valuable sharks. Current research is directed at investigation of life-history parameters necessary to conduct robust stock assessments, including age, growth, reproduction and maturity, stock delineation, and the effectiveness of MPAs in the management of shark populations.

Age, validation and growth studies, which are necessary for accurate and up-to-date stock assessments, are being conducted for blue mako, soupfin, as well as leopard catsharks *Poroderma pantherinum*, cow and puffadder shysharks *Haploblepharus* spp., pyjama sharks *Poroderma africanum,* smoothhound and white-spotted smoothhound sharks.

In order to develop appropriate management strategies for shark resources, it is vital to elucidate pertinent aspects of their reproductive biology, such as fecundity, size-and age-at-maturity, sexual segregation, pupping and mating migrations, and the use of nursery grounds. Such investigations are currently being carried out on blue, smoothhound and white-spotted smoothhound sharks.

Sharks are highly mobile and exhibit dramatic large-scale migrations, including vertical migrations and even transoceanic migrations. Such movement and migration of commercially important sharks will affect the supply of sharks to fishing areas, the density of fish in less exploited areas and the effectiveness of MPAs as a management tool for sharks. Movement studies are thus currently being undertaken on smoothhound, soupfin, cow, blue and mako sharks.

Current status

There is a paucity of data on life-history characteristics, movements and migrations for most South African sharks. In addition, there are also currently no fishery-independent surveys dedicated to sharks, making assessment of the status of shark resources difficult. The paucity of data is not restricted to South Africa – stock assessments for Atlantic blue and mako sharks conducted by the International Commission for the Conservation of Atlantic Tunas (ICCAT) have been inconclusive due to poor quality data and high levels of under-reporting.

Despite the difficulties as a result of inadequate information for most sharks, stock assessments recently conducted on the commercially valuable smoothhound and soupfin sharks indicate that their stocks are overexploited. Catches of soupfin sharks have increased markedly over the past three years (Table 7), despite large fluctuations in the CPUE. Catches of smoothhound sharks have remained stable over the past three years, and CPUE for this species has also shown a marked decline. It is thought that the changes in catches are largely in response to market trends.

Elasmobranch fisheries are widely accepted as being unsustainable as sharks have life-history strategies that render them inherently vulnerable to overexploitation. Stock assessments are the responsibility of Regional Fisheries Management Organisations (RFMOs) such as the Indian Ocean Tuna Commission (IOTC) and ICCAT. These organisations are currently unable to adequately assess the stocks due to poor life-history data. However, there is global concern as to the status of these stocks. The International Union for Conservation of Nature (IUCN) red list status of other sharks targeted or caught as bycatch by shark fisheries in South Africa have recently been changed; these include the oceanic white tip (Vulnerable), soupfin (Vulnerable), longfin mako (Vulnerable), great hammerhead *Carcharhinus longimanus* (Endangered – not commonly caught in South Africa) and spiny dogfish (Vulnerable) sharks.

Catches of pelagic sharks (all species combined) increased sharply since 2006 (247 t), and has remained stable in 2007 and 2008 at 758 and 748 t respectively, increasing to 825 t in 2009 (Table 8). Catches of mako sharks have more than doubled between 2006 and 2009, and CPUE has also decreased significantly during this time. Catches of blue sharks have increased almost four times over the same period, although

Table 8: Catches and normalised catch per unit caught as bycatch and target in pelagic longline fisheries

	Catch (number)				CPUE (kg hook^{-1})			
Species	Mako shark	Blue shark	Thresher shark	Requiem shark	Mako shark	Blue shark	Thresher shark	Requiem shark
2006	170.3	69.07	0	7.91	1.21	1.05	0	1.06
2007	536.68	198.69	6.21	16.75	0.97	0.77	3.1	0.57
2008	464.57	264.32	1.7	17.97	0.9	1.09	0.89	0.65
2009	500.78	274.78	0.01	49.71	0.92	1.08	<0.01	1.71

the CPUE has fluctuated markedly. These trends suggest that mako stocks may be overexploited in South Africa, and that effort is being switched from mako to blue sharks. Such a change in effort is characteristic of a shark 'boom and bust' fishery.

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Small pelagic fish (sardine and anchovy)

Underexploited	Optimally exploited	Overexploited, threatened, endangered or collapsed	Status uncertain

Introduction

Anchovy *Engraulis encrasicolus*, sardine *Sardinops sagax* and round herring *Etrumeus whiteheadi* are the targets of the pelagic purse-seine fishery, which has been operational off the coast of South Africa since the late 1940s. Catches by this fishery are far larger than those from any other commercial fishery off South Africa, and only the demersal fishery is more valuable. Apart from their importance to the economy and as a source of protein, these small pelagic fish also play an important role in regulating ecosystem functioning. Given their mid-level position in the food-web, they are capable of influencing the abundance of both the plankton they feed on and the predators that feed on them.

Small pelagic fish are highly mobile, short-lived, and feed close to the bottom of the food chain. These characteristics make them highly sensitive to environmental influences and extremely variable in their abundance, distribution and recruitment. Evidence of this variability was witnessed during the first few years of this decade, when record levels of anchovy and sardine recruitment led to a period of exceptionally high adult biomass and increased catches. However, this was followed by a period of low sardine recruitment since 2003, which has led to a rapid decline in the biomass of sardine.

A distributional shift, whereby most of the sardine population became located farther to the east, was observed concurrently with the increase in biomass during the latter part of the 1990s and early 2000s. This shift has had severe logistical and cost implications for the fishery, as well as having ecosystem effects through impacting on important predators, including seabirds. Only recently have implications of the distributional shift in terms of management of the fishery and the ecosystem as a whole been fully appreciated. A similar, but smaller-scale, shift in the distribution of anchovy has also been observed, although, unlike for sardine, this occurred abruptly and has been linked to environmental change. Results from the most recent two spawner biomass surveys, and from commercial catch data, suggest that the distribution of both anchovy and sardine is again shifting westwards.

History and management

Initially, targeting sardine, the industry prospered from the late 1950s with sardine dominating the escalating catches until 1964. Following rapid declines in the landings of sardine during the mid-1960s, the industry changed its fishing strategy and used smaller-meshed nets to target anchovy as they moved from the West Coast nursery grounds to the spawning grounds off the South Coast. Anchovy dominated the catches for the next two and a half decades, but a slow and steady increase in the biomass of sardine was observed during this period. Sardine catches increased substantially in the early 2000s as a consequence of exceptional sardine recruitment and subsequent rapid growth in the size of the population. These large catches of sardine coincided with increased catches of anchovy and resulted in annual total pelagic fish landings in excess of 500 000 t between 2001 and 2005. A recent rapid and substantial decline in the size of the sardine stock has, however, resulted in reduced sardine catches, whilst anchovy catches have remained high.

Round herring are mainly caught when they become available close inshore off the South-West Coast at the start (March–May) of the pelagic fishing season and before anchovy recruits arrive on the West Coast fishing grounds. This resource is perceived to be underutilised; presently only supplementing pelagic fish catches when anchovy and sardine are not available or when the

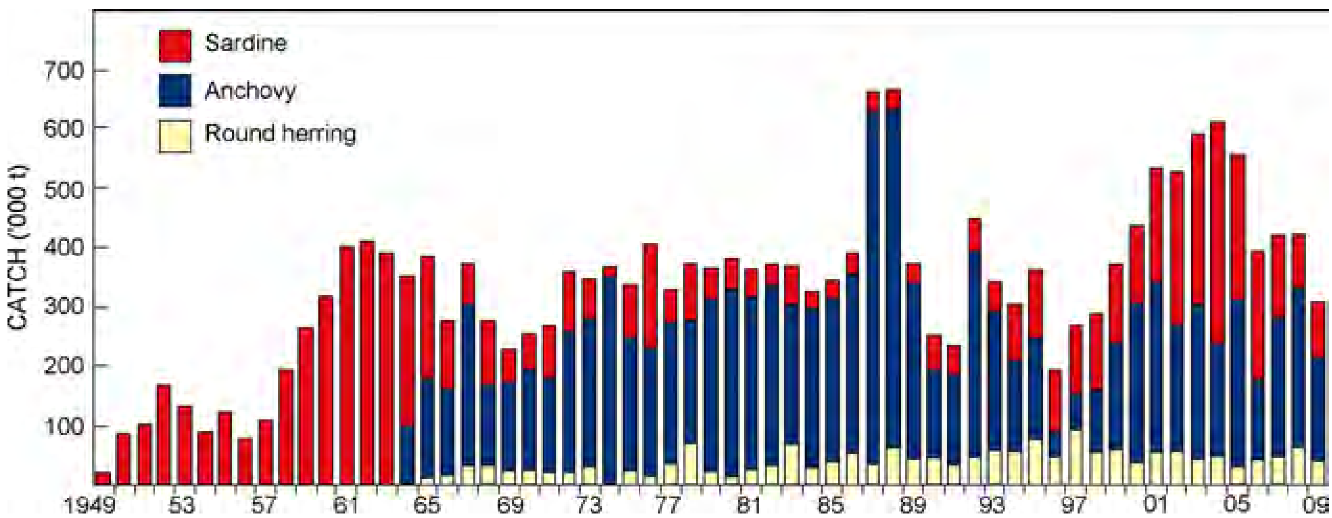

Figure 24: Catches of sardine, anchovy and round herring taken by South Africa's pelagic fishery, 1950–2009

biomass of one or both of these species declines.

Current management of anchovy and sardine is based on an OMP consisting of agreed formulae that base the TAC on observed stock sizes. The OMP formulae have been selected with the objectives of maximising average directed sardine and anchovy catches in the medium term, subject to constraints on the extent to which TACs can vary from year to year in order to enhance industrial stability. The OMP is used to set an annual TAC for directed sardine and an annual initial and final TAC for anchovy, the latter depending on observed anchovy recruitment strength. A fixed precautionary upper catch limit (PUCL) of 100 000 t applies for round herring, irrespective of the size of this population.

Juvenile sardine and juvenile horse mackerel are both taken as bycatch during anchovy-directed fishing operations, and a total allowable bycatch (TAB) limit is set for juvenile sardine and a fixed PUCL of 5 000 t is set for horse mackerel.

Ecosystem considerations in this fishery currently include the experimental closure of areas to fishing around some important seabird (e.g. African penguin *Spheniscus demersus* and Cape gannet *Morus capensis*) breeding colonies (islands) in an attempt to assess the impact of localised fishing effort on the survival and breeding success of these birds. An area around Dassen Island on the West Coast was closed to fishing at the start of 2008 and another area around St Croix Island and Riy Bank was closed for a two-year period commencing in January 2009. Area closures around other penguin breeding colonies are presently being considered for 2011. A model of penguin dynamics is under development for use in conjunction with the small pelagic fish OMP so that the impact on penguins of predicted future pelagic fish biomass trajectories under alternative harvest strategies can be evaluated.

Research and monitoring

Populations of anchovy and sardine are closely monitored by means of hydro-acoustic surveys conducted annually since 1984. Two main assessment surveys are conducted each year, including a summer spawner biomass survey that estimates the total size of the stock and a recruit survey in winter that estimates the number of fish that recruit to the population. These surveys also provide data for the estimation of a number of other key biological parameters (e.g. age structure) that are required as input for the OMP, many of which can only be estimated accurately from data collected during fishery-independent surveys. Samples for a variety of studies on aspects of the biology and ecology of small pelagic fish species are also collected during these surveys.

The use of improved technology during the hydro-acoustic surveys over time has led to a major revision and improvement of the acoustic time-series of abundance estimates. Currently, the quantity and quality of information provided by these surveys is among the best in the world, and corrections to account for differences between the old and new systems and to take account of new information are incorporated into the current anchovy and sardine assessment models.

Apart from these fishery-independent surveys, the management of the pelagic fishery is also highly dependent on accurate reporting of catch statistics (landed mass, catch position and date) and representative sampling of the commercial catches, in particular the length and age frequency distributions of harvested fish.

Further investigations into changes in the distribution of anchovy and sardine observed during the 1990s are ongoing. Several hypotheses have been suggested for having caused these distributional shifts, including climate change, shorter-term environmental variability, localised fishing pressure, and

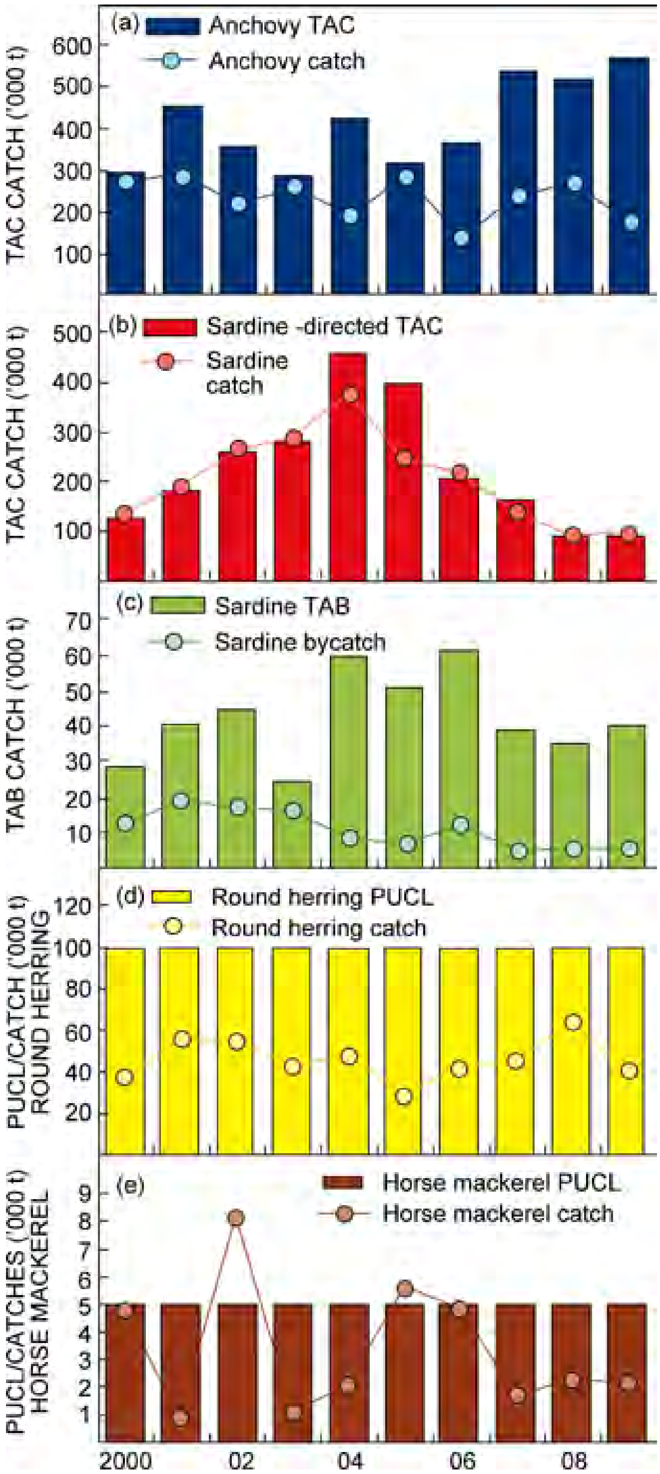

Figure 25: Total allowable catches (TACs), Total allowable bycatch (TAB) and precautionary upper catch limits (PUCL), and subsequent landings for each by the South African fishery for (a) anchovy, (b) directed sardine,(c) sardine by-catch and (d) round herring and horse mackerel, 2000–2009

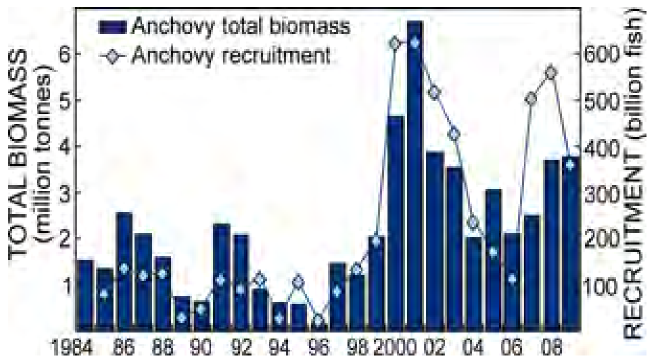

Figure 26: Time-series of acoustically estimated recruitment strength and total biomass of anchovy 1985-2009

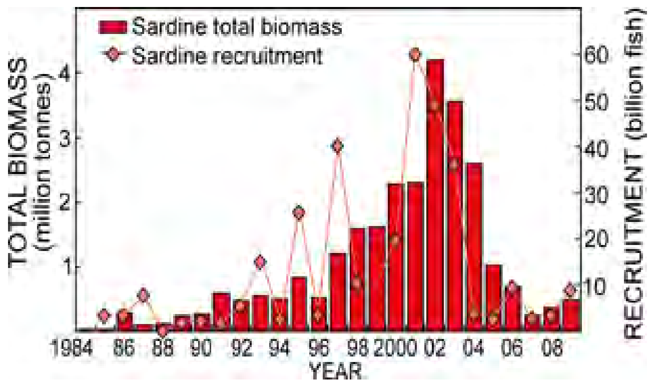

Figure 27: Time-series of acoustically estimated recruitment strength and total biomass of sardine, 1985–2009

changes in stock structure and natal homing arising as a result of shifts in major spawning locations. Additional development and testing of the OMP to take into account the possible existence of sardine substock structure and spatially disproportionate fishing pressure are also being considered.

Current status

Annual TACs and landings

Since the recent peak between 2001 and 2005 when catches exceeded 500 000 t per annum, total pelagic landings between 2006 and 2008 had levelled off at around 400 000 t (Figure 24). During this period, declines in sardine catches were partially offset by increased catches of anchovy and round herring. In 2009, however, the total catches declined to just over 300 000 t because of very poor anchovy catches.

Although the combined anchovy and sardine TACs in 2008 (slightly over 600 000 t, excluding bycatch allowances) decreased from that in 2007 (700 000 t), owing mainly to a large reduction in the directed sardine TAC, the fishery only caught two-thirds of this amount. A similar situation occurred again in 2009, primarily due to an undercatch of anchovy (Figure 25a) brought about by harsh winter conditions that negatively affected anchovy schooling behavior and severely disrupted fishing operations, rather than as a reflection of the status of the resource.

Directed sardine TACs and landings increased steadily up to 2004, but declined sharply thereafter (Figure 25b) following six successive years of poor sardine recruitment and consequent decline in population size and hence TAC. The bycatch of sardine taken in anchovy-directed fishing operations has been substantially below the TAB in recent years (Figure 25c), also as a result of the low sardine recruitment. The majority of sardine continues to be caught off the South Coast, although a relatively higher proportion was taken from the south-western and western part of the fishing grounds in 2008 and 2009 than has been the case in recent years. This may reflect some increase in availability of sardine in the west or may be a consequence of the reduced sardine TAC limit.

Annual landings of round herring have been under 50 000 t in recent years, substantially below the PMCL. In 2008, however, 64 000 t of round herring were landed, most likely in response to the decrease in sardine TAC and recent interest expressed by industry to process this species for human consumption. Catches of juvenile horse mackerel have continued to be well below the PUCL since 2006 (Figure 25d).

Recruitment strength and adult biomass

Anchovy total biomass has increased since 2006 owing to higher than average recruitment since 2007 (Figure 26). The recently estimated 2009 anchovy recruitment of 363 billion fish was again appreciably above the long-term average of 225 billion fish and resulted in a high spawner biomass estimate of around 3.8 million tonnes in November 2009 and a relatively high initial anchovy TAC of just over 300 000 t for 2010.

The estimate of total sardine biomass increased slightly, though not significantly, from a very low level of 260 000 t in 2007 to 380 000 t in 2008 (Figure 27). The 2009 recruit estimate of 9.2 billion fish was similar to that measured in 2006 and appreciably higher than during 2007 and 2008, and contributed to a slight increase in the sardine spawner biomass by the end of 2009. Recruitment of sardine, however, has remained below average for six consecutive years and as such growth in the abundance of the adult population remains slow.

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South Coast rock lobster

Underexploited	Optimally exploited	Overexploited, threatened, endangered or collapsed	Status uncertain

Introduction

South Coast rock lobsters *Palinurus gilchristi* are endemic to the southern coast of South Africa, where they occur on rocky substrata at depths of 50–200 m. The fishery operates between East London and Cape Point and up to 250 km offshore along the outer edge of the Agulhas Bank, and fishing gear is restricted to longlines with traps. It is the second largest rock lobster fishery in South Africa, and is capital intensive, requiring specialised equipment and large ocean-going vessels. For this reason, it is restricted to a commercial sector.

Products (frozen tails, whole or live lobster) are exported to the USA, Europe and the Far East. Sales are affected by seasonal overseas market trends and competition from other lobster-producing countries. High prices on international market and the declining of Rand to Dollar exchange rate make the sector lucrative. Prices for commodities fluctuate and the sales prices in the USA in 2007/08 were the equivalent of R350–400 per kg tail mass.

Longline trap-fishing is labour intensive and as such each boat requires approximately 30 officers and crew. The total sea-going complement of the fleet is about 300, mostly all previously disadvantaged individuals. In addition to sea-going personnel, the sector employs approximately 100 land-based factory (processing) and administrative personnel, also mostly previously disadvantaged people. The total export value in 2007/2008 was approximately R150 million.

History and management

The South Coast rock lobster was first described in 1900 and was recorded occasionally in trawler catches for soles at a depth of about 70 m. The commercial fishery only commenced in 1974, after the discovery of concentrations of rock lobsters on rocky ground at a depth of around 110 m off Port Elizabeth. Numerous local and foreign fishing vessels converged on the fishing grounds, giving rise to the expansion of the fishery. However, foreign fishing vessels had to withdraw from the fishery in 1976, when the species was recognised as occurring wholly within South African waters. From 1977 onwards, the sector operated solely as a local commercial fishery.

The fishery has a management history stretching back to 1974. It was initially regulated only by limiting the number of traps permitted per vessel. Catches and catch rates declined significantly between 1977 and 1979 (Figure 28). The introduction of management measures such as reduction of effort and catches during the early 1980s resulted in resource recovery (Figures 28 and 29). An annual TAC was introduced in 1984, based on the performance of the fishery in the previous years. The TAC and limited entry stabilised the sector until the 1993/94 season (Figure 28), and a more rigorous procedure for stock assessment was developed in 1994.

The fishing season for South Coast rock lobsters is year-round, extending from 1 October to 30 September of the following year. The management strategy is a combination of TAC and total allowable effort (TAE). The TAC limits the total catch and is based on an annual resource assessment, whereas the TAE is measured in fishing days allocated to each vessel. A vessel may fish until its fishing days expire or its quota is filled, which ever occurs first. The number of days spent at sea by each vessel is monitored. Catches may only be off-loaded in the presence of Marine Control Officers, and are weighed at designated off-loading points. Skippers must, at the conclusion of each trip, provide MCM (now Branch Fisheries [DAFF]) with accurate daily catch rate statistics.

The scientific recommendations for catch limits are based on an OMP. The objective of the 2008–2010 OMP is to keep the interannual TAC change restricted to 5% and increase the spawning biomass of the resource by 20% over the next 20 years.

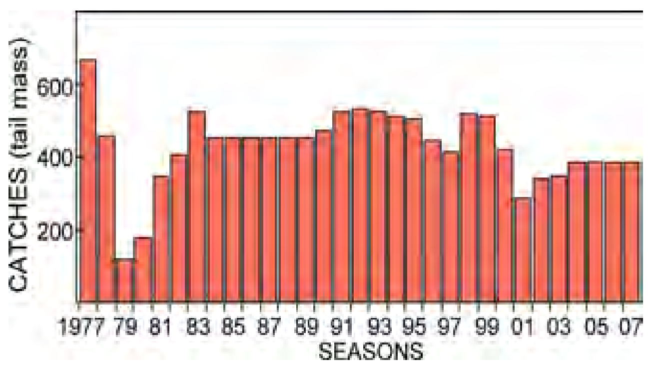

Figure 28: Annual catches of South Coast rock lobster from 1974–2009

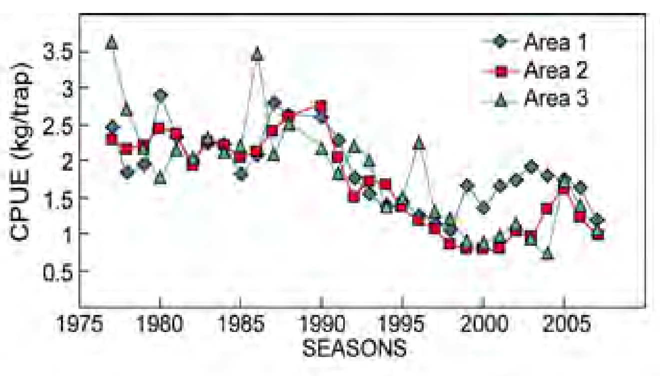

Figure 29: Trend in CPUE South Coast rock lobster by area

Table 9: South Coast rock lobster historical records of TAC, TAE and standardised CPUE by area

Season	TAC (tail mass,t)	TAE (Allocated seadays)	Standardised CPUE (kg trap^{-1})		
			Area 1	Area 2	Area 3
1977/1978			1.791	1.635	2.585
1978/1979			1.335	1.541	1.940
1979/1980			1.414	1.561	1.550
1980/1981			2.082	1.742	1.256
1981/1982			1.669	1.679	1.537
1982/1983			1.443	1.373	1.437
1983/1984			1.617	1.600	1.637
1984/1985	450		1.577	1.554	1.506
1985/1986	450		1.300	1.415	1.559
1986/1987	450		1.469	1.484	2.439
1987/1988	452		1.983	1.671	1.462
1988/1989	452		1.888	1.823	1.748
1989/1990	452		1.850	1.905	1.518
1990/1991	477		1.643	1.433	1.278
1991/1992	477		1.237	1.049	1.534
1992/1993	477		1.079	1.210	1.401
1993/1994	477		0.974	1.183	0.974
1994/1995	452		0.999	0.964	1.056
1995/1996	427		0.864	0.829	1.608
1996/1997	415		0.793	0.742	0.934
1997/1998	402		0.774	0.592	0.859
1998/1999	402		1.176	0.555	0.636
1999/2000	377		0.952	0.556	0.619
2000/2001	365	2 339	1.169	0.561	0.698
2001/2002	340	1 922	1.207	0.727	0.810
2002/2003	340	2 146	1.369	0.688	0.648
2003/2004	350	2 038	1.285	0.938	0.511
2004/2005	382	2 089	1.242	1.147	1.200
2005/2006	382	2 089	1.141	0.884	0.985
2006/2007	382	2 089	0.865	0.721	0.760
2007/2008	382	2 089	0.905	0.906	1.083
2008/2009	363	2 675	N/A	N/A	N/A

Research and monitoring

The stock assessment model used for South Coast rock lobsters (an age-structured-production model) is based, *inter alia*, on size and age composition of the catch, somatic growth rates, and population size estimates. A tagging programme supplies the critical growth and population size estimates, as well as estimates of migration. Lobsters are tagged by trained observers during commercial fishing operations. Recaptured lobsters are returned by commercial fishers, with details of the date and location of recapture. Tagging covers as wide an area and range of size classes as possible.

Scientific observers are deployed aboard commercial rock lobster fishing vessels. These observers primarily collect data relating to catch composition, take biological measurements (length, sex and reproductive state), estimate catch and effort, report on gear used, observe fishing practices such as discarding, dumping and bycatch proportions and also record the areas where fishing takes place. The data are utilised in the annual stock assessment used to determine the TAC.

Commercial CPUE data are captured from landing slips. These provide input data for TAC and TAE management.

New research planned for this resource aims to use baited 'video fishing' techniques to offer a standardised, non-extractive method for estimating relative abundance and behaviour of South Coast rock lobster. Very precise and accurate length and biomass estimates will also be recorded by stereo-camera pairs. The baited underwater video camera traps will be used to monitor the effect that bycatch species have on catch rates, the fate of bait and other bycatch and discards, and to help measure metabolic rates, swimming speed and foraging behaviour of the lobsters.

Collaborative research between DAFF and the South Coast Rock Lobster Fishing Industry Association aims to examine the spatial and temporal distribution of berried females throughout the known distribution range of the rock lobsters and to investigate whether the possibility for introduction of a fisheries-independent survey for this resource.

The effect of benthic environmental factors on daily catches of South Coast rock lobsters has not been investigated to date. However, new research is directed at establishing these relationships.

Current status

In 1977–1979/80, fishing effort and catches increased above sustainable levels, thereafter the catches declined rapidly to 122 t tail mass (Figure 30). The decline in catches was partly as a result of the withdrawal of the foreign vessels from South African waters in 1976 and overfishing. By the end of the 1970s, several of the remaining local fishing vessels were forced out of the fishery by low catch rates. Gradual recoveries of catches between 1980 and 1984 and of catch rates between 1980 and 1982 were accompanied by a resurgence of interest in the fishery by fishers who had previously withdrawn. In response to the possibility of overfishing, a TAC was introduced into the fishery, and quotas were allocated to companies that were active in the fishery. This measure effectively limited the number of participants in the fishery.

The TAC restricted the total catches to 450 t tail mass (970 t whole mass) per year (Table 9); fluctuations in the TAC up to 1994 included the addition of 2 t (tail mass) for research purposes in the 1988/89 fishing season, and the addition of 25 t in 1990/1991. The latter increase was justified by the inclusion of a previously unfished area off the Ciskei coast after 1990. The TAC remained stable at 477 t up to the 1993/1994 fishing season (Table 9).

Resource assessments introduced in 1993–1994 indicated that an annual catch of 477 t could not be sustained. Consequently, a programme of annual TAC reductions was initiated in 1994–1995, reducing the TAC in steps of 25 t per year. In spite of the steady reduction in the TAC (from 477 t in 1994–1995 to 365 t in 2000–2001), the 2001 assessment of the resource indicated that the reductions had failed to impact significantly on the trend of declining abundance. The 2001 CPUE-index indicated that the abundance of this resource declined by 65% over the 12 years between 1988 and 2000 (Table 9).

The exploitable biomass is currently around 33% of pristine, spawner biomass is around 37% of pristine and MSY is 359–440 t tail mass. The present outlook for the fishery is positive, with recorded catch rates having remained constant over the past four fishing seasons (Figure 30). There was an increase in CPUE in all three areas from 2006 until 2008 and the industry also reported an increase in the CPUE. This follows a decade of continued declines in catch rates. This turnaround in the fishery is attributed to a number of changes that took place during 2000 and 2001, including the introduction of a combined TAC and TAE management strategy, a reduction in the number of vessels active in the fishery by 30%, and a reduction in the illegal catch.

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Squid

Underexploited	Optimally exploited	Overexploited, threatened, endangered or collapsed	Status uncertain

Introduction

Squid *Loligo reynaudii* occur around the coast from Namibia to the Wild Coast. They are fast-growing, reaching reproductive size after approximately one year and their lifespan is less than two years. Males can reach a maximum size of 46 cm total length and females 28 cm during this time. Spawning occurs on the seabed, mostly inshore in water <40 m deep. Spawning is year-round with a peak in summer, and its distribution is governed largely by environmental conditions. Distribution of squid, particularly during spawning, profoundly affects their abundance. Their main prey items are crustaceans and fish, but they also sometimes prey on other cephalopods, and cannibalism is fairly frequent.

The abundance of squid fluctuates widely. These fluctuations are governed by biological events such as spawning distributions, survival rates of hatchlings and juveniles, and by environmental factors such as temperature, currents, turbidity and large-scale environmental events such as *El Niños*. Fisheries appear to play an increasing role in these fluctuations in abundance.

Squid is mostly frozen at sea in small blocks. They are landed between Plettenberg Bay and Port Alfred and are exported whole to European countries, most notably Italy. The squid fishery is fairly stable and provides employment for approximately 3 000 people. The fishery can generate in excess of R 480 million in the best years. Apart from the directed fishery, squid is also used as bait by linefishers, and taken as a bycatch in the demersal trawl fishery that operates between Cape Town and Mossel Bay.

History and management

In the 1960s and 1970s, the squid resource was heavily exploited by foreign fleets, predominantly from the Far East. Foreign fishing activity was phased out in the late 1970s and early 1980s following South Africa's declaration of an EEZ. Since then, squid and other cephalopods continued to be taken by South African trawlers. The squid bycatch in the demersal trawl fishery fluctuates annually between 200 and 600 t.

A commercial jigging fishery for squid began seriously in 1984. Hand-held jigs are used to catch squid, making this a particularly labour-intensive fishery. In 2004, the jig fishery registered its highest catch of over 12 000 t. Average catches in the 1990s ranged between 6 000 and 6 500 t, and in the 2000s between 8 000 and 9 000 t. Between 1986 and 1988, a licensing system was introduced with a view to limiting the number of boats participating in the fishery. Fishing is effort-controlled and is currently capped at a maximum of 2 422 crew or 136 vessels. In addition to the effort controls, a five-week closed fishing season was introduced in 1988 to protect spawning squid and improve recruitment for the following year runs from October to November. An additional two closed seasons of three weeks each were instituted in 2008 in order to further reduce fishing effort. These closed seasons run between March–April and July–August, but these are currently under review.

The current management objective for the squid fishery is to cap effort at a level that secures the greatest catches in the longer term, without exposing the resource to the threat of reduction to levels at which recruitment success might be impaired or catch rates drop below economically viable levels.

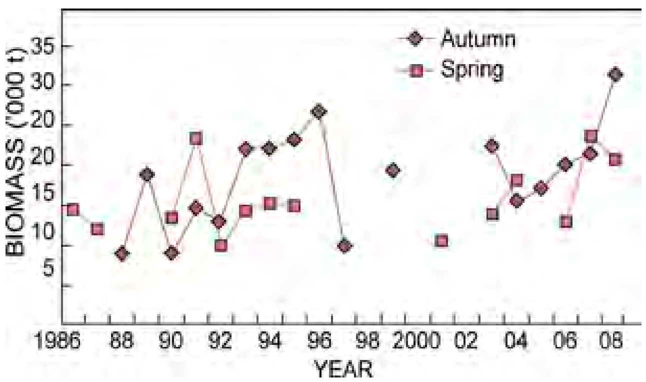

Figure 30: Biomass estimates from spring and autumn research survey data, 1996–2009

Research and monitoring

Fishery-independent research cruises using large vessels are conducted annually to collect information for assessment of the status of the squid resource, and to further understand their biology and their relationship with the environment. A biomass estimate is also calculated from data collected on research cruises.

The spring biomass estimates fluctuate, because during this time jig fishing is more intensive and squid also tend to start aggregating in depths <40 m. The research cruises, aimed primarily at hake, tend not to survey these areas intensively. There has been a steady increase in squid biomass estimates from autumn surveys between 2004 and 2008, increasing from approximately 15 500 t to 31 000 t in 2008 (Figure 30). This is a more reflective estimate of biomass and suggests a healthy population that is being fished sustainably.

Further research is also being conducted on the importance of the deep spawning grounds on the South Coast. These spawning grounds are not affected by the jig fishery. The study aims to determine if the deep spawning populations should be included in the recruitment calculations and form part of the stock assessment of squid.

Catch-and-effort data are collected on a regular basis from the commercial fishery. Catch data suggest that since 2001, there was an increase in squid catches until 2004, with a leveling off of catches at approximately 9 000 t between 2005 and 2008 (Figure 31). This trend supports the belief that the current catch level of squid is sustainable.

In the past, squid data were recorded along with catches of linefish, and stored in the NMLS. In 2006, a new log book was introduced specifically for the squid fishery, which allowed for the recording of more detailed catch-and-effort information. These data are now stored in a dedicated database. This new reporting system has indicated that the previous data may not be as reliable as had originally been assumed, so studies are currently underway to assess the reliability of these data. As a result of these current data discrepancies, effort in the fishery is conservative at present. Efforts continue to improve the quality of data used for assessment of the resource, and to develop reliable indices for input to future assessment models.

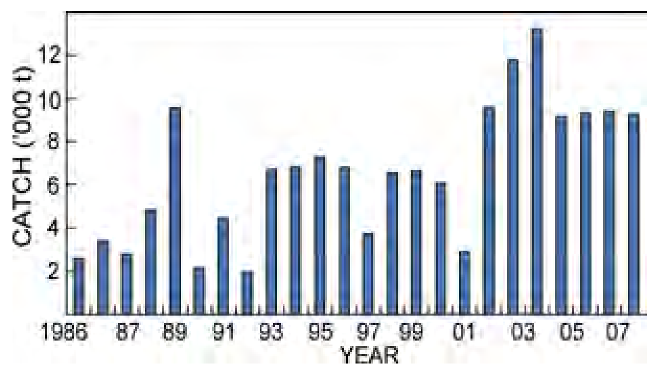

Figure 31: Annual squid catches made by the jig fishery. Data are from the (SABS) South African Bureau of Standards (by Industry for period 1985–2007, and by MCM for 2008)

Current status

Uncertainties in the reliability of the catch-and-effort data available make it difficult to assess the current status of the resource in a meaningful way, or with any confidence. In the absence of an updated and reliable assessment, the TAE has been maintained at a constant level over the past four years.

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Tunas and swordfish

Underexploited Swordfish (Atlantic)	Optimally exploited Albacore (Atlantic & Indian) Yellowfin Tuna (Atlantic & Indian) Bigeye Tuna (Atlantic & Indian) Swordfish (Indian)	Overexploited, threatened, endangered or collapsed Southern Bluefin Tuna (Atlantic & Indian)	Status uncertain

Introduction

Tuna species, including albacore *Thunnus alalunga*, yellowfin *T. albacares*, bigeye *T. obesus*, southern bluefin *T. maccoyii* and swordfish *Xiphias gladius,* are highly migratory species. They are distributed throughout the Atlantic Ocean, except for southern bluefin, which are confined to the Southern Hemisphere.

Spawning of yellowfin, southern bluefin and bigeye tuna takes place in tropical and subtropical waters when environmental conditions are favourable. Bigeye juveniles are often found together with yellowfin. Satellite tagging studies have shown that bigeye tuna exhibit daily vertical migration patterns, inhabiting deeper water during the day than at night. Tuna feed on a variety of fish, molluscs and crustaceans.

Albacore are found in more temperate waters of the Atlantic Ocean and currently two different stocks are recognised, a South and North Atlantic stock, which are separated at 5˚N. Southern bluefin are the largest of the tuna species and can reach a length of up to 2 m and a weight of 200 kg.

Swordfish have recently been separated into three different stocks, a Mediterranean, northern and southern stock. They can attain weight of up to 500 kg by three years of age. Swordfish feed on a variety of fish and invertebrate species, and spawn in the tropics.

South Africa has three commercial fishing sectors, which catch tuna and tuna-like species in the Atlantic and Indian oceans. These sectors are the longline, pole and line/ rod, and reel fisheries. There is also a boat-based sportfishery.

History and management

Although domestic commercial longlining for tuna has been documented from the early 1960s with catches reaching around 2 000 t, the fishery declined rapidly in the mid-1960s as a result of a poor market for low quality bluefin and albacore tuna landed by South African fishers. Interest in targeting tuna using longline gear was expressed again in 1995, when a joint venture with a Japanese vessel confirmed that tuna and swordfish could be profitably exploited within South Africa's waters. In response to fishers expressing interest in longlining for tunas, 30 experimental longline permits were issued for South African waters towards the end of 1997, primarily for catching tuna. Catches peaked at over 2 500 t during the experimental phase of the fishery, with the main target species being swordfish, yellowfin and bigeye tuna. Other important bycatch species included albacore, southern bluefin, and blue and mako sharks.

The experimental longline fishery was formalised into a commercial fishery in 2005 when long-term rights were allocated. The primary objectives of this allocation were to develop a tuna catch performance for South Africa and to adopt methods to suit our fishery. In this allocation process, 18 rights were issued

for the swordfish-directed fishery and 26 for the tuna-directed fishery. The policy was to allocate one right to one vessel.

Because large pelagic resources are highly migratory and fished by many nations, these resources are managed by Regional Fisheries Management Organisations (RFMOs), South Africa received a swordfish catch limit of 1 200 t for 2007–2009 from the ICCAT. South Africa was also allocated a southern bluefin quota of 40 t from the Commission for the Conservation of Southern Bluefin Tuna (CCSBT) for 2007–2009. In preparation for bigeye tuna quotas, which will be allocated by the Indian Ocean Tuna Commission (IOTC) in 2010, South Africa is limited to a maximum of 50 longline vessels in the Indian Ocean. No other quotas have been allocated to South Africa thus far.

In 2000, the linefishery was declared to be in a crisis. To alleviate fishing pressure on linefish stocks the former commercial handline sector was split into three sectors for the 2002 rights allocation process. The three sectors are traditional linefish, hake handline and tuna pole, with the latter sector mainly established for the targeting of albacore and some vessels targeting yellowfin tuna since 2003. A maximum of 200 rights (200 vessels with a crew of 3 600) were available in the tuna pole sector. In essence, this allocation was based on the number of vessels targeting albacore prior to 2002. Although the tuna pole sector was undersubscribed in the medium-term rights allocation (only 163 vessels and 2 734 crew allocated), the long-term allocation policy in 2005 still made provision for 200 vessels with a crew of 3 600 as albacore (the primary target species) was considered underexploited.

Research and monitoring

South Africa has an established onboard scientific observer programme to obtain length frequencies, biological samples, and fisheries information on target and bycatch species. The observer coverage is aimed at 20% for domestic vessels and 100% for foreign-flag vessels.

The main focus of research on large pelagic resources in South Africa has been on the life history and stock structure of swordfish in southern African waters. The observer programme has been used extensively since 1998 to collect swordfish length frequencies and biological material for age and growth studies, sex ratios and maturity, and dietary studies. Genetic studies have also been conducted to better understand the mixing dynamics of swordfish in the boundary region between the Atlantic and Indian oceans.

A pilot tagging programme for swordfish, bigeye and yellowfin, using commercial longliners as a tagging platform, was conducted between 2004 and 2006, with approximately 300 large pelagic fish tagged. One swordfish was recaptured from this tagging programme just a few months later from the same vicinity where it was originally tagged. However, there have been too few recaptures to draw any meaningful conclusions about the movements of these fish. Given the cooperation from the skippers and relatively high observer coverage, it could be possible to make in-water tagging a permanent programme, if supported by the IOTC.

The Department is actively collaborating with the World WildLife Fund (WWF) and Birdlife SA by using the observer data collected since 1998 to assess the impact of longline fisheries on seabirds, turtles and sharks in South African waters, and to investigate various measures to mitigate and manage this bycatch. The impact of predators on longline catches is also being investigated under this programme.

Studies are currently underway to investigate the size and dynamics of recreational and commercial fisheries targeting yellowfin tuna. This research will also obtain length measurements and biological samples to determine length frequencies, diet, age and growth, sex ratios and maturity, and contribute to yellowfin tagging efforts. Ageing studies on bigeye tuna are also currently being conducted by DAFF.

Current status

Stock assessments and country allocations for the Atlantic and Indian oceans stocks are the responsibility of ICCAT and the IOTC, whereas stock assessments for southern bluefin tuna are conducted by the CCSBT.

The last stock assessment for yellowfin tuna conducted by ICCAT (in 2008) indicated that the yellowfin tuna stock in the Atlantic Ocean was under- to optimally exploited. The 2006 catches in the Atlantic Ocean were estimated to be well below MSY levels. The ICCAT has expressed concern regarding the status of this resource because of the recent high levels of juvenile mortality estimates from tagging studies. The agreement to bring the stock assessment forward to 2008 was indicative of this concern. The IOTC has also expressed concern regarding the status of the Indian Ocean yellowfin tuna stocks as catches of this resource have far exceeded sustainable levels since 2003. Their recommendation was to reduce total catch and effort to the levels recorded between 1999 and 2002. Of further concern is the uncertainty regarding the origin of the fish caught in South African waters. Research is currently being conducted to determine the stock delineation for these fish.

The last full southern Atlantic albacore stock assessment was conducted by ICCAT in 2007, using an age-structured production model. The results indicated that the southern Atlantic albacore stock had to be rebuilt in order to achieve MSY. In order to work towards rebuilding of the stocks, the Commission adopted a catch limit of 29 900 t in the South Atlantic.

Swordfish stock assessments were conducted by ICCAT and IOTC in 2009. These indicated that the stock in the Atlantic Ocean is not overexploited, with catches of 11 108 t in 2008 being well below the estimated MSY level of 15 000 t In contrast, the outlook for the swordfish stock in the Indian Ocean is concerning, because of the high effort and catches made in the

South-West Indian Ocean.

The most recent stock assessment for bigeye tuna was conducted in 2007. The current MSY level was estimated to be 93 000 t. The yield in 2007 was 67 172 t and the replacement yield was slightly below MSY. The resource is currently seen to be optimally exploited.

Southern bluefin stock status indicators were recently reviewed by the CCSBT Scientific Committee in 2009. The indicators continue to support the contention that this tuna resource is overexploited. The CCSBT set a global TAC of 11 810 t per year for the period 2007–2009. However, owing to further evidence of a decline of stocks of this resource, the global TAC was reduced to 9 449 t for 2010 and 2011. The Commission will consider further reduction of the global TAC for 2012, unless there is a demonstrable improvement in stock status indicators before then.

Stock assessments of pelagic sharks, conducted by the ICCAT in 2008, were inconclusive due to widespread under-reporting catch-and-effort data for sharks. Despite this, there is still huge international concern regarding the stock status of pelagic sharks due to the biology of these species and the current high fishing capacity that exists worldwide. As a precautionary measure the RFMOs have called for the capping of effort on sharks and have requested that nursery grounds for these species be protected.

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West Coast rock lobster

Underexploited	Optimally exploited	Overexploited, threatened, endangered or collapsed	Status uncertain

Introduction

The West Coast rock lobster *Jasus lalandii* fishery is the most important rock lobster fishery in South Africa on account of its high market value (R260 million per annum) and its importance in providing employment for about 4 200 people from communities along the west coast of South Africa. The West Coast rock lobster is a cold-water temperate spiny lobster species that occurs from Walvis Bay in Namibia to East London. In South Africa, the commercial fishery operates between the Orange River mouth and Danger Point in waters up to 100 m deep. This slow-growing species inhabits rocky areas and exhibits a seasonal inshore-offshore migration, governed by its biology and environmental factors. Currently, 20% of the resource is harvested by hoop nets in the nearshore region up to one nautical mile offshore and 80% by offshore trap vessels operating up to water depths of >100 m. The resource in the nearshore region is also harvested by recreational fishers and the informal small-scale subsistence fishers operating exclusively in the nearshore region during the summer.

The invasion of West Coast rock lobsters in to the traditional abalone fishing zones east of Cape Hangklip marked the onset of the eastward shift in lobster distribution. Commercially viable quantities of lobster in this area resulted in the opening of three new lobster fishing zones. However, the fishery on the West Coast that historically landed the bulk (60%) of the lobster catch now lands only 40% of the total catch annually. This decline in catch had a devastating effect on the coastal communities with economic hardships experienced by most fishers along the West Coast. In the face of resource decline an OMP was developed that aimed to rebuild the stock to sustainable levels.

History and management

The commercial harvesting of West Coast rock lobster commenced in the late 1800s, and peaked in the early 1950s, yielding an annual catch of 18 000 t (Figure 32). Lobsters were predominantly caught with hoop nets prior to the 1960s and from 1965 more efficient traps and motorised deck boats were also used. Catches declined by almost half to 10 000 t during the 1960s and continued to decline sharply to around 2 000 t in recent years. The decline in catches is believed to be due to a combination of changes in fishing methods and efficiency, changes in management measures, overexploitation, environmental changes, and reduced growth rates.

A number of management measures have been put in place during the history of the fishery. A minimum size limit was introduced in 1933 (89 mm carapace length, CL), which protected a large proportion of the slower-growing female component of the population, and a tail-mass production quota was imposed in 1946. However, catches declined sharply during the 1950s, particularly in the northern areas, in response to overfishing. A minimum legal size limit of 76 mm CL was implemented in 1959, after which the catch increased to around 10 000 t until the mid-1960s. However, catches declined again from 1966 and continued to decline during the 1970s when a minimum legal size limit of 89 mm CL was implemented. In 1979, the tail-mass production quota was replaced by a whole lobster quota, which led to the introduction of the TAC management system in the early 1980s.

Under the TAC management system, annual catch limits were subdivided for the 10 traditional West Coast fishing areas (Figure 33, Zones A–D). A new fishing ground in False Bay (Zone E) was opened in 1987, and Zone F was opened in 1999 following the eastward migration of lobster to the area east of Cape Hangklip. Currently, the stock is managed on a per zone (super-area) basis. The resource in Zones A, E and F are exclusively harvested by hoop-net fishers operating in the nearshore region.

Other management controls applied included protection of females with eggs (berried) and soft-shelled lobsters, a closed winter season, and a daily bag limit for recreational fishers. Catches stabilised around 3 500-4 000 t until 1989 when the resource started to decline further. This continued decline in the resource during the 1990s and early 2000s was attributed to mass strandings of lobster and reduced growth caused by low oxygen events along the West Coast. During this period, the size limit was decreased from 89 to 75 mm CL to reduce mortalities resulting from discards of undersized lobsters. By 1996, catches declined to their lowest levels of 1 500 t and showed no marked signs of recovery.

In the face of decreases in growth rates, catch rates and biomass, an OMP was implemented in 1997 to rebuild the resource to more healthy levels (defined as pre-1990). The initial target for the OMP developed in 1997 was to increase resource abundance to 20% above the 1996 levels by 2006. By 2003, the resource had improved to 16% above the 1996 level. However,

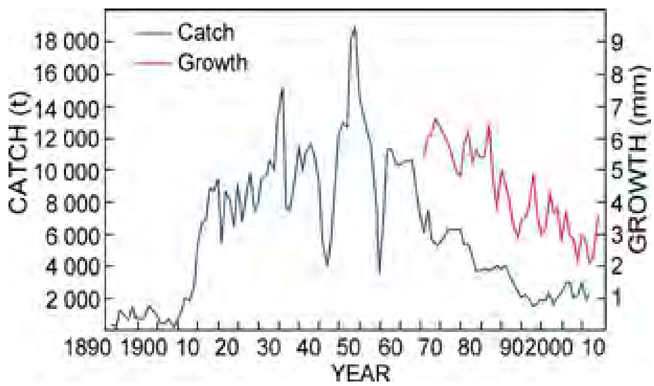

Figure 32: Historical catches of West Coast rock lobster, with the associated trend in growth indicated for the period post-1960

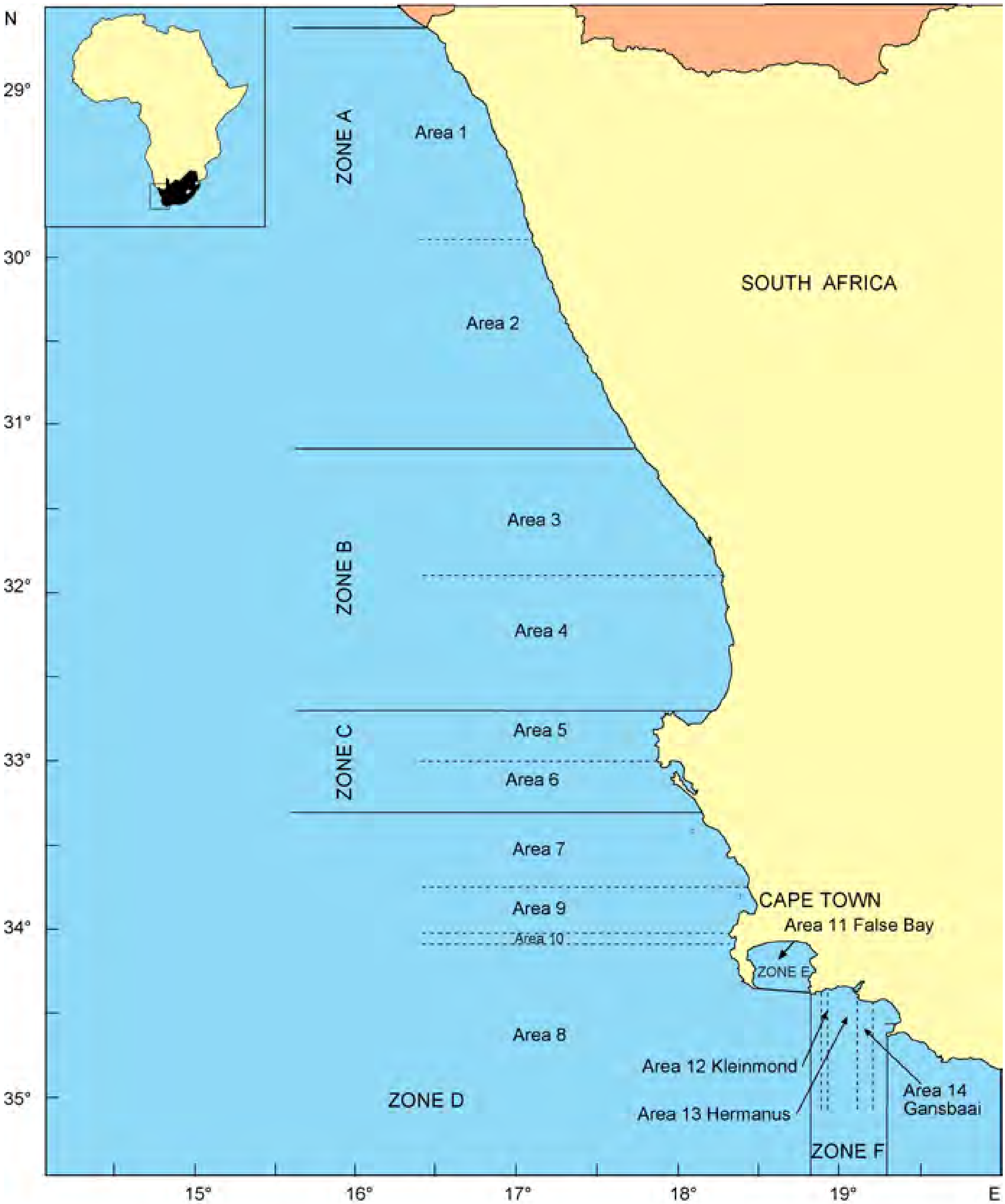

Figure 33: West Coast rock lobster fishing zones and areas. The five super-areas are Zone A (Area1–2), Zone B, (Area 3–4), Zone C, (Area 5–6), Area 7 being the northernmost Area within Zone D, and Area8+ comprising Area 8 of Zone D in conjuction with Zone F

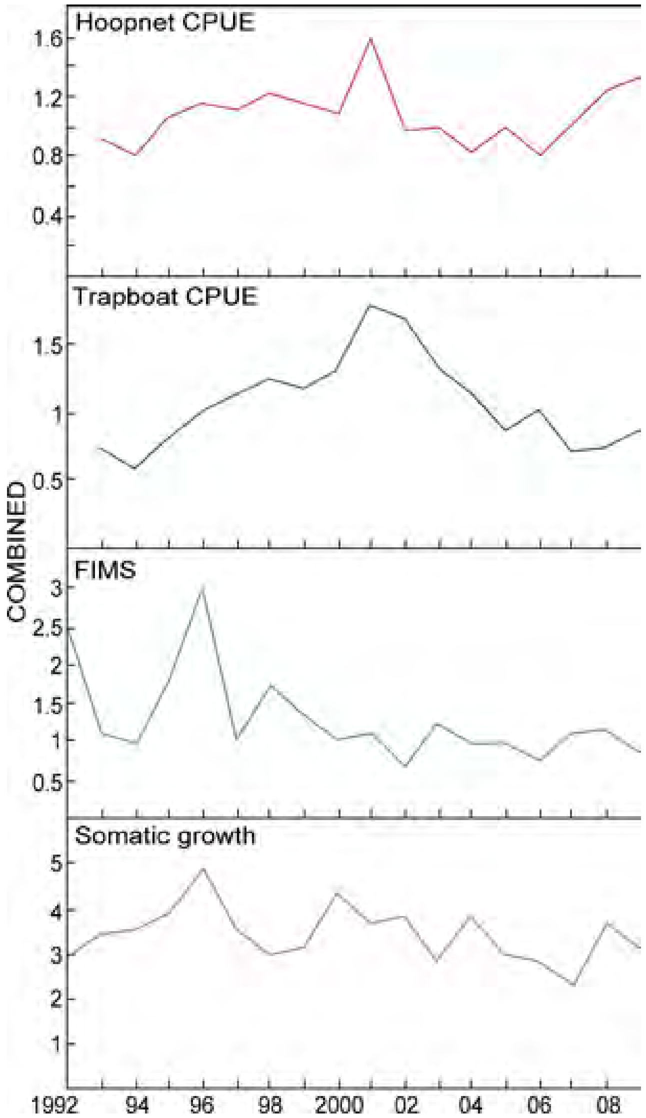

Figure 34: Input data combined across super areas that are used as input into the OMP used for the 2009/10 TAC computaton

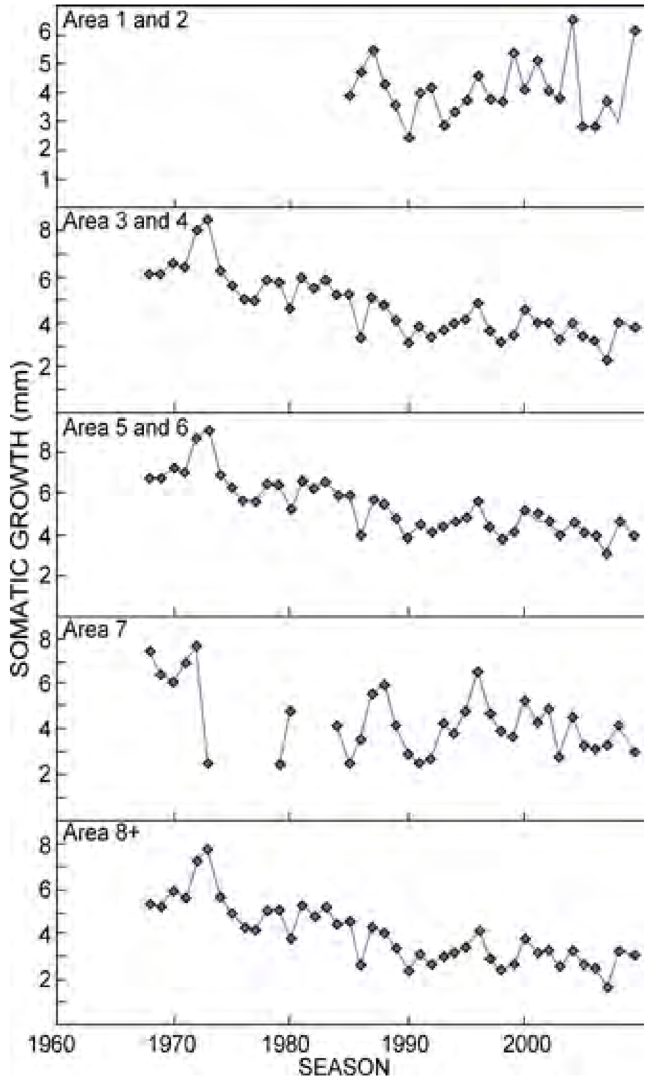

Figure 35: Annual somatic growth (the mean annual somatic growth rate of a 70 mm male lobster)

by 2006, resource abundance had decreased again dramatically to 18% below the 1996 level. This decline was due to recruitment failure and increased fishing pressure (increase in the number of nearshore right-holders) during the long-term rights allocation process in 2003/2004. The commercial TAC was decreased by 10% for the following three consecutive seasons (2006/2007, 2007/2008 and 2008/2009) in an attempt to rebuild the stock to the new target of 20% above 2006 levels by 2016. The OMP is continuously revised and improved to meet the rebuilding targets.

Research and monitoring

Research and monitoring of West Coast rock lobster continues to provide and improve essential data inputs for assessing the sustainability of the stock, its management and setting annual catch limits for the fishery. Indices of abundance such as CPUE derived from the Fishery-Independent Monitoring Survey (FIMS) and commercial catch statistics, annual assessments of somatic growth rate, and estimates of recreational and interim relief catch, are used as input data to the OMP assessment model.

Monitors record fishing effort and catch landed by commercial nearshore and offshore right-holders and Interim Relief fishers on landing slips after each fishing trip. Recreational catch is estimated from catch-and-fishing effort statistics reported during an annual recreational telephonic survey.

Growth of West Coast rock lobsters is monitored by tagging pre-moult male lobsters (>75 mm CL) along the West Coast from July to November. Growth increment and release-recapture times are incorporated into a 'moult probability growth model' to estimate the growth per moult cycle.

Information on sex, reproductive state, size frequency and bycatch are also recorded during FIMS and ship-based observer monitoring surveys onboard commercial vessels to derive abundance indices of subadult, legal-sized male and female (>75 mm CL) lobsters, which are used as inputs into the size-structured assessment model. This information, together with environmental data, is also used in providing ongoing scientific advice for management of the resource. Historical FIMS data and analysis methods have been recently rechecked, and

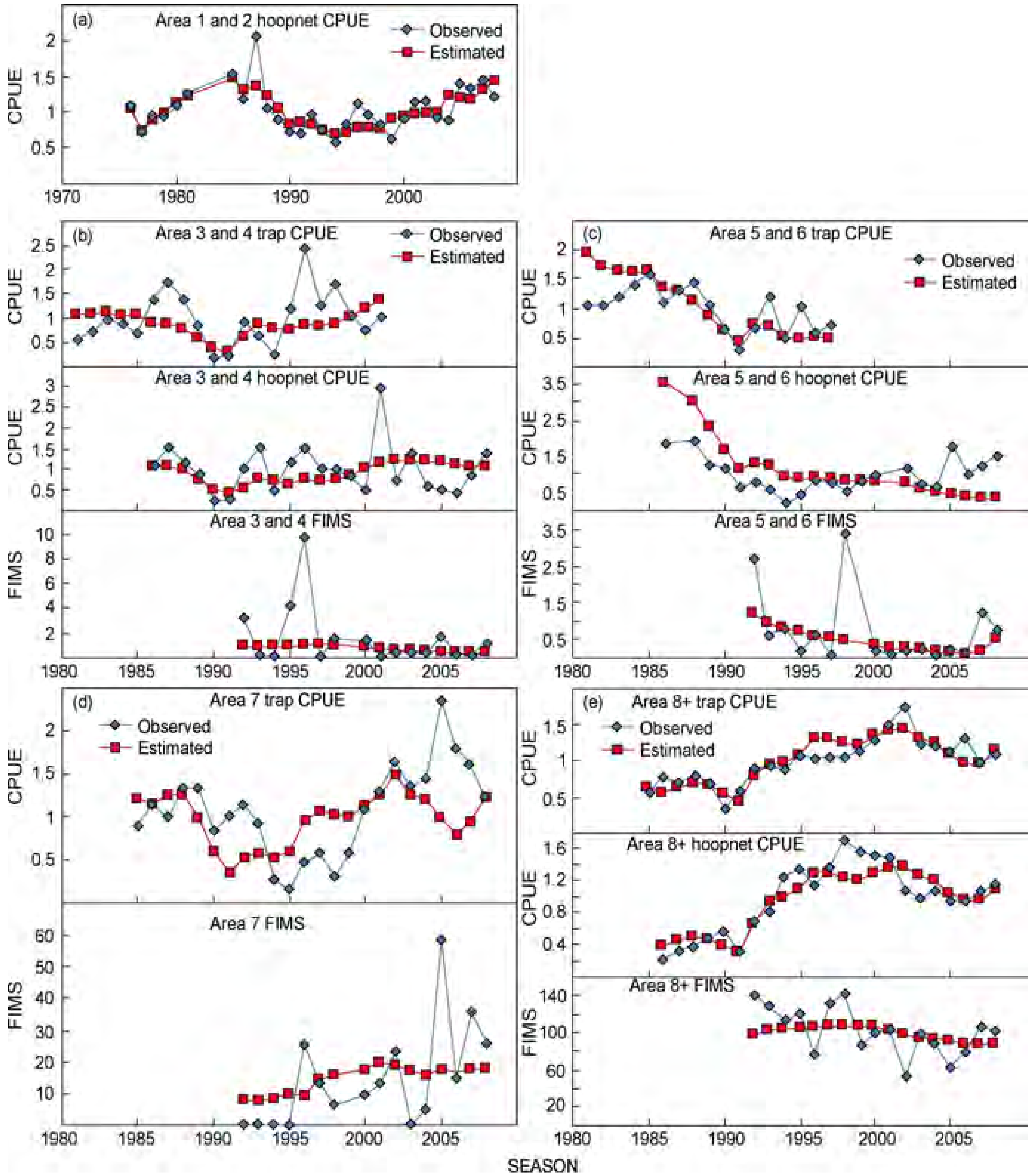

Figure 36: Annual CPUE and FIMS data fitted to reference Case Area (a) 1 and 2, (b) 3 and 4, (c) 5 and 6, (d) 7 and (e) 8,1976–2008

changes in weather conditions have been identified as a source of variation in CPUE. The associated effects of changes in bottom oxygen, temperature and current speed on catch rates is also currently being investigated.

The OMP assessment model provides projections of future biomass, under the assumption that future recruitment and growth will follow trends similar to those observed in the past. New research projects are being developed to provide indices of future recruitment, growth and catch to refine OMP projections of future biomass. Studies on the recruitment of post-larval and juvenile lobsters have been initiated to establish a long-term index of prerecruit abundance that could be used in predicting future recruitment and catch (6–7 years in advance). The function of internal energy sources in regulating growth and reproduction in females is under investigation, to formulate energy-growth-reproduction conversion factors for predicting future trends in growth and reproductive potential.

Current status

Resource monitoring indices used in the 2009 assessment of the West Coast rock lobster resource showed some improvement compared to indicators used in the previous assessment. The most recent indicators show that resource productivity as a whole has increased mainly due to increases in somatic growth and catch rates (Figure 34). Somatic growth rates have improved by 22%, on average, as indicated by the positive growth increments in all of the super-areas, except for Area 1+2 (Figure 35). Changes in the environment and food availability are the most likely factors responsible for the poor somatic growth of lobsters in Area 1+2.

Nearshore hoop-net catch rates increased by 27% on average for the overall resource, and are reflected in the improved catch rates observed in all super-areas, except for Area 5+6 (Figure 36a–e). In Area 5+6, hoop net-observed CPUE has decreased since 2005, but appears to be on the increase following much lower catches experienced during the 2006/2007 season. Despite the improved catch rates in Area 8, trap CPUE was 14% lower than in 2005/2006 for the overall resource. Fisheries-independent catch rates were similar to those during 2005/2006 in all super-areas, except for Area 5+6 where CPUE has increased.

Catch estimates reported from recent telephone surveys have indicated that the annual recreational catch has not decreased substantially since 2000, but rather remained in the vicinity of its estimated level for earlier years of some 300 t. However, over the past several years, there are indications of some decrease in the catches. This is in line with the intended decrease in recreational catch brought about two years ago, when the recreational season length was reduced according to the OMP rules.

A thorough analysis has been conducted on the catch returns received from fishers fishing under the Interim Relief provisions for the 2007–2009 seasons. Estimates of annual catch were calculated from catch return data that generally reflect weekly catches, repeated 22 times during the season. The resultant estimates of the Interim Relief catch are about 170 t for each of the 2007 and 2008 seasons.

The biomass of lobsters above the legal size limit has increased significantly over the past 3-4 years for the resource as a whole (Figure 37). On a super-area level, biomass increases were most evident in Areas 7 and 8, probably because of the stronger recruitment of lobsters in these areas (Figure 38). Lobster biomass in Areas 1+2 and 3+4 remained relatively

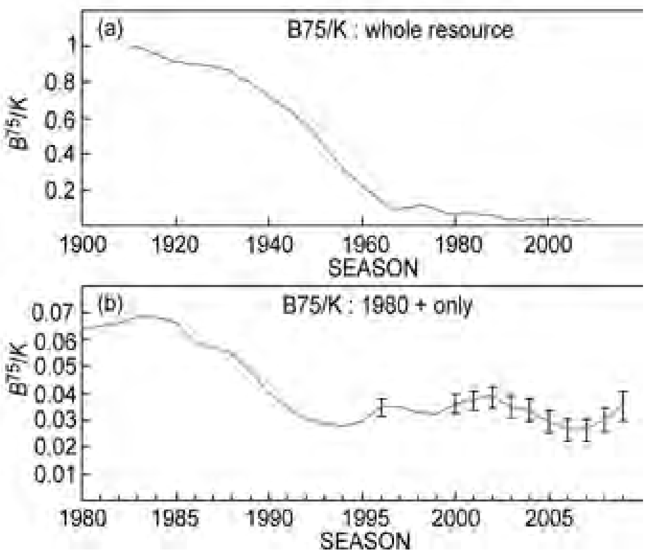

Figure 37: (a) Current biomass in relation to pristine (B^{75}/K) values for the resource as a whole (i.e. summed over the five super-areas); (b) values for 1980+ only. The 95% confidence intervals are shown for 1996 and 2000+ years

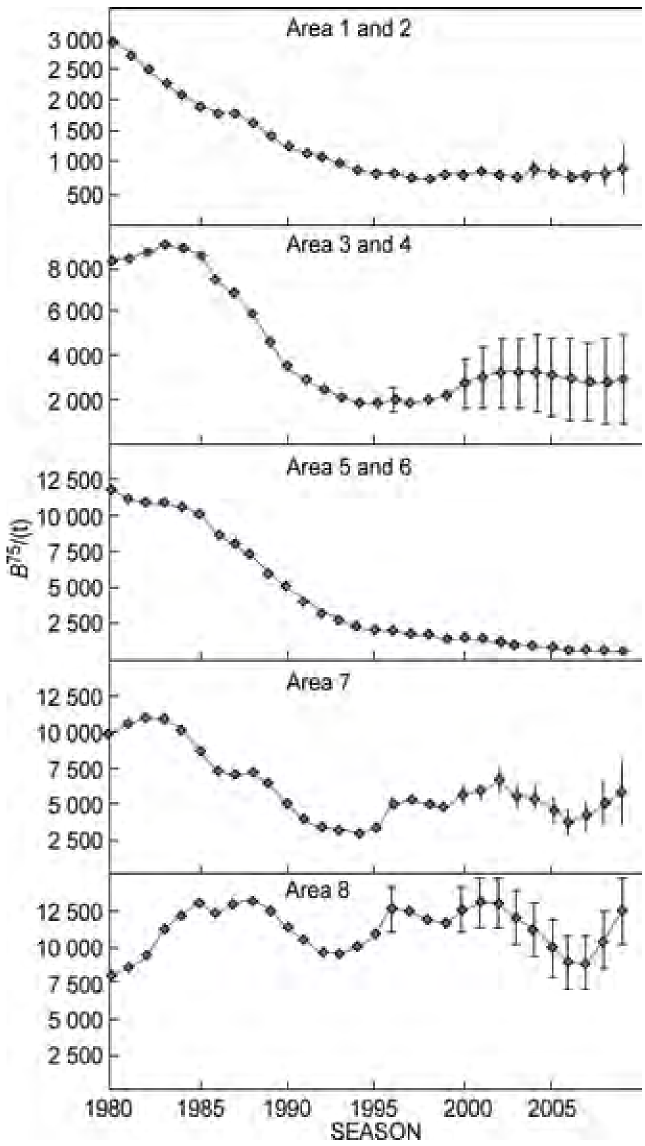

Figure 38: Biomass (B^{76}) trajectories in absolute abundance terms for each of the five super-areas, 1980-2009. The 95% confidence intervals are shown for 1996 and 2000+ years

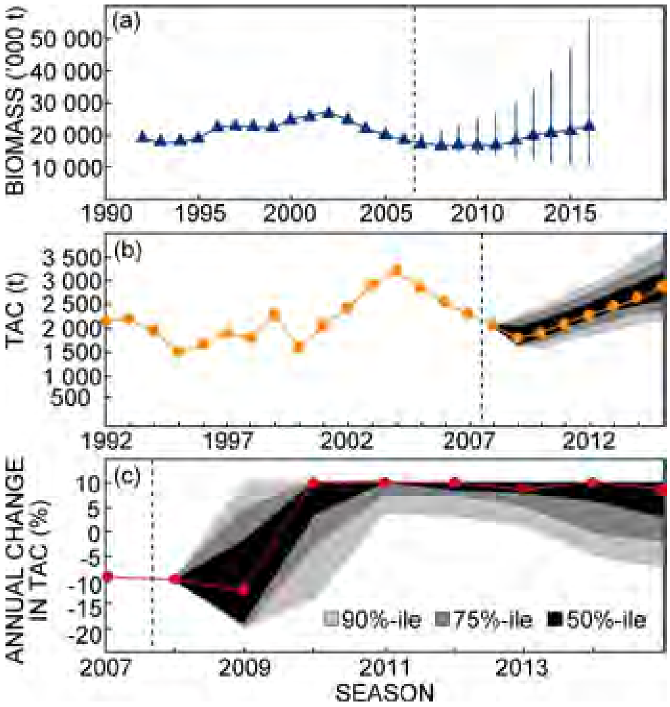

Figure 39: Projections of the OMP: (a) indicates the trend in male biomass 75 mm CL (B^{75}+), showing the median with 5th and 95th percentiles, (b) the commercial TAC, showing the median with 50th (black), 75th (dark-grey) and 90th percentiles (light grey), and (c) the commercial TAC annual variation, showing the median, with 50th, 75th and 90th percentiles - shading as for (b). In each plot, the vertical hashed line indicates the start of the projection period

unchanged over the past five years, most likely as a result of slow growth and poor recruitment experienced in Areas 1+2 and 3+4 respectively. Though the resource model estimated that the harvestable biomass in Area 5+6 is declining, this is in conflict with the observed data. Biomass estimates in Area 5+6 therefore warrant further investigation.

The previous assessment of the West Coast rock lobster resource in 2006 indicated that the resource was heavily depleted to 2.6% of pristine biomass levels. Following the 10% reductions in commercial catch limits over the past three seasons, the 2009 assessment results show a reversal of this decreasing trend in abundance (Figure 39b). Lobster abundance was estimated to have increased from 18 500 t in 2005/2006 to 22 700 t in 2008/2009, which puts the resource at 3.4% of pristine biomass. As a result, the OMP estimated that the TAC for 2009/2010 is 2 393 t, 53 t higher than the TAC for 2008/2009.

The prognosis for the fishery, as indicated by OMP future catch projections, is that this recovery trend in catch will continue until 2016 (Figure 39b), assuming that no unsustainable allocations over and above the TAC are made during this period. These projections indicate that biomass will have increased to 20% above 2006 levels by 2016 and that harvestable biomass will have increased to 4% of pristine levels if fishing levels remain within the recommended TAC. However, if allocations exceed this level, stock recovery will be compromised.

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White mussels and small invertebrates

Underexploited	Optimally exploited	Overexploited, threatened, endangered or collapsed	Status uncertain

Introduction

White mussels

White mussels of the species *Donax serra* occur from northern Namibia to the Eastern Cape of South Africa. Abundance is highest along the West Coast on account of higher plankton production compared with the rest of the South African coast. As a result, the existing commercial harvest is restricted to the West Coast, whereas recreational harvest spans the entire distribution range of the species. Mussels are harvested along sandy beaches in the intertidal zone and are used commercially for bait.

Octopus

The common octopus *Octopus vulgaris* occurs along the entire South African coastline. It is found inshore in intertidal rock pools and offshore in depths of over 200 m, and inhabits various substrata including shell, gravel, sand and reef. A pilot study on the biology and fishery potential of this species paved the way for a five-year experimental fishery, which commenced in September 2004 and culminated at the end of September 2009.

Whelks and crabs

The distributions of the whelk *Bullia laevissima* and three-spotted swimming crab *Ovalipes trimaculatus* range from Namibia to the Wild Coast on the east coast of South Africa. A small-scale experimental hoop-net fishery was established in 1989 along the West Coast, employing a fishing method similar to that of the rock lobster fishery, but on sandy substrate. The original target species was the three-spotted swimming crab; however, catch rates of whelks were greater, which gave rise to the current exploratory fishery targeting whelks with the crabs as a bycatch.

Red bait

The sea-squirt red bait *Pyura stolonifera* is distributed along the entire South African coastline in intertidal rock pools. The removal of red bait is an antifouling operation, and is a necessity for most marine aquaculture operations. The red bait removed during this process is sold as a means of cost-recovery and in turn creates employment opportunities.

History and management

White mussels

Management of the commercial fishery is currently effort-controlled and TAE is considered the most effective regulatory tool for this sector. The recreational sector is controlled by a daily bag limit of 50 mussels. For both sectors, a minimum legal size of 35 mm applies.

The fishery for white mussel started in the late 1960s as part of the general commercial bait-fishery, until 1988 when the bait rights were revoked. Subsequent to stock assessments conducted in 1988/1989, harvesting of white mussels was retained as a commercial fishing sector and limited to seven areas along the West Coast. Surveys conducted in the 1990s showed that commercial catch levels amounted to <1% of the standing biomass in the relevant areas, consequently the resource was considered underexploited. In the decades preceding the 1990s, catches declined continuously (Figure 40). In 2001, four-year commercial harvesting rights were awarded in this sector, followed by a new term of two-year rights in 2006. Since 2007, the commercial sector has been managed by means of a TAE of seven right-holders (eight 'pickers' including the right-holder), each harvesting only one of seven commercial fishing areas along the West Coast. Each right-holder was limited to a monthly catch of 2 000 mussels. However, due to unreliable data from the fishery, under-reporting and difficulties with catch monitoring, catch limits were not considered as an adequate regulatory tool to monitor this fishery. Therefore, from October 2006, the monthly catch limit was lifted, with the aim of improving the quality of catch-and-effort data for use in future resource assessments.

Octopus

A pilot study paved the way for a five-year experimental pot-fishery, which ran from October 2004 until September 2009. Eight areas were allocated between Saldanha Bay and East London, with two permits operational per area. Longline fishing was employed with unbaited pots deployed at different depths between 10 m and 50 m on suitable substrate (coarse/sandy/shelly). Pot types, numbers of pots and soak times were prescribed. There has been approximately 100% observer coverage for this sector.

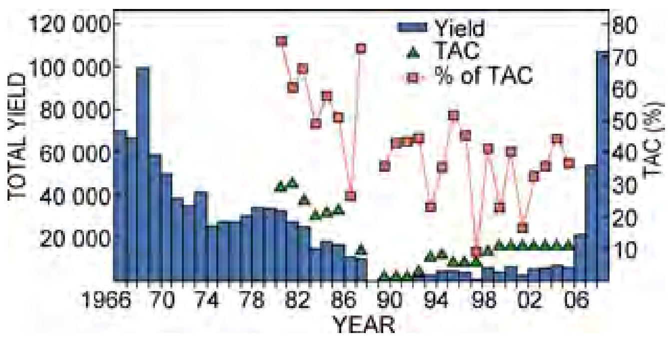

Figure 40: Total number of white mussels harvested commercially, and the TAC and percentage of the TAC taken,1966–2008

Table 10: Survey data for white mussels by study site

Site	Year	Number per 1-m transect	Above minimum legal size (%)	Beach length (km)
Brittania Bay	1982	4 272	93.9	2.0
Brittania Bay	1989	3 092	97.0	1.0
Paternoster	1982	1 986	80.1	2.0
Paternoster	1989	150	80.0	0.7
Elands Bay	1989	1 320	77.6	2.5
Dwarskersbos	1988	2 884	60.3	8.0
Dwarskersbos	1989	2 959	54.1	22

Whelks and crabs

A small-scale experimental hoop-net fishery was established in 1989 along the West Coast. Catch rates were as high as 160 kg h^{-1} for whelks and 17 kg h^{-1} for crabs. Whelks are considered to have excellent potential for the export market. The experimental fishery ended in 1993 due to processing and marketing problems. Also, a severe red tide depleted the catch rates of whelks. Only one permit-holder commenced fishing in May 2009. In May 2008, an exploratory fishing permit was granted for targeting whelks and swimming crabs (an expected bycatch). Fishing grounds are between west of Seal Island (False Bay) and Cape Town Harbour, and a maximum of 100 baited hoopnets may be utilised. This fishery is limited to weekdays only and no overnight setting of hoopnets is allowed.

Red bait

In June 2009, a single permit was issued for the removal of red bait as an antifouling operation. The whole animal is removed from the structures but only the inner flesh is sold as bait; the hard outer casing is discarded. The total allocated amount is 7 t and this may only be harvested by hand, using knives and gaffs. The harvesting area is limited to the marine aquaculture area within Saldanha Bay and the Portnet structures in the port of Saldanha, and collection of washed-up red bait is permitted on the beaches immediately bordering the port.

Research and monitoring

White mussels

In the early 1990s, research on white mussels was confined to a few *ad hoc* area-specific stock assessment surveys carried out in response to requests for commercial permits. Stock assessment surveys have been conducted since September 2007 and data are being collected in order to provide a better understanding of the abundance of the white mussel resource on an area-by-area basis (Table 10). In order to provide such recommendations, regular surveys are conducted on each area throughout the year over several years.

Catch monitors have been deployed since 2009 at each of the commercial sites and commercial and recreational catch data are regularly recorded.

Octopus

The octopus fishery had a positive start at its beginning in 2005, with 12 activated permits and 66 trips undertaken. Unfortunately, the fishery declined rapidly thereafter, with no fishing effort being recorded in 2008. In 2009, only three permits were activated. As a consequence, the experiment has not yet provided the data necessary to assess the status of the octopus resource and to determine the viability of a potential commercial fishery.

Whelks and crabs

A permit for this fishery was issued in May 2008 and subsequently in mid-2009 and a few trips were undertaken during 2009. Subsampling of the catches was undertaken and reports from the permit-holder have been received. Data reported include mass, length and breadth, and the total live mass of the catch. The data are then used to monitor any changes in the catch throughout the year.

Red bait

It is not considered necessary to monitor this resource as the harvesting thereof is only undertaken from populations growing on man-made structures and there is no harvesting of the naturally occurring stocks.

Current status

Although new research on white mussels, in the form of fishery-independent surveys, has been initiated by MCM since 2003, it is still too early for a comprehensive assessment of this resource. In addition to the fishery-independent surveys, commercial catch data is also required in order to obtain reliable data for setting a TAE. Not all the permits for the seven areas have been activated for a whole year and the maximum effort at each area has not been fully subscribed. The lifting of the upper catch limit in 2006 led to a steep increase in the number of white mussels collected over the past three years (ranging from 216 196 in 2006 to 1 068 296 in 2008; Figure 40). It should be noted that the largest component of the overall catch of white mussels is by the recreational sector; yet these catches are not monitored routinely. There are also gaps in information on the level of exploitation by subsistence harvesters and the levels of illegal take. Due to irregularities in the catch-and-effort data, these data are considered unreliable. The current research programme will help to gather sufficient data to allow for proper assessment of the white mussel resource in the medium term.

Insufficient data were collected during the octopus experimental fishery to address key questions regarding the status of the resource, and for the possible further development of this fishery. Preliminary studies of octopus biology and population dynamics indicate that this resource appears to be underexploited.

The stock status for whelks and crabs has not yet been determined.

Scientific investigation on red bait is needed to establish the subtidal stock of this resource.

Further reading

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