STATUS OF THE SOUTH AFRICAN MARINE FISHERY RESOURCES 2014

agriculture,
forestry & fisheries

Department:
Agriculture, Forestry and Fisheries
REPUBLIC OF SOUTH AFRICA

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Department of Agriculture, Forestry and Fisheries
(Cape Town, South Africa)

Foreword

Food security and nutrition, job creation and contribution to GDP are three central pillars of the Department of Agriculture Forestry and Fisheries (DAFF) policy for the foreseeable future. The fisheries sector in South Africa is worth around six to seven billion rand per annum and directly employs, in the commercial sector, some 27 000 people. Many thousands more people depend on fisheries resources for food and as a source of income to meet basic needs. The importance of maintaining or even increasing the yields from these fisheries by sustainable harvesting and the recovery of depleted stocks is therefore of paramount importance.

Sound scientific research remains one of the cornerstones for sustainable utilization of fisheries resources and, together with the Resource Management, Monitoring Control and Surveillance functions it strives to ensure that our fisheries contribute to the Department's stated goals.

The Status of South African Marine Resources Reports produced by DAFF are now recognized as an important contribution to our understanding of South Africa's exploited marine resources. The information is presented in a way that is of use to both scientists, fisheries managers; fishing industry stakeholders and the public. The maintenance of the high standard of research on our exploited marine resources is essential especially given the many challenges that face the sector including the imminent implementation of the Small Scale Fisheries Policy.

This third edition of the Status of South African Marine Resources Report attempts to collate the most up-to-date information about these valuable resources based on our own and other research efforts. We are proud to have maintained the production of such a valuable and quality publication, alongside the African Journal of Marine Science, our in-house journal. The latter is a world class science journal which attempts (and generally succeeds) in capturing the best work of especially African scientists.

I would like to thank the scientists and technicians of the Department, the people at the coal-face of research planning, surveys, data capture, analysis and reporting. The contribution of external scientists via the various Scientific Working Groups is also acknowledged.

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DIRECTOR GENERAL

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Acronyms and abbreviations

ASPM	Age-structured production model
CAL	Catch-at-length
CCAMLR	Convention for the Conservation of Antarctic Marine Living Resources
CCSBT	Commission for the Conservation of Southern Bluefin Tuna
CL	Carapace length
CoG	Centre of gravity
CPUE	Catch per unit effort
DAFF	Department of Agriculture, Forestry & Fisheries
EC	Exceptional circumstances
EEZ	Exclusive economic zone
EFZ	Exclusive fishing zone
FIAS	Fishery-independent abalone survey
FIMS	Fishery-independent monitoring survey
FMSY	Fishing mortality that would produce MSY level
GERMON	Genetic structure and migration of albacore tuna project
GIS	Geographic information system
GLM	General linear model
GLMM	General linear mixed model
ICCAT	International Convention for the Conservation of Atlantic Tunas
ICSEAF	International Commission for the South East Atlantic Fisheries
IFREMER DIO	French Research Institute for Exploration of the Sea, Indian Ocean Delegation
IOTC	Indian Ocean Tuna Commission
IUCN	International Union for Conservation of Nature
IUU	Illegal, unreported and unregulated fishing
KZN	KwaZulu-Natal
LMP	Linefish management protocol
MLRA	Marine Living Resources Act
MLS	Minimum legal size
MPA	Marine protected area
MSY	Maximum sustainable yield
NMLS	National marine linefish system
NPOA	National plan of action
NRCS	National Regulator for Compulsory Standards
OMP	Operational management procedure
ORI	Oceanographic Research Institute
PEI-EEZ	Prince Edward Island exclusive economic zone
PMCL	Precautionary management catch limit
PSAT	Pop-up satellite archival tag
PUCL	Precautionary upper catch limit
RFMO	Regional fisheries management organization
SB	Shell breadth
SPOT	Smart position-only tag
SSB	Spawning stock biomass
SSBMSY	Spawning stock biomass at MSY level
SWIO	Southwest Indian Ocean
SWIOFP	Southwest Indian Ocean Fisheries Project
TAB	Total allowable by-catch
TAC	Total allowable catch
TAE	Total allowable effort
TRAFFIC	The Wildlife Trade Monitoring Network
TURF	Territorial user rights in fisheries
USA	United States of America
WWF	World Wildlife Fund




Overview

This report presents the most up-to-date information and analyses of the status of in excess of 20 marine fishery resources in South Africa. The latest assessments indicate that a total of 48% of stocks are considered not to be of concern (blue and green categories)[1]. Of these, 11% are considered abundant and lightly fished, and 37% optimal. However, 50% of stocks are considered to be of concern (orange and red categories). Of these, 22% are considered depleted or heavily fished, and 28% are considered heavily depleted. There is a small improvement since the report of two years ago (2012), when 44% of stocks were considered not to be of concern and 54% were considered to be of concern[2].

The perception of the status of three stocks has deteriorated since the last report (2012). These include yellowfin and bigeye tunas in the Indian Ocean and squid. In contrast, the perception of the status of nine stock's has improved. These include deep-water hake, anchovy, hottentot, carpenter, slinger, line-caught yellowtail, Indian Ocean swordfish, and both Atlantic and Indian Ocean albacore.

The following is a brief summary for each resource:

- **Abalone:** The status of the abalone resource continues to decline in response to extremely high levels of illegal harvesting and over-allocation of Total Allowable Catches.
- **Agulhas sole:** Much uncertainty remains regarding the true status of Agulhas sole. Apparent declines in the resource in recent years have been attributed to changes in fishing effort and responses of the resource to environmental variability.
- **Cape hakes:** Deep-water hake has shown excellent recovery, recovering almost to its estimated Maximum Sustainable Yield Level, while shallow-water hake remains well above its estimated Maximum Sustainable Yield Level.
- **Cape horse mackerel:** Recent increases in abundance of Cape horse mackerel have been attributed to strong recruitment over the past few years. Further horse mackerel-directed surveys are required to validate the modelling results.
- **Linefish:** Newly-conducted assessments give a more optimistic outlook for a number of linefish resources, including hottentot, carpenter and slinger, and indicate the apparent beginning of stock rebuilding in these resources. However, other important stocks are still being overfished (notably silver kob), and protection of both adults and juveniles remains critical to the recovery of others such as red steenbras, seventy-four and dageraad
- **Netfish:** Harders, which are the main target of the beach-seine and gillnet fisheries, appear to have shown some degree of recovery. However, these gains are threatened by increasing illegal harvesting and adverse environmental conditions which disrupt the breeding cycles of these fish.
- **Oysters:** Oyster resources in KwaZulu-Natal are consid-

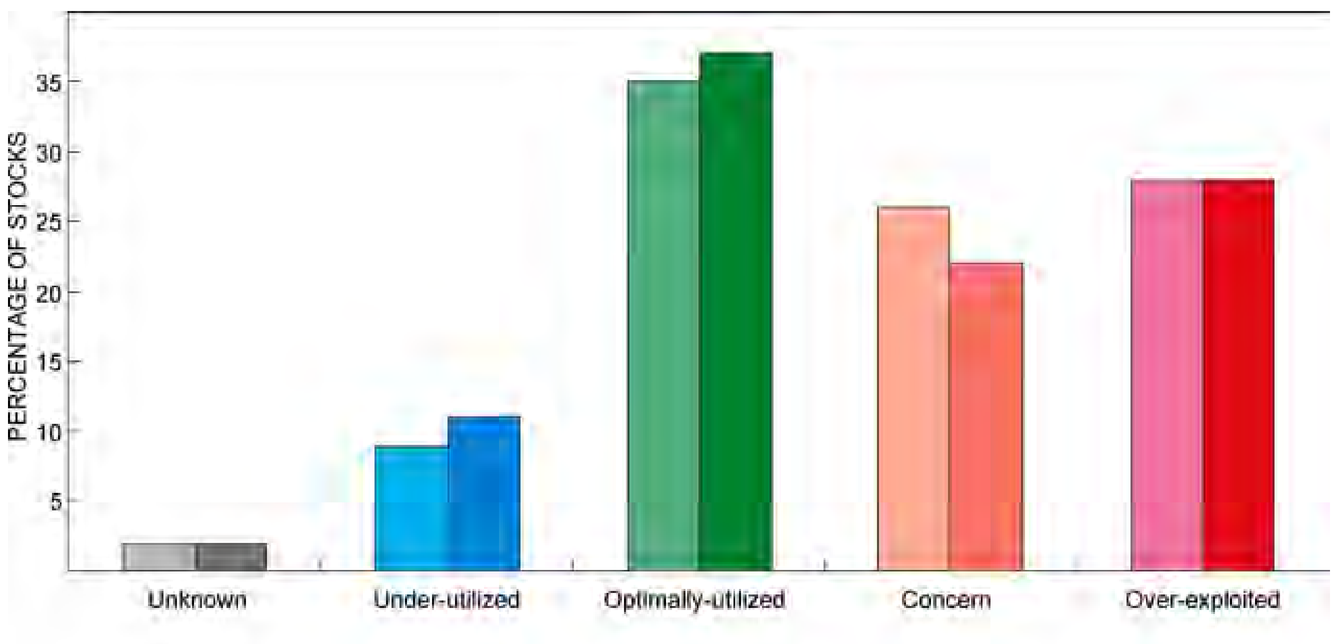
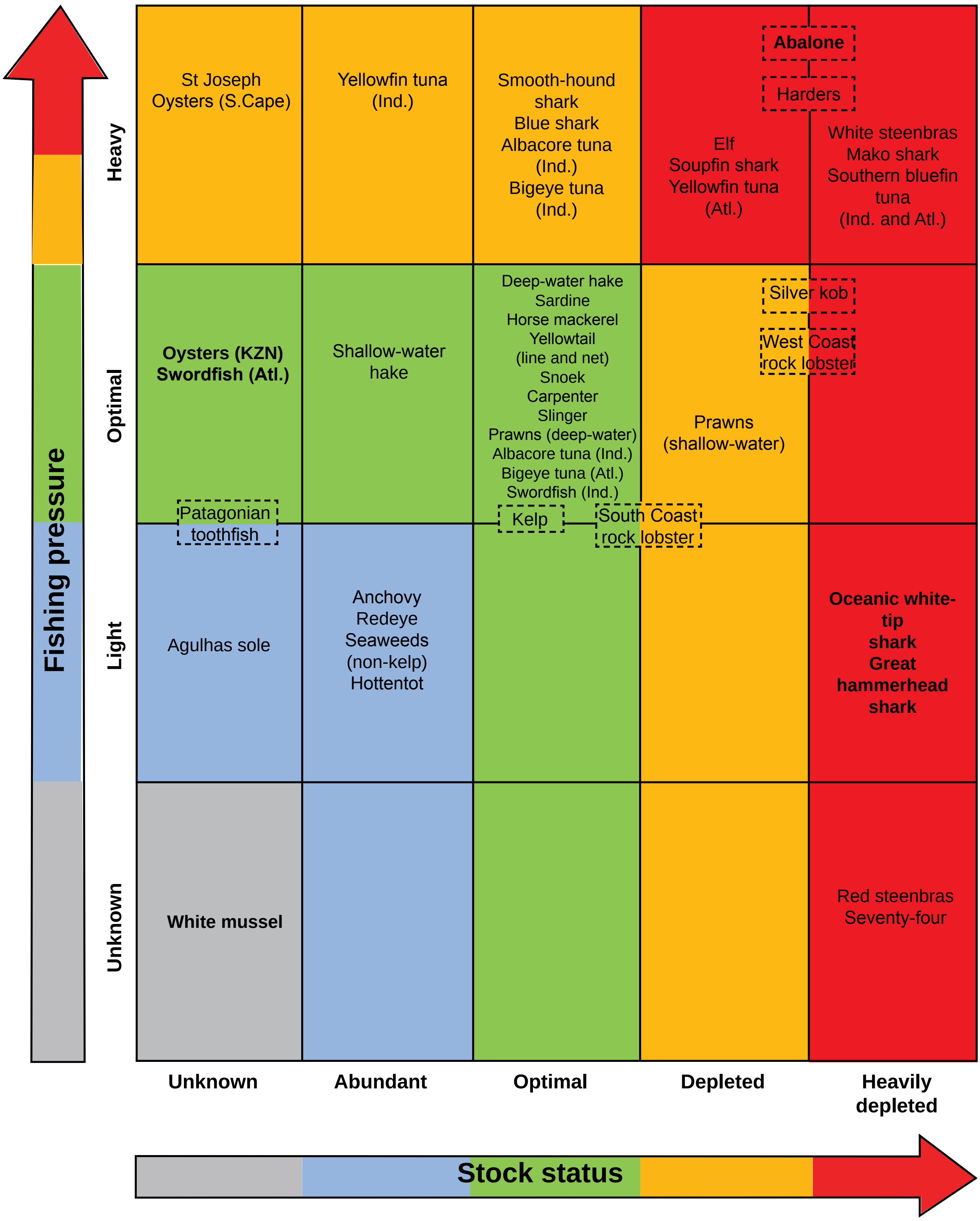


Figure 1: Percentage of stocks according to status. Dark bars represent the results of the most recent assessments, and light bars represent the previous situation as indicated in the 2012 report.

[1]For this summary appraisal, where a particular resource falls across two categories of stock status or pressure, precaution was applied and the resource has thus been assigned to the 'worse case scenario'.
[2]Perceptions of stock status may vary with improvements in the information available for that stock. Thus either deteriorations or improvements in the perception of status may not necessarily be indicative of actual changes in the stock status.

ered to be in an optimal state and optimally utilized. A paucity of suitable data for oysters in the Southern Cape means that their status remains largely uncertain, but their level of exploitation, and particularly illegal harvesting from subtital 'mother beds', is a cause for concern.

- **Patagonian toothfish:** Updated assessments including additional data suggest that the resource may be healthier than indicated by previous assessments, but uncertainty still remains regarding the accuracy of the assessments.
- **Prawns:** Prawn resources are considered to be in an optimal (deep-water) to depleted (shallow-water) state, with optimal to light fishing pressure. Continued low catches of shallow-water prawns are attributed to poor recruitment due to the drought and closure of the mouth of the St Lucia Estuary.
- **Seaweeds:** The status of kelp resources is considered optimal, and there is possibly room for further harvesting. Other seaweed resources are considered underutilized.
- **Sharks:** Concerns around stock status and harvesting rates remain for most shark resources. A paucity of reliable data for both directed catch and bycatch results in high levels of uncertainty around stock status for most shark resources.
- **Small invertebrates and new fisheries:** Despite ongoing and increased harvesting of white mussels in recent years, an ongoing shortage of data means that the status of and fishing pressure on this, and other small invertebrate resources, remains unknown. A number of new fisheries are currently under investigation, including octopus, whelks and crabs, redbait and redeye in KwaZulu-Natal.
- **Small pelagic fishes:** Small pelagic fishes are characterized by high levels of variability. Sardine stocks are currently at a low level after several years of poor recruitment. Although anchovy stocks are currently high, the Total Allowable Catches are not being filled because of the associated by-catch of juvenile sardine. The eastward shift of anchovy persists, but sardine appears to be more abundant in the West again.
- **South Coast rock lobster:** The South Coast rock lobster resource is considered to be in an optimal to depleted state, with fishing pressure on this resource optimal to light in an attempt to rebuild the stock. Catches have remained stable over the past few years.
- **Squid:** Updated analyses suggest that the squid resource is less productive than previously thought. De clines in the stock have been detected, necessitating a reduction in fishing effort.
- **Tunas and swordfish:** There are concerns regarding the stock status of most large pelagic resources, and a paucity of reliable data available to the Regional Fisheries Management Organisations that assess these stocks means that great uncertainties regarding stock status remain.
- **West Coast rock lobster:** The West Coast rock lobster resource remains severely depleted, with the stocks being only 2.6% of their pre-fished levels. Reductions in catches and illegal harvesting are imperative if recovery of this resource is to be effected.



Fishing pressure
Heavy
Optimal
Light
Unknown
St Joseph
Oysters (S.Cape)
Yellowfin tuna
(Ind.)
Smooth-hound
shark
Blue shark
Albacore tuna
(Ind.)
Bigeye tuna
(Ind.)
Abalone
Harders
Elf
Soupfin shark
Yellowfin tuna
(Atl.)
White steenbras
Mako shark
Southern bluefin
tuna
(Ind. and Atl.)
Oysters (KZN)
Swordfish (Atl.)
Shallow-water
hake
Deep-water hake
Sardine
Horse mackerel
Yellowtail
(line and net)
Snoek
Carpenter
Slinger
Prawns (deep-water)
Albacore tuna (Ind.)
Bigeye tuna (Atl.)
Swordfish (Ind.)
Silver kob
West Coast
rock lobster
Prawns
(shallow-water)
Patagonian
toothfish
Kelp
South Coast
rock lobster
Agulhas sole
Anchovy
Redeye
Seaweeds
(non-kelp)
Hottentot
Oceanic white-
tip
shark
Great
hammerhead
shark
White mussel
Red steenbras
Seventy-four
Unknown
Abundant
Optimal
Depleted
Heavily
depleted
Stock status

About the report

The purpose of this report is to make available information related to the current status of South Africa's major exploited marine fishery resources, and largely reflects the work of the Fisheries Research and Development Chief Directorate up to and including 2013.

A quick-view assessment appears at the beginning of each section, is colour-coded for ease of reference, and provides an indication of stock status and fishing pressure. The first line indicates the present status of the resource, which is the result of different pressures, such as fishing and environmental fluctuations, and past management practices. The second measure indicates the present level of fishing pressure exerted on that resource. The aim of sustainable management is to have resources that are in an optimal state and that are fished at optimal levels. However, historical over-fishing may have reduced some stocks to depleted or heavily depleted levels, and rebuilding these stocks could be attempted by reducing fishing pressure. Such re-building can take several years or even decades as the rate of recovery is dependent both on the biology of the species concerned and on natural recruitment fluctuations. Additionally, short-lived species (e.g. anchovy and squid) typically show high levels of recruitment variability that can result in substantial inter-annual fluctuations in population size; these could lead to the status of that resource changing from being depleted in one year to being optimal in the next. Five categories are defined for stock status, ranging from 'Abundant' though to 'Heavily depleted', and including an 'Unknown' category for which there are insufficient or con-flicting data to enable an accurate estimate to be made. Four categories of fishing pressure are defined, from 'Light' though' Optimal' to 'Heavy', and again including an 'Unknown' category for data-poor resources. The definitions used to assign a re-source to a status or category and fishing to a pressure category are given in the following tables:

Stock status

Category	Abundant	Optimal	Depleted	Heavily depleted	Unknown
Definition	$B > B_{MSY}$	$B \approx B_{MSY}$	$B < B_{MSY}$	$B << B_{MSY}$	B = ?

where B is the present biomass level (or population size) and B_{MSY} is that biomass level at which maximum sustainable yield (MSY) is obtained.

Fishing pressure

Category	Light	Optimal	Heavy	Unknown
Definition	$F < F_{MSY}$	$F \approx F_{MSY}$	$F > F_{MSY}$	F = ?

where F is the present fishing pressure and F_{MSY} is that fishing pressure level at which MSY is obtained.

For some, but not all, multiple-species fisheries, both the status and pressure measures are given per species. In some cases, the stock status and/or fishing pressure may vary around South Africa's coastline, which is indicated using multiple categories. Furthermore, available information may not unambiguously indicate the appropriate category for a resource, and this is also indicated by using multiple categories

Abalone

Stock Status	Unknown	Abundant	Optimal	Depleted	Heavily Depleted
Fishing pressure	Unknown	Light	Optimal	Heavy	

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 to 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 less than 20 m depth, but the highest densities occur in waters less than 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 on 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 about 65 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, experimental and subsistence permits were allocated along the East Coast in the past, and new experimental allocations were approved in 2010. 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

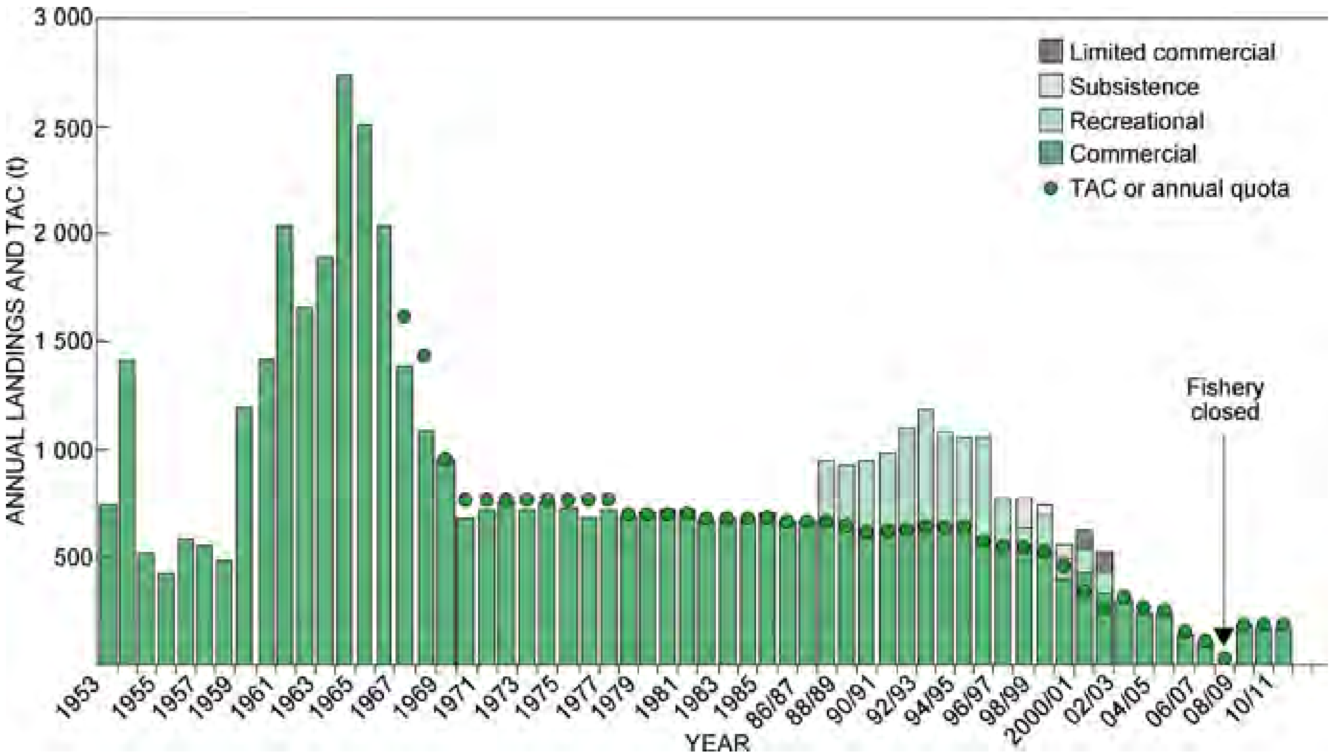


Figure 1: Total allowable catch (TAC) and recorded (legal) annual landings for the abalone fishery from 1953 to 2011/2012. Landings for the recreational sector are only available since 1988/1989. Note that the substantial recent illegal catches are not shown.

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 abalone fishing areas. The commercial fishery subsequently reopened in July 2010.

History and management

The commercial (diver) 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 close to 3 000 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, until the mid-1990s, after which there were continuous declines in commercial 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 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 Use 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 regards 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.

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 confis-

Figure 2: Distribution of abalone, *H. midae* (insert) and abalone fishing Zones A to G, including TURF sub-zones. The experimental fishery on the Eastern side of False Bay and in the Eastern Cape, and the experimental extension on the Western Side of False Bay of the current commercial Zone E, are also shown.

cated abalone are 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 led to the introduction of diving prohibitions in selected areas and the closure of the commercial fishery in February 2008. The fishery was subsequently reopened in July 2010, with TAC allocations of 150 t in the 2009/2010 and 2010/2011 seasons that were conditional on a 15% per annum reduction in poaching. This was based on a management objective for the sustainable utilisation and recovery of the abalone resource which was to prevent the abalone spawning biomass in each zone from dropping below 20% of its estimated pre-fished biomass (a 'limit reference point'), and to see it recover to 40% of that level (a 'target reference point') within 15 years of the re-opening of the commercial fishery in 2009/2010, i.e. by the 2024/2025 season.

The required reduction in illegal harvesting has not been achieved – in fact indices suggest a continued and substantial increase in poaching. At this time, some four years after the re-opening of the fishery, estimates indicate that poaching has increased by some 150%, whilst a net 50% reduction in poaching was required under the rebuilding plan.

Research and monitoring

Data from both the fishery and directed research surveys are used to assess the abalone resource. The commercial fishery is 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 have been derived from fishery independent abalone surveys (FIAS) since 1995. Twenty fixed-line transects are surveyed annually in each of five of the seven fishing zones by means of diving with scuba (the only exception being Zone F in which 16 transects are sampled) (Figure 2). The number and size of all abalone larger than 100 mm shell length are recorded to provide an index of abundance. Surveys are concentrated in the shallow (2-5 m) depth range, i.e. on the "inshore" component of the resource, since earlier findings indicated that the highest abalone densities occurred within the 0-5 m depth range. FIAS surveys of the deeper ("offshore") component of the resource are undertaken in Zones A to D, but these were of lower priority and received less attention in earlier years. However, there has been increased sampling of the deeper component since 2009, with 12 deep transects surveyed annually in each of Zones A to D. Survey results show substantial declines in mean density since 1995 in Zones A to D (Figure 3).

Surveys are also undertaken around Dyer Island and the Betty's Bay Marine Protected Area (MPA). Recent surveys undertaken at Betty's Bay indicated that the mean density of adult abalone has dropped to 1% of the level recorded in the 1990s. Surveys undertaken at Dyer Island in 2013 indicated some increase in the mean density since the closure in

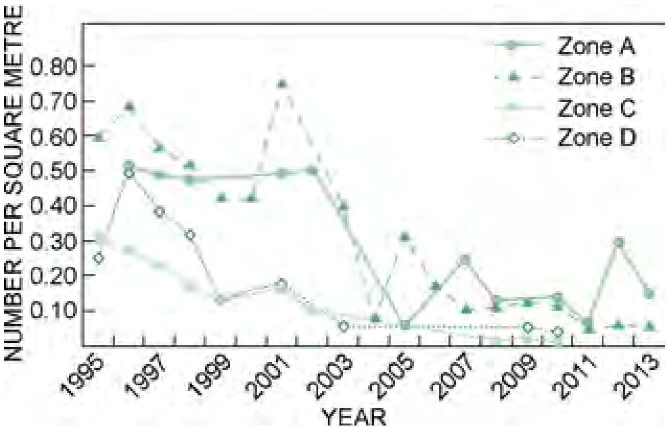


Figure 3: Mean densities of abalone in Zones A to D recorded during Fishery Independent Abalone Surveys (FIAS) from 1995 to 2013.

2004, although the current density around Dyer Island is still considered to be at a very low level with only 4% of abalone there being above minimum legal size (MLS). This indicates that there has been little recovery over this approximately 10-year period - consistent with reports of continued poaching of abalone around the island.

Recruitment surveys were undertaken annually from 1988 to 1993 and provided evidence of an ecosystem shift, with a decline in urchins and juvenile abalone in Zones C and D, and a simultaneous increase in the abundance of West Coast rock lobster. In 2002 a collaborative survey involving DAFF and the commercial abalone industry was undertaken in Zones B and C. This survey provided information on total population size structure and, in particular, further information on the decline in juvenile recruitment in Zone C compared to Zone B. This survey is being repeated to assess whether recruitment is still at similar (low) levels; initial results do not indicate any major change since 2002.

The illegal sector is monitored by means of recording and sampling the confiscated abalone to obtain estimates of poaching trends, total illegal take and size per zone. Compliance efforts are also factored in for improved estimates of poaching trends.

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, abundance estimates from the FIAS surveys, and catch-at-age information. The model also estimates the illegal catch, and the reduction in recruitment of juvenile abalone due to ecosystem changes.

The areas along the West Coast are not subject to such model analyses because of data limitations, and advice for these zones is based on decision rules in response to trends in CPUE from the commercial fishery, density from research surveys (Zone F) and size information.

Controlled experimental fisheries for abalone are being undertaken in False Bay and the Eastern Cape Province - areas that are not presently part of the commercial fishery. The purpose of these experiments is to determine the spatial distribution and abundance of the resource and whether these areas may be able to support viable and sustainable fisheries in the future. These experiments commenced in 2011 in False Bay and in 2012 in the Eastern Cape and are each planned to run over a period of three seasons. A 12 t experimental catch has been allocated per season on the eastern side of False Bay, in three sub-areas from Cape Hangklip to the Steenbras River. A 31.5 t experimental catch was allocated per season in the Eastern Cape, and split across seven areas ranging from the Groot River to Dwesa. Sub-area catch allocations are in place to ensure that the experiments do not overly deplete the resource in any one particular area, and to ensure the geographical coverage necessary to provide the information required to properly assess the fishery potential of the resource in these areas.

Priority research areas for the future include extending the full population surveys geographically, studies on abalone aggregation dynamics and the extent to which the potential of abalone to reproduce may be affected by the density of abalone in an area. Further improvements in illegal catch estimates and a review of the decision rules used for the assessment of the resource in the fishing zones along the West Coast (Zones E–G) are also priorities.

Current status

Poaching trends

Recommendations for the 2009/10 and 2010/11 seasons were based on a recovery strategy for abalone that recommended a target to recover the resource to 40% of its estimated pre-exploitation spawning biomass over 15 years. Analyses indicated this would have been possible if there were to be a 15% per annum reduction in the estimated levels of poaching throughout the 15-year recovery period.

The requirement to reduce poaching by 15% per annum was a pivotal component of the recovery plan and unless poaching off-take was reduced by at least that amount annually from 2009, the fishery would be unsustainable and would, in time, collapse. Data from various sources were used to assess poaching trends.

Data on confiscations and inspection ('policing') effort suggest that poaching has been increasing over the last four years at a rate of 22.7% per year for the South Coast as a whole. This corresponds to a net increase of about 150% in the four years since the fishery was re-opened. Increasing trends were estimated for the region overall, as well as for Zones A to D and Zones E to G when analysed separately, assuming a non-linear relationship with time (Figure 4). These estimates are well above the targeted poaching level required under the abalone recovery plan.

An analysis of international trade data of imports of *Haliotis midae* into key importing countries provided by TRAFFIC estimated that there was a net increase of 50% in the number of abalone poached over three years (2010 to 2012), compared to the annual average over the previous two years (Figure 5). The trade data for 2013 were not all available for this year's assessment, but an analysis of the first half of the year's data on monthly imports into Hong Kong suggests that there has been an increasing trend in poaching from January 2012 to June 2013. This trend broadly corroborates the inferences from the compliance data of a recent increase in abalone poaching (as shown in Figure 4).

Recently completed Masters studies into illegal fishing around the Cape Peninsula also suggest that poaching has been increasing in areas along the West Coast and around Robben Island (Zone F) in particular, where there is a high level of illegal fishing that is estimated to be considerably larger than the legal harvest.

Information from records of abalone and rock lobster poaching incidents recorded by the civil society group, Seawatch, suggest that poaching in the area from Rooiels to Kleinmond (Figure 2) was about 25% higher over the years

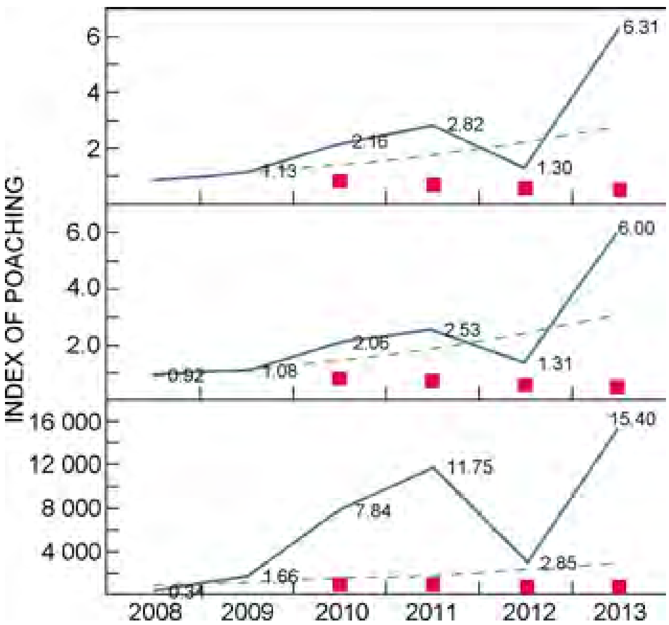


Figure 4: The solid line is the index of the annual level of poaching from a non-linear analysis of compliance data on number of abalone confiscations and policing effort for: the whole South Coast (top plot), Zones A-D only (middle plot), and Zones E-G only (bottom plot), normalised to their 2008-2009 model year average values. The squares reflect the 15% annual decrease in poaching sought under the abalone recovery plan, while the dashed line represents the model-estimated poaching trend. Note that only data for the first few months of 2013 were available for these analyses, and consequently the analysis down-weights that year compared to the others.

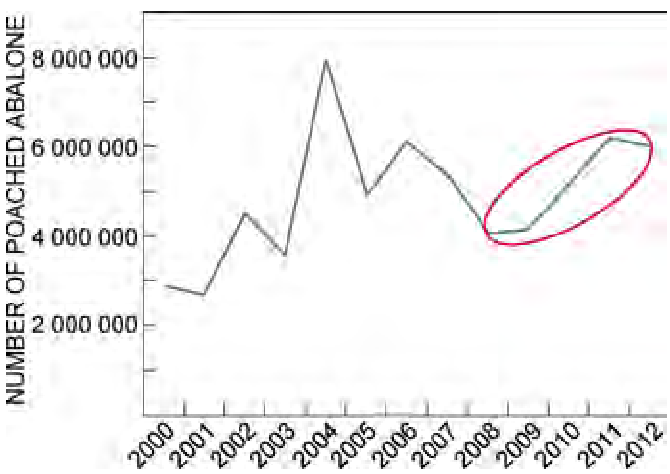


Figure 5: Estimated number of abalone poached based on international trade data for the calendar years 2000 – 2012, with the period (years) for current review of the recovery plan encircled. Data supplied by TRAFFIC.

2010 and 2011 when compared to the average over the previous 2 years.

Zones A and B

Current spawning biomasses and future projections are shown in Figure 6. Results of the 2013 assessment show that the resource has declined further in both zones from 2012 to 2013. Projections show continuing resource decline at current estimated levels of poaching, even if there is no legal harvesting (solid line).

In addition to the base case projection that assumes poaching continuing at current levels with no commercial TAC (solid line), extra projections were included in Figure 6 for illustrative purposes, to show spawning biomass trajectories if:

a) the current TAC remains allocated but poaching were to be completely stopped (bold dashed line),

b) the current TAC remains and poaching continues at current levels (dashed line) and

c) under the current TAC, the reduction in poaching that is required to keep the biomass at its present level into the future (dotted line), i.e. to meet a sustainability objective (though not the agreed resource recovery objective).

If major reductions in the illegal catch can be achieved, then current estimates indicate that sustainable commercial allocations will be possible for Zones A and B (dotted line). Without an appreciable reduction in removals, whether legal or illegal, commercial extirpation of a valuable resource in the not-too- distant future will be inevitable.

The Allee effect is a reduction in reproductive efficiency that occurs at low densities. Model results with an Allee effect included (the bottom plots in Figure 6) show even more pessimistic projections. Given the current low densities shown in the FIAS survey transects (<10 abalone per 60m^2 transect), this more negative scenario should be considered a plausible one.

Zones C and D

Spawning biomass projections based on current estimates of poaching show continuing declines in resource abundance in these zones. The resource in these zones has been severely reduced by the lobster-urchin effect on recruitment (see below), in addition to the effect of poaching. Because of this, and because the populations in these two zones are estimated to be below the 20% limit reference point set out in the management objectives, continued commercial catch allocations of zero have been maintained in these zones.

Zones E, F and G

Based on an inspection of the commercial catch and survey data, and application of a set of decision rules in the 2013 assessment, no change to the current management was indicated as being required for Zones E and G. In the case of

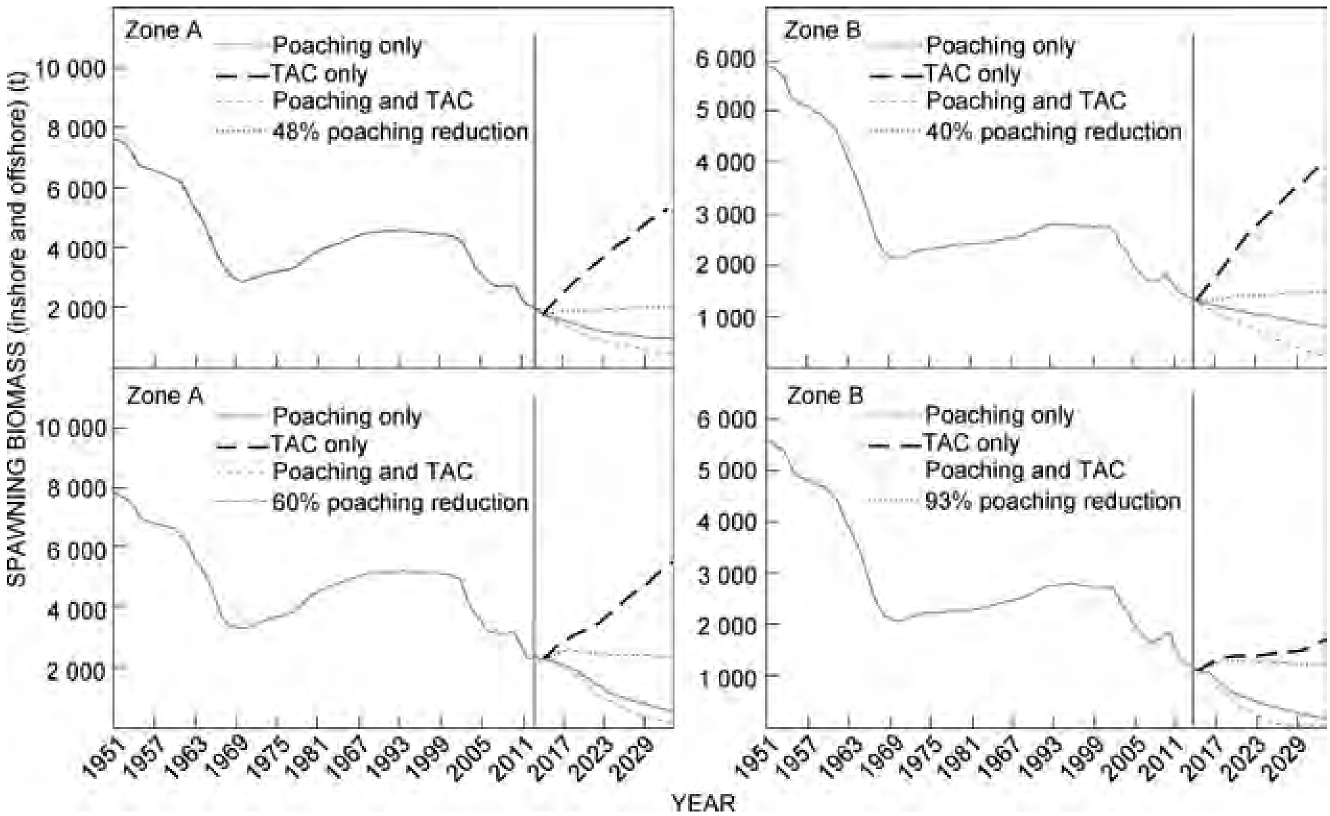


Figure 6: Total (inshore + offshore) spawning biomass projections for Zones A and B. The 20-year projections shown after the vertical line represent four different scenarios for resource status under future commercial and poaching catches. Unless a zero amount is assigned, future poaching levels are assumed to remain at the current estimated level (average of 2012 and 2013 estimates) and future commercial catches in each of these two zones are set to the current TAC of 50 t. The top two plots show projections when no Allee effect is taken into account, while the bottom two plots include an Allee effect. In each plot, the required reduction in poaching necessary to keep the resource stable at its present level under the current TAC is also shown, with the required reduction indicated in the legend.

Zone F, however, all indicators suggest a decline in resource abundance, and a 20% reduction in the TAC was recommended for Zone F for the next season.

It is important to note that the basis for setting the catch levels for Zones E–G is not as refined as for Zones A–D and there is consequently a greater associated uncertainty/risk of either over-or under-fishing in these zones. In addition, there are indications of increases in poaching overall, and in the Zone E to G region over the past few years, that were not fully accounted for in the decision rules. Furthermore, recruitment of juvenile abalone in this area is sporadic and therefore resource productivity in these zones has historically been much lower than in the South Coast zones (A–D).

Ecosystem interactions

Since the early 1990s, ecological changes have severely disrupted normal abalone recruitment patterns in two of the major fishing zones, i.e. Zones C and D. These involved the large-scale incursion of West Coast rock lobsters into Zones C and D. The lobsters have now altered the ecosystem by consuming large numbers of sea urchins as well as most other invertebrate species, including juvenile abalone. Sea urchins perform the important function of providing protection for juvenile abalone. A recent study found that, in Zone D, there have been substantial increases in rock lobsters, seaweeds and sessile species and a substantial decline in grazers (of which abalone are a component). The current ecosystem state in Zone C is similar to Zone D.

The ecosystem state in Zones A & B is currently different to Zones C and D, with very few lobsters present, a lower biomass of seaweeds and sessile species, more encrusting corallines, and urchins and grazers still present in relatively high abundance.

The combined effect of poaching and ecological changes has resulted in severe declines in the abalone resource in Zones C & D. The Betty's Bay Marine Protected Area (MPA), situated within Zone D, was also affected, which meant the loss of the main conservation area for abalone. As a result, Dyer Island has been closed to commercial fishing since the 2003/2004 season to function as a refuge area for abalone. FIAS surveys undertaken at Betty's Bay MPA in 2012 indicated that the mean density of abalone dropped to 1% of the level recorded in the 1990s. This confirms that Betty's Bay no longer functions as a closed area (reserve) for abalone, so that Dyer Island should continue as a closed area

Useful statistics

Total Allowable Catches (TACs) and catches for the abalone fishery for the past 20 seasons (1993/1994 season to 2012/2013 season).

Season	TAC (t)	Total commercial catch (t)	Total recreational catch (t)
1993/94	615	613	549
1994/95	615	616	446
1995/96	615	614	423
1996/97	550	537	429
1997/98	523	523	221
1998/99	515	482	127
1999/00	500	490	174
2000/01	433	368	95
2001/02	314	403	110
2002/03	226	296	102
2003/04	282	258	0
2004/05	237	204	0
2005/06	223	212	0
2006/07	125	110	0
2007/08	75	74	0
2008/09	0	0	0
2009/10	150	150	0
2010/11	150	152	0
2011/12	150	145	0
2012/13	150	*	0

*Note that data for the 2012/13 season were not yet complete at the time of preparation.

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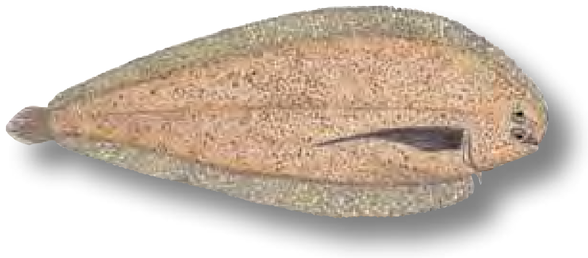
Agulhas sole



Stock Status	Unknown	Abundant	Optimal	Depleted	Heavily Depleted
Fishing pressure	Unknown	Light	Optimal	Heavy	

Introduction

Agulhas or East Coast sole (*Austroglossus pectoralis*) belong to a group of fish referred to as flatfish because they lie on the seabed on their sides. During larval development, both eyes migrate to one side of the head, and well-developed fins encircle the body. They are bottom-dwelling, preferring sand or silt substrates, and feed on small crustaceans, molluscs, worms and brittle stars. Although distributed primarily in depths of between 10 and 120 m depth, they have occasionally also been caught in deeper water during research surveys (Figure 7). The maximum total length has been documented as 58 cm, but the average size caught during research surveys over the period 1986-2011 is 25 cm.

The Agulhas sole resource is a small but commercially important component of the mixed-species inshore trawl fishery on the South-East Coast. The inshore trawl fleet currently comprises 18 active vessels, of which seven primarily target the sole resource but also rely on hake by-catch, while the remainder of the fleet targets primarily hake. The current

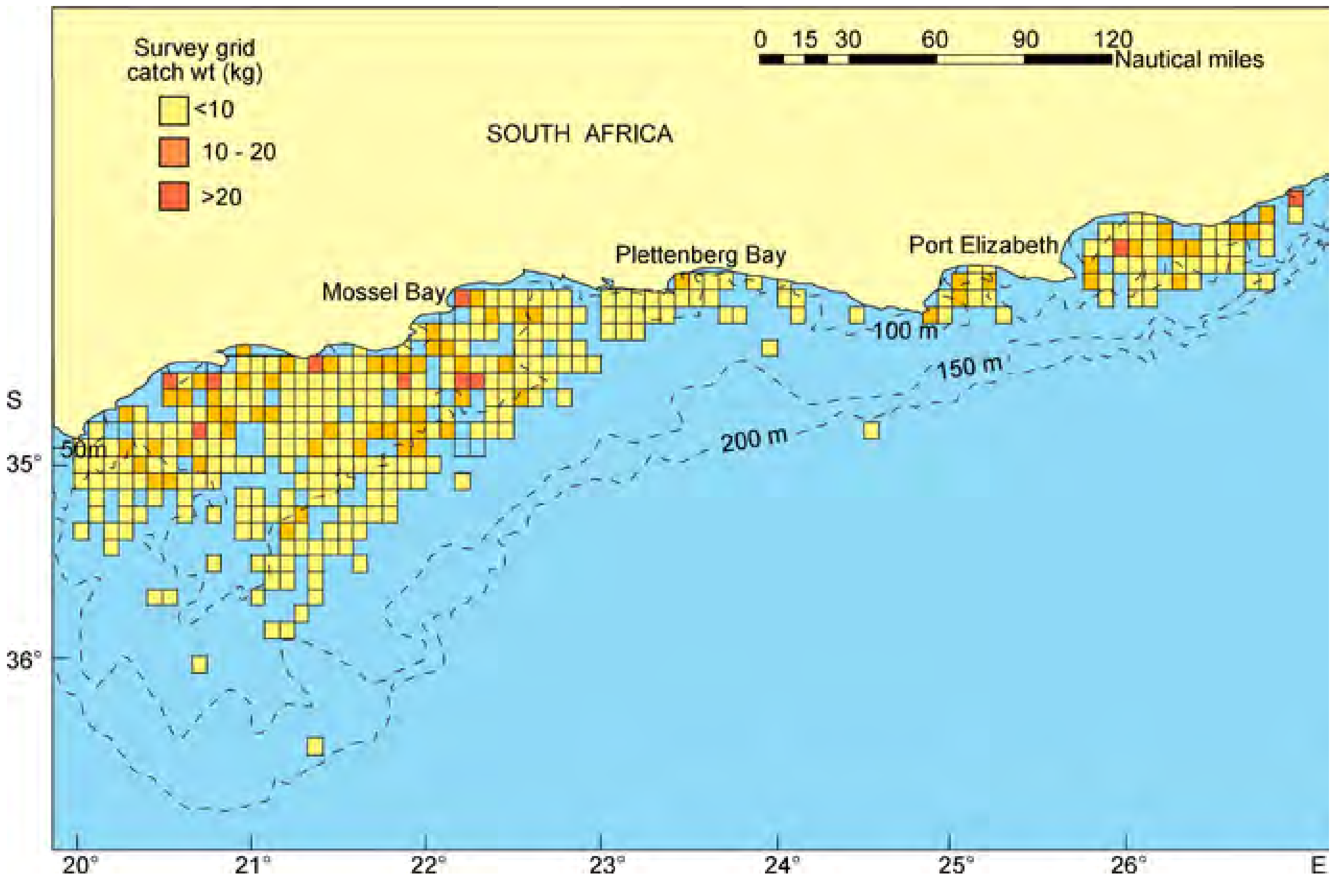


Figure 7: Distribution of Agulhas sole catches made during research surveys (1986-2011)

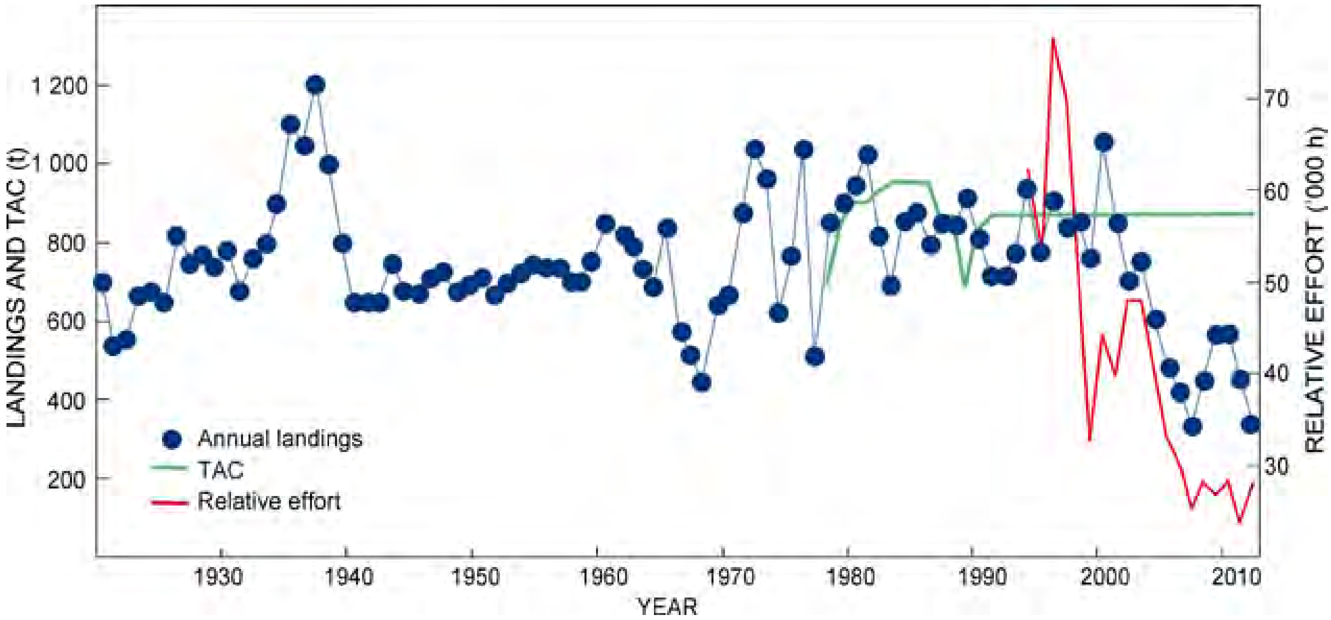


Figure 8: Annual landings, TACs and relative effort in the Agulhas sole fishery on the South-East Coast of South Africa, 1920-2012.

annual Total Allowable Catch (TAC) is worth approximately R36 million

History and Management

The Agulhas sole resource has 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 was the economic base for the early fishery on the Cape South Coast and was the driving force for the development of the coastal fishing fleet.

Several factors have influenced the performance of the inshore trawl fishery over the years: the fishery has shifted from targeting Agulhas sole in the 1930s to targeting several species from 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.

Agulhas sole catches per calendar year (since 1920) and the TAC (since 1978) are illustrated in Figure 8. It is important to draw a distinction between calendar-year catch (as used in assessment models) and quota-year catch (used for resource management purposes), as part of the allocation for a 'quota year' has in recent years occasionally been taken at the beginning of the following calendar year. Consequently, catches within a calendar year that are above or below the TAC in Figure 8 do not necessarily reflect over- or under-catch 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 over-catch of the 2001 allocation resulted in 37 t of the TAC being withheld and contributing to the apparent under-catch in 2002.

Although annual catches have generally been between 600 t and 1 000 t, there is substantial interannual variability in the time series (Figure 8). This variability is thought to be driven primarily by environmentally-induced fluctuations in Agulhas sole availability, linked to strong North-Westerly fronts. The decline in catches over the period 2003-2007, however, was primarily attributable to a reduction in the number of active vessels in the sector, which is manifested as a decline in fishing effort (illustrated by the 'relative effort' in Figure 8). The reduction in the number of active vessels in the fishery has largely arisen from companies not replacing old or damaged vessels, the reasons for which are primarily attributable to the high costs of replacing vessels in a volatile industry (there have been substantial adjustments in this sector following the implementation of the Long-Term Rights Allocation Process in 2006) and recent changes in market incentives. The increase in fishing effort and resultant catches apparent over the past three years suggests that this situation is improving.

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. An annual TAC of 700 t was first introduced in 1978, and individual quotas were introduced in 1982. The TAC remained fairly stable thereafter, varying between 700 t and 950 t between 1982 and 1992, since when the TAC has been maintained at 872 t (Figure 8).

The current management objective for the Agulhas sole fishery is to maintain a stable TAC, provided that there is no indication that this is depleting the resource. Attention is being directed at developing a refined assessment to determine whether this TAC might be increased while still remaining sustainable.

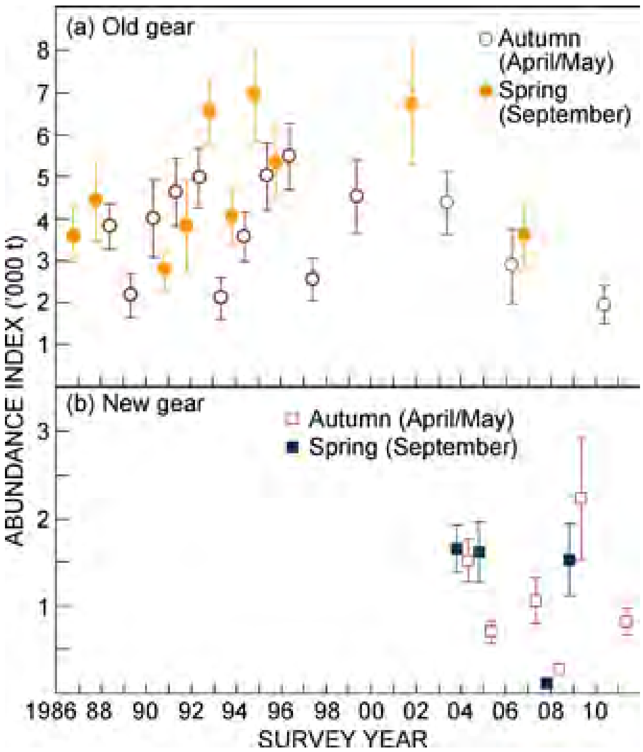


Figure 9: Spring and autumn survey abundance estimates with 95% confidence intervals for the Agulhas sole resource on the South-East Coast of South Africa. The upper panel illustrates estimates obtained using the "old gear" while the lower panel shows results of the surveys using the "new gear".

Research and Monitoring

Abundance estimates for Agulhas sole are derived from demersal research surveys using the swept-area method. These surveys are designed primarily to estimate the abundance of hakes, but other demersal species (including Agulhas sole) are also included in the research. South Coast demersal abundance surveys were generally conducted twice a year (autumn and spring) over the period 1986 to the present (Figure 9). However, for technical reasons, only one survey per year was completed in 1996, 1997, 1999, 2001, 2005, 2009, 2010 and 2011 and none in 1998, 2000, 2002, 2012 and 2013. The research trawl gear on the research ship *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', so they are illustrated separately in Figure 9.

Four intensive Agulhas sole-directed surveys have been conducted (September 2006, April 2007 & 2008 and September 2008) to improve temporal and spatial coverage and allow a revised assessment of Agulhas sole. Unfortunately, budgetary constraints have precluded further Agulhas sole-directed surveys, and it is not possible to draw definitive conclusions from four surveys over a period of three years.

A modeling approach was first used in 1989 to assess the status of the resource. Concerns regarding the reliability of the assessment model were raised during the early 1990s. However, financial and capacity constraints have prevented the collection of the data required to address these concerns. The fishery has consequently been managed using a constant catch strategy (an annual TAC of 872 t) since 1992.

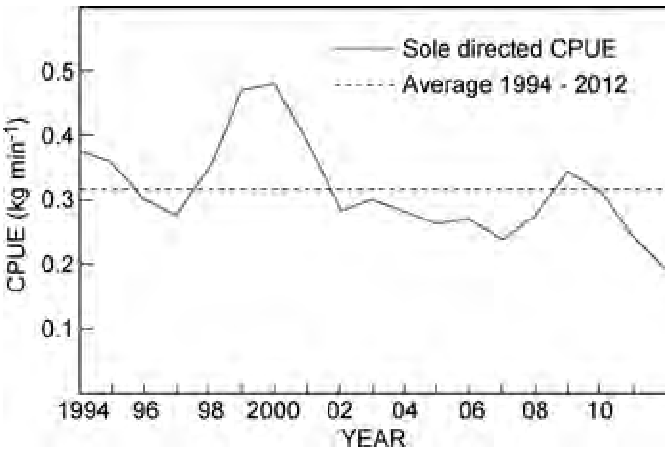


Figure 10: Standardised CPUE for seven small Agulhas-sole-specialist vessels on the Agulhas sole grounds over the period 1994-2012. The dashed line indicates the average CPUE over the illustrated period.

Current Status

Survey-derived abundance indices show considerable variability (Figure 9). Within-year differences between survey abundance indices in some years (e.g. 1993 and 1994) are too large to be attributed to changes in absolute abundance, and they are thought to reflect primarily environmentally-induced changes in the availability of Agulhas sole to the research trawl gear during the surveys. In particular, the September 2007 and April 2008 surveys were compromised by bad weather that may have reduced the availability of Agulhas sole to the gear, resulting in artificially reduced estimates of abundance. Estimates derived using the 'old gear' suggest that the Agulhas sole resource has remained reasonably stable over time (with a period of relatively higher abundance during the mid-to-late-1990s). The low April 2010 estimate may be an artefact resulting from bad weather that shortened the duration of the survey as well as potentially reducing Agulhas sole availability to the gear. Unfortunately, no September estimate is available to provide further information for this period. The time-series of 'new gear' estimates is not yet sufficiently extensive to draw any conclusions concerning resource trends.

Another information source that can be used to assess trends in the status of the Agulhas sole resource is a standardized Catch Per Unit Effort (CPUE) time-series based on seven vessels that target Agulhas sole. This time-series (Figure 10) suggests that the abundance of the resource has remained relatively stable over time, with periods of high abundance during the period 1998 to 2001 and again from 2008 until 2010. However, standardised catch rates indicate a continued decline in resource abundance since 2009, with the 2012 level being the lowest observed since 1994 (Figure 10). It is, therefore, no longer possible to attribute the under-catch of the TAC to reductions in vessels alone. The lack of South Coast surveys since autumn 2011 has prevented any data collection that may have shed light on the nature of anomalous environmental conditions that have been reported to be prevailing on the South Coast since mid-2011. The poor catch rates over recent years of other South Coast inshore resources (squid, hake on the inshore grounds) leads credence to the possibility that poor catch rates of Agulhas sole are mainly attributable to some common environmental effect.

Available data are, however, insufficient to establish whether the observed trends merely reflect a decline in catchability as opposed to a reduction in abundance. Until sufficient data are collected to properly assess the status of the resource, a responsible, cautious management approach is warranted. Attention is being directed at implementing an equitable effort limitation scheme to avoid possible over-exploitation of Agulhas sole during this period of uncertainty regarding the status of the resource.

Ecosystem considerations

The Agulhas sole fishery is managed as part of the mixed-species inshore trawl sector. The Agulhas sole grounds are areas of particularly high species diversity, and sole-directed fishing incurs appreciable by-catch. Although more than 100 species are caught, 20 species account for 98% of the catch, comprising a mix of linefish species (silver kob, carpenter, panga, white stumpnose and geelbek), gurnards, St Joseph sharks, a number of skate species and other species which are already assessed and managed within the trawl fishery (hake, horse mackerel, kingklip, monk and squid). The majority of these by-catch species are marketable (often referred to as "joint product"), and are consequently landed rather than being discarded at sea. A strategy is being developed, in co-operation with the inshore trawl and linefish sectors, to manage by-catch in the trawl fishery. A suite of measures, including extension of existing closed areas and setting catch limits for non-quota species of concern, are being considered.

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Useful statistics

Total catch (tons) of Agulhas sole per calendar year and the annual TACs (tons) for the period 2001-2010.

Year	Catch	TAC
1978	850	700
1979	899	850
1980	943	900
1981	1 026	900
1982	817	930
1983	682	950
1984	857	950
1985	880	950
1986	796	950
1987	855	868
1988	839	868
1989	913	686
1990	808	834
1991	716	872
1992	704	872
1993	772	872
1994	938	872
1995	769	872
1996	909	872
1997	840	872
1998	859	872
1999	757	872
2000	1 060	872
2001	850	872
2002	702	872
2003	754	872
2004	612	872
2005	485	872
2006	428	872
2007	331	872
2008	448	872
2009	568	872
2010	570	872
2011	442	872
2012	338	872

Cape hakes

Stock status	Unknown	Abundant	Optimal	Depleted	Heavily depleted
		Shallow-water hake	Deep-water hake		
Fishing pressure	**Unknown**	**Light**	**Optimal**	**Heavy**	
			Shallow-water hake Deep-water hake		

Introduction

The South African hake resource comprises two species, shallow-water Cape hake *Merluccius capensis* and deep-water Cape hake *M. paradoxus*. The Cape hakes are distributed on the continental shelf and upper slope around the coast of southern Africa. Deep-water hake are distributed from northern Namibia to southern Moçambique, while shallow-water hake are distributed mainly from southern Angola to northern KwaZulu-Natal. As the names suggest, the distributions of the two hake species differ with depth, although there is a substantial overlap in their depth ranges. Shallow-water hake are distributed over a depth range of 30 to 500 m with most of the population occurring between 100 and 300 m. In contrast, deep-water hake are distributed over a depth range of 110 m to deeper than 1 000 m with most of the population occurring in depths of between 200 and 800 m. As the sizes of both species increase with depth, large shallow-water hake co-exist with (and feed extensively on) smaller deep-water hake. It is difficult to distinguish between the two hake species, so they are generally processed and marketed as a single commodity.

Cape hakes are targeted by four fishery sectors: deep-sea demersal trawl, inshore demersal trawl, hake longline and hake handline, with most of the catch being taken by the deep-sea trawl sector (Figure 11). Hakes are also caught as incidental by-catch in the horse mackerel-directed midwater trawl and demersal shark longline fisheries, and to a lesser extent in the linefish sector. The inshore trawl and handline sectors operate only on the South Coast, whereas the deep-sea trawl and longline fleets operate on both the West and South coasts. On the West Coast, the continental shelf is fairly narrow so most trawling is in deep water on the shelf edge and upper slope, and as much as 90% of the hake caught are 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. While not the largest fishery in terms of tonnage (the small pelagic purse fishery targeting sardine and anchovy lands the largest amount of fish at present), the hake fishery is the most valuable of South Africa's marine fisheries, providing the basis for some 30 000 jobs and an annual landed value in excess of R5.2 billion.

History and management

The demersal fishery off southern Africa started with the arrival of the purpose-built research vessel, *Pieter Faure*, in 1897 and the first commercial trawler, *Undine*, in 1899 off the Cape. In the early years of the fishery, Agulhas and West Coast sole (*Austroglossus pectoralis* and *A. microlepis* respectively) were the primary target species, with hake being caught as an incidental by-catch only. Directed fishing of Cape hakes began only towards the end of the First World War, with catches averaging about 1 000 t per annum until 1931. The fishery then began escalating during and after the Second World War, with catches increasing steadily to about 170 000 t by the early 1960s. The incursion of foreign fleets in 1962 led to a dramatic increase in fishing effort, and catches in South African waters eventually peaked at over 295 000 t in 1972 (Figure 11). By this time, effort had extended farther offshore

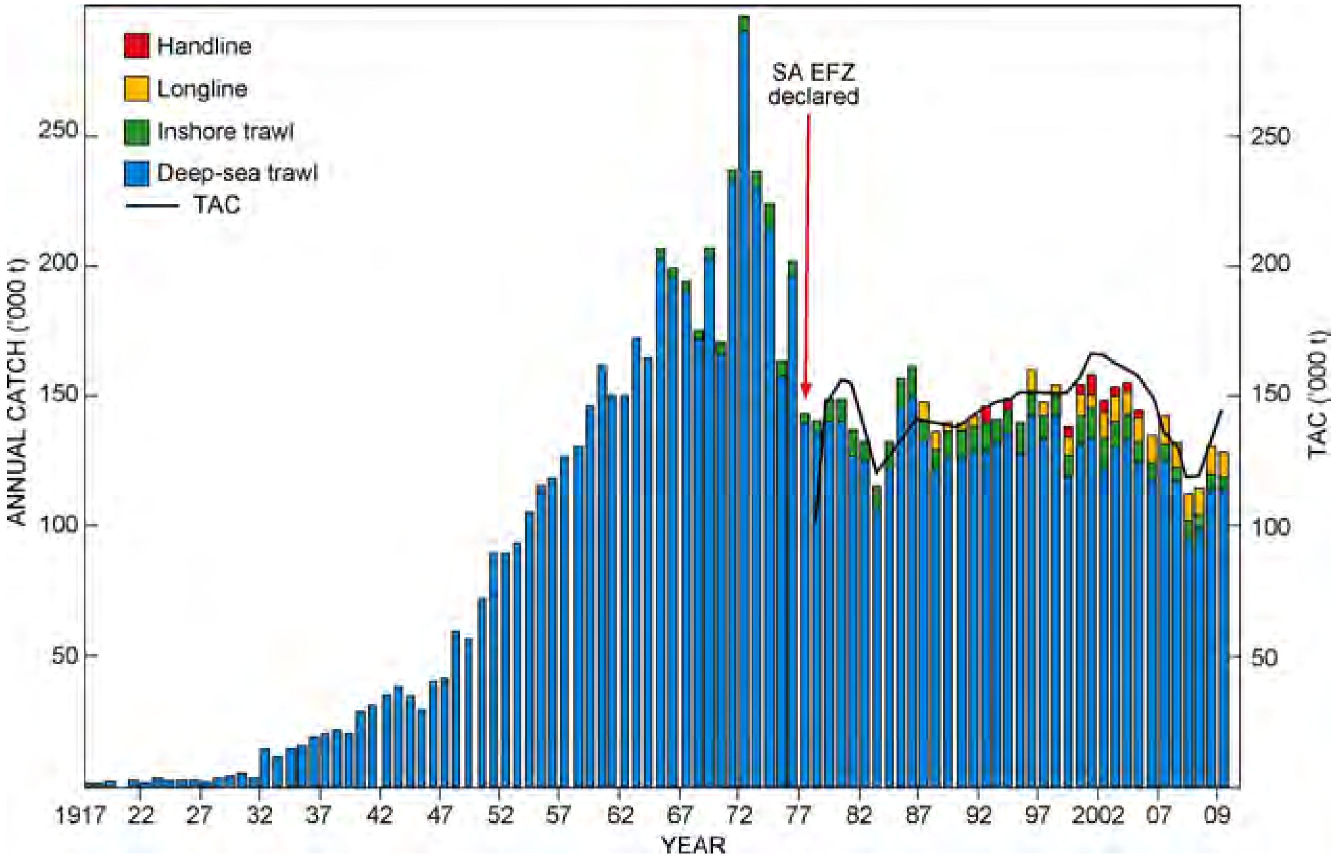

Figure 11: Annual catches of Cape hakes landed by the various fishing sectors in South African waters over the period 1917–2012 (bars). Annual Total Allowable Catches (TACs) are shown by the black line.

and also into Namibian waters, with over 1.1 million tons being caught in the South-East Atlantic in 1972.

In 1972, following concerns over the combination of increasing catches and decreasing catch rates, the International Commission for the South-East Atlantic Fisheries (ICSEAF) was established in an attempt to control what had become an international fishery. Various management measures such as a minimum mesh size, international inspections and quota allocations to member countries were implemented through this organisation. However, catch rates continued to decline, and in November 1977 the declaration of a 200 nautical mile Exclusive Fishing Zone (EFZ) by South Africa marked the onset of direct management of the South African hake resource by the South African government, and the exclusion of foreign vessels (with the exception of a few vessels operating under bilateral agreements and subject to South African regulations).

Subsequent to the declaration of the EFZ, South Africa implemented a relatively conservative management strategy in order to rebuild the hake stocks to the maximum sustainable yield level (MSY). Total Allowable Catch (TAC) restrictions were imposed on the fishery, aimed at keeping catches below what were considered to be sustainable levels in order to promote stock rebuilding. The TACs were recommended on the basis of assessments of the resource using first steady-state models, then dynamic production models, and finally age-structured production models. An Operational Management Procedure (OMP) approach was adopted in 1990 in a move to provide a sounder basis for management of the hake resources. The hake OMP is essentially a set of rules that specifies exactly how the value of the TAC is calculated from stock-specific monitoring data (commercial CPUE indices and indices of abundance derived from demersal research surveys – see below). Implicit in the OMP approach is a schedule of OMP revision (every four years) to account for possible revised datasets and understanding of resource and fishery dynamics. Assessments are routinely updated every intervening year to check that resource behaviour remains within the bounds considered likely when adopting the OMP.

Because of the substantial overlap in distribution and the difficulty of distinguishing between the two hake species, spe-

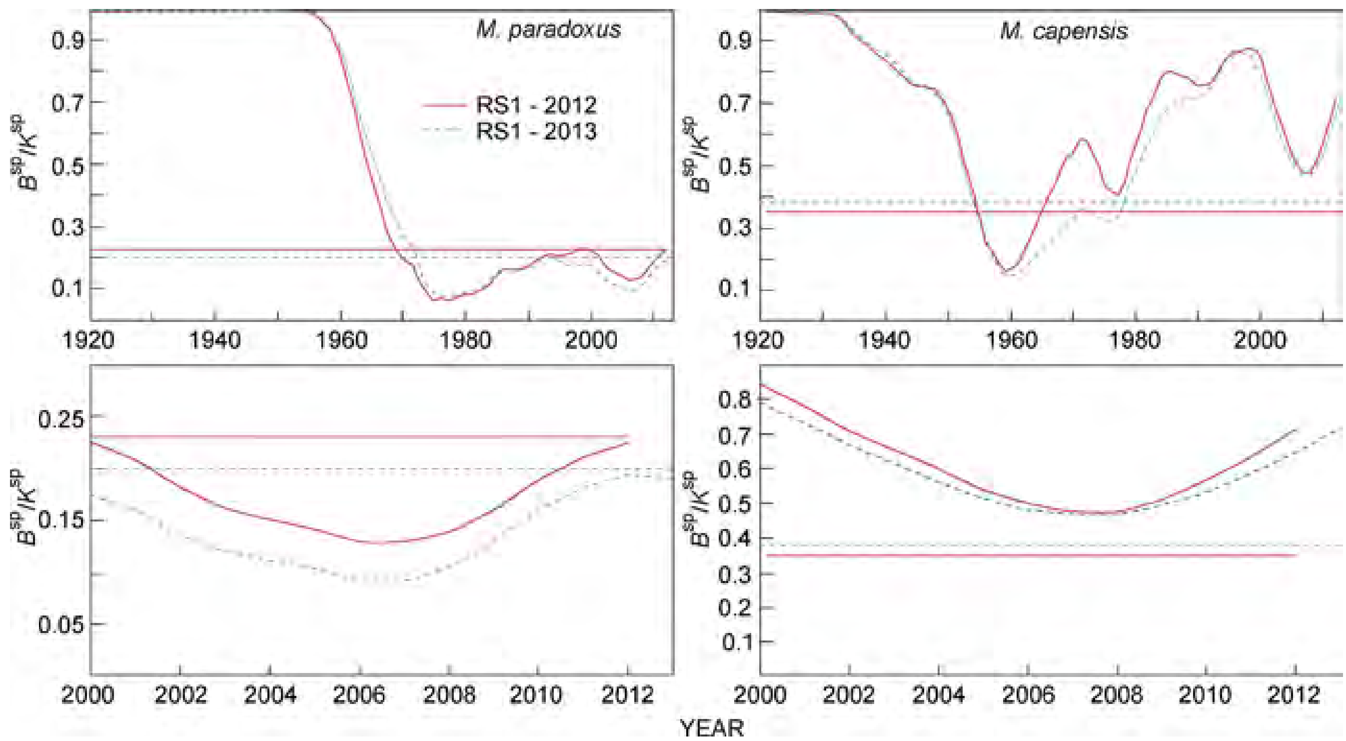

Figure 12: Trajectories of female spawning biomass (relative to estimated pre-exploitation biomass) estimated in the 2012 (RS1-2012) and 2013 (RS1-2013) assessments. The horizontal dashed lines represent the target (B^{sp}_{MSY}) level (see Table 1). The lower panels are plotted on a more recent time scale to better illustrate recent trends.

cies-specific catch-and-effort data are not available from the commercial fishery, and the two species were first assessed and managed as a single resource. However, the development of the longline fishery during the 1990s led to shifts in the relative exploitation rates of the two species, rendering species-combined assessments of the resource inappropriate. Efforts were therefore directed at developing species-disaggregated assessment models. The first such model was developed during 2005 and was used in the development of the revised OMP implemented in 2006 to calculate the TACs for the 2007 to 2010 fishing seasons.

The management strategies implemented since the EFZ was declared initially showed positive results with both catch rates and research survey abundance estimates, and hence TACs and annual catches, increasing gradually through the 1980s and 1990s (Figure 11). In the early 2000s, however, the hake fishery experienced declining catch rates, indicating substantial depletion of the hake resource. Results of the species-disaggregated assessments revealed that the decline was primarily attributable to a reduction in the deep-water hake resource to well below its MSY level (Figure 12). Although the shallow-water hake resource had also declined, the estimated biomass was still above MSY. The decline was likely a response to several years of poor recruitment for both species in the late 1990s and early 2000s. Deep-water hake showed below average recruitment level over the period 1996–1999 and again in 2001–2003 and 2009–2012 whereas shallow-water hake showed low recruitment over the entire 1999–2004 period (Figure 13). The reasons for poor recruitment during these periods are not known.

The OMP developed in 2006 was based on a fully species-disaggregated assessment then available for the first time, and amidst industry concerns about financial viability given the downturns in catch rates. This OMP was first implemented in 2006 and provided TAC recommendations for the period 2007–2010 that aimed to allow recovery of the deep-water hake resource to 20% of its pre-exploitation level over a 20-year period, while restricting year-to-year fluctuations in the TAC to a maximum of 10% in order to provide stability for the industry. Implementation of this OMP led to substantial reductions in the TAC from 2007 until 2009 (Figure 11), but TACs subsequently increased as the resource responded positively to the recovery plan, with both commercial catch rates and sur-

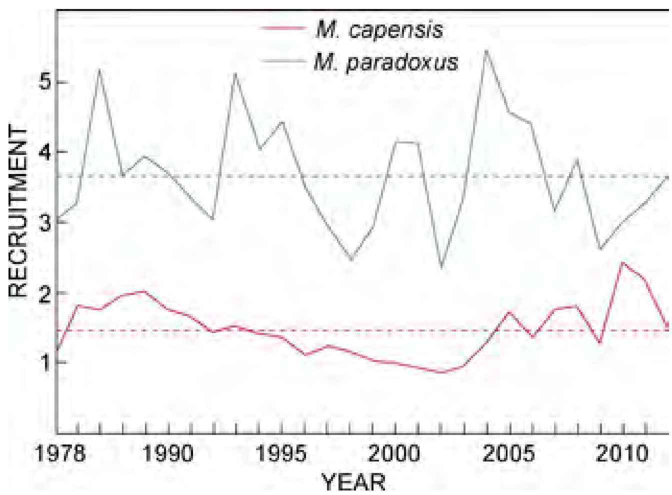

Figure 13: Time series of hake recruitment (0-year olds x10^9) estimated in the 2013 assessment. The horizontal dashed lines indicate the mean of the estimates over the time period illustrated.

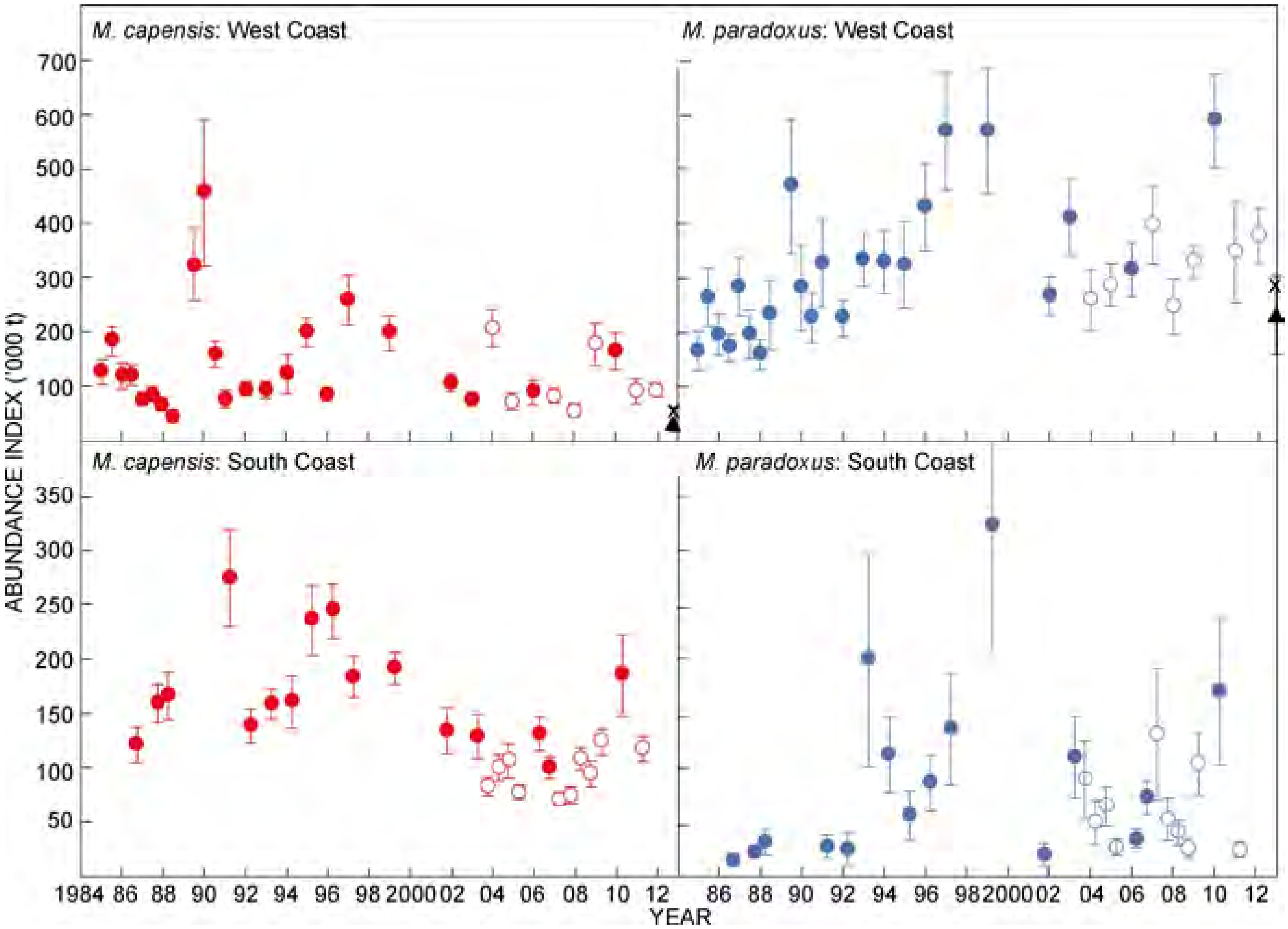

Figure 14: Estimates of the abundance of the two hake species on the West and South Coasts obtained from swept area demersal surveys. Indices obtained using the "old" and "new" gear configurations are indicated by dots and circles respectively. Two estimates are shown for the 2013 West Coast survey, those obtained from the Andromeda survey (∆) and from adjusting the *Dr. Fridtjof Nansen* estimate (X) – see text.

vey indices of abundance turning around to show increasing trends (Figures 14 & 15). In accordance with the agreed OMP revision schedule, a revised OMP was developed in 2010 (OMP-2010) to provide TAC recommendations for the years 2011-2014. The implementation of OMP-2010 appeared to facilitate a continued recovering trend in the *M. paradoxus* resource (Figure 12), and annual TACs responded to this, increasing over this period (Figure 11). The hake OMP will again be revised during 2014 to provide the TAC recommendations for the years 2015–2018.

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 recently established Benguela Current Commission aims to work towards joint management of this resource, if it is established that there is sufficient sharing of the resource between the two countries to warrant this.

Research and monitoring

Data are collected from both fishery-independent surveys and from the commercial fishery. Fishery-independent abundance indices are determined from annual research surveys conducted on the West Coast in summer and winter and South Coast in spring and autumn. For each survey, a minimum of 100 trawl stations are selected using a pseudo-random stratified survey design. The survey area (coast to the 500 m depth contour) is subdivided by depth and latitude (West Coast) or longitude (South Coast) into a number of strata, and the number of stations selected within each stratum is proportional to the area of the stratum. Areas of rough ground that cannot be sampled using demersal trawls are excluded from the station selection process, and it is assumed that fish densities in these areas are the same as those in adjacent areas that can be sampled. Trawling is conducted during the day only to account for the daily vertical migration of hake; hake move off the sea floor and into the water column at night to feed.

Operational problems with the departmental research vessel (*FRS Africana*) have prevented this vessel conducting any surveys subsequent to January 2012. In the absence of *FRS Africana* survey abundance estimates for January 2013, the data collected by the *Dr. Fridtjof Nansen* during the January 2013 Benguela Current Commission transboundary survey were used to generate abundance estimates for use in the 2013 assessment update and implementation of the OMP to calculate a TAC for 2014. This was possible due to the two vessels (*Nansen* and *Africana*) having conducted a number

Table 1: Estimates of the management quantities of the hake resources arising from the 2013 assessment update (RS1-2013), compared to the 2012 assessment (RS1-2012). Note that estimates of biomass levels (pre-exploitation, current and Maximum Sustainable Yield Level) are for spawning females only, while the Maximum Sustainable Yield estimates apply to the whole population. Note also that "current" female spawning biomass (B_{sp}) estimates are for 2012 in the case of RS1-2012, and 2013 in the case of RS1-2013.

		M. paradoxus		*M. capensis*	
		RS1-2012	RS1-2013	RS1-2012	RS1-2013
K^{sp}	Pre-exploitation female biomass (tons)	586 000	834 000	251 000	288 000
B^{sp}	Current female spawning biomass	131 000	158 000	179 000	207 000
B^{sp}/K^{sp}	Depletion (current female spawning biomass relative to pre-exploitation level)	0.22	0.19	0.71	0.72
$B^{sp}{}_{MSY}$	Biomass providing Maximum Sustainable Yield	134 000	164 000	89 000	109 000
$B^{sp}{}_{MSY}/K^{sp}$	B_{MSY} relative to pre-exploitation level (target)	0.23	0.20	0.3.5	0.38
$B^{sp}/B^{sp}{}_{MSY}$	Current status (current spawning biomass relative to target)	0.98	0.96	2.01	1.90
MSY	Maximum sustainable yield	113 000	116 000	70 000	62 000

of comparable surveys (similar survey areas and periods) on the West Coast, the data from which could be used to set up a *Nansen* versus *Africana* calibration, and the "*Nansen*" abundance estimate thereby converted to an equivalent "*Africana*" abundance estimate (Figure 14). In the absence of the *Africana*, the Department took the initiative to conduct a West Coast research survey on board a commercial vessel, the *MV Andromeda,* in February 2013. While data collected during this survey cannot at this time be used in assessments and the hake OMP due to possible catchability differences between the two vessels, analyses are being conducted to address this issue and to ensure that the data can be incorporated into the existing time-series (the abundance estimates derived from the *Andromeda* survey are, nevertheless, illustrated in Figure 14 for comparative purposes).

Abundance indices from surveys (Figure 14) are calculated using the swept-area method, which relies on fishing methods and gear remaining unchanged between surveys. In 2003, it was considered necessary to change the trawl gear configuration on the *FRS Africana* because net-monitoring sensors showed that the gear used was unbalanced and was being over-spread. The change in trawl gear configuration resulted in non-comparability in the time-series. In selecting a new gear configuration, particular emphasis was placed on minimising the possible effect of herding on the abundance indices. This change is currently taken into account in the assessment model by the application of conversion factors estimated from experiments. Another recent (2011) change to the survey design is to extend the survey area into deeper water (1 000 m) to encompass the full extent of the deep-water hake resource. However, abundance estimates for input to TAC evaluations are still calculated for the historic survey area for consistency. It will be possible to incorporate abundance indices from the extended survey area into the assessment models only once a sufficiently long time-series is available. Biological sampling of research catches is routinely conducted to collect data on size structure, feeding, age and growth, and maturity and fecundity. Genetics research is also being conducted to investigate the stock structure of the Cape hakes to determine whether there are genetically discrete stocks off southern Africa, and to assess the extent to which the hake populations may be shared between South Africa and Namibia.

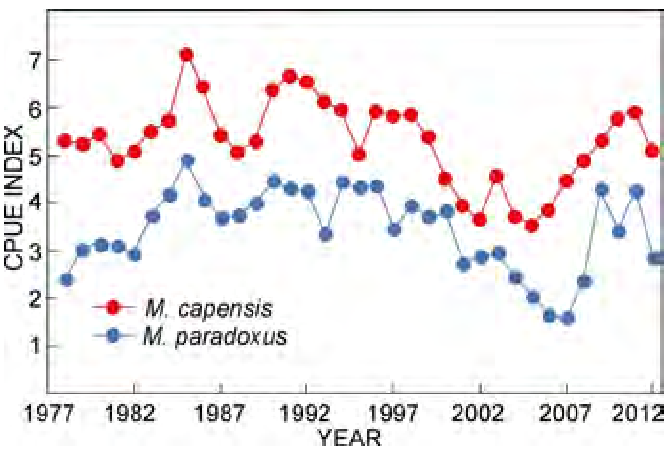

Figure 15: General Linear Model standardised catch-per-unit-effort abundance indices for the Cape hakes derived from the deep-sea trawl fleet.

Catch and landing data for the two hake species combined are submitted by the industry, and these data are disaggregated to the species level using an algorithm based on the relationship of species ratios to fishing depth and fish size as recorded during the research surveys. Species-specific CPUE time-series are standardised using general linear modeling techniques to account for differences in factors such as depth, area, and vessel power. This time-series is then used in the assessment to provide additional estimates of resource abundance and trends (Figure 15).

Current status

A routine update assessment of the hake resource incorporating updated commercial (catches and CPUE) and survey (abundance estimates) data for the period up to and including 2012 was conducted in 2013. The results of this updated assessment (Table 1, Figure 12) indicate that the deep-water hake resource has not yet quite recovered to the MSY level, and is currently estimated to be at 96% of this target level (slightly below the 98% estimated in the 2012 assessment). Although at a slightly lower level than that estimated in 2012, the shallow-water hake resource remains well above its MSY level (Table 1, Figure 12). Implementation of the OMP resulted in the TAC for the 2014 fishing season being set at 155 280 t (i.e. a decrease of 0.5 % from the 2013 level of 156 075 t).

Useful statistics

Annual catches of Cape hakes ('000 tons) and TACs

Year	*M.paradoxus*	*M.capensis*	Total	TAC
1917	0.000	1.000	1.000	
1918	0.000	1.100	1.100	
1919	0.000	1.900	1.900	
1920	0.000	0.000	0.000	
1921	0.000	1.300	1.300	
1922	0.000	1.000	1.000	
1923	0.000	2.500	2.500	
1924	0.000	1.500	1.500	
1925	0.000	1.900	1.900	
1926	0.000	1.400	1.400	
1927	0.000	0.800	0.800	
1928	0.000	2.600	2.600	
1929	0.000	3.800	3.800	
1930	0.000	4.400	4.400	
1931	0.000	2.800	2.800	
1932	0.000	14.300	14.300	
1933	0.000	11.100	11.100	
1934	0.000	13.800	13.800	
1935	0.000	15.000	15.000	
1936	0.000	17.700	17.700	
1937	0.000	20.200	20.200	
1938	0.000	21.100	21.100	
1939	0.000	20.000	20.000	
1940	0.000	28.600	28.600	
1941	0.000	30.600	30.600	
1942	0.001	34.499	34.500	
1943	0.001	37.899	37.900	
1944	0.002	34.098	34.100	
1945	0.004	29.196	29.200	
1946	0.011	40.389	40.400	
1947	0.021	41.379	41.400	
1948	0.059	58.741	58.800	
1949	0.113	57.287	57.400	
1950	0.275	71.725	72.000	
1951	0.662	88.838	89.500	
1952	1.268	87.532	88.800	
1953	2.558	90.942	93.500	
1954	5.438	99.962	105.400	
1955	10.924	104.476	115.400	
1956	19.581	98.619	118.200	
1957	34.052	92.348	126.400	
1958	51.895	78.805	130.700	
1959	76.609	69.391	146.000	
1960	100.490	60.410	160.900	
1961	104.009	45.999	150.008	
1962	109.596	39.619	149.215	
1963	129.966	41.457	171.423	
1964	126.567	37.964	164.531	
1965	159.704	45.834	205.538	
1966	154.109	43.737	197.846	
1967	147.059	46.981	194.040	
1968	127.848	47.122	174.970	
1969	150.005	56.794	260.799	
1970	125.000	43.300	170.300	
1971	175.462	61.038	236.500	
1972	217.076	78.245	295.321	
1973	161.524	73.614	235.138	
1974	143.170	80.739	223.909	
1975	104.948	58.504	163.452	
1976	140.273	61.291	201.564	
1977	99.775	43.025	142.800	
1978	112.638	27.391	140.029	103.000
1979	105.465	41.071	146.536	147.500
1980	109.159	39.950	149.109	155.700
1981	97.097	38.720	135.817	154.500
1982	93.990	38.806	132.796	136.000
1983	81.368	33.483	114.851	120.000
1984	92.019	39.588	131.607	128.000
1985	111.794	44.020	155.814	130.500
1986	120.411	39.848	160.259	138.500
1987	109.198	36.638	145.836	141.000
1988	95.898	39.202	135.100	139.900
1989	94.540	42.128	136.668	138.500
1990	98.861	38.313	137.174	138.500
1991	105.326	35.674	141.000	141.004
1992	109.145	32.455	141.600	145.000
1993	117.586	23.888	141.474	147.000
1994	116.005	31.172	147.177	148.000
1995	108.942	32.098	141.040	151.000
1996	123.216	36.047	159.263	151.000
1997	118.492	29.188	147.680	151.000
1998	125.433	28.789	154.222	151.000
1999	104.545	32.855	137.400	151.000
2000	110.631	43.790	154.421	155.000
2001	115.662	42.709	158.371	166.000
2002	111.967	35.435	147.402	166.000
2003	120.331	33.669	154.000	163.000
2004	121.268	32.918	154.186	161.000
2005	116.696	26.821	143.517	158.000
2006	110.006	23.836	133.842	150.000
2007	115.682	26.052	141.734	134.998
2008	106.164	23.377	129.541	130.532
2009	86.652	24.530	111.182	118.578
2010	91.324	22.380	113.704	119.860
2011	101.367	27.950	129.317	131.846
2012	106.323	20.771	127.094	144.671

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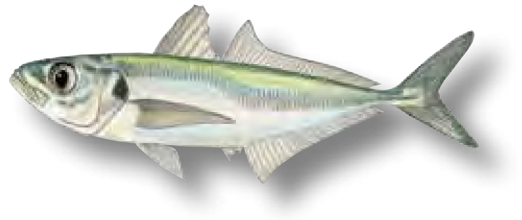
Cape horse mackerel



Stock Status	Unknown	Abundant	Optimal	Depleted	Heavily Depleted
Fishing pressure	Unknown	Light	Optimal	Heavy	

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 recognised by a distinct dark spot on the gill cover and a row of enlarged scutes (spiny scales) along the lateral line. It is, however, not easy to distinguish between the three species that occur in southern Africa. Cape horse mackerel generally reach 40-50 cm in length and become sexually mature at around three years of age when they are roughly 20 cm long. They feed primarily on small crustaceans, which they filter from the water using their modified gillrakers.

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. Adult horse mackerel currently occur more abundantly on the South Coast than the West Coast of South Africa.

Adult Cape horse mackerel are currently caught as incidental by-catch 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 catches juvenile horse mackerel as incidental bycatch during directed fishing for small pelagic fish (primarily sardine and anchovy). 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 16). In the 1990s, purse-seine catches of juvenile Cape horse mackerel again showed an increasing trend, reaching 26 000 t in 1998 (Figure 16). Although this catch level appears low compared to historic levels, the number of fish per ton of catch in the 1990s was much greater than was the case during the 1950s due to the smaller size of fish being caught in the 1990s. The increasing pelagic catches prompted modelling of the likely effects of large catches of juvenile Cape horse mackerel on the trawl fishery for adults. The results of the analyses led to the introduction of a 5 000 t Precautionary Upper Catch Limit (PUCL) for the purse-seine fishery in 2000, following which the average annual purse-seine catch has been 3 400 t.

In early 2011, unusually large numbers of juvenile horse mackerel on the West Coast presented the small pelagic purse-seine fishery with a serious obstacle to utilising their anchovy rights (Figure 16), as the PUCL was reached relatively early in the season. In order to prevent the anchovy fishery from being closed, two *ad hoc* additions to the juvenile horse mackerel PUCL were approved to enable continued fishing for anchovy. This was based on projected resource trends that indicated that such a once-off decision would not introduce any serious risk to the resource. A final PUCL of 12 000 t was therefore set for 2011. The PUCL remained at 5 000 t for 2012 pending analyses aimed at incorporating more flexibility into the management of horse mackerel by-catch to minimize impacts on small pelagic fishing operations. Once these analyses had been completed, a new management rule was implemented in 2012, which, rather than an annual 5 000 t bycatch restriction, introduces a by-catch restriction of 18 000 t spread over a three-year period, i.e. the amount of horse mackerel bycatch "available" for any given year is 18 000 tons less the bycatch taken in the two preceding years. The PUCL for 2013 was set at 12 500 t using this rule.

In the 1950s and 1960s, horse mackerel trawl catches on the South Coast were incidental to directed hake and sole fishing and amounted to less than 1 000 t per annum (Figure 16). Japanese vessels using pelagic and semi-pelagic gear began targeting the resource in the mid-1960s and catches rapidly

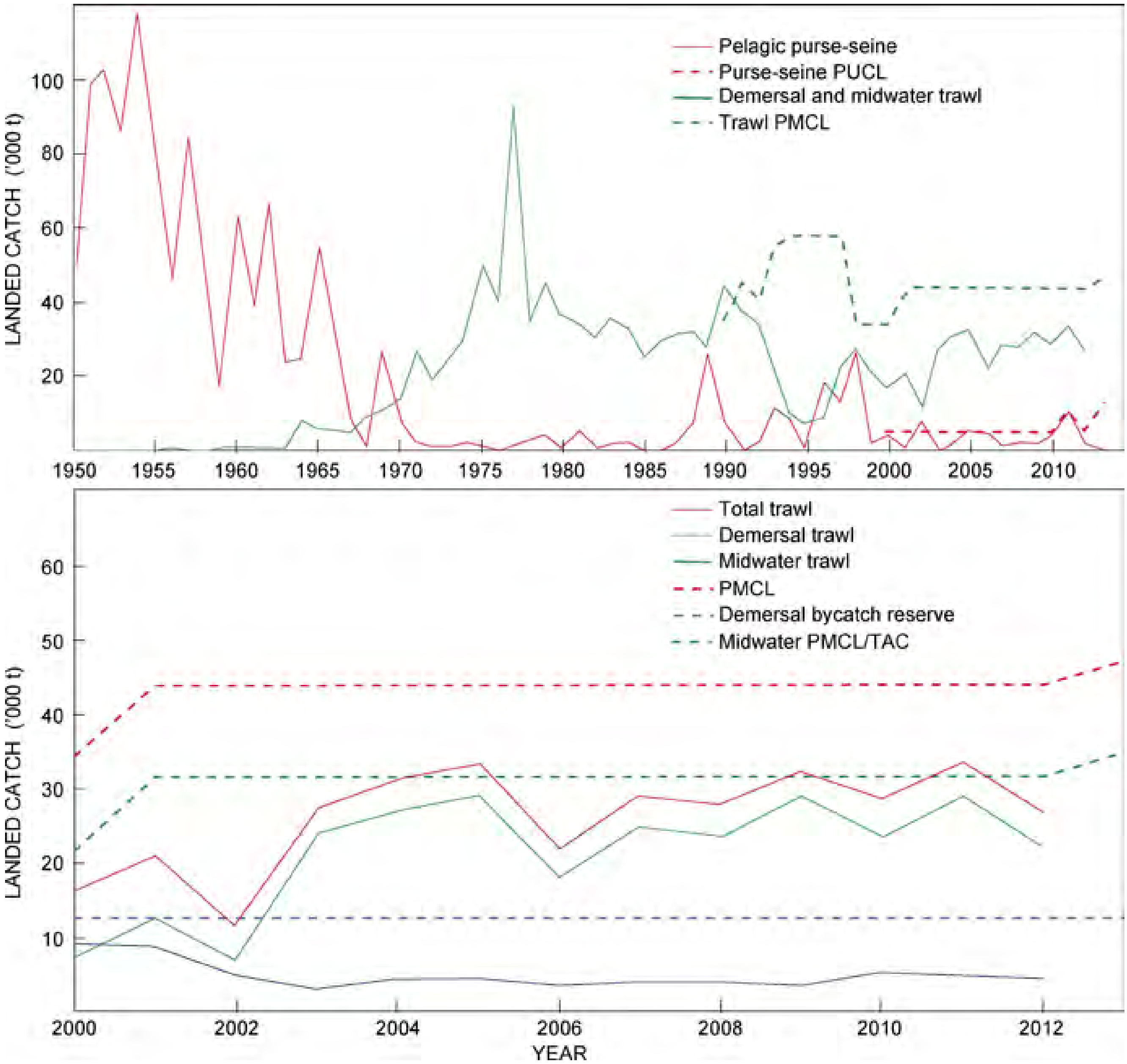


Figure 16: Annual horse mackerel catches and regulatory limits for the period 1950 to 2012. In the upper panel, catches are shown separately for the pelagic purse-seine and trawl fisheries, and the relevant PUCLs (purse-seine) and PMCLs (trawl) are indicated with dashed lines. Note that the trawl catches comprise landings both by the midwater and demersal trawl sectors. Trawl catches by sector for the period 2000 to 2012 are shown in the lower panel, with the associated catch limit levels indicated with dashed lines.

escalated, peaking at 93 000 t in 1977. Following the declaration of the South African Exclusive Fishing Zone (EFZ) in 1977, foreign participation in the fishery was controlled and catches stabilised at between 25 000 t and 40 000 t per annum. When foreign fleets were finally phased out in 1992, annual catches (now by South African vessels only) declined to below 10 000 t in 1995 and 1996. Whereas demersal trawl catches have subsequently remained low, the re-establishment of a midwater fishery for Cape horse mackerel in 1997 resulted in an increase in the annual catch (Figure 16), which has fluctuated between 11 000 t and 33 000 t since the 2000 fishing season.

Annual Total Allowable Catch (TAC) restrictions for the trawl fishery (both demersal and midwater) were set for the years 1990 to 1992 using assessments of the resource based on Catch Per Unit Effort (CPUE) data derived from the Japanese fleet, combined with survey biomass and egg abundance indices. With the phasing out of the foreign fleets in 1992, the Japanese CPUE time-series was terminated and this modelling approach was no longer appropriate. A Precautionary Maximum Catch Limit (PMCL) of 40 000 t was set for 1992. Thereafter, a yield-per-recruit modelling approach was adopted on which to base PMCLs until 1999, when an age-structured production model of the resource was developed.

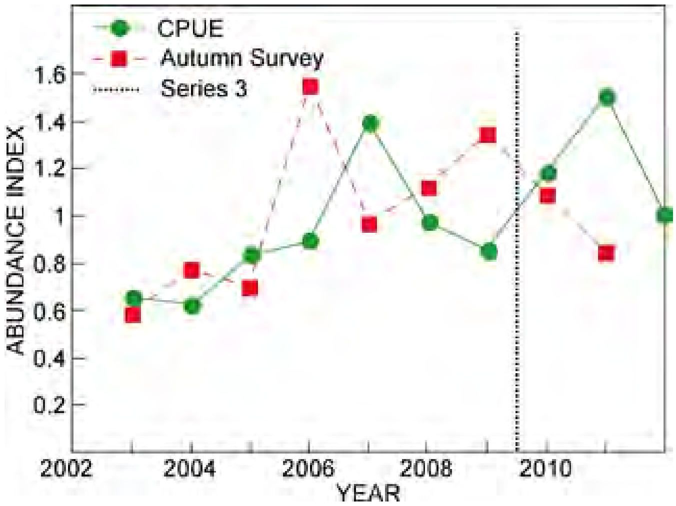


Figure 17: Commercial GLM standardized CPUE and Autumn demersal survey abundance indices. The dotted vertical line indicates the division between "recent" and "historical" indices used in calculating the 2013 directed midwater trawl TAC.

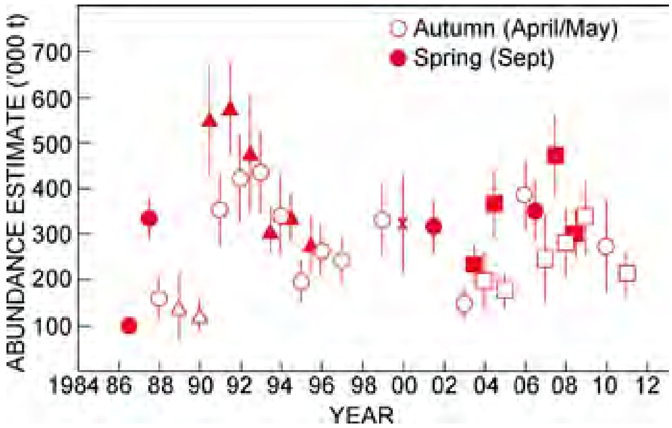


Figure 18: Horse Mackerel survey abundance indices and associated standard errors from 1985 to 2011 on the South Coast of South Africa. The circles (open and solid) represent the old gear and the squares (open and solid) represent the new gear.

Biomass projections using the model indicated that a PMCL of 34 000 t for the trawl fishery combined with a 5 000 t PUCL for the purse-seine fishery would be appropriate, and these catch restrictions were imposed for the 2000 fishing season. The trawl PMCL was increased to 44 000 t for 2001, and was maintained at that level until 2012. Since 2002, the trawl PMCL has been separated into a 12 500 t reserve to account for incidentalbycatch of horse mackerel in the hake demersal trawl fishery, and a 31 500 t PMCL for the directed midwater trawl sector.

In 2012, an OMP approach, that incorporates a fluctuating TAC to enable increased catches during periods of high horse mackerel abundance, was implemented for the directed midwater trawl fishery to improve utilisation of the resource without undue increase in the risk of unintended reduction of resource abundance. Updated assessments indicated that a 10% increase in the directed midwater trawl component of the PMCL could be implemented on a short-term basis with no additional risk to the resource. A control rule has consequently been developed that enables adjustments of the midwater TAC (both increases and decreases) depending on the level of current resource abundance indices relative to averages over a fixed past period (Figure 17). Accordingly, the 2013 midwater TAC was increased by 10% from 31 500 t to 34 650 t. Note that this experimental approach applies only to the directed midwater trawl fishery; the demersal bycatch reserve has been maintained at 12 500 t.

Research and monitoring

The assessment and proper management of the horse mackerel resource is currently limited by uncertainties regarding resource abundance. Current abundance estimates used in the assessment are derived from swept-area demersal surveys conducted annually on the South Coast in April, and September in some years (Figure 18). It is likely, however, that these estimates may be lower than the true abundance of the resource, due to the distribution and movement of the species in the water column. It is probable that, during demersal surveys, an unknown amount of fish is distributed above the headline of the sampling gear, and these fish are consequently not sampled during the survey. Unfortunately, acoustic methods are also unable to provide unbiased biomass estimates as it is not possible to detect horse mackerel acoustically when they are close to the seabed. Dedicated horse mackerel surveys employing both swept-area and hydro-acoustic techniques may enable the quantification of the level of error inherent in swept-area estimates of horse mackerel abundance. Plans to further this research have been unsuccessful due to budgetary and ship time constraints, but a dedicated horse mackerel survey using both swept-area and hydro-acoustic techniques is planned for 2014.

A second source of information concerning resource abundance has recently been developed from commercial midwater trawl catches. CPUE data (Figure 17) are standardised using general linear modelling techniques to account for factors such as depth, location, time of day, lunar phase and wind speed.

Current status

The most recent update of the horse mackerel assessment was conducted in 2011 to take account of further catch and survey data. In addition, length-frequency data from surveys and the commercial mid-water trawl fishery, and a GLM-standardised CPUE series from the fishery, were also included when fitting the model to the data. The assessment indicated an increase in abundance of about 20% over the preceding five years, primarily as a result of good recruitment. However, long-term projections under different levels of future catches remain fairly similar to those of the earlier assessment conducted in 2007. It was further recognised that a more flexible management approach could improve utilisation of the resource. The operating models developed during the 2011 assessment were used during the testing of the adaptive control rule for the directed midwater trawl fishery discussed above. The data used in implementing the control rule (Figure 17) show that, while the indices of abundance have decreased in recent years, current abundance is still higher than the historical average agreed on as the limit reference point.

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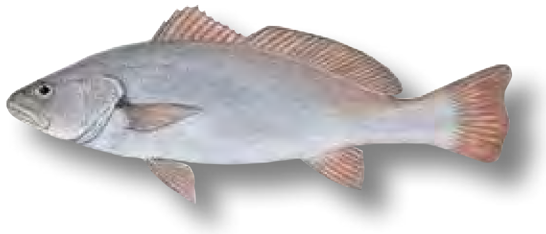
Linefish



Stock status	Unknown	Abundant	Optimal	Depleted	Heavily depleted
		Hottentot	Snoek Yellowtail Carpenter Slinger		Silver kob Red steenbras* Seventy-four*
Fishing pressure	**Unknown**	**Light**	**Optimal**	**Heavy**	
		Hottentot	Snoek Yellowtail Carpenter Silver kob Slinger	Silver kob	

* No fishing pressure has been assigned to these species as they are both currently under total catch moratoriums.

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 South Africa's 2 200 marine fish species.

Linefish species are typically predatory in nature, and include a number of apex predators such as sharks, groupers, tunas and red steenbras. Most of the linefish caught are not targeted exclusively by this fishery, but form important components of the catch or the by-catch of other fisheries. This complicates the management of this resource.

The commercial linefishing sector is exclusively boat-based. The total number of registered vessels operating in this sector was estimated at 700 in the late 1990s, which accounted for 37% of all boats operating in marine fisheries in South Africa. From 2006 until the end of 2013, 455 boats have been in operation. Line-fishing 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 of all South African fisheries. The total value of the linefishery is in excess of R2.2 billion per annum.

The recreational boat-based sector expanded rapidly after the introduction of the trailerable skiboat in the 1970s, with an estimated minimum of 4 000 vessels. Subsistence fishing was formally recognised in the year 2000 to accommodate 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, 85% of whom 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 19th Century was already quite considerable (between 0.12 and 0.37 boats per kilometre of coastline). This increased dramatically during the 20th Century and peaked in the 1980s and 1990s (>3 boats per kilometre of coastline). The sharp increase in fishing effort, together with the increase in operational range through the introduction of motorised skiboats on trailers, the rapid development in fishing technology (echosounders, nylon line,

etc.) and the additional offtake by other fleets such as trawl and purse-seine, led to overfishing of most of the linefish resources around the coast during the last quarter of the 20th Century.

Despite its long history, the first comprehensive management framework for the linefishery was only introduced in 1985 when this fishery was formally recognised. However, successive research surveys indicated continuing declines. In December 2000, the Minister of Environmental Affairs and Tourism, taking cognisance 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). Effort was reduced and fixed at 450 vessels and the hake and tuna components were developed into separate sectors. To rebuild collapsed stocks and to achieve a sustainable level of utilisation, a Linefish Management Protocol (LMP) was developed in 1999 in order to base regulations in the linefishery on quantifiable reference points. This still remains the basis of linefish management.

A number of regulations were put in place to manage fishing pressure on linefish resources. Due to the large number of users, launch sites and species targeted, and to flexibility of the operational range, the commercial linefishery is currently managed through a Total Allowable Effort (TAE) allocation, based on boat and crew numbers. The recreational fishery is managed by a number of output restrictions, such as size and bag limits, closed areas and seasons. The subsistence fishery is managed through a combination of these. The level of commercial effort was reduced to the levels stipulated in the declaration of the emergency when linefish rights were allocated in 2003-for the medium-term-and in 2005 for the long-term fishing rights. The 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 also been a reduction in recreational fishing pressure through the implementation of more realistic species-specific daily bag and size limits since 2005.

Although this 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 remain 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 unregulated subsistence fishing in sensitive estuarine and nearshore habitats, and also due partly to increased linefish catches by other fishing sectors such as the inshore trawl.

With the policy for the small-scale fisheries sector being currently in the implementation process, a large number of species, the majority of which are part of the linefishery, will be shared between the small-scale sector and the commercial and recreational sectors. To achieve this without compromising the recovery of these valuable stocks, a comprehensive revision of the Linefish Management Protocol is envisaged.

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-based observer programme that aimed to record statistics on catch and effort at all the fishing centres. Comprehensive per-species catch-and-effort data from the boat-based commercial fishery have been collected since 1985 and stored in the National Marine Linefish System (NMLS). A national observer programme was implemented from 2008 until 2010, in which observers confirmed recorded catch-and-effort data and collected size frequencies per species from the boat-based fishery at access points around the country. A comparison between this information and the data handed in by the fishery confirmed the accuracy of the NMLS catch data, which is based on mandatory catch reports by the fishery.

With the increased focus on formalizing the small-scale and subsistence fishery around the country, a national, shore-based monitoring programme for this fishery has been designed and implemented. Data from this programme will be used to investigate whether current fishing effort and catch are sustainable and will aid in determining management measures for the 'basket' of resources allocated for this fishery.

In addition to fisheries-dependent data, which can only provide indirect measures of resource status, novel methods to investigate fish abundance and species composition are being employed. A comprehensive comparison of monitoring methods, including standardized angling, underwater visual census by divers and remote underwater video suggests that the latter provides the most unbiased census method. After successful application of this method in selected areas, an even more sophisticated version, the stereo Baited Remote Underwater Video (sBRUV) technique will be used during a nationwide investigation of fishing hotspots and marine protected areas to determine fish abundance, species composition and size frequencies of reef-associated linefishes.

The biology of the fish caught in the linefishery has been remarkably well studied, even more so when considering the large variety of target species in comparison with other fisheries. It is also this variety, however, that makes information on linefishes difficult to access for researchers and for the general public. Recognizing this shortcoming, a project was initiated in 2011 to collate information on biology, life history and fisheries parameters of linefishes in one database. Phase one of this project has been completed in the form of recently published species profiles with updated information on 139 linefish species. In phase two, this information will be made available as a web-based interactive database.

Marine Protected Areas (MPAs) not only provide reference areas for research on the effects of fishing and climate change but can enhance and sustain surrounding fisheries. A recent study has shown that, in some instances, this can be achieved without the commonly predicted negative effects on the fishery, in particular for depleted temperate reef fish stocks with complicated life histories such as roman *Chrysoblephus laticeps.*

Due to the depleted status of the stocks there is little hope to increase fishing effort on the linefishery in the near future, yet there are numerous ways to increase the profitability of the fishery. Studies are underway to investigate handling and cold chain management of line-caught snoek, the most important species for the fishery in terms of catch volume. Improved handling and cooling protocols are necessary to compete with imports of this species from industrial fisheries in South America, Asia and New Zealand. In addition, more research is necessary to understand and mitigate the impact of other fisheries, aquaculture and imports of linefishes on the local fishery.

Assessing the status of linefish stocks has been a priority in recent years, but is difficult due to the multi-species, multi-area nature of the fishery. Drawing on the enormous body of spatially-referenced fisheries data contained in the NMLS, the largest spatially-referenced marine dataset in the world, a novel method to standardize Catch Per Unit Effort (CPUE) data, used as an index for stock abundance, has been developed. Simulation testing of this approach with computer-generated data has proved that this method outperforms existing methods, laying the foundation for the first comprehensive stock assessment framework for the linefishery with state-of-the-art modeling techniques. The new assessment framework will allow us to determine the appropriate effort levels for this fishery more accurately, as the likely impact of different management tools can be simulation-tested. The new framework will be incorporated in an update of the Linefish Management Protocol.

Current Status

If the linefishery could be carefully managed to return to more sustainable levels, it has the potential to become one of the most ecologically and economically viable fisheries in South Africa, due to the following factors: (i) the fishing method can be highly selective and by-catch 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 damage on the ecosystem.

The first results of the new stock assessments indicate that the drastic reduction of fishing effort from 2003 resulted in the partial recovery of some species, such as the slinger, hottentot and carpenter. However, other important stocks such as silver kob are still being overfished, due partly to the cumulative impact of the line-and the commercial inshore-trawl fishery on this species. The recovery of reef-associated sparids, such as red steenbras and dageraad, hinges on the continued protection of juveniles and spawning stock of these species inside MPAs and offshore refugia, as well as the rigorous enforcement of bag and size limits.

If reliable catch return information is provided by all fishers, the new stock assessment framework will enable tracking of the stock trajectories of the most important linefish species, providing a strong foundation for scientifically-based sustainable management. Nevertheless, other stock status indicators such as standardised CPUE, a change 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 management actions, as it is not possible to carry out annual assessments of all species caught in this fishery.

Ecosystem Interactions

Given the nature of passive fishing gear that can be used selectively to target desired species, the by-catch in the linefishery is negligible. However, fishing with rod and line on high-biodiversity habitats such as temperate or tropical reefs will yield a range of species, some of which it is undesirable to catch because of their highly depleted status, such as the red steenbras and the seventy-four, as well as a number of shark species. Although captured fishes can be released, there might still be significant mortality due to barotrauma and hook damage. A recent study has shown that this effect is species-specific, but can be detrimental to a significant proportion of released individuals.

Interactions with sharks and seals have consistently been reported by linefishers and a study is underway to investigate the extent of this problem in the case of sharks.

Useful statistics

Annual catch (tons) of key linefish species from 2000 to 2012

Species	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Snoek	6 543	6 839	3 837	4 532	7 278	4 787	3 529	2 765	5 223	6 322	6 360	6 205	6 809
Yellowtail	320	327	242	329	883	739	310	478	313	330	171	204	382
Kob	547	416	392	272	360	324	400	421	358	442	419	312	221
Carpenter	441	285	231	177	228	184	159	265	226	282	263	363	300
Slinger	186	139	101	88	184	169	192	157	194	186	180	214	240
Hottentot	234	109	79	106	254	168	87	128	120	184	144	216	160
Geelbek	894	395	315	513	672	580	419	448	403	495	408	286	337
Roman	23	11	12	13	21	15	18	30	18	21	15	19	34
Rock cods	46	33	27	20	33	39	36	32	40	33	27	26	30
Elf	15	3	2	5	14	35	13	25	16	6	4	2	11
Red Steenbras	26	7	8	3	3	2	3	7	2	5	3	2	2

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Netfish

Stock Status	Unknown	Abundant	Optimal	Depleted	Heavily Depleted
	St Joseph		Yellowtail	Harders Elf	Harders White steenbras
Fishing pressure	**Unknown**	**Light**	**Optimal**	**Heavy**	
			Yellowtail	**Harders** **St Joseph** **Elf** **White steenbras**	

Introduction

There are a number of active beach-seine and gillnet fisheries throughout South Africa. By far the biggest are the fisheries for harders (or mullet) *Liza richardsonii*, with 28 and 162 Right Holders respectively 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 *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 by-catch. Excessive effort granted under Interim Relief as well as a substantial illegal component, which may in some years equal or exceed legal catches of harders and by-catch, 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. The main targets then 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) had retired from fishing activities and participated in the netfishery to supplement incomes and food supplies. Many, both historically advantaged and disadvantaged, were desperately poor and were 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 from the active participants about harders being plentiful. 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 full-time fishers.

During this time, approximately 6 000 t were landed per annum by the beach-seine and gillnet fisheries. The gillnet fishery accounted for, on average, 3 250 t of harders, 650 t of St Joseph and 130 t of by-catch 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 by-catch, 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 of between 20 and 60%, especially in over-subscribed areas. The loss experienced by most fishers also indicated the part-time or "recreational" nature of many of the participants. Indeed, in the Berg River Estuary, fewer than 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 subsidisa-

tion, 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 just over 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 by-catch, most of which was composed of species regarded as overexploited or collapsed. In turn, most of the catch of overexploited or collapsed species were juveniles below minimum legal size, i.e. 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 compromising 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.

Research and monitoring

Fishery-dependent data sources consist of ongoing length-frequency measuring, observer data, compulsory monthly catch returns by Right Holders and an intermittant National Linefish Survey. The most important of the fishery-dependent data sources has been the National Linefish Survey 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. This survey, however, has not been able to be repeated since 1995. Encouragingly, an opportunity exists to complete a survey of the beach-seine and gillnet fisheries during the course of 2014–2015.

Fishery-independent data are 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 as 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 beginning of 2014.

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 exists 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 19). 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 minimum legal size, i.e. before they were recruited into the linefishery and before they were able to reproduce and thus

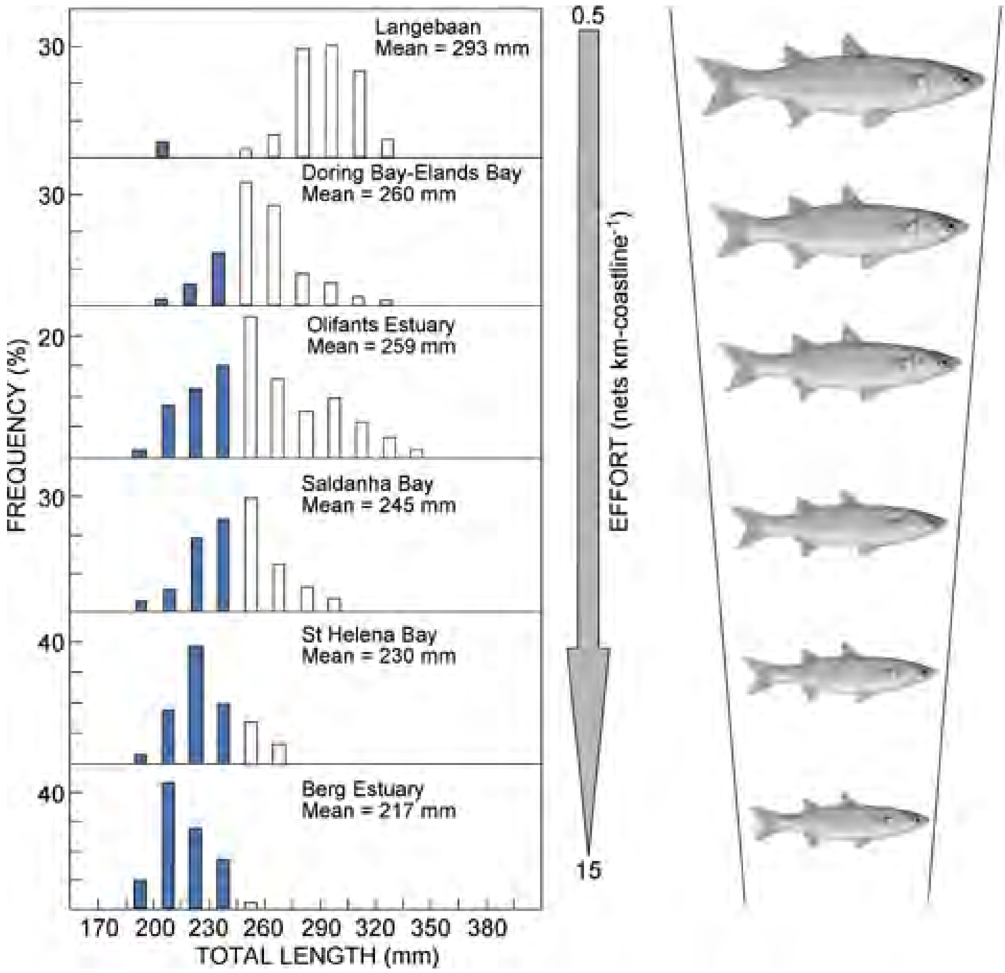

Figure 19: Length-frequency distributions of harders (*Liza richardsonii*) landed by commercial gillnetters in different regions. Potential effort levels (nets km-coastline^{-1}) and fish scaled to actual size are included for illustration. Shaded bars represent immature fish. However, the nets also 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.

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 indicated a recovery in the numbers and size of harders and by-catch 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 400 t are harvested illegally from the Berg River Estuary alone each year. A total of 500 t reduction in reported catches strengthens the veracity of this 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 four 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 Coast and West Coast populations of these species.

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Oysters

Stock Status	Unknown (KwaZulu-Natal and Southern Cape)	Abundant	Optimal	Depleted	Heavily Depleted
Fishing pressure	Unknown	Light	Optimal (KwaZulu-Natal)	Heavy (Southern Cape)	

Introduction

The Cape rock oyster *Striostrea margaritacea*, which is targeted in this fishery, has an extensive geographic distribution and occurs on rocky reefs from Cape Agulhas to Mozambique. These oysters are found in the intertidal zone down to about 6 m water depth. The Cape rock oyster occurs naturally and is sold in South African restaurants. Another species that is available in restaurants is the Pacific oyster *Crassostrea gigas*, which is imported and widely used in marine aquaculture. Cape oysters along the KZN coast have been found to take 33 months (almost three years) to reach marketable size (60 mm right valve length). Oysters are broadcast spawners, and those along the KZN coast 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. In recent years, however, this has gradually been expanded towards the fringes of the sub-tidal zone (see below). 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 artificial breathing apparatus is not allowed. No harvesting is permitted from the sub-tidal 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 handful of individuals (less than 8 people) held concessions to harvest oysters and employed

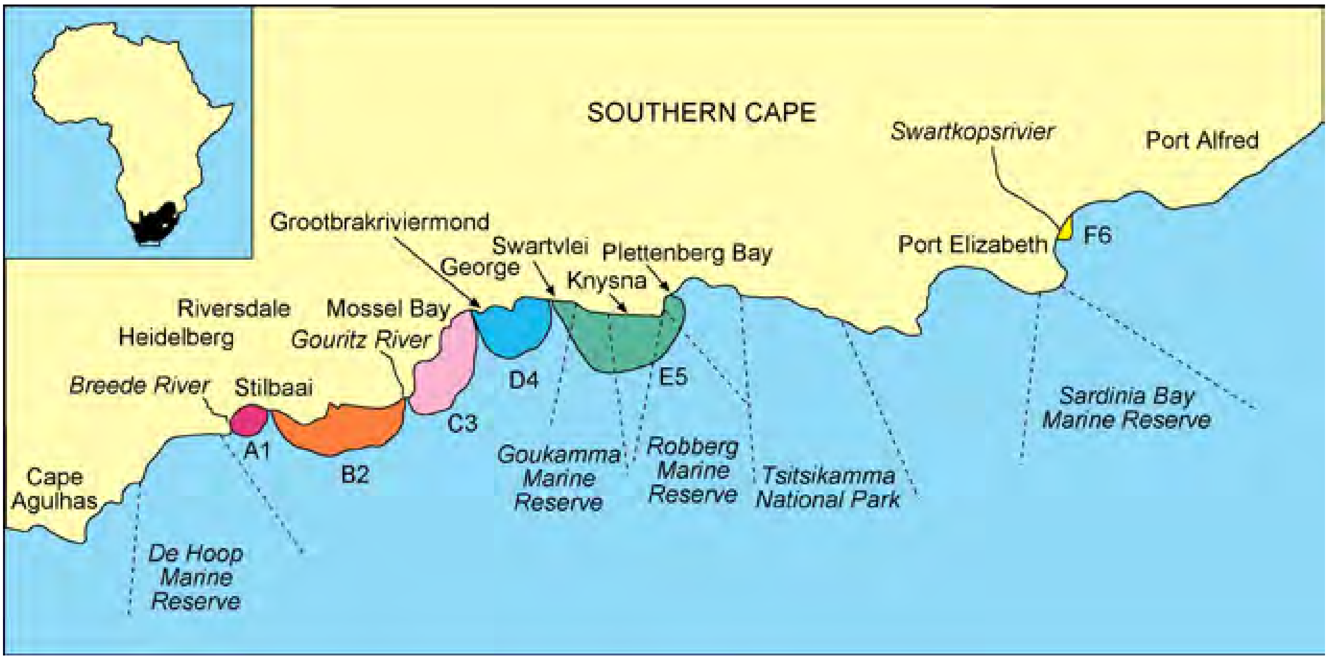

Figure 20: Oyster fishery in Port Elizabeth and the Southern Cape. The colour-coded areas indicate dedicated oyster collection zones

large numbers of 'pickers' to assist with collections. In 2002, rights were redistributed and medium-term (4-year) rights were allocated to 34 Right Holders, the majority of whom 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 rights allocation process, the sector was further transformed and 3-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 oyster harvesting for their livelihood. In this 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 related to their areas of operation, namely the Southern Cape Coast and the KZN 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 recognised, namely the Southern Cape, Port Elizabeth, KZN North and KZN South (Figures 20 & 21). Regional differences regarding regulations and harvesting patterns have been retained.

Research and monitoring

Research on the oyster resource has begun only recently. Since oysters are of relatively low value in comparison to other commercially exploited species, the fishery was not prioritised in terms of research effort and management attention in the past. The consequence is that the Total Allowable Effort (TAE) for 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, given that the patchy distribution and cryptic nature of oysters make accurate sampling of this resource in the intertidal zone exceedingly difficult. Once the method is refined and a reliable index of oyster abundance is obtained, improved scientific advice on sustainable harvesting levels will be able to be provided.

Due to the uncertain status of the resource, and evidence of overexploitation in the Southern Cape, this region has been prioritised for research efforts aimed at establishing indices of abundance, estimating density and population size structure, and determining a more accurate TAE. Research and monitoring in KZN is carried out by the Oceanographic Re-

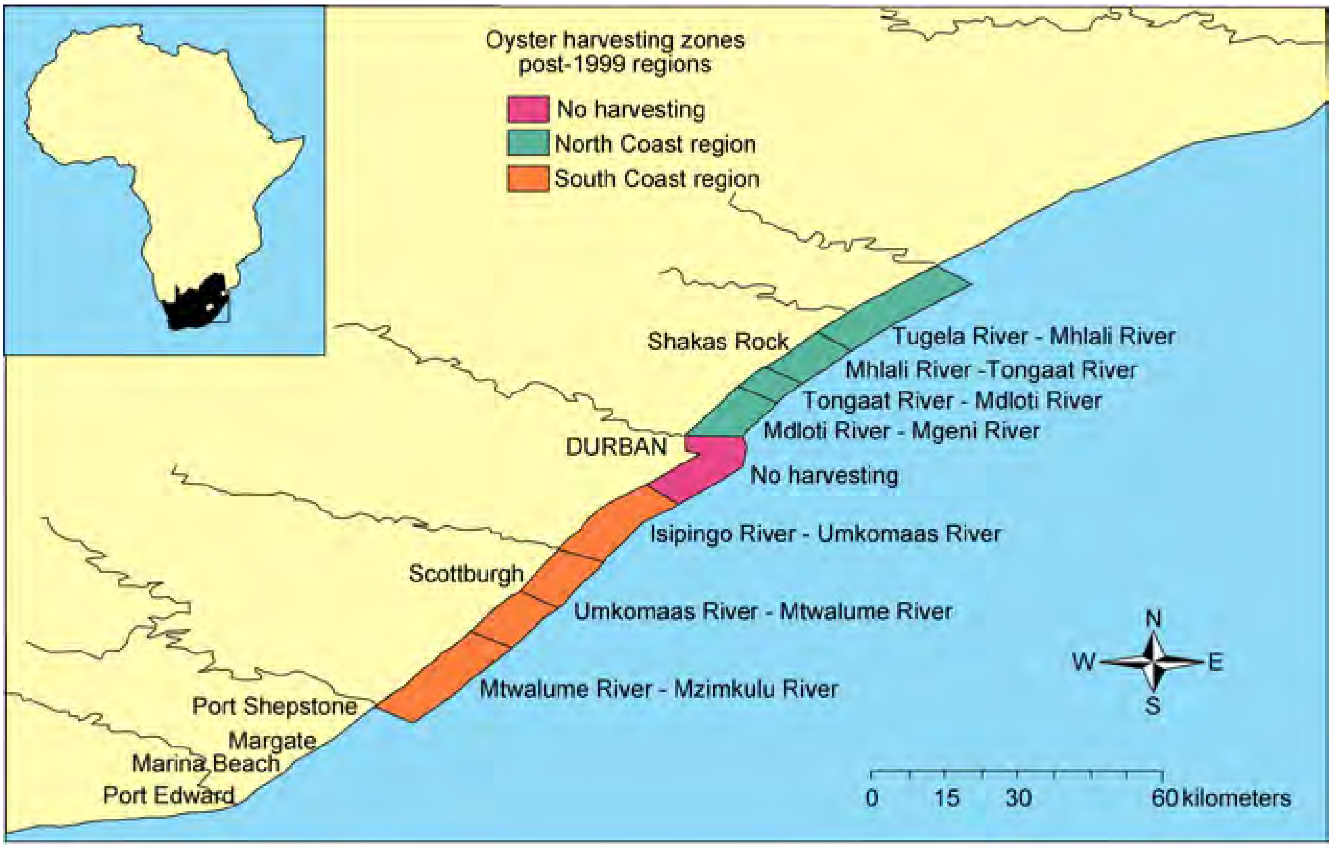

Figure 21: Oyster fishery in KwaZulu-Natal (rezoning of South Coast included)

search Institute under contract to the Branch: Fisheries Management with the purpose of providing information on which to base recommendations for this region of the coast.

Current status

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

Total catches between 2002 and 2005 were between approximately 600 000 and 730 000 oysters, the majority of which were harvested in the Southern Cape (Figure 22). Data for 2006 are not available because catch reporting was poor on account of the new rights allocation and the change of Right Holders. The low catches in KZN in 2008 (3 491 individuals) was an exception, caused mainly by problems during the permit processing. It is noteworthy, however, that catches in KZN have nearly halved compared with the period from 2000 until 2005, but this is thought to be due to problems with permit allocation and catch reporting.

The oyster resource along the KZN coast is considered to be fully exploited. Resource assessments undertaken in 2006 during a research project outsourced to the Oceanographic Research Institute (ORI) showed that, although the oyster stocks declined since 1980, they were stable or showed a slight decline for approximately 20 years prior to the study. Harvesting figures have, however, declined over the last decade. This may be a result of reduced effort (due to non-activation of permits), especially along KZN South Coast, poor catch reporting or a decline in resource availability. Further research is required for an updated assessment.

In the Southern Cape there is concern that the intertidal zone is being denuded of oysters as a result of being over-harvested. Surveys undertaken between 2000 and 2004 that measured oyster density and size composition suggested that the intertidal component of the oyster stock along the Southern Cape Coast appeared to be over-exploited. Moreover, there have been reports of divers illegally harvesting oysters from subtidal 'mother beds'.

Catch Per Unit Effort (CPUE) data for the Southern Cape oyster fishery are considered to be unsuitable for the purposes of stock assessment, and the status of this resource thus remains uncertain.

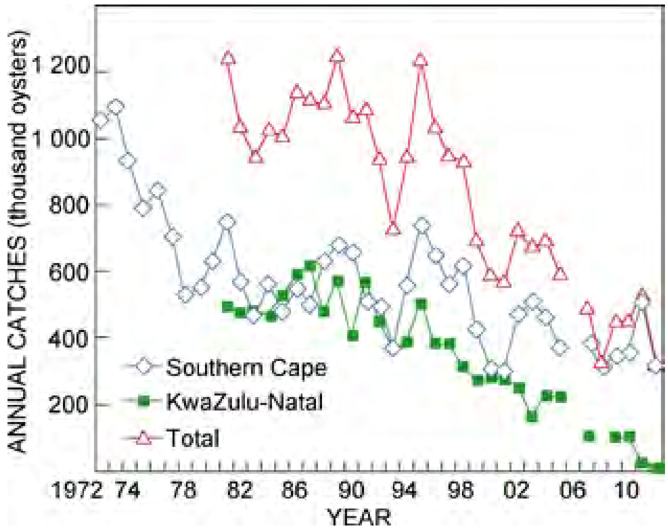

Figure 22: Total number of oysters harvested from the Southern Cape and KwaZulu-Natal coasts for the period 1972–2012.

Ecosystem interactions

The harvesting of rock oysters involves the direct picking of individual organisms from the rocks, and the use of diving masks by pickers allows more precise fishing, thereby reducing the potential for dislodgement of non-target species. Oyster harvesting is therefore considered to have minimal significant disturbance on the surrounding biological communities, although research is required to substantiate this view.

Useful statistics

Total Allowable Effort (TAE) (number of pickers) and Total Catch (number of oysters) for the oyster fishery for the period 2000 to 2012

		2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012*
Southern Cape and PE	TAE	105	105	105	105	105	105	105	105	105	105	105
	Catch	471 360	511 946	468 485	373 322	-	387 831	316 295	346 375	358 406	508 134	311 186*
KwaZulu-Natal	TAE	40	40	40	40	40	40	40	40	40	40	40
	Catch	257 238	163 357	227 067	222 864	-	105 552	-	103 684	102 168	24 924	12 544*

- No catch data were available due to no or poor catch returns

*Catch data for 2012 may be incomplete since catch returns are often submitted late

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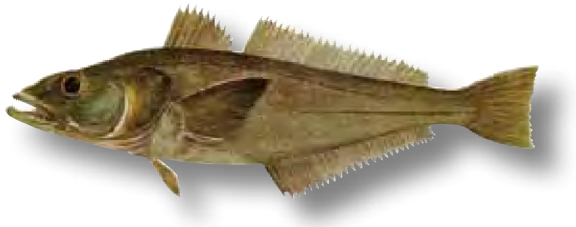
Patagonian toothfish



Stock status	Unknown	Abundant	Optimal	Depleted	Heavily depleted
Fishing pressure	Unknown	Light	Optimal	Heavy	

Introduction

Patagonian toothfish (*Dissostichus eleginoides*) belong to the family Nototheniidae, a family of fish that occurs in the Southern Ocean. Unlike other species in the family, Patagonian toothfish appear to lack antifreeze molecules in the blood and they are not found in waters colder than 2ºC. They are replaced by Antarctic toothfish (*D. mawsonii*) in the colder Antarctic waters. Patagonian toothfish are slow–growing, reaching sexual maturity at about 90 to 100 cm (9 to 10 years old) and attain a maximum total length of over 200 cm. Patagonian toothfish occur at depths between 70 and 1 600 m around sub-Antarctic Islands and seamounts, mainly between 40ºS and 55ºS. A fishery for this species has developed in the South African Exclusive Economic Zone around the Prince Edward Islands (PEI-EEZ).

Patagonian toothfish fetch a high price on markets in the United States and Japan and have consequently been the target of extensive fishing, primarily using longline gear. As a large part of their distribution is on remote seamounts and islands, they have been, and still are, subjected to substantial illegal, unreported and unregulated (IUU) fishing. Fisheries for Patagonian toothfish are further characterised by losses through marine mammals (mostly killer whales *Orcinus orca*) taking fish off the lines (termed "depredation"). In some fisheries this depredation can be substantial and during a single trip in the fishery in the PEI-EEZ it was estimated to represent a loss of be as much as 80% of the catch on a single day and 30% to 50% of the catch during that trip.

Most of the Patagonian toothfish distribution falls within the area managed by the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR). As an original member of CCAMLR, South Africa remains committed to its objectives, and has voluntarily applied the CCAMLR conservation measures (CMs) within the PEI-EEZ. According to CCAMLR CM 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 within the PEI-EEZ.

History and management

An experimental fishery for Patagonian toothfish in the PEI-EEZ was initiated in 1996. Five Permit Holders participated in the experimental fishery from its inception until 30 November 2005. In 2006, the experimental fishery was converted to a commercial fishery through the allocation of five long-term fishing rights. At the start of the commercial fishery there were two active vessels, one representing the largest Right Holder and a second, larger vessel operating for a consortium of the other four Right Holders. The consortium soon withdrew their vessel from the fishery, advising that fishing was uneconomical due to poor catch rates and high losses to marine mammals. Consequently, only a single vessel operated in the Prince Edward Islands EEZ from 2006 until the consortium re-introduced a second vessel into the fishery in late 2010.

Various gear configurations have been employed to exploit the resource since the inception of the fishery. At the commencement of the fishery in the 1990s, the primary fishing gear employed was a form of longline known as an "autoline", with a few vessels using the Spanish double line system. Apart from a brief period (2004–2005) when one vessel deployed pots, the period from 2000 onwards was characterized by an increasing shift to the use of Spanish longlines, and auto-

Table 2: Catches (tons) per fishing season of Patagonian toothfish estimated to have been taken from the Prince Edward Islands EEZ

	Season	Total longline	Pot	Total legal	TAC	Estimated IUU catch	Estimated total catch
EXPERIMENTAL	1996/1997+	2 754.9		2 754.9		21 350	24 104.9
	1997/1998	1 224.6		1 224.6		1 808	3 032.6
	1998/1999	945.1		945.1		1 014	1.959.1
	1999/2000	1 577.8		1 577.8		1 210	2 787.8
	2000/2001	267.8		267.8	2 250	352	619.8
	2001/2002	237.3		237.3	600	306	543.3
	2002/2003	251.1		251.1	500	256	507.1
	2003/2004	182.5	72.6	255.1	500	156	411.1
	2004/2005	142.6	103.5	246.1	450	156	402.1
	2005/2006	169.1		169.1	450	156	325.1
	2006/2007	245.0		245.0	450	156	401.0
COMMERCIAL	2007/2008	145.2		145.2	450	156	301.2
	2008/2009	72.5		72.5	450	156	228.5
	2009/2010	223.7		223.7	450	156	379.7
	2010/2011	291.4		291.4	400	0	291.4
	2011/2012	276.1		276.1	320	0	276.1
	2012/2013*	165.5		165.5	320	0	165.5

+ Catch data for the 1996/1997 season include catches made during October and November 1996 (i.e. effectively the 1995/1996 fishing season
* Data for the 2012/2013 season are currently incomplete, and therefore do not reflect the total catch made during this fishing season

lines were eventually phased out altogether by 2008. Another shift in the gear employed began with the introduction in 2008 of a modified longline gear, the trotline, that appreciably decreases the loss of catch to marine mammal depredation and has a higher retention of large fish. Use of this gear has subsequently increased to the extent that almost no Spanish longline gear was used during the 2011 fishing season (Figure 23). These gear changes have complicated the assessment of the status of the resource (see below), and hence its management. An experiment to calibrate catch rates between Spanish longlines and trotlines was initiated in the 2011/2012 season and continued through to the end of the 2012/2013 fishing season.

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. Estimated IUU catches declined subsequently and were assumed to be constant at 156 t per annum over the period 2003 to 2009 (Table 2). Recent information indicates that no IUU fishing has occurred in the Prince Edward Islands EEZ since 2010.

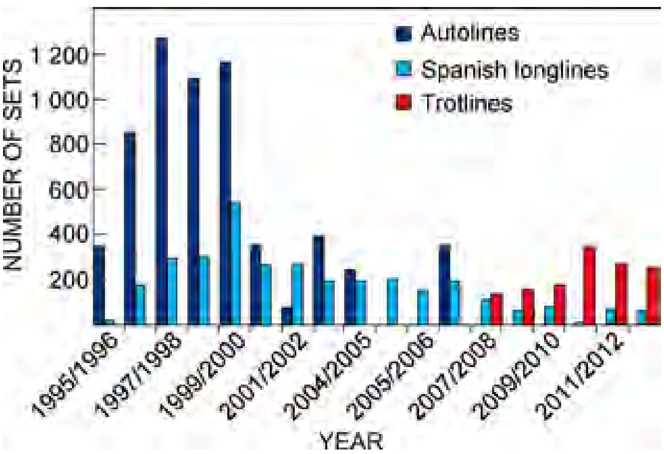


Figure 23: Number of longline sets deployed per fishing season in the Prince Edward Islands EEZ. Data are shown for the three different longline gear configurations deployed in the fishery over time.

Regulation of the fishery was initiated in the 2000/01 fishing season by means of a Total Allowable Catch (TAC) restriction of 2 250 t. The first assessment of the status of the resource was conducted in 2001 and used an Age Structured Production Model (ASPM) that was base d on catch-per-unit-effort (CPUE) data derived from Spanish longline sets. The results of the assessment indicated severe depletion of the stock, and the apparent depressed status of the resource led to a decrease in the TAC from 2 250 t in the 2000/01 season to 600 t in the 2001/02 season. The CCAMLR Scientific Committee recommended that South Africa set a TAC of not more than 400 t for the 2002/03 season. In consultation with industry representatives, a compromise was reached between the 400 t recommended by CCAMLR's Scientific Committee and the 600 t TAC that was set in the 2001/02 season. This compromise was firstly to demonstrate South Africa's commitment to CCAMLR, and secondly to provide sufficient catch to maintain a year-round legal fishing presence in the Prince Edward Islands EEZ as a means of deterring further IUU fishing in the area. The TAC was thus set at 500 t for the 2002/03 season and maintained at that level for the 2003/04 fishing season.

The ASPM was extended to incorporate catch-at-length (CAL) data as a basis for TAC recommendations in 2003. Despite refinements to the model, the two primary resource monitoring indices (CPUE and CAL) yielded conflicting estimates of resource status. While the CPUE data indicated that the resource was severely depleted, the CAL data suggested that the situation was less serious. Attempts to reconcile these two indices were unsuccessful. These circumstances led to major difficulties in making scientific recommendations for appropriate catch limits for this resource, and a pragmatic approach was adopted that led to a reduction in the TAC to 450 t for the 2004/05 season. The consortium of four Right Holders withdrew their vessel in 2006 due to economic pressures, leaving only a single Right Holder, with an allocation of 27% of the TAC, active in the fishery. Consequently the annual TAC

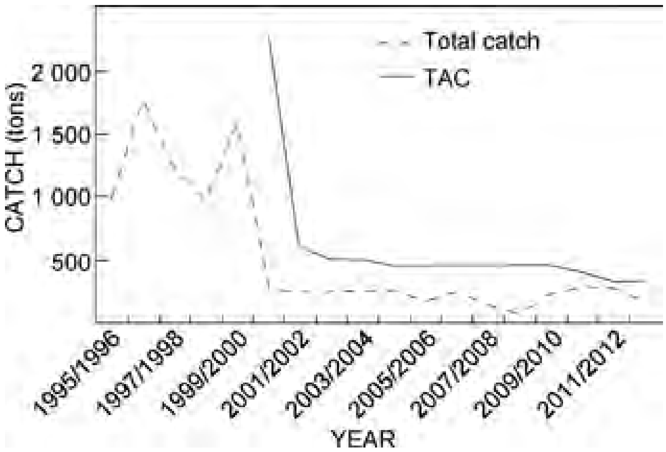


Figure 24: Legal catches of Patagonian toothfish taken from the Prince Edward Islands EEZ since the inception of the fishery. Also shown are the Total Allowable Catch (TAC) restrictions that have been imposed since the 2000/2001 fishing season. Note that the catches for the 2012/2013 fishing season are incomplete as the data are still being collated and archived. The total catch for 2012/2013 is likely to be close to the TAC.

was maintained at 450 t until 2010 when the consortium of four Right Holders re-entered the fishery. The annual catches over the 2006 to 2010 period were well below the TAC (Figure 24) as a result of only one Right Holder being active in the fishery. With the re-introduction of a second vessel into the fishery, all rights became active, prompting a reduction of the TAC to 400 t for the 2010/2011 season due to uncertainties regarding the status of the resource.

An updated analysis of the status of the resource incorporating additional catch data (2007 – 2010) was conducted in September 2011. The analysis was complicated by the gear change (Spanish longline to trotline) in the fishery in recent years. Depending on the data and approach used in the analysis, standardised CPUE dropped by between 16% and 34% in 2010 relative to preceding years. On the basis of these results, the TAC for the 2011/2012 fishing season was reduced by 20% from the 2010/2011 level to 320 t, and this level was maintained for the 2012/2013 season, pending further work on calibrating the Spanish longline and trotline CPUE indices.

A Marine Protected Area in the PEI-EEZ that contains a "no-take" area within 12 nautical miles of Prince Edward and Marion Islands and three limited access areas was promulgated in 2013. The Marine Protected Area is primarily aimed at protection of biodiversity.

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.

Some toothfish were tagged during 2005 as a trial, and a tagging program was initiated in 2006 (Table 3). Vessels are required to tag and release one fish per ton of catch (in line with CCAMLR Conservation Measure 41-01). Fish should be

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	Tagged	Recaptured
2005/2006	94	1
2006/2007	128	1
2007/2008	120	4
2008/2009	140	0
2009/2010	74	7
2010/2011	46	4
2011/2012	136	6
2012/2013	254	10
Total	992	33

selected at random for tagging (say every 100th fish) so that a range of sizes is tagged. Unfortunately fishermen 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. A tag-overlap statistic has been developed by CCAMLR to measure the similarity between the size structures of the tagged fish and of the retained catch, and a requirement for a tag-overlap statistic in excess of 60% was introduced. These regulations have resulted in a marked improvement in the size range of tagged fish. To date 992 fish have been tagged and 33 have been recaptured (Table 3).

Assessment models incorporating tag data have been developed for many of the Antarctic and Patagonian toothfish stocks in the CCAMLR region. Efforts during 2014 will be directed at incorporating the tag data into the existing ASPM model, which may contribute to resolving the conflicting results from the current models.

The change of fishing gear used in the fishery described above compromised the time-series of the abundance index that is used to assess the status of the resource. This index is a General Linear Model (GLM)-standardised CPUE time series derived from autoline and Spanish longline catch and effort data (the two gear types are considered to be equivalent for this analysis). A research strategy was consequently implemented during the 2011/2012 and 2012/2013 fishing seasons with the objective of calibrating the trotline CPUE against that for Spanish longline, to enable the computation of a unified CPUE time- series over the entire period. The strategy involved operators deploying paired sets of both Spanish longline and trotline gear in close spatial (3 nm) and temporal (2 weeks) proximity to each other in order to compare catch rates obtained with the two gear types. The data collected during this exercise enabled the calculation of a calibration factor for the two gear types, which could then be applied to the General Linear Mixed Model (GLMM)-standardised CPUE time series for each gear type to obtain a calibrated overall "longline" CPUE abundance index for the entire duration of the legal fishery (Figure 25).

Efforts are also being directed at continuing work on developing an Operational Management Procedure to enhance effective management of the resource and fishery in a manner that takes proper account of the current uncertainty about resource status. Efforts are also being directed at attempting to improve estimates of depredation by marine mammals, which is currently a major source of uncertainty in the assessment process.

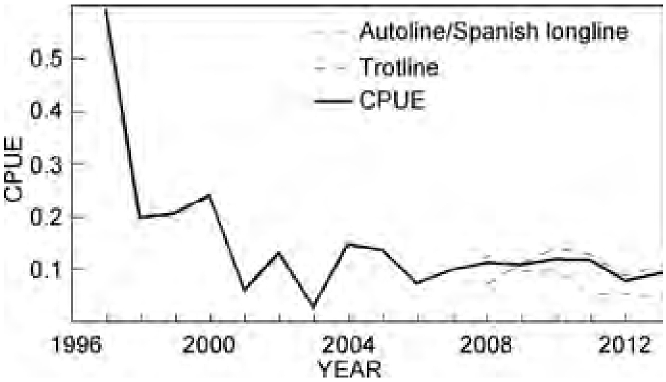


Figure 25: GLMM standardised CPUE trends for the Spanish longline and trot line (calibrated to Spanish longline) gear types, and the "calibrated" longline CPUE time series.

Current status

The assessment model of the Prince Edward Islands toothfish resource was updated during 2013 to take account of further catch, GLMM-standardised CPUE and catch-at-length information that has become available for the years 2007 to 2013. The assessment allowed for three fleets to accommodate data from the pot fishery that operated in 2004 and 2005 and the trotline fishery since 2008, in addition to the Spanish longline operations. The resource is estimated to be at a depletion of about 87% of its average pre-exploitation level in terms of spawning biomass, but this requires large recruitment pulses in the 1990s and does not reflect the large CPUE decline when the fishery commenced. Imposing alternative constraints led to a depletion of about 43%. These different assessments imply rather different sustainable yields, but all suggest that the status of the resource is healthier than has been suggested in previous assessments.

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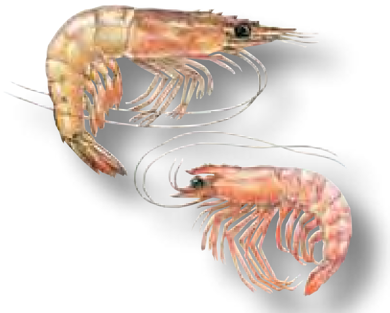
Prawns



Stock status	Unknown	Abundant	Optimal Deep-water prawns	Depleted Shallow-water prawns	Heavily depleted
Fishing pressure	**Unknown**	**Light**	**Optimal** Both	**Heavy**	

Introduction

The KwaZulu-Natal prawn trawl fishery consists of two components: a shallow water (5 to 40 m) fishery on the Thukela Bank and at St Lucia in an area of roughly 500 km^2, and a deep-water fishery (100 to 600 m) between Cape Vidal in the north and Amanzimtoti in the south, covering an area of roughly 1700 km^2 along the edge of the continental shelf. Species captured in the shallow-water trawl fishery 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 1-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*, langoustines *Metanephrops mozambicus* and *Nephropsis stewarti*, 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 via effort-control 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 by-catch and setting Total Allowable Effort (TAE) levels that reflect the high inter-annual variability of the shallow-water resource. Closed shallow-water fishing seasons are used to reduce by-catches 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. Most recently, however, the effort has been low, with only four vessels operating in 2012. Recruitment failure on the Thukela Bank as a result of inadequate river run-off has severely impacted on the shallow-water fishery in recent years.

Research and Monitoring

There is ongoing research on the by-catch of this fishery and the fishery is monitored by observers. The collection of data is, however, patchy and not comprehensive. In the absence of suitable biological data (growth rate, size at sexual maturity) 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. 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 were available. The catch and effort data which were finally used were those provided by skippers on the daily trawl drag sheets, and which spanned the period from 1990 to 2006. Annual estimates of total catch were based on the

Table 4: Total catches of the KZN prawn trawl fishery in the various species groups. All figures are given in tons

	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
2009	8	197	60	21	10	53	268
2010	7	172	51	23	22	69	345
2011	10	150	79	20	23	63	344
2012	8	153	82	22	18	71	354

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 was 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), also resulting in unrealistic estimates of MSY and FMSY. 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.

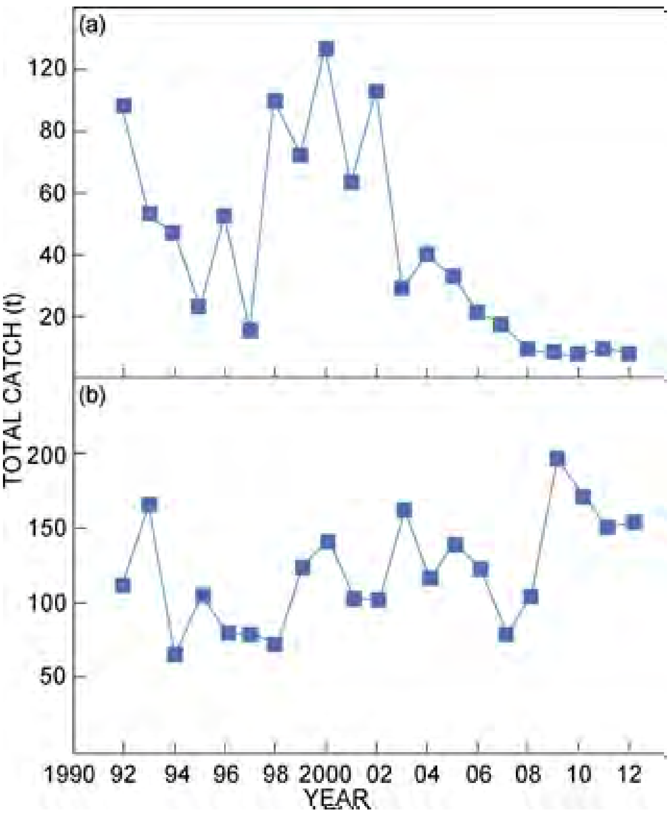


Figure 26: Total annual catches of (a) shallow-water prawns and (b) deep-water prawns in KwaZulu-Natal for the period 1992 to 2012.

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 by-catches. 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 4 vessels were active in the KZN fishery in 2012).

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 was developed for the 1988-2000 period by the then Department of Water Affairs and Forestry. Very low catches in recent years (Figure 26) 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 has therefore been blocked, leading to recruitment failure on the Thukela Bank in the last 10 years. This has severely impacted on the shallow-water fishery and resulted in the catch remaining close to the historic low of 7–10 t since 2008, compared with, for example, a catch of 107 t in 2000 (Figure 26, 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 substratum types are selected to achieve a desired species mix or highest economic value. Landings of deep-water prawns increased from a low level of 79.2 t in 2007 to 153.4 t in 2012, confirming an increasing trend of catches during the past 5 years (Figure 26). Langoustine catches dropped from 59.8 t in 2009 to 51.2 t in 2010, but increased to around 80 t in the last 2 years. Catch of rock lobster remained at the level of about 20 t since 2010. Catches of red crab increased slightly from 19.7 t in 2011 to 21.6 t in 2012, remaining at the low level reached in 2002 (Table 4).

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Seaweeds

Stock status	**Unknown**	**Abundant** Non-kelps	**Optimal** Kelp	**Depleted**	**Heavily depleted**
Fishing pressure	**Unknown**	**Light** Kelp, Non-kelp	**Optimal** Kelp	**Heavy**	

Introduction

The South African seaweed industry is based on the commercial collection of kelps and the red seaweed *Gelidium*, and 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. Beach-cast gracilarioids (agar-producing red seaweeds of the genera *Gracilaria* and *Gracilariopsis*) were collected in Saldanha Bay and St Helena Bay, but there has been no commercial activity there since 2007. *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 at least 300 jobs. Much of the harvest is exported for the extraction of gums. The international seaweed industry is controlled 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 often stockpile material while negotiating prices.

Collection and drying of seaweed is a low-tech activity, while 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 high-value, plant-growth stimulants that are marketed internationally and nationally.

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 has historically been 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 27). 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 Total Allowable Effort (TAE), except for fresh kelp, for which a Maximum Sustainable Yield (MSY) is set in annual permit conditions. It should be noted that, since 2012, the commercial season for permits and reporting of seaweed harvests was changed from a calendar year to 1 April of year 1 to 31 March of year 2.

Figure 27: Map of seaweed rights areas in South Africa

Table 5: Annual yields of commercial seaweeds in South Africa, 2001–2012. '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 from 2003. "Kelpak" refers to the amount of kelp harvested for the production of liquid plant growth extract. Note that from 2012, the commercial season for permits and reporting of seaweed harvests was changed from a calender year to 1 April of year 1 to March of year 2. Prior to 2012, calender years apply

Year	*Gelidium* (kg dry weight)	*Gracilarioids* (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)
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
2010	103 903	0	696 811	5 336 503	205 707	1 264 739
2011	102 240	0	435 768	6 023 935	249 651	1 617 915
2012	108 060	0	871 139	5 226 258	1 396 227	1 788 881
Total	1 350 674	633 089	9 341 096	56 744 726	6 548 916	13 414 808

Kelps

Until the mid-1990s, kelp use in South Africa was restricted to the collection, drying and export of beach-cast kelp 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. Since then yields of <1 000 t dry weight per annum have been more usual (Table 5).

Since the early 1980s, a local company has been producing a liquid extract ("Kelpak" - a liquid plant-growth stimulant) from *Ecklonia maxima* and marketing this nationally and internationally. A second local company is starting to produce 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 2012 a total of 6 622 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.

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 27), where they have been harvested from intertidal areas since the mid 1950s. Yields, which come almost entirely from Area 1, vary with demand but are usually about 120 t dry weight annually. Since 2010 there has been no harvesting from areas 20, 22 and 23 (in the former Transkei) and in 2012 only 1.4 t was collected from Area 21, because of low *Gelidium* prices on international markets.

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 tons dry weight, and the resource is regarded as unreliable. No gracilarioids have been collected commercially since 2008.

Other resources

Other seaweeds have been harvested commercially on occasion, including *Porphyra*, *Ulva*, *Gigartina* species 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, 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 our West Coast in order to improve biomass estimates and to docu-

Table 6: Maximum sustainable yield of harvested kelp for all areas for the 2012 season (1 April 2012—30 March 2013)

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

ment their relative distributions in the event of possible climate changes in the future.

Assessment of the *Gracilarioid* resource is performed on an *ad hoc* basis because only beach-cast seaweed 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* were 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 Eastern Cape coast where harvesting is done, and annual biomass and density measurements at two permanent study sites: one in the centre and one near the southern edge of the most intensively harvested Area 1. 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 were held in 2012. No commercial activity was reported in five of these areas: in two of them Right Holders could not access the resource. Two Right Holders did not activate their rights during 2012.

Yields of dry beach-cast kelp totalled 871 t in 2012 (Table 5). A further 1 396 t wet weight of fresh beach-cast kelp was supplied to abalone farms, together with 5 226 t wet weight harvested directly as abalone feed. These yields have remained fairly 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 5 abalone farms in the Gansbaai – Hermanus area, they are supplied by 4 rights areas (Areas 5, 6, 7 and 8), with a substantial potential MSY between them. The fact that on parts of the coast there is still substantial potentially harvestable biomass ('spare' MSY) bodes well for the expansion of abalone farms in this area.

In some areas harvests (Table 6) were well below MSY. The under-harvest 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 status of the resource in those areas. In Area 9, the production of Kelpak (plant-growth stimulant) used almost 1 789 t of fresh kelp in 2012 (87% of MSY). In all rights areas except 11, the fresh kelp resource can be regarded either as well (but incompletely) exploited, or under-exploited.

Monitoring, visual inspections and reports from Right Holders show that the kelp resource is stable and healthy.

Gelidium

In 2012 substantial quantities of *Gelidium* were collected only 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, at present fetch low prices on Asian markets, and only Area 21 provided some harvest (1.4 t). Catch returns from Area 1 (108 t dry weight) were slightly higher than those for the previous year. Inspections and measurements done in February and May 2013 indicate very healthy *G. pristoides* populations with density and biomass values well within normal limits.

Gracilarioids

Biomass of this unreliable resource varied during 2012, but large wash-ups were observed early in winter. These periodic fluctuations appear to have natural causes and have been recorded before. This resource must at present be regarded as commercially unreliable, despite such occasional wash-ups.

Other seaweed resources

Despite some commercial interest in *Ulva* and *Porphyra* in Area 11, where research has shown there to be a small but viable resource, no further developments have taken place.

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

Ecosystem interactions

In the case of *Gelidium pristoides*, which makes up the bulk of the *Gelidium* harvest, considerable research has shown that harvesting, as currently practised, has negligible ecosystem effects.

Ecosystem effects of kelp harvesting have been dealt with in a few studies, and are the subject of ongoing research. Results indicate that ecosystem effects are slight. Future studies will incorporate possible climate change interactions.

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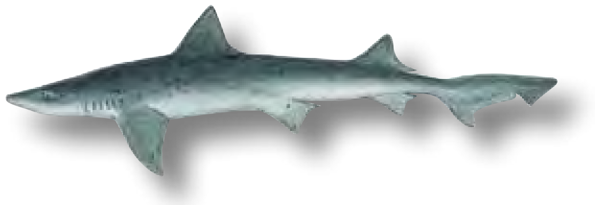
Sharks



Stock status	Unknown	Abundant	Optimal Smoothhound Blue	Depleted Soupfin	Heavily depleted Oceanic whitetip Great hammerhead Longfin Mako
Fishing pressure	Unknown	Light Oceanic whitetip Great hammerhead	Optimal	Heavy Soupfin Smoothhound Blue Mako	

Introduction

There are more than >200 species of sharks, skates, rays or chimaeras identified in South African waters, of which 98 (54%) are caught in 12 fisheries: ten commercial, one recreational and the KwaZulu-Natal bather protection system. Approximately 4 000 t per annum are landed. Target fisheries for sharks include the demersal longline, bather protection (shark net and drumline), commercial and recreational line- and gillnet fisheries.

By-catch fisheries include the inshore and offshore trawl, beach seine, tuna and swordfish pelagic longline (including the shark-directed vessels), mid-water trawl, hake longline and prawn trawl fisheries. Sharks are landed at virtually all Western Cape ports and many other ports along the South African coast. Approximately 98 species, including some generic species groupings, are reported. Only the major fisheries for which data are collected by the Department of Agriculture, Forestry and Fisheries (DAFF), with their reported species, are contained in this report. These include target fisheries: demersal shark longline, and commercial linefish, and by-catch fisheries: inshore and offshore trawl and pelagic longline (tuna and swordfish-directed). Two main groups of sharks are targeted, demersal and pelagic.

Both the demersal shark longline and the commercial line fisheries target smoothhound sharks *Mustelus mustelus* & *M. palumbes*, soupfin shark *Galeorhinus galeus*, bronze whaler shark *Carcharhinus brachyurus*, dusky shark *C. obscurus*, hammerhead species *Sphyrna* spp., cow sharks *Notorynchus cepedianus* and St Joseph *Callorhinchus capensis*.

The bulk of soupfin and smoothhound shark trunks (headed, gutted and finned) are exported to Australia for use in the fillet trade. Due to the increased mercury levels of larger sharks, 2-8 kg is the preferred size range targeted for the fillet trade. Larger sharks are targeted for the value of their fins.

The offshore and inshore trawl fisheries catch similar species to those taken by the commercial linefish and demersal longline fisheries as retained by-catch. However, many other species of sharks, skates, rays and chimaeras are also caught, including dogfish and catsharks. Fins from pelagic sharks are exported to Asia.

History and Management

Initially the shark longline fishery included both demersal and pelagic longline vessels. It was later separated into distinct demersal and pelagic longline fisheries. The demersal fishery targets demersal sharks using bottom-set gear in inshore environments (shallower than 100 m); whilst the pelagic fishery targets pelagic sharks using pelagic drifting gear offshore.

The demersal longline fishery targets primarily smoothhound and 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. Due to poor fishery performance this was reduced, initially to 23 permits in 1998 and then, in 2004, to 11 permits. Since 2008 only 6 permits have been issued. Due to a greater biodiversity on the East Coast of South Africa, together with more limited habitat, demersal shark longline vessels may not fish east of East London. Targeting of bull sharks (*Carcharhinus leucas*) is prohibited.

Due to concerns about high catches of pelagic sharks such as blue sharks (*Prionace glauca*), mako sharks (*Isurus oxyrinchus*), and thresher sharks (*Alopias* spp.) in the historic pelagic longline fishery, this sector was merged with the swordfish and tuna longline sectors in March 2011. Under current management, the by-catch limit for sharks in the “large pelagic” fishery is set at 2 000 t dressed weight. Under the new management regime, shark-directed fisheries are required to switch their effort to swordfish. Should this by-catch limit be attained the large pelagic fishery would have to stop for the year.

The fishery catches offshore oceanic species such as mako sharks, blue sharks, and, to a lesser extent, carcharhinid

Table 7: Dressed weight of sharks reported by the demersal shark longline, commercial linefish and inshore, offshore and midwater trawl fisheries in 2011

Species	Dressed weight (t)				
	Demersal shark longline	Large pelagic longline	Linefish	Trawl	Total
Unidentified sharks	0.0	0.0	66.5	53.4	1 120.0
Unidentified skates and rays	6.7	0.0	0.0	759.7	766.4
St Joseph (*Callorhinchus capensis*)	0.3	0.0	0.0	701.2	701.5
Shortfin mako shark (*Isurus oxyrinchus*)	0.0	644.2	0.2	0.0	644.4
Blue shark (*Prionace glauca*)	0.3	542.6	0.5	0.0	543.4
Soupfin shark (*Galeorhinus galeus*)	56.0	0.4	53.8	59.6	169.8
Smoothhound shark (*Mustelus mustelus*)	102.5	0.0	16.8	50.1	169.4
Requiem sharks (*Carcharhinidae* spp.)	8.9	32.5	27.0	0.0	68.4
Broadnose sevengill cow shark (*Notorynchus cepedianus*)	0.0	0.0	3.9	0.0	4.0
Spotted gully shark* (*Triakis megalopterus*)	0.0	0.0	2.7	0.0	2.7
Hammerhead sharks (*Sphyrna* spp.)	0.0	0.0	2.2	0.0	2.3
Thresher sharks (*Alopias* spp.)	0.0	0.0	0.9	0.0	1.0
Dogfish (*Squalus* spp.)	0.0	0.0	0.0	1.0	1.0

*species morphologically similar to smoothhound sharks and may be retained due to misidentification

sharks. Permit conditions for the large pelagic longline fishery include a prohibition on the use of wire tracers by all vessels except those that were previously part of the pelagic shark longline fishery. No thresher (*Alopias* spp.), hammerhead (*Sphyrna* spp.) oceanic whitetip (*Carcharhinus longimanus*), dusky (*C. obscurus*) or silky sharks (*C. falciformis*) may be retained on board the vessel. When fins are removed from trunks they may not exceed 8% and 13% of the trunk weight for mako sharks and blue sharks respectively, the difference being due to large variations in fin-to-trunk ratios.

The commercial linefishery has the longest history of targeting sharks in South Africa. Shark catches in this fishery have fluctuated dramatically in response to market forces. Since 1991, however, there has been a steady increase in catches, correlated with a decrease in the availability of valuable teleost species. Few catch limitations currently exist for the commercial linefishery, but recreational fishers have a daily bag limit of one shark, skate, ray or chimaera per species, with a maximum total catch of 10 cartilaginous fish.

The trawl fishery, is responsible for significant catches of demersal shark and other cartilaginous fish species (Tables 7 & 8). Cartilaginous fishes landed by inshore trawlers include biscuit skate (*Raja straeleni*), smoothhound sharks, soupfin sharks and St Joseph. Between 1979 and 1991, sharks comprised 0.3% of South Africa's total commercial landings by mass. Annual shark catches for both fisheries in 1990 were estimated at 606 t. Owing to a high level of discarding and non-reporting, the actual number of cartilaginous fishes caught in the trawl fisheries is difficult to quantify. The incentives for trawlers to target sharks and other cartilaginous species have increased with the advent of additional markets and hence an increasing market value of sharks.

Research and Monitoring

Historically there has been little co-ordinated research relating to the biology and stock assessment of commercially valuable sharks. Previous stock assessments conducted on such sharks from South African waters have been hampered by the lack of fishery-independent data, poor data quality and few life-history studies. Furthermore, the limited understanding of the movement and reproduction of these sharks complicates their assessment and limits the formulation of useful management advice.

Since 2008 there has been an increase in research by the Department, with effort directed at collecting fishery-independent data and investigation of life-history parameters necessary to conduct robust assessments. Studies related to movement and reproductive biology have also been conducted in order to determine stock boundaries of commercially valuable shark species and to identify nursery areas.

Current research is directed mainly at collecting fishery-independent data for demersal and pelagic sharks from the *RV Ellen Khuzwayo*. A demersal shark survey was initiated in 2008; due to operational constraints the survey was restricted initially to the area around Robben Island. In 2010 this survey was extended to include the entire area between Mossel Bayon the Southern Cape Coast and Dassen Island on the West Coast. This encompasses the fishing area for five of the six vessels operational in the demersal shark longline fishery. Although initial surveys included Robben Island only, these data will be useful for future assessments.

A shark component was included in the independent survey conducted on the *RV Ellen Khuzwayo* of the large pelagic fishery. Data on catch composition, length, sex and biological attributes are currently being collected. For logistical reasons, no fishery-independent surveys have been under-

Table 8: Dressed weight of sharks reported by the demersal shark longline, commercial linefish and inshore, offshore and midwater trawl fisheries in 2012

	Dressed weight (t)				
Species	Demersal shark longline	Large pelagic longline	Linefish	Trawl	Total
Unidentified sharks	0.0	0.0	29.6	52.6	82.2
Unidentified skates and rays	6.1	0.0	0.0	637.4	643.5
St Joseph (*Callorhinchus capensis*)	0.1	0.0	0.0	745.3	745.4
Shortfin mako shark (*Isurus oxyrinchus*)	2.2	313.6	0.1	0.0	315.9
Blue shark (*Prionace glauca*)	0.0	330.1	0.1	0.0	330.2
Soupfin shark (*Galeorhinus galeus*)	16.7	0.0	56.7	71.8	145.4
Smoothhound shark (*Mustelus mustelus*)	48.5	0.0	31.7	66.8	147.0
Requiem sharks (*Carcharhinidae* spp.)	7.1	17.4	42.0	0.0	66.6
Broadnose sevengill cow shark (*Notorynchus cepedianus*)	1.0	0.0	2.1	0.0	3.1
Spotted gully shark (*Triakis megalopterus*)	0.0	0.0	0.0	0.0	0.0
Hammerhead sharks (*Sphyrna* spp.)	2.9	0.0	1.1	0.0	4.0
Thresher sharks (*Alopias* spp.)	0.0	0.0	1.2	0.0	1.2
Dogfish (*Squalus* spp.)	3.3	0.0	0.0	2.7	6.0
Zambezi (*Carcharhinus leucas*)	0.0	0.0	0.0	0.0	0.0

taken since 2011.

In order to develop appropriate management strategies for shark resources, it is vital to understand their reproductive biology. Life history information on growth, maximum age, fecundity, size and age at maturity, sexual segregation, pupping and mating migrations, and the use of nursery grounds will aid sustainable utilisation of sharks.

Sharks are highly mobile and some species exhibit large-scale movement, including vertical and even transoceanic migrations. Movement of commercially important sharks affects the availability of sharks to fishing areas, the abundance of sharks in less-exploited areas and the effectiveness of Marine Protected Areas as a management tool for sharks. Movement studies are thus currently being undertaken on smoothhound sharks, soupfin sharks, cow sharks, blue sharks and shortfin mako sharks. Results indicate that blue sharks move freely between the Atlantic and Indian Oceans suggesting the existence of a single southern stock as opposed to separate southern Atlantic and southern Indian Ocean stocks. This research has also highlighted the existence of a nursery ground for blue sharks off southern Africa in the Benguela/warm Agulhas Current transition zone. This finding has significant implications for stock assessments conducted by Regional Fisheries Management Organizations (RFMOs). It is possible that similar movements occur in other large pelagic species. South Africa is well placed geographically to study further the movement patterns of large pelagic species with a view to understanding stock separation between the Indian and Atlantic oceans.

Research conducted by the Department on smoothhound sharks in Langebaan Lagoon has shown that these commercially valuable species spend a large proportion of their time within the confines of the Marine Protected Area (MPA). These sharks use the MPA for reproduction, feeding and as a nursery ground. Occasionally they leave the protection of the MPA and then become available to fishing. The existence of eight other MPAs within the distribution of the smooththound shark could provide considerable benefits to the fishery in the form of spillover if nursing areas are included. Research into life-history parameters, movement and stock delineation, as well as the collection of fishery-independent data and eventual stock assessment, is a long-term and ongoing endeavour. Once sufficient data are collected, key species will be reassessed according to their priority listing. The National Plan of Action for Sharks (NPOA) South Africa was released in 2013. This document provides a detailed plan for improving data streams from all fisheries where sharks are targeted and or caught as by-catch in order to conduct future stock assessments.

Current Status

There is a paucity of data on life-history characteristics, movements and migrations, and key habitats for most South

African sharks. This 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 have been difficult because of poor quality data and high levels of under-reporting.

Fishery dependent data is currently being collected for only eight species and a further seven families (Tables 7 & 8). This represents a small proportion of the 98 species of sharks caught by South African fisheries. However, the information is representative of the most commonly caught species and therefore the bulk of the tonnage taken. Certain groups of sharks are difficult to identify and are currently being combined in the data, including *Carcharhinus* spp, dogfish, skates and rays.

National stock assessments have been attempted for the following demersal shark species: soupfin shark, smoothhound shark and spotted gully shark. The results indicate that soupfin sharks are over-exploited whilst smoothhound sharks are marginally over-exploited. Anecdotal evidence from the demersal shark longline industry suggests a shift in targeting from soupfin to smoothhound and requiem sharks due to a perceived decline in the South African population of soupfin sharks. There is literature that suggests that the soupfin fishery, once a dominant fishery in fishing villages in the Western Cape, suffered a serious decline in 1949 and subsequently has not recovered to previous levels. Although spotted gully sharks cannot be legally harvested (i.e. they are legislated as a recreational no-sale species), they are sometimes misidentified as smoothhound sharks and therefore landed in target and bycatch fisheries.

As in the pelagic longline sector, CPUE has decreased since 2010 for shortfin mako-and blue sharks and increased for requiem sharks. Catches of thresher-and hammerhead sharks have decreased as per permit conditions. Spatio-temporal analyses of nominal and standardised CPUE revealed seasonality in catches of blue shark, with CPUE peaking in summer and autumn off the West Coast of South Africa. Standardized CPUE revealed that blue shark abundance has remained relatively stable from 1998 to 2008. This is contradictory to findings reported from observer data from the tuna-directed longline fishery, which suggest a significant reduction in CPUE over a shorter period, from 2001 to 2005. Catch and effort data from previous years have suggested that mako stocks may be over-exploited in South Africa and that effort is being switched from mako to targeting blue shark. Data from 2008 onwards show a constant CPUE. Such fluctuations in catch trends are common in shark fisheries, especially those targeting large species that migrate over long distances.

Shark fisheries are widely accepted as requiring conservative management as they have life-history strategies that make them inherently vulnerable to overexploitation. Stock assessments of pelagic species are the responsibility of Regional Fisheries Management Organisations (RFMOs) such as the Indian Ocean Tuna Commission (IOTC) and the International Commission for the Conservation of Atlantic Tunas (ICCAT). These organizations are currently unable to adequately assess stocks due to poor life history data. However, there is global concern as to the status of these stocks. The IUCN red list status of a number of sharks targeted or caught as bycatch by shark fisheries in South Africa have recently been changed to reflect an increased threat. These include the oceanic whitetip shark (Vulnerable), soupfin sharks (Vulnerable), longfin mako shark (Vulnerable), great hammerhead shark (Endangered – not commonly caught in SA but showing a decline in local waters), and spiny dogfish (Vulnerable).

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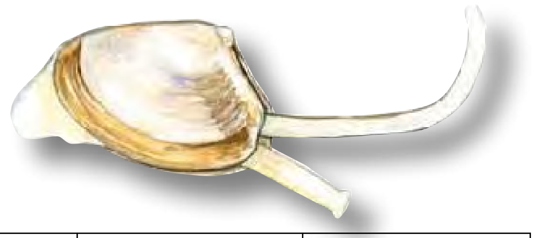
Useful statistics

Dressed weight and normalised Catch Per Unit (CPUE) of pelagic shark species caught by the large pelagic fisheries between 2010 and 2012

	Catch (t)			CPUE (kg 1 000 hooks^{-1})		
	2010	2011	2012	2010	2011	2012
Shortfin mako shark (*Isurus oxyrinchus*)	581.0	644.2	313.6	1.0	1.0	1.0
Blue shark (*Prionace glauca*)	298.2	542.6	330.1	1.0	1.6	1.4
Requim sharks (*Carcharhinus* spp)	24.1	32.5	17.4	1.0	1.2	1.9

Small invertebrates and new fisheries



Stock status	Unknown	Abundant	Optimal	Depleted	Heavily depleted
Fishing pressure	Unknown	Light	Optimal	Heavy	

White mussels

White mussels of the species *Donax serra* are found in the intertidal zone of sandy beaches. They occur from northern Namibia to the Eastern Cape of South Africa. Their abundance is highest along the West Coast on account of the higher plankton production there compared with the rest of the South African coast, associated with upwelling of the Benguela Current.

The fishery for white mussels started in the late 1960s as part of the general commercial bait fishery and was suspended in 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 (Figure 28). Surveys conducted in the 1990s showed that commercial catches amounted to less than 1% of the standing biomass in the relevant areas, and the resource was considered under-exploited.

Prior to 2007, each Right Holder was limited to a monthly maximum catch of 2 000 mussels. However, due to unreliable data from the fishery from under-reporting and difficulties with catch monitoring, catch limits were not considered as an adequate regulatory tool to monitor this fishery. Therefore, as of October 2006, the monthly catch limit was lifted with the aim of removing constraints and thereby improving the quality of catch-and-effort data for use in future resource assessments. Since 2007 the commercial sector has been managed by means of a Total Allowable Effort allocation (TAE) of seven Right Holders (a Right Holder may have up to seven 'pickers') each harvesting within only one of the seven fishing areas along the West Coast.

In the decades preceding the 1990s, commercial catches declined continuously (Figure 29). Recent significant increases in commercial catches since 2006 can be attributed to the lifting of the commercial upper catch limit at that time.

The Interim Relief sector started in 2007. During the 2013/2014 season, 1 995 Interim Relief permits were issued for the Western and Northern Cape combined. This sector is subject to a limit of 50 mussels per person per day. The recreational sector is also limited by a daily bag limit of 50 mussels per person per day. For all sectors, a minimum legal size of 35 mm applies.

In the early 1990s, research on white mussels was confined to a few *ad hoc* area-specific stock assessment surveys which were carried out in response to requests for commercial permits. Fishery-independent surveys, aimed at providing information that can be used to assess the stocks, have been conducted since September 2007 and data are being collected in order to provide insights into the abundance of the white mussel resource on an area-by-area basis.

Research on white mussels, in the form of fishery-indep-

Figure 28: Areas allocated for commercial harvesting of white mussel (*D. serra*) along the West Coast of South Africa

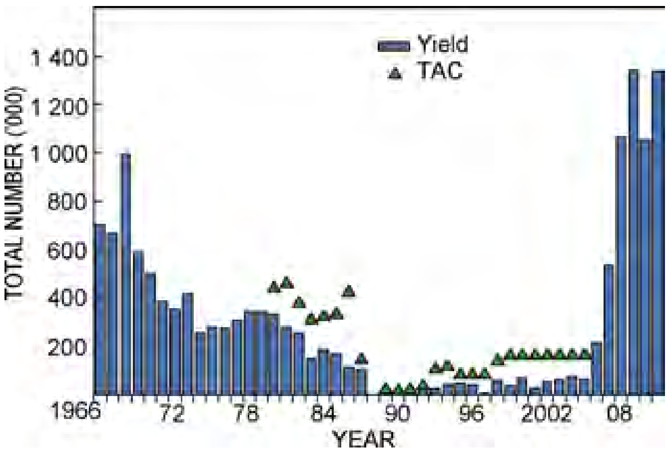


Figure 29: TAC and yield (total number) of white mussels harvested commercially per annum, 1966–2011

endent surveys, has been conducted by the Department since 2003. However, it is still too early for a comprehensive assessment of this resource. In addition to the fishery-independent surveys, commercial catch data are also required in setting the TAE. The lifting of the commercial upper catch limit in 2006 led to a steep increase in the number of white mussels collected by this sector over the last few years (Figure 28). It should be noted that not all the areas allocated are being harvested, and that the largest component of the overall catch of white mussels is by the recreational sector, but these catches are not monitored. There are also information gaps on the level of exploitation by Interim Relief harvesters and the levels of illegal take. On account of irregularities, the catch-and-effort 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. Comprehensive fishery-independent surveys are required in each of the areas and these surveys will take at least 3–5 more years to yield sufficient information for meaningful assessment. Uncertainty therefore remains regarding the current status of the white mussel resource.

Octopus

Octopus are commercially fished in many parts of the world, including Australia, Japan, Mauritania and countries in Europe and South America. Markets for octopus exist in countries where this resource is considered a delicacy, for example Japan, China, Portugal, Spain and Greece. However, there is currently no commercial octopus fishery in South Africa, nor a local market for this product.

The common octopus *Octopus vulgaris* is the most sought-after octopus species. They occur along the entire South African coastline from intertidal rock pools down to depths of over 200 m, and they inhabit various substrata including shell, gravel, sand and reef. Traditionally, octopus have been harvested primarily for subsistence purposes and bait, but there is currently no commercial fishery for octopus in South Africa. A pilot study to investigate the potential for a commercial fishery for octopus paved the way for a five year experimental pot-fishery, which ran from October 2004 until September 2009. Difficulties caused by gear loss and damage from rough seas, vandalism and theft, access to suitable vessels and equipment, and the rigidity of the experimental framework, resulted in this experimental fishery not yielding sufficient information to assess the feasibility of establishing a commercial fishery. Lessons learned during these attempts were, however, used in developing and initiating a further 5-year exploratory fishery, which commended in 2012.

The exploratory fishery for octopus aims to improve performance by participants by introducing greater flexibility as regards the experimental design. Sixteen fishing areas have been designated. The sampling protocol makes provision for participants to set and retrieve an average of 3-5 lines per day, with 50-100 Ivy Blue pots per line, resulting in a potential maximum of 500 pots being set per day. However, with three trigger traps on a cradle and each line carrying 40 cradles, the total number of pots set per fishing day is up to 600 if using the Australian trigger traps.

Previous restrictions on pot type have also been removed, so that participants may use whichever pot design is most appropriate to their own operations. On retrieval of each line, octopus in each pot are recorded separately, and any by-catch is also identified and counted.

Whelks & three-spotted swimming crabs

Whelks are large marine predatory snails, belonging to the Mollusc family Buccinidae. They are generally cold-water species occuring on various bottom types, but prefer muddy or sandy bottoms where they scavenge on dead animals. Three-spotted swimming crabs, *Ovalipes trimaculatus,* are similarly found in sandy habitats where they prey on bivalves and gastropods, including whelks. The two species are captured together in nets, traps or pots.

The distributions of the whelk *Bullia laevissima* and three-spotted swimming crab *Ovalipes trimaculatus* range from Namibia to the Wild Coast. At present there is no commercial fishery for whelks or three-spotted swimming crabs in South Africa. However, whelks are landed as by-catch in crab trawl fisheries in North Carolina in the United States of America. Whelks are harvested in many regions around the world using different traps and various bait types. Traps range from conical pots known as “Korean Pots” to homemade traps made from plastic tubs and buckets. Whelk traps are usually weighted with cement. Other whelk fisheries exist in Nova Scotia, Quebec, Great Britain and the Gulf of Maine. These fisheries process and market whelks into different products including fresh (live), whole cooked, frozen, pickled, smoked and as canned meat. There is a small market for whelk in the United States of America, with the main market in Europe and Asia, particularly Japan and Hong Kong. The Japanese prefer large whelk for use in the high-end sashimi market while smaller specimens are usually used in the lower-end sushi bars. The price for whelk meat is uncertain and often the cost of production is very close to or exceeds revenue generated.

An experimental hoop-net fishery for whelks and three-spotted swimming crabs 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 three-spotted swimming crabs. The experimental fishery ended in 1993 due to processing and marketing challenges, and a severe red tide that depleted populations of these resources.

Although of low value, whelks in particular are still considered to be an excellent candidate for a potential new fishery. In May 2008, an exploratory fishing permit was granted targeting whelks and three-spotted swimming crabs (an unavoidable bycatch), and fishing commenced in 2009. Fishing grounds were between the west of Seal Island in False Bay and Cape Town Harbour, and a maximum of 100 baited hoop-nets were initially used, with longline traps also being used later. Various challenges were faced by this exploratory fishery, and the fishery did not yield sufficient results to draw any conclusions regarding the potential for the establishment of a new fishery. A further attempt was made in 2012 with a hoop-net and longline trap exploratory fishery within the western side of False Bay. A total of just over 2 t was harvested. Only half a ton has so far been exported to markets in the East. Unfortunately, operational challenges again put an end to this exploratory fishery without sufficient data having been collected with which to determine the fishery potential for these species.

Red-bait

The sea-squirt red-bait, *Pyura stolonifera*, is distributed along the entire South African coastline in intertidal rock pools and on shallow subtidal reefs. The thick outer test protects the soft inner flesh, which is bright orange-red in colour. Although marketed for human consumption in the East, in South Africa red- bait is used solely as bait, and is much sought-after as bait for a variety of linefish species. Red-bait occasionally washes up on beaches along the coast after rough winter seas, when it can be easily collected. It also grows prolifically on man-made structures such as jetties and other marine installations. There is currently no commercial fishery for red-bait in South Africa, but exploratory fisheries are underway to investigate the potential for a viable commercial fishery.

An exploratory fishery for red-bait began in Saldanha Bay in June 2009. Initially only washed-out red-bait was collected from the beach for this fishery. However, this proved too intermittent a supply for commercial viability. Live red-bait is now collected from man-made structures in Saldanha Bay during contracted cleaning of yacht jetties. Whole organisms are removed from the structures by divers using hand-held knives and gaffs. The total allocated amount is 7 t, with the harvesting area limited to the yacht jetties within Saldanha Bay. The bait is sold on the local market only, and used as bait for fishing. However, potential new markets in Namibia are also under investigation. At present this fishery provides additional job creation opportunities for qualified divers.

A further exploratory fishery is concerned with the collection of washed-up red-bait on the Cape South Coast. However, yields have been sporadic and quantities small, and this exploratory fishery will require a further period to evaluate the potential for economic viability. The red-bait gathered is sold as bait which creates only a few employment opportunities and modest financial returns.

It is not considered necessary to monitor the red-bait resource as the harvesting thereof is only undertaken from populations growing on man-made structures, or of naturally washed-up red-bait, and there is thus no direct impact on naturally-occurring stocks.

Redeye round herring (KwaZulu-Natal)

Redeye round herring is a small pelagic shoaling fish which occurs from Walvis Bay to Durban. On the West Coast they are caught as by-catch in sardine- and anchovy-directed purse-seine fishing operations. Exploratory fisheries have been established along the coast of KwaZulu-Natal in order to assess the abundance of the resource here, and to investigate the potential for directed fishing on this resource here. One exploratory operation uses purse-seining to target redeye, while two others utilize jig fishing. Shoals of redeye are highly seasonal, and fluctuate according to sea conditions, so that targeting of this resource is difficult. To date, these exploratory fisheries have not yielded sufficient information to be able to assess the abundance of the resource or its potential as a new fishery.

Additional resources which are also currently the subject of new fisheries exploration:

Livebait (tuna pole)
Squids (See Chapter on Squid).
Abalone (See Chapter on Abalone)
Hagfish

Resources which have been investigated as potential new fisheries, but have been found not to be able to support viable fisheries:

Horse mackerel purse-seine
Periwinkles
Limpets (West Coast)
Alikreukels
Sea urchins
Sea cucumbers

Further reading

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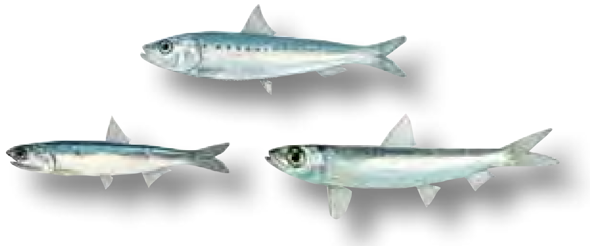
Small pelagic fish (sardine, anchovy and round herring)



Stock status	Unknown	Abundant Anchovy Redeye round herring	Optimal Sardine	Depleted	Heavily depleted
Fishing pressure	Unknown	Light Anchovy Redeye round herring	Optimal Sardine	Heavy	

Introduction

Off the coast of South Africa, small pelagic forage fish consisting predominantly of anchovy *Engraulis encrasicolus*, sardine *Sardinops sagax* and redeye round herring *Etrumeus whiteheadi* generally account for more than 90% of the total pelagic purse-seine catch. Forage fish are usually found in the continental shelf waters between Hondeklip Bay on the West Coast and Durban on the East Coast. They generally exhibit schooling behaviour, have a small body size with rapid growth rates, have short life spans and exhibit strong population responses to environmental variability, which results in large natural fluctuations in abundance over space and time. Long-term changes in the relative abundance of anchovy and sardine, over decadal and centennial time scales, have been observed both locally and worldwide. These species alternations are generally associated with variability in the recruitment of both species, owing to changing environmental factors that affect, amongst others, transport of eggs and larvae and feeding conditions.

Pelagic fish resources are important to the country for several reasons. Firstly, the purse-seine fishery in which they are caught is South Africa's largest fishery (in terms of landed mass) and second only to the hake fishery in terms of value. Secondly, pelagic fish are an important and high-quality source of protein. Anchovy and round herring are mostly reduced to fish meal and oil in industrial-scale factories and used as a protein supplement in agri- or aqua-feeds. Sardine is mainly canned for human and pet consumption, with a small amount packed whole for bait or as cutlets for human consumption. Thirdly, the pelagic fishery employs a large workforce in fishing and related industries. Finally, pelagic fish occupy a key position in the marine food web where they are the link that transfers energy produced by plankton to large-bodied predatory fish, seabirds, and marine mammals. Because many animals and humans depend on forage fish, it is important to manage the fishery that targets them in a manner that accounts for their high degree of variability and importance to the ecosystem. This is so because of the potentially severe risks of local depletion of forage fish for dependent species such as seabirds, particularly in years of low fish abundance in certain areas.

The primary approach that has been used to limit catches of forage fish is rights-based management with a specified annual Total Allowable Catch (TAC). Incorporation of ecosystem considerations and the development of ecosystem-based management is being under taken through the revised Operational Management Procedure (OMP-13) currently being developed. In revising the OMP, additional performance statistics related to several ecosystem objectives under different harvest strategies will be evaluated, over and above those related to resource risk and average catch. Central to the new

OMP will be the consideration of harvest strategies that include spatial management of sardine, given the likely existence of two or more local stocks of this resource. Such spatial management potentially also has the associated benefit of preventing local forage fish depletion and heightened competition between dependant predators and the fishing industry.

In attempting to quantify the effect of fishing on the ecosystem, African penguins (*Spheniscus demersus*) were chosen as a key predator species for consideration because they feed predominantly on anchovy and sardine and because of their conservation status (Endangered) which has been of recent concern. Additionally, penguins are sensitive to changes in pelagic fish abundance and distribution as a consequence of their land-based breeding sites and their limited foraging range during breeding. To this end, a model of penguin dynamics has been developed for use in conjunction with the small pelagic fish OMP to assess the impact on penguin population(s) of alternative harvest strategies. Results so far have indicated that even with large reductions in sardine catches under an alternative OMP there would be little benefit for penguins, but further evaluation of these results under a sardine 2-stock operating model and the possible introduction of spatial management will be undertaken early in 2014. Furthermore,

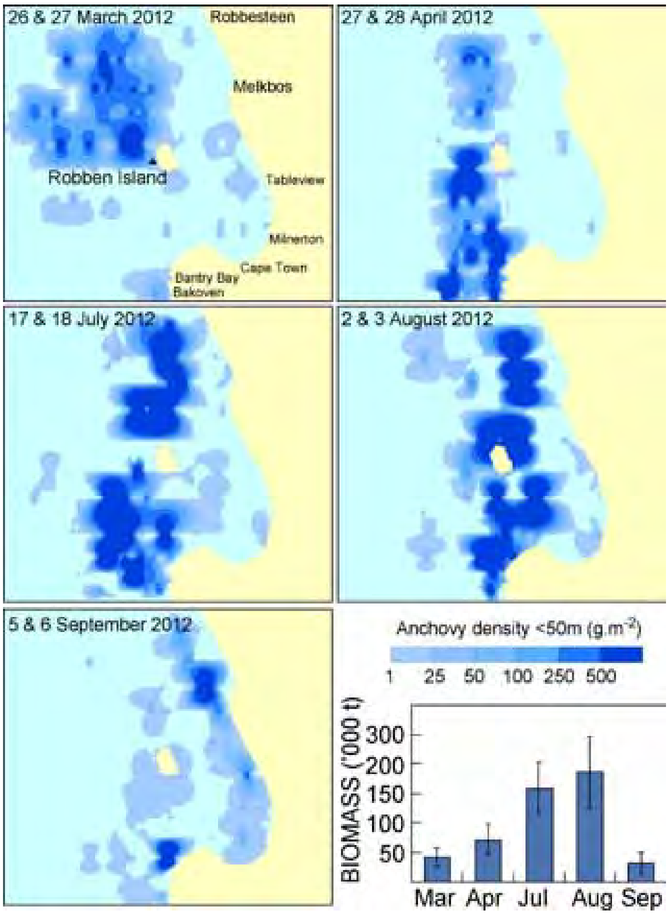


Figure 30: The distribution and relative abundance of anchovy fish in the upper 50 m of the water column, within a 20 km radius of Robben Island during the 2012 African penguin breeding season. Also shown is the combined biomass and coefficient of variation of forage fish within the upper 50 m of the water column for each of the surveys conducted.

the potential benefit to the reproductive success of penguins of closing areas around penguin breeding colonies to purse-seine fishing is under consideration.

History and management

The first pelagic fishing operations began in South Africa in 1935, but commercial operations started in 1943 only in the St Helena Bay area only in response to the increased demand for canned products during the Second World War, with purse-seiners operating between Lambert's Bay and Cape Hangklip. Sardine and horse mackerel (*Trachurus capensis*) dominated pelagic catches in the early years. Annual sardine catches increased rapidly from less than 200 000 t in the 1950s to more than 400 000 t in the early 1960s, whereas annual horse mackerel catches, which had peaked at around 120 000 t by the mid-1950s, decreased to less than 30 000 t annually by the end of the 1960s. As sardine and horse mackerel stocks started collapsing in the mid-1960s, the fishery changed to using smaller-meshed purse-seine nets to target juvenile anchovy, which dominated catches and largely sustained the South African purse-seine fishery for the next 30 years. Anchovy catches peaked at around 600 000 t in the late 1980s then subsequently decreased to a low of 40 000 t in 1996. Catches of sardine gradually increased throughout the 1990s under a conservative management strategy, and sardine catches reached 374 000 t during the early-2000s following rapid population growth, particularly on the Cape South Coast. Anchovy catches also recovered quickly during the early-2000s, resulting in total pelagic landings in excess of 500 000 t between 2001 and 2005. Several successive years of low sardine recruitment since then have resulted in annual sardine catches in the order of 90 000 t over the past five years. Anchovy catches currently dominate the fishery again, with average catches of around 200 000 t over the past five years. Round herring catches have been reported since the mid-1960s but have never exceeded 100 000 t or dominated the pelagic landings, despite several attempts by the pelagic industry to increase catches of this species.

Historically, the fisheries for sardine and anchovy were managed separately in South Africa. Since 1991 the South African anchovy fishery has been regulated using an OMP approach, which is an adaptive management system that is able to respond rapidly, without increasing risk, to major changes in resource abundance. The first joint anchovy-sardine OMP was implemented in 1994, with subsequent revisions. The OMP formulae are 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. These formulae are also conditioned on low probabilities that the abundances of these resources drop below agreed threshold levels below which successful future recruitment might be compromised.

The joint anchovy-sardine OMP is needed because sardine and anchovy school together as juveniles, resulting in the bycatch of juvenile sardine with the mainly juvenile anchovy catch during the first half of the year. This results in a trade-off between catches of anchovy (and hence juvenile sardine) and future catches of adult sardine, and the OMP aims to ensure the sustainable utilization of both resources. TACs for both species and a Total Allowable Bycatch (TAB) for sardine by-catch are set at the beginning of the fishing season, based on results from the adult biomass survey of the previous November. However, because the anchovy fishery is largely a recruit fishery, the TAC of anchovy and the juvenile sardine bycatch allowance is revised mid-year following completion of the recruitment survey in May/June. The relative stability of South African pelagic fish yields since the introduction of the OMP approach has been attributed largely to this effective, conservative and adaptive management method.

Research and monitoring

Ongoing research on a number of issues that have an impact on the sustainable use and management of small pelagic fisheries off the coast of South Africa includes regular monitoring of pelagic fish abundance, development and revision of management procedures, and investigation into, amongst others, population structure, biology and ecology, catch patterns, distribution and behaviour of key species.

The biomass and distribution of anchovy and sardine, but also of other schooling pelagic and meso-pelagic fish species such as round herring, juvenile horse mackerel and lantern- and light fish (*Lampanyctodes hectoris* and *Maurolicus walvisensis*, respectively) are assessed biannually using hydro-acoustic surveys. These surveys, which have been conducted without interruption for the past 30 years, comprise a summer adult biomass survey and a winter recruit survey. Data for the estimation of a number of other key biological measurements needed as input into the OMP and information pertaining to the environment are also collected during these surveys. Given the fluctuating nature of the abundance of pelagic fish species, these surveys continue to provide estimates that are far more reliable than those that would have been obtained through mathematical estimation from commercial catch data only, and have enabled optimal use of these resources at times of high biomass while offering protection to them at low biomass levels.

Following mechanical breakdown of the research vessel the *RV Africana* midway during the November 2012 survey, and the importance of these surveys in ensuring sustainable utilisation of these pelagic resources and their safeguarding at low biomass, a decision was taken to complete the survey on board an industry fishing vessel, the *Compass Challenger*. Subsequently, the May 2013 and November 2013 surveys were also successfully conducted on the same vessel. This has ensured that this valuable time-series has not been compromised and that the pelagic fishing industry has not been disadvantaged by the need for very conservative management measures and hence reduced catch allocations that would have been adopted should no survey have taken place.

Further frequent small-scale acoustic monitoring of pelagic fish abundance using a small semi-rigid inflatable boat in the vicinity of penguin breeding colonies has continued and is providing valuable insight into the effects of localised forage fish abundance on penguin breeding success and the potential role that fishing plays in depleting forage fish abundance in these sensitive areas. These surveys, initiated around Robben Island in 2009 and which have since also been conducted off Dassen, Bird and St Croix islands, are key to finalisation (by the end of 2014) of a feasibility study which aims to investigate whether a longer-term experiment which includes the closure of areas around these islands to purse-seine fishing will in fact be able to quantify the effect of fishing on penguin reproductive success. Results from surveys conducted to date suggest that, once the winter recruitment run has started, fish are available in close proximity to both West Coast colonies throughout the penguin winter breeding season (Figure 30), generally increasing towards a peak in June around Dassen Island and July/August around Robben Island each year before decreasing as the recruits move farther south. Furthermore, results also suggest that the time-series of annual recruitment estimates is a good indicator of forage fish availability throughout the breeding season, with small-scale survey biomass estimates increasing substantially during high recruitment years and decreasing during times of low recruitment strength.

The small boat used for these surveys has recently been replaced with a larger inflatable (Figure 31) that is capable of working in worse weather conditions and with a longer range, which enables more efficient sampling. Additionally, experiments with a custom-made small pelagic trawl for deployment during these surveys and identification of pelagic fish are underway.

Of increasing concern to the pelagic fishing industry and scientists alike has been the large under-catch of the anchovy TAC during recent years. Since 2000 only 53% on average of the TAC allocated for this species has been caught, and in 2013 the percentage of the anchovy TAC landed dropped to an all-time low of 17% with only 80 000 t of the 450 000 t TAC caught, despite above-average recruitment having been measured. The tendency of forage fish to form large shoals as a defence against natural predators should render them easily detectable and catchable by modern fishing technologies. It appears however, as if pelagic right holders are finding it increasingly difficult to successfully catch their annual allocations. Several factors have no doubt contributed to this under-catch, including: reduced processing capacity in the light of increasingly stringent environmental regulations governing factory emissions and effluent discharge; severe winter weather and sea conditions; and disruptions caused by high bycatches of juvenile horse mackerel and sardine at times, along with the industry's resultant attempts to minimize these by temporarily stopping fishing in such areas. In 2013 sev-

Figure 31: The acoustic survey vessel "*Abyss*". Equipped with state-of-the-art navigational instrumentation, acoustic equipment and long-range fuel tanks, this vessel is ideal for inshore survey work such as fish biomass estimation and the mapping of inshore habitats.

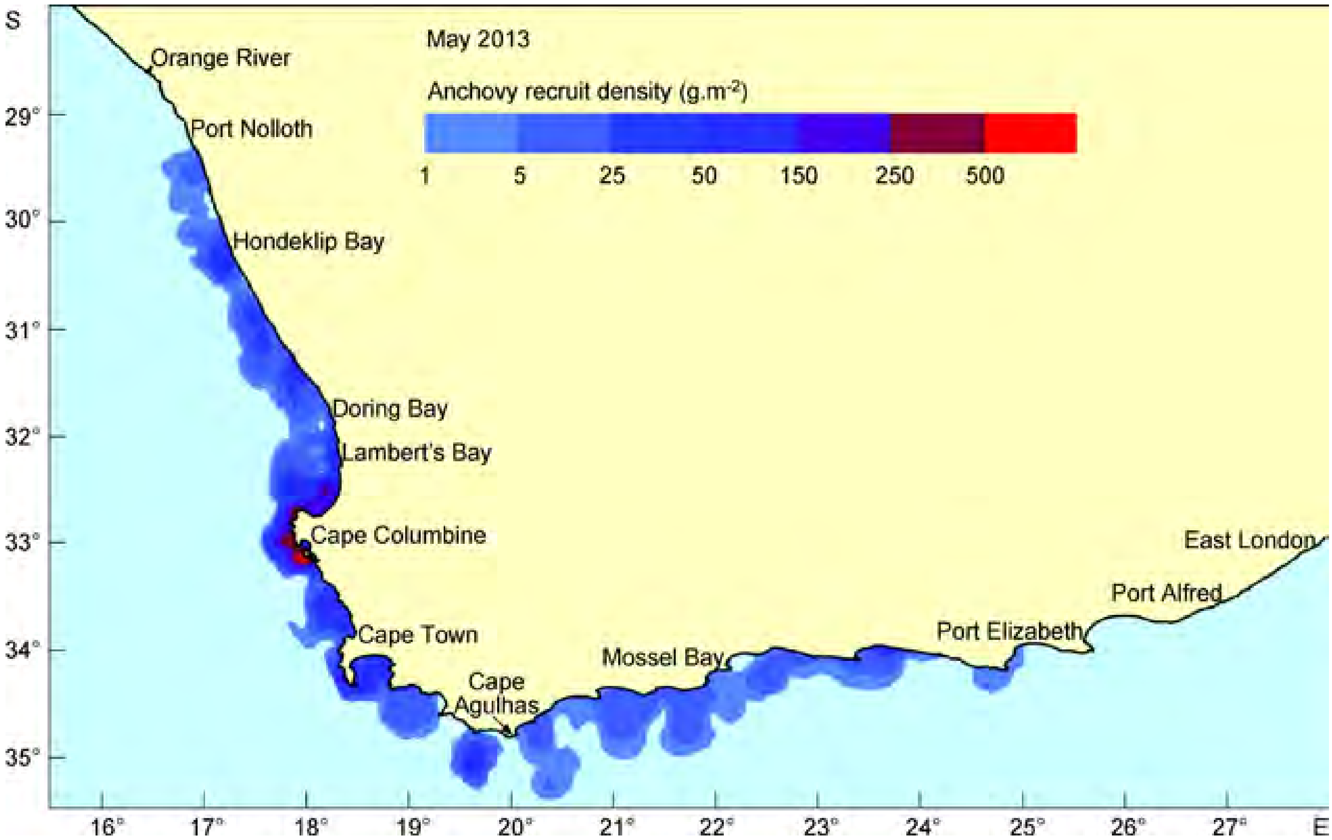


Figure 32: The distribution and relative density of anchovy recruits observed during the May 2013 recruitment survey.

eral other factors were suggested as reasons for the very low catch of anchovy, including: the close proximity of anchovy to the coast in areas too shallow to fish; a decreased size and density of anchovy schools; and their deeper occurrence close to the seabed where they are not accessible to purse-seine gear. A multivariate analysis of data on anchovy schools collected during the 2013 recruitment survey was conducted to test these claims, but this failed to find significant differences in any of these shoaling characteristics compared to two previous years (2005, 2012) in which the anchovy catch was high. Instead, it was shown that the spatial distribution of anchovy recruits, particularly the patchiness of high density areas, may have played a role in affecting the availability of anchovy to the fishery. Despite an almost-continuous distribution of anchovy recruits along most of the coast recorded during the 2013 recruitment survey, a high percentage of the anchovy biomass was observed in a small area in the vicinity of St Helena Bay and Cape Columbine (Figure 32). In fact, analyses of the acoustic density of anchovy shoals revealed that >50% of the biomass in the area between Doring Bay and Cape Point was located within a few very dense aggregations (Figure 33). This patchiness may have impacted the industry's ability to detect shoals sufficiently dense for capture once this high density patch had moved further south, but further work on this and other suggested factors potentially affecting the catchability of anchovy is needed.

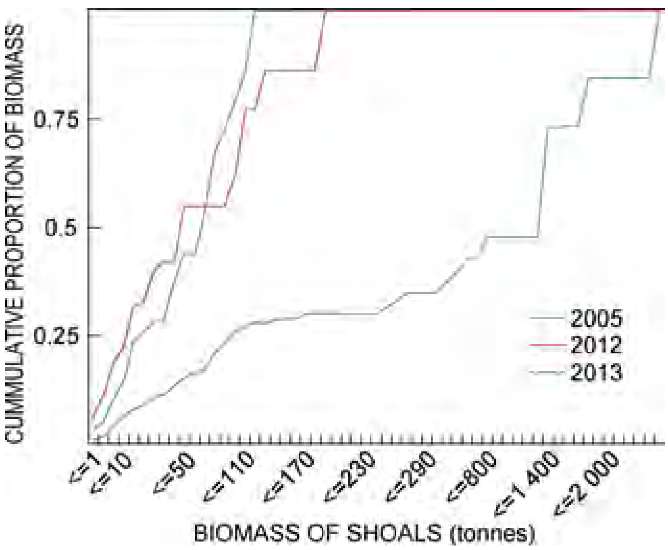


Figure 33: The cumulative contribution to the biomass of anchovy recruits by each shoal, ranked in ascending order. More than 50% of the biomass between Doring Bay and Cape Point was contained in a few dense aggregations in 2013

Data on catch statistics including landed mass, species composition, and catch position and date are obtained from the pelagic fishery. Samples from commercial catches are processed to obtain the length frequency distributions of harvested fish that are required as input in the species-specific population dynamics models, in addition to other data on biological characteristics such as sex and gonad maturity stage, and fish condition.

Round herring (West Coast red eye) is presently considered to be under-utilised, and analyses of the fishery and the collection of biological data for the development of an assessment model for this species have recently been conducted. The bulk

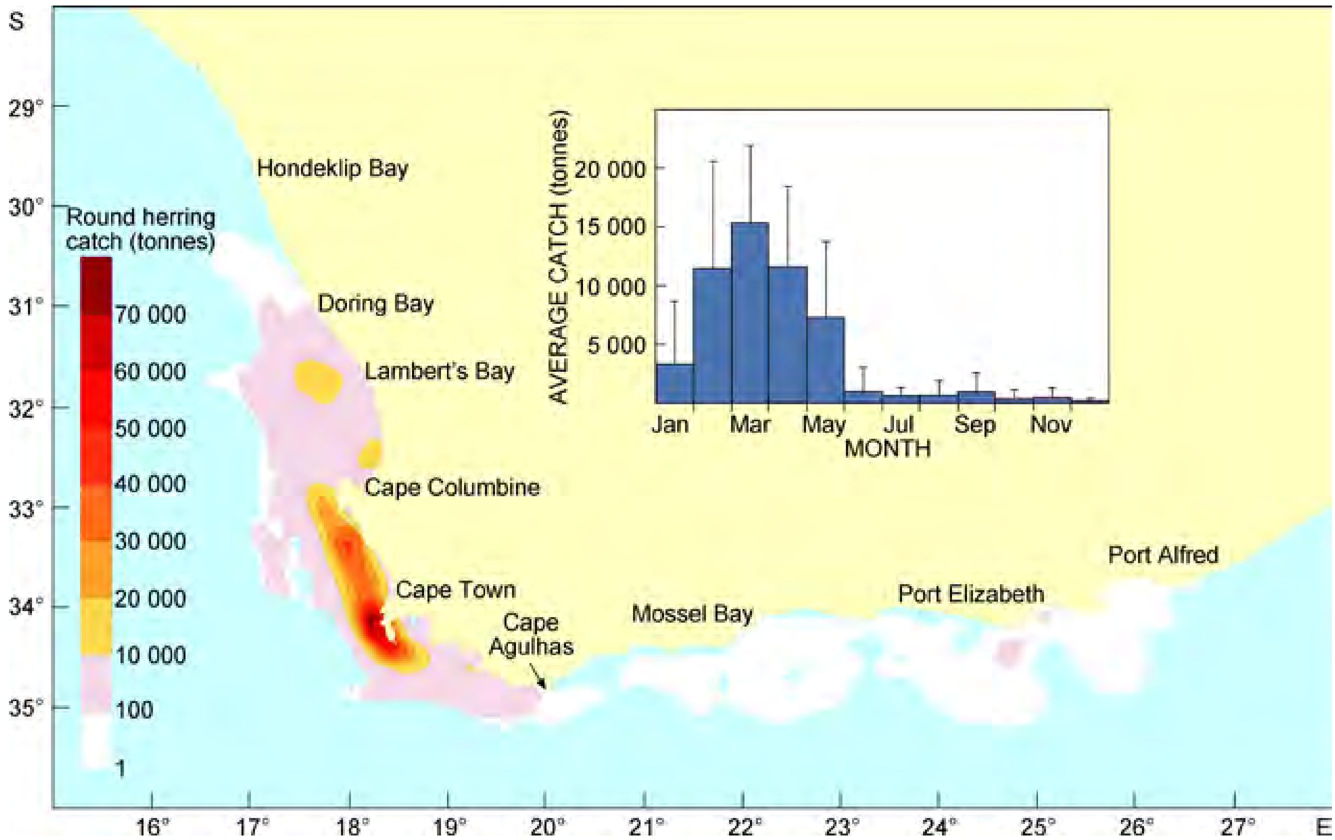


Figure 34: Composite catch distribution and average monthly catch (histogram, with one standard deviation shown), of round herring (directed and bycatch combined) over the period 1987-2012.

(>90%) of round herring caught are adults taken in directed fishing operations, but some juvenile round herring are also taken as by-catch in anchovy-directed fishing and a very small amount of adults are taken as by-catch in sardine-directed fishing. Spatially-explicit catch data collected since 1987 has shown that most round herring are caught off the West Coast between Doring Bay and Cape Agulhas (Figure 34), with virtually no fish taken to the east of Cape Agulhas except for negligible amounts off Port Elizabeth. The area of greatest round herring catch is typically inshore (within 30 nautical miles of the coast) between Cape Columbine and Cape Point, although large catches can also be taken to the north or south of this region in some years. Juvenile round herring taken as bycatch with anchovy are mainly caught in St Helena Bay. Most of the adult round herring catch is taken between January and May, with very little taken during the remainder of the year (Figure 34). Centre of Gravity (CoG – the "average" spatial position of catches) values of round herring catches have been calculated for each year since 1987 and the latitude and longitude of annual CoGs are shown in Figure 35. The data indicate significant southward (i.e. decreasing latitude) and eastward (i.e. increasing longitude) shifts in annual CoGs through the time-series, similar to the southward and eastward shift in sardine catches seen during the early 2000s and the eastward shift in relative adult anchovy biomass observed since 1996. However, this southeast shift in round herring catches appears to have been reversing in recent years. Possible links between changes in catch distributions of round herring and other small pelagic fish, and between these and environmental data, will be investigated.

A major recent focus of research has been a multi-disciplinary investigation into the population structure of sardine, including the use of parasites as biological markers, the comparison of meristic (number of vertebrae and gill-rakers) and morphometric (body shape, otolith shape, gill-raker length and spacing) as well as life-history characteristics between sardine caught on the Cape West and South coasts. This work stems from mounting evidence that the previously reported eastward shift of sardine was in fact brought about by differential growth in the sizes of discrete western and southern sardine stocks. Recently, an International Scientific Review Panel reconfirmed that a two-stock scenario is more plausible than that of a single sardine stock. The implications of

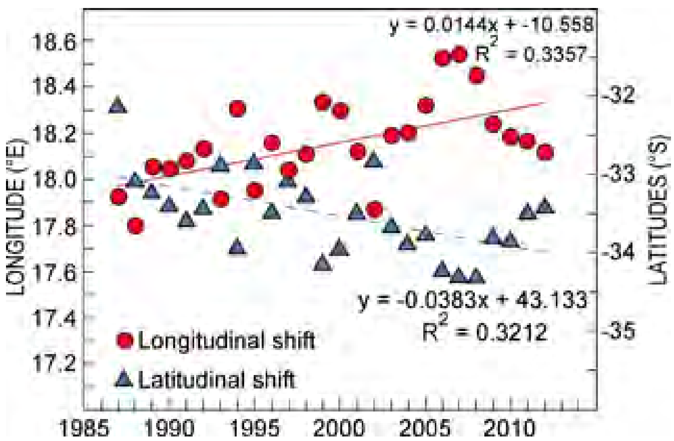


Figure 35: Scatterplots and fitted linear regressions of the longitude and latitude of the Centre of Gravity (CoG) of round herring catches against year for the period 1987-2012.

the sardine resource consisting of two stocks rather than a single stock is being investigated in the development of a new OMP, which may include the introduction of spatial management measures to safeguard the sardine resource, possibly in the form of separate sardine- directed TACs for the areas to the west and east of Cape Agulhas.

Current Status

Annual TACs and landings

The total combined catch of anchovy, sardine and round herring landed by the pelagic fishery in 2012 was 485 000 t, up by more than 60% from 2011 and due mainly to a substantial increase in the catch of anchovy from 120 000 t in 2011 to more than 300 000 t in 2012. The combined catch for 2013 was, however, just over 200 000 t and is well below the long-term average annual catch of 335 000 t. This decrease since 2012 was due mainly to a substantial and unexpected reduction in the catch of anchovy (Figure 36a) from more than 300 000 t in 2012 to less than 80 000 t in 2013. This poor catch of anchovy in 2013 was the lowest since 1997, despite a TAC for this species of 450 000 t.

The sardine-directed catch in 2012 was 98 000 t, the highest since 2007 (Figure 36b). In 2013, the sardine-directed TAC was reduced back to 90 000 t, the minimum allowed under the current OMP and which had also applied between 2008 and 2011. This TAC, although filled, reflected the depleted state of the sardine resource, which had failed to recover from several years of poor recruitment.

Sardine by-catch, at around 12 000 t in 2012 and only 3 500 t in 2013 (Figure 36c), was substantially less than that allowed for – mainly reflecting the low level of sardine recruitment measured in 2012 and the small anchovy catch taken in 2013. This under-catch of the sardine TAB is encouraged because the OMP, whilst making provision for occasional high by-catch levels, assumes that the TAB will be under-caught on average. Furthermore, industry has also put in place measures to avoid areas with high by-catches of sardine so as to improve the chances of a recovery in the size of the adult sardine population.

The 68 000 t catch of round herring in 2012 was the second highest since 2000 and similar to the catch of 65 000 t taken in 2011 (Figure 36d). In 2013, however, the catch of this species was only 32 000 t, possibly reflecting a reduced availability since 2011, when the adult round herring biomass was at least double that measured at the end of 2012.

Following two *ad hoc* increases to the horse mackerel Precautionary Upper Catch Limit (PUCL) in 2011, necessitated by high by-catches of horse mackerel in the anchovy fishery, the process for setting that PUCL was reviewed. Instead of a constant annual PUCL of 5 000 t, a three-year rule, whereby the PUCL over any consecutive three-year period would total to 18 000 t, was introduced in 2013. This has allowed for increased flexibility and increased catches of horse mackerel in years when horse mackerel recruitment is high and incidental by-catch with anchovy is unavoidable. This rule seems to be working well and should assist the anchovy fishery to optimise catches even when horse mackerel availability is high. In 2012, only 2 000 t of the 5 000 t PUCL was landed. This revised rule resulted in a PUCL of over 12 000 t in 2013, of which only 600 t was caught (Figure 36e).

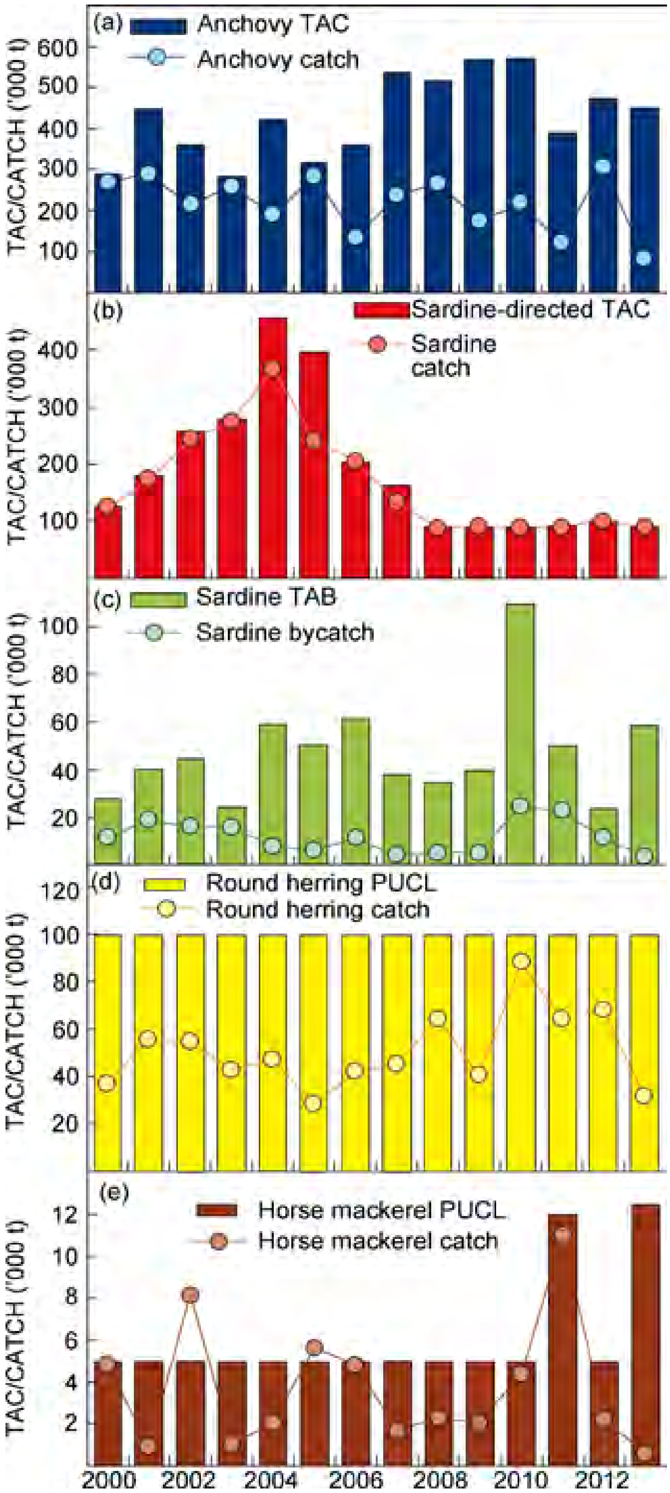


Figure 36: Total Allowable Catches (TACs), Total Allowable Bycatch (TAB) and Precautionary Upper Catch Limits (PUCLs), and subsequent landings for the South African pelagic fishery, for (a) anchovy, (b) sardine-directed, (c) sardine bycatch, (d) round herring and (e) horse mackerel, 2000–2013.

An annual PUCL for mesopelagic fish of 50 000 t was introduced in 2012, following increased catches of lantern- and light fish by the experimental pelagic trawl fishery in 2011, when just over 7 000 t of these species were landed. Since then,

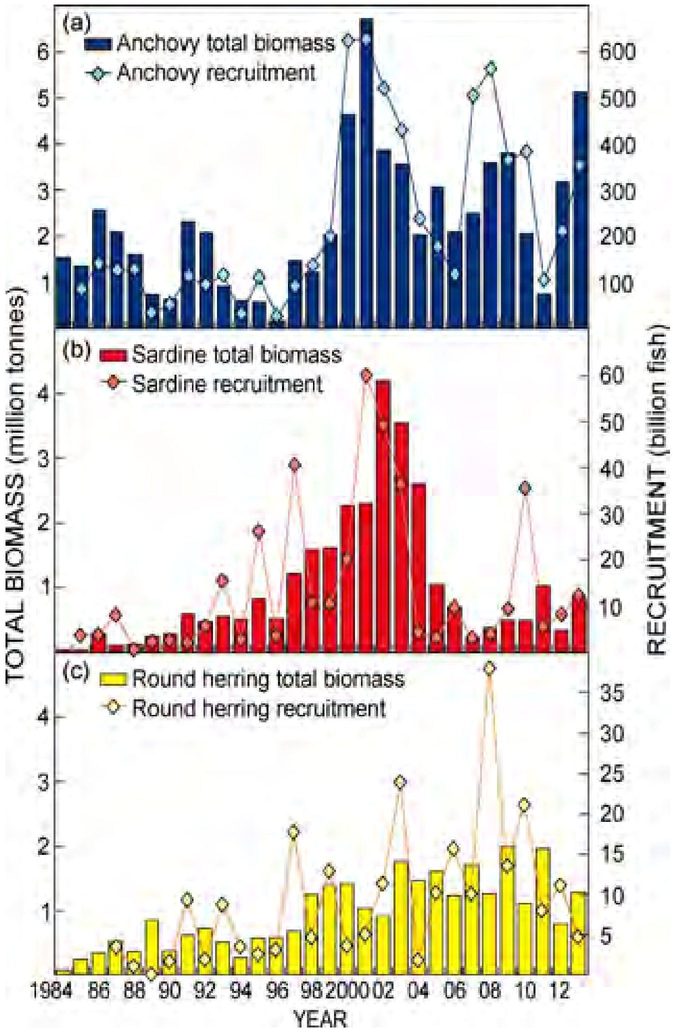


Figure 37: Time-series of acoustically-estimated recruitment strength and total biomass of (a) anchovy, (b) sardine and (c) round herring, 1984-2013.

however, catches have not exceeded 1 000 t. It is anticipated that catches of mesopelagic fish may again increase in 2014 with resumption of this experiment.

Recruitment strength and adult biomass

Anchovy recruitment measured in 2012 was 210 billion fish, almost double that measured in 2011 and very similar to the long-term average of 227 billion fish (Figure 37a). This good recruitment resulted in a sharp increase in the adult anchovy biomass by November 2012 to over 3 million t. An exceptionally high anchovy recruitment of more than 350 billion fish was recorded in 2013 with a resultant increase in the adult biomass to over 5 million t by November 2013. This estimate of adult anchovy biomass is the second highest on record and the highest since 2001.

Recruitment of sardine in 2012 remained low at around 8 billion fish and no increase of the adult sardine biomass by the end of 2012 was observed. In fact, the biomass of adult sardine had decreased from just over 1 million t in 2011 to less than 350 000 t by 2012, the lowest level since 2007 (Figure 37b). The estimate of sardine recruitment in 2013 was slightly more encouraging, and at just over 12 billion fish was higher than that measured in the previous two years and closer to the long-term average of 13 billion fish. Apart from 2010, this recruit estimate was also the highest measured since 2003. The adult sardine biomass responded positively to this slightly improved recruitment and increased substantially from the low level in 2012 to over 850 000 t by the end of the year. This estimate is, however, still well below the long-term (1984-2012) average of 999 000 t for this population.

Despite slightly improved recruitment of round herring in 2012 compared to 2011, the adult biomass of this species declined sharply from close to 2 million t in 2011 to around 800 000 t in 2012 (Figure 37c). Another year of low recruitment was observed in 2013, the lowest since 2004. The adult biomass, however, recovered slightly from that measured in 2012 to around 1.2 million t by the end of 2013.

Shifts in the distribution both of anchovy and sardine adults that have previously been reported on (see Status of the South African Marine Fishery Resources Report of 2012) continue to be monitored. The abrupt eastward shift of anchovy that occurred in 1996 still persists and seems to have intensified in recent years, with only 30% of the adult anchovy biomass observed in the area to the west of Cape Agulhas in November 2013 (Figure 38a). Despite this low percentage, the biomass in this western area remains high at over 1.5 million t, a level at which future recruitment should not be compromised.

Around 77% (> 600 000 t) of the sardine biomass was found in the area to the west of Cape Agulhas in 2013 (Figure 38b). This is the highest proportion of the total sardine biomass observed in the western area since 1997. This suggests that the recently observed periodic “reversal” of the so-called eastward

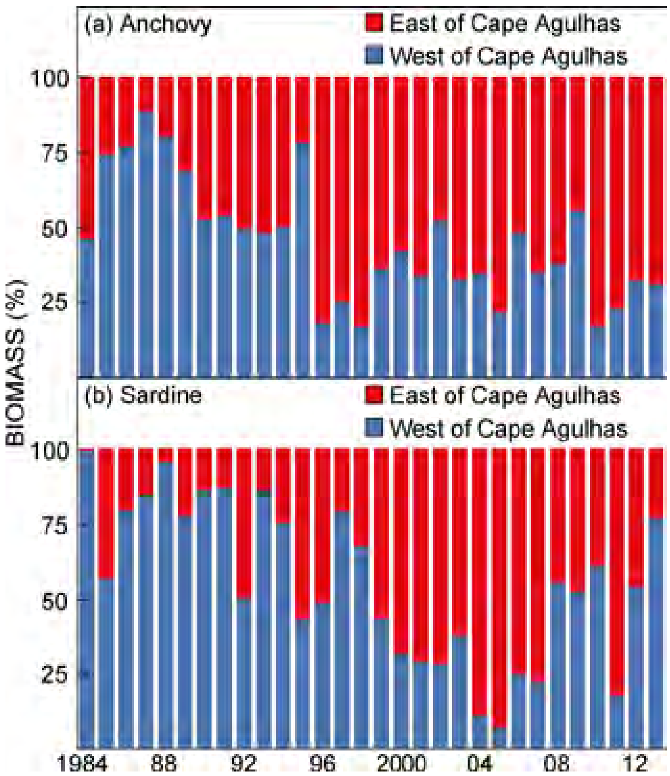


Figure 38: Percentage of the adult (a) anchovy and (b) sardine biomass found to the west and east of Cape Agulhas, 2000-2013.

shift in the distribution of sardine persists in certain years and is likely unrelated to long-term environmental change. Alternatively, this pattern could reflect likely different dynamics between the putative western and southern sardine stocks, should these exist. This increase in the biomass of sardine to the west of Cape Agulhas may also lead to improved recruitment, given enhanced transport of eggs and larvae to the West Coast nursery area from there.

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South Coast rock lobster

Stock status	Unknown	Abundant	Optimal	Depleted	Heavily depleted
Fishing pressure	Unknown	Light	Optimal	Heavy	

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 specialized equipment and large ocean-going vessels.

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 markets and the decline of the Rand to Dollar exchange rate make the sector lucrative. Prices for commodities fluctuate and the sales prices in the USA are currently the equivalent of R440-R600 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 individuals, nearly all previously disadvantaged individuals. In addition to sea-going personnel, the sector employs approximately 100 land-based factory (processing) and administrative personnel, mostly previously disadvantaged people. The total export value in 2011/2012 was approximately R160 million.

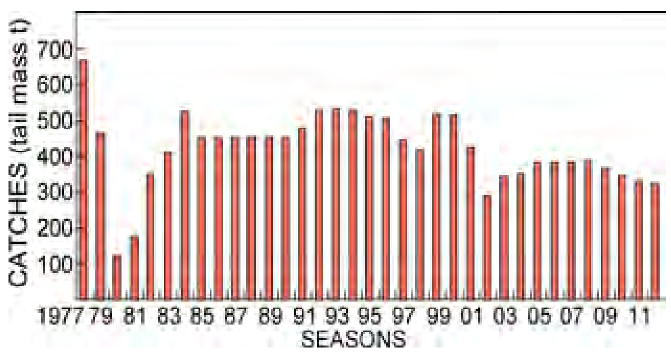

Figure 39: Annual catches of South Coast rock lobster from 1977-2011.

History and Management

The South Coast rock lobster was first described in 1900 and was recorded occasionally in trawler catches for sole at a depth of about 70 m. The commercial fishery 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 South Coast rock lobster was recognized as a species 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. The fishery was regulated initially by limiting the number of traps permitted per vessel. Catches and catch rates declined significantly between 1977 and 1979 (Figure 39). The introduction of management measures such as reduction of effort and catches during the early 1980s resulted in resource recovery (Figures 39 & 40). An annual Total Allowable Catch (TAC) was introduced in 1984, based on the performance of the fishery in the previous years. The TAC and limited entry stabilized the sector until the 1993/94 season (Figure 39), and a more rigorous procedure for stock assessment was developed in 1994.

The fishing season for South Coast rock lobster is year-

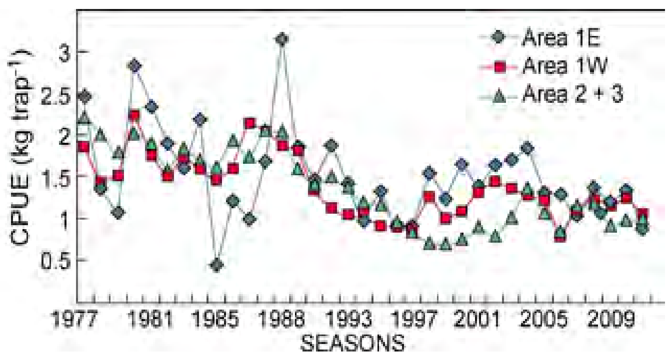

Figure 40: South Coast rock lobster CPUE by area.

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

Season	TAC (Tons tail mass)	TAE (allocated seadays)	Standardised CPUE (kg trap^{-1})		
			Area 1E	Area 1W	Area 2 & 3
1977/1978			2.43461	1.830596	2.209819
1978/1979			1.343891	1.423537	1.984076
1979/1980			1.058453	1.511065	1.74513
1980/1981			2.803713	2.196475	2.000458
1981/1982			2.326619	1.72981	1.880897
1982/1983			1.877846	1.497355	1.561131
1983/1984			1.584522	1.711344	1.806019
1984/1985	450		2.160244	1.581641	1.677658
1985/1986	450		0.429814	1.415739	1.594602
1986/1987	450		1.188891	1.584688	1.915427
1987/1988	452		0.969778	2.132922	1.719243
1988/1989	452		1.679732	2.0257	2.027488
1989/1990	452		3.139269	1.845362	2.024472
1990/1991	477		1.830287	1.80543	1.574334
1991/1992	477		1.411262	1.317082	1.390148
1992/1993	477		1.865395	1.115079	1.501401
1993/1994	477		1.396891	1.017449	1.357582
1994/1995	452		0.952926	1.072289	1.155796
1995/1996	427		1.317593	0.884394	1.147112
1996/1997	415		0.945638	0.878578	0.934557
1997/1998	402		0.854528	0.870347	0.841463
1998/1999	402		1.515569	1.238054	0.681564
1999/2000	377		1.21861	0.981219	0.674625
2000/2001	365	2 339	1.622069	1.058044	0.734638
2001/2002	340	1 922	1.361775	1.279738	0.875085
2002/2003	340	2 146	1.626267	1.416818	0.784133
2003/2004	350	2 038	1.673402	1.329891	0.992331
2004/2005	382	2 089	1.820171	1.266285	1.362022
2005/2006	382	2 089	1.315549	1.190208	1.044668
2006/2007	382	2 089	1.265963	0.770813	0.826614
2007/2008	382	2 089	1.040644	1.07557	1.122395
2008/2009	363	2 675	1.345814	1.190109	1.163164
2009/2010	345	2 882	1.164132	1.147909	0.86426
2010/2011	328	2 550	1.294187	1.216505	0.951682
2011/2012	323	2 443	0.885952	1.030985	0.954992

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, whichever 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 the Department of Agriculture, Forestry and Fisheries (DAFF) with accurate daily catch rate statistics.

The scientific recommendations for catch limits are based on an Operational Management Procedure (OMP) which was introduced in 2008 and modified ("retuned") in 2010. A full review of the OMP was planned for 2013 but this was postponed until 2014 due to time constraints. However, as a core component of this review process, the assessment model for South Coast rock lobster was updated in 2013 and incorporated a number of recommendations made at the International Stock Assessment Workshop held in 2012. The major change between the previous and current assessments is in the geographical split in the available resource information.

The objective of the OMP is to increase the spawning biomass of the resource by 20% over the 20 year period from 2006 until 2026, while restricting the inter-annual TAC fluctuations to a maximum of 5%.

Research and Monitoring

The stock assessment model used for South Coast rock lobster (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 South Coast 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 Catch Per Unit Effort (CPUE) data are captured from landing slips. These provide input data (CPUE, Landings) for TAC and TAE management.

New research planned for this resource aims to use baited 'video fishing' techniques to offer a standardised, non-extractive methodology 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 by-catch species have on catch rates, the fate of bait and other by-catch and discards, and to help measure metabolic rates, swimming speed and foraging behavior of South Coast rock 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 South Coast rock lobsters and to investigate the feasibility of introducing of a fisheries independent survey for this resource.

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

Current Status

In 1977–1980, fishing effort was above sustainable levels, and catches declined rapidly to 122 tons tail mass (Figure 39). 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 1990/91. The latter increase was justified by the inclusion of a previously unfished area off the former Ciskei coast after 1990. The TAC remained stable at 477 t up to the 1993/94 fishing season (Table 9).

Resource assessments introduced in 1993-1994 indicated that an annual catch of 477 t could not be sustained. Consequently, a program 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 41% of pristine and spawner biomass is around 35.7% of pristine. The TAC declined from 382 t in 2007-2008 to 323 t in 2011-2012 (Figure 39). The decrease was caused by the slight net downward trend in CPUE over the past five years (Figure 40) when a weighted average was taken over the three areas.

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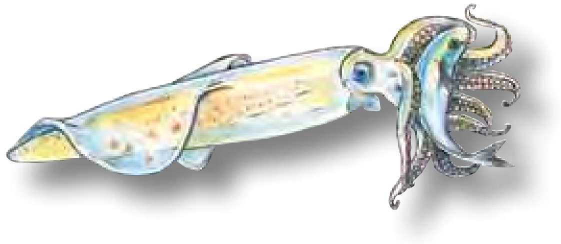
Squid



Stock status	Unknown	Abundant	Optimal	Depleted	Heavily depleted
Fishing pressure	Unknown	Light	Optimal	Heavy	

Introduction

Squid *Loligo reynaudi*, locally known as 'chokka', is an ubiquitous loligonid squid that occurs around the coast from Namibia to the Wild Coast off the Eastern Cape. They are fast-growing, reaching reproductive size in approximately one year or less and their total life-span is less than two years. Males can reach a maximum mantle length of 48 cm and females 28 cm during this time. Chokka spawning occurs all year round, with a peak in summer, and its distribution is governed largely by environmental conditions. Spawning occurs on the seabed, mostly in inshore areas of less than 40 m depth, and occasionally in deeper waters. Their chief prey items are fish and crustaceans, but they also sometimes feed on other cephalopods, and cannibalism is fairly frequent. The abundance of squid fluctuates widely, mainly due to biological factors such as spawning distribution and survival rates of hatchlings and juveniles, and environmental factors such as temperature, currents, turbidity and macro-scale events such as *El Niños*. Fishing pressure appears to play an increasing role in these fluctuations in abundance.

Chokka are mostly frozen at sea in small blocks. They are landed mainly between Plettenberg Bay and Port Alfred and exported whole to European countries, most notably Italy. Squid are also used as bait by linefishers. The squid fishery is fairly stable and provides employment for approximately 3 000 people locally. The fishery is believed to generate in excess of R480 million in a good year. Apart from the directed fishery, squid are also taken as by-catch in the demersal trawl fishery that operates between Cape Town and Mossel Bay.

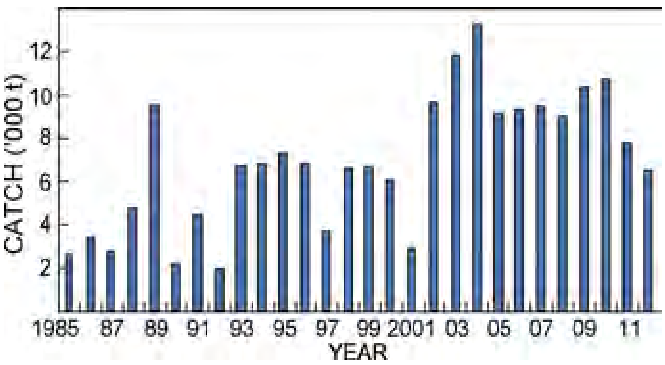


Figure 41: Annual catches of jig-caught squid off South Africa, 1985–2012. Data are from the South African Bureau of Standards (SABS) provided by Industry for the period 1985–2007, and the National Regulator for Compulsory Standards (NRCS) for the period 2008–2012.

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 have continued to be taken by South African trawlers. Over the last decade, the squid by-catch in the demersal trawl fishery has fluctuated between 200 and 800 t annually.

A commercial jigging fishery for squid began in earnest 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 13 000 t (Figure 41). Catches in the 1990s ranged between 2 000 and 7 000 t, and in the 2000s between 3 000 and 13 000 t. Between 1986 and 1988 a licensing system was introduced with a view to limiting the number of boats participating in the fishery. The fishery is effort-controlled and current fishing effort is capped at a maximum of 2 422 crew or 136 vessels, whichever occurs first. In addition, a 5-week closed season (October-November each year) has been implemented since 1988, with the intention of protecting spawning squid and improving recruitment the following year. Provision is also made for the Minister to impose additional closed seasons if assessments suggest that such closures are warranted.

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

Research and Monitoring

Biomass estimates (as well as accompanying size structure and biological information) are determined from data collected on demersal swept-area research surveys. The spring biomass estimates (Figure 42) show a relatively flat trend from surveys utilizing the old gear, and an increasing trend in more recent years from surveys using new gear. Both old and new gear estimates for the autumn survey show an increasing trend. It is of concern that, for various reasons, no spring surveys have been conducted since 2008 and therefore data for updating the biomass assessment model are lacking (the spring surveys provide information related to the spawning stock since they take place just before the peak spawning season).

Catch-and-effort data are collected on a regular basis from the commercial jig fishery and additional landings data are available from the National Regulator for Compulsory Specifications (NRCS). The NRCS catch data indicate an increase in squid catches over the period 2001 to 2004, followed by catches stabilizing at approximately 9 000 t between 2005 and 2008, and then increasing again to just over 10 000 t in 2009 and 2010 (Figure 41). Since 2010 catches have declined in both the jig and trawl fisheries. This may be an availability issue, to some extent, possibly related to unexplained anomalous environmental events, given that other species on the Cape South Coast have been similarly affected. It may, however, also in part be as a result of the target effort level in the jig fishery being exceeded in recent years (Figure 43).

In the past, squid data were recorded along with catches of linefish, and stored in the National Marine Linefish System. In 2006, a new logbook was introduced specifically for the squid fishery, allowing for the recording of more detailed catch-and-effort information, and the data are now stored in a dedicated database. This new reporting system has indicated that the previous data were not as reliable as had originally been assumed. Efforts to improve the quality of the data used for assessment of the resource, and to develop reliable indices for input to future assessment models, are ongoing.

Chokka squid is one of the best researched squid species in the world and aspects of its early life history and adult ecology are relatively well known. Current research is focused on the distribution and survival of paralarvae, genetics of adults (stock identity), environmental influences on stocks, the importance of the deep spawning grounds on the South Coast, acoustic mapping of inshore spawning grounds, and investigating the potential damage of anchors on squid egg beds. It is envisaged that results from these studies will assist in enhancing the management of this resource.

In 2013, a new exploratory fishery for a number of other squid species was initiated. These include three ommastrephid species (*Todarodes angolensis*, *Todaropsis eblanae* and *Ommastrephes bartramii*), one loligonid squid (*Uroteuthis duvauceli*) and one thysanoteuthid (*Thysanoteuthis rhombus*).

Current Status

A biomass-based stock assessment model is applied to assess the status of the squid resource, and results from the assessment model are expressed in terms of the number of person-days permitted in the fishery. Previously the translation of the number of person-days into number of fishers (a more practical application for implementation and control purposes) was hindered by uncertainty regarding the reliability of the available catch-and-effort data. In recent years the reliability of these data has improved, making it possible now to allow for a conversion from person-days to number of fishers.

The squid assessment model was revised during 2013, based upon recommendations made by a panel of experts at the annual International Stock Assessment Workshop held in November 2012. Updated results from the revised model indicate that the squid resource is less productive than previously thought, that recruitment is estimated to be below average for 2010 and 2011 and that biomass is declining. Future projections of biomass indicate that, in order to continue utilizing the resource without undue risk, effort should be reduced somewhat for the coming seasons.

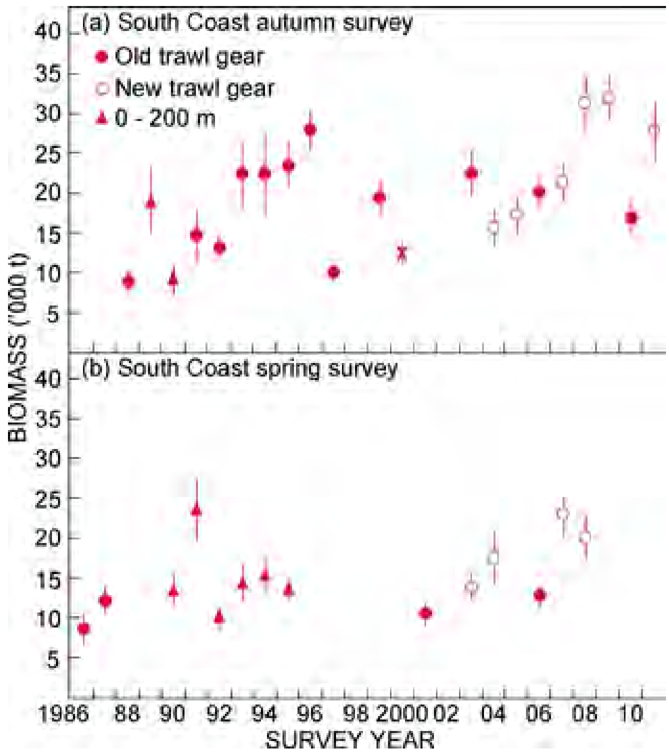


Figure 42: Survey abundance indices with 95% confidence intervals from the spring and autumn demersal trawl research surveys. Note that the trawl gear was changed in May 2003 and the time-series using the old trawl gear (closed circles) is not directly comparable with the time-series using the new gear (open circles). Triangles represent old gear survey estimates restricted to depths less than 200 m and the x in the autumn survey panel represents a biomass estimate obtained from a survey by the *RV Fridjhof Nansen*.

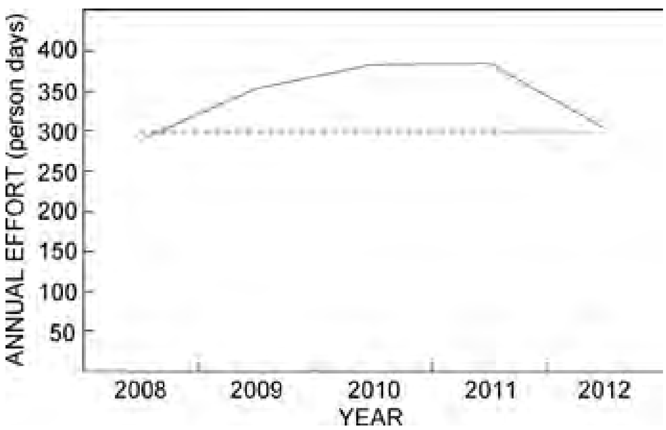


Figure 43: Annual effort (person-days) exerted in the jig fishery over recent years. The horizontal line represents the target effort level.

Useful statistics

Total squid catches from the jig fishery and as bycatch from the demersal trawl fishery, as well as squid TAE over the last ten years (2003–2012)

Year	Squid jig catches (t)	Squid landings as bycatch from hake trawls (t)	Squid TAE
2003	11 820	338	2 423 unrestricted crew* 41 restricted crew*
2004	13 261	391	2 423 unrestricted crew* 41 restircted crew*
2005	9 147	374	2 423 unrestricted crew* 22 resricted crew*
2006	9 291	358	2 423 crew or 138 vessels, whichever occurred first
2007	9 438	496	2 422 crew or 136 vessels, whichever occurred first
2008	9 021	523	2 422 crew or 136 vessels, whichever occurred first
2009	10 341	759	2 422 crew or 136 vessels, whichever occurred first
2010	10 777	561	2 422 crew or 136 vessels, whichever occurred first
2011	7 796	460	2 422 crew or 136 vessels, whichever occurred first
2012	6 458	227	2 422 crew or 136 vessels, whichever occurred first

***N.B.** Unrestricted permits applied to rights holders who were not restricted to fishing in any particular area, whereas restricted permits applied to rights holders who were only allowed to fish off the Ciskei. Restricted permits were eventually phased out of the fishery from 2006

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Tunas and swordfish

Stock status	Unknown	Abundant Yellowfin (Ind.)	Optimal Albacore (Ind. and Atl.) Bigeye (Ind. and Atl.) Swordfish (Ind.)	Depleted Yellowfin (Atl.)	Heavily depleted Southern bluefin (Ind. and Atl.)
Fishing pressure	**Unknown**	**Light**	**Optimal** Albacore (Atl.) Bigeye (Atl.) Swordfish (Ind. and Atl.)	**Heavy** Albacore (Ind.) Yellowfin (Ind. and Atl.) Bigeye (Ind.) Southern bluefin (Ind. and Atl.)	

Introduction

South Africa has two commercial fishing sectors which target tuna and tuna-like species in the Atlantic and Indian Oceans. These sectors are the pelagic longline and tuna pole-line fisheries. The inclusion of rod and reel into the tuna pole commercial fishery will be effective from 2014 onwards (and will then be called the tuna pole-line fishery). Additionally, there is a boat-based recreational fishery that undertakes game fishing.

Tuna species, including temperate albacore *Thunnus alalunga* and southern bluefin *T. maccoyii*, tropical yellowfin *T. albacares* and bigeye *T. obesus*, and billfish such as swordfish *Xiphias gladius* are highly migratory species. They are distributed throughout the Atlantic and Indian Oceans, except for southern bluefin tuna, which is confined to the Southern Hemisphere. Southern bluefin tuna is the largest of the tuna species and can reach a length of up to 2 m and a weight of 200 kg. Bigeye tuna, yellowfin tuna and swordfish are the main targeted species in the longline sector. Albacore tuna, blue sharks (*Prionace glauca*) and shortfin mako sharks (*Isurus oxyrinchus*) are the main bycatch species in the longline sector. Juvenile and sub-adult albacore and, to a growing degree, yellowfin tuna, are the main targets in the tuna pole-line fishery. Species that aren't commonly caught in either sector are the billfish species. With South Africa having such a low quota for southern bluefin tuna, this species is generally not targeted by longline vessels.

Tuna and billfish species will migrate to tropical and subtropical waters to spawn when environmental conditions are favourable. Juvenile bigeye, yellowfin and skipjack (*Katsuwonus pelamis*) tunas are often found together, with fewer occurrences of mixed schools of the temperate albacore. Pop-up satellite tagging studies have revealed that, for many of the large pelagic species, there is a daily vertical movement pattern with the fish, inhabiting the surface waters at night and diving deep during the day. It is thought that they display this swimming pattern for thermoregulation and feeding. Tuna and billfish are opportunistic feeders with high metabolic rates, feeding on a variety of fish, molluscs, and crustaceans.

A single stock for the entire Atlantic Ocean is assumed for yellowfin tuna and bigeye tuna. For albacore and swordfish, two different stocks are recognized in the Atlantic, a North and South stock, separated at 5˚N. The Indian Ocean is considered to have one stock of yellowfin, bigeye and albacore tunas. Swordfish have been separated into two different stocks in the Indian Ocean; Indian Ocean and South-West Indian Ocean. There is a management boundary that separates the Indian and Atlantic Oceans at 20˚E, though there is concern over its biological validity and the extent to which tuna and billfish cross this boundary

History and management

Pelagic longline

Although domestic commercial longlining for tuna has been documented from the early 1960s, with catches reaching approximately 2 000 t, the fishery declined rapidly in the mid-1960s as a result of a poor market for the low-quality blue-

fin and albacore tuna landed by the South African fishery. Foreign vessels fished in South Africa's waters from the 1980s through to the 2000s under bilateral agreements. Interest in targeting tuna by South Africans 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 in South African 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 and yellowfin and bigeye tuna. Other important species caught in smaller quantities included albacore and southern bluefin tuna, 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 record of tuna catches to indicate South Africa's performance and abilities in the fishery and to nationalise the fishery. In this allocation process, 18 rights were issued for the swordfish-directed fishery and 26 for the tuna-directed fishery (1 right = 1 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 has been a member of the International Commission for the Conservation of Atlantic Tunas (ICCAT) since 1967. The country is a Co-operating Non-contracting party of the Indian Ocean Tuna Commission (IOTC) and the Commission for the Conservation of Southern Bluefin Tuna (CCSBT), though membership of both has been approved by Cabinet and should be approved by Parliament in 2014, sealing South Africa's membership in these two RFMOs.

ICCAT and CCSBT have quota controls or a Total Allowable Catch (TAC) for individual species. South Africa received a swordfish catch limit of 1 001 t for 2014–2016 and a catch limit of 4 400 t for albacore from ICCAT in the Atlantic Ocean. The country was also allocated a southern bluefin quota of 40 t from the CCSBT for 2014 and 2015. Subject to CCSBT approval before the 31st May for that respective year, South Africa will receive an increased quota from 40 t to 150 t. In preparation for bigeye tuna quotas, which were meant to be allocated by the IOTC in 2010, South Africa has been limited to a maximum of 50 longline vessels in the Indian Ocean. No other quotas have been allocated to South Africa thus far.

Pole and line/rod and reel

Traditionally, albacore is the main target of the South African tuna pole-line (baitboat) fleet, which operates in waters up to 1 000 km off the South and West coasts of South Africa and off Namibia, from October to May. The fishery started in the late 1970s and originally targeted yellowfin tuna, but switched to albacore when yellowfin moved off the Cape waters in 1980, a pattern that repeated itself from 2005 - 2007, when the yellowfin became abundant again around the Cape. Although tuna occur in mixed shoals, catches of bigeye tuna and skipjack are caught in low numbers in comparison to albacore.

The tuna pole-line fishery was originally managed as part of the linefishery, but it became a separate sector after an environmental emergency was declared in 2000 due to the collapse of most of the targeted sparid (sea bream) and sciaenid (kob) stocks. The other two sectors that were created were traditional linefish and hake handline. Since the medium-term rights allocation in 2002, the tuna pole fishery has consisted of 191 vessels of more than 10 m length, of which on average 130 are active each year. A maximum of 200 rights (200 vessels or 2 600 crew) were made available for this sector. The next long- term rights have recently been allocated for a period of 15 years (2014 to 2029).

In the South Atlantic, the Chinese-Taipei longline fleet accounted for 46–90% of the total annual southern Atlantic albacore landed between 1970 and 2004. The South African baitboat fleet follows that of Chinese-Taipei, landing approximately 4 000 t annually. Catches vary depending on the availability of albacore and yellowfin tuna in inshore waters and on foreign exchange rates. Other important southern Atlantic albacore fisheries are Brazil (longline), Namibia (baitboat) and Japan (longline).

Pelagic shark

Due to concerns about high pelagic shark catches, the pelagic shark longline fishery was merged into the large pelagic longline fishery in March 2011. The Department is currently undertaking measures to terminate targeting of pelagic sharks for the following reasons: (1) blue sharks are a near-threatened species and shortfin mako sharks are vulnerable as described by the IUCN; (2) substantial pelagic shark by-catch is expected in the tuna/swordfish fisheries; (3) sharks are slow-growing, mature late, and have low fecundity, which makes them paticularly susceptible to overfishing; and (4) concerns over ecosystem effects of reducing numbers of appex predators. Under current management, the bycatch limit has been set using a Precautionary Upper Catch Limit (PUCL) of 2 000 t dressed weight. Once this limit is reached, fishing in the large pelagic fishery would close. The domestic pelagic longline fishery originally only targeted tuna and swordfish, although shark by-catch was also recorded. Foreign pelagic tuna-directed fisheries are comprised of Japanese vessels that take a bycatch of offshore oceanic species such as mako sharks, blue sharks and carcharhinid sharks such as silky sharks *Carcharhinus falciformis*.

Research and monitoring

The scientific observer programme for domestic longline vessels came to an end in March 2011. Currently, 100% coverage is achieved on foreign-flag vessels but no coverage has been achieved on domestic vessels since March 2011. The scientific observer coverage on the foreign-flag vessels obtains length frequencies, biological samples, and fisheries information on target and bycatch species. The observer coverage will be aimed at 20% of catch days for domestic longline vessels, once the programme is re-established. Port-side monitoring of tuna pole vessels will also re-commence upon the re-establishment of the scientific observer programme.

The relatively recent establishment of a large pelagic fishery represents an important milestone in the development of South African fisheries. However, research activities directed at the large pelagic species targeted by longline are in their infancy, though to date four dedicated research trips have been undertaken since 2008.

The main focus of past research on large pelagic resources in South Africa has been on the life history and stock structure of swordfish in southern African waters. This species is commercially important to the local longline fleet, and the research was sparked in response to the sharp decline in catch rates. Furthermore, the IOTC recognises the South-West Indian Ocean (SWIO) region as having a sub-population with its own scientific and management advice. As South Africa fishes in the SWIO region, it has been of interest to further the knowledge on this species in our waters. The scientific observer programme was used extensively from 1998 to collect swordfish length frequencies and biological material for age and growth studies, sexing, maturity staging and dietary studies.

A pilot tagging programme for swordfish and bigeye and yellowfin tuna, 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 in the same vicinity as it was originally tagged. However, there have been too few recaptures to draw any meaningful conclusions about the movements of these fish.

South Africa's involvement in the South West Indian Ocean Fisheries Project (SWIOFP), through Component 4 (assessment and sustainable utilisation of large pelagic resources), has provided momentum to the research programme. The primary focus is to understand the distribution and movement of swordfish and bigeye and yellowfin tuna within the SWIO region, to which end 15 pop-up satellite archival tags (PSATs) have been provided for deployment on these species, as well as hook monitors and time-depth recorders for deployment on an instrumented longline.

In 2009, two bigeye tuna were successfully tagged with PSATs. The animals were found to move north, following the direction of the Benguela Current. In 2010, three yellowfin tuna were tagged with PSATs. The three tags popped up and transmitted data earlier than they were programmed to do, indicating that the animals had died prematurely and the tags had exceeded their depth limit of 1 200 m. The trends in the data are yet to be analysed in detail to understand the cause of these premature pop-ups. Three blue sharks were tagged with PSATs in 2010 and a further two blue sharks were tagged with SPOT (Smart Position Only) tags in 2011. The Department's national research cruise in 2011 was a momentous achievement during which 11 swordfish were successfully PSAT-tagged in the SWIO region. Swordfish have proven to be very sensitive to handling on the line and South Africa is the first country to achieve PSAT-tagging of swordfish in this region. Tags had been programmed for either 90 or 180 days. Four tags remained on the fish for more than 60 days. The tag results revealed that all swordfishes remained within the region but one fish crossed the 20^{o} longitude boundary, twice indicating that there might be a link to the Southern Atlantic stock.

The Department continues to collaborate with WWF and

Birdlife SA to assess the impact of longline fisheries on seabirds, turtles and sharks, and to investigate various mitigation and management measures. A National Plan of Action (NPOA) for seabirds was published in 2008, which aims to reduce seabird mortalities below 0.05 seabirds 1 000 hooks^{-1}. Good collaboration with the fishing industry, researchers and managers, continual refining of mitigation measures, the implementation of stringent management measures through permit conditions, and close monitoring, has resulted in a decrease of seabird mortalities and is currently almost at the goal identified in the NPOA-Seabirds. The NPOA-Sharks, a comprehensive plan that covers issues around the consumptive use of sharks, has been published as of November 2013, and its implementation needs to be coordinated.

The ICCAT and IOTC have expressed concerns over the movement of species between the 20°E management boundary that separates the Indian and Atlantic oceans. The extent of the mixing between the two oceans has strong implications for the outcomes of stock assessments. South Africa is in a position to begin to address this issue, for the benefit not only of South Africa, but of neighbouring fishing fleets too. A multidisciplinary approach is required, coupling tagging, genetic, stable isotope research. Further research initiated in South Africa is using swordfish genetics to ascertain stock delineation between the two oceans.

South Africa is currently a collaborator in the GEnetic StRucture and Migration Of Albacore TuNa (GERMON) project being headed up by the French Research Institute for Exploitation of the Sea, Indian Ocean's Delegation (IFREMER DOI). The project aims to further the knowledge information on the stock structure and biology of albacore in the Indian Ocean and the area between the Indian and Atlantic oceans. The sampling is currently underway and the project will conclude in 2015. Coupled with the GERMON project, South Africa has recently tagged albacore with PSAT tags to complement the outcomes of the genetic, stable isotope analyses.

The RFMOs are responsible for conducting stock assessments of large pelagic species. South Africa has contributed standardised catch-per-unit-effort (CPUE) for inclusion in ICCAT stock assessments for albacore and swordfish since 1996.

Current status

Stock assessments and country allocations for the Atlantic and Indian ocean stocks of tuna and tuna-like species are the responsibility of ICCAT and the IOTC, while stock assessments for southern bluefin tuna are conducted by the CCSBT.

Yellowfin tuna

A stock assessment for yellowfin tuna conducted by ICCAT in 2011 (using catch-and-effort data through 2010) indicated that the yellowfin stock in the Atlantic Ocean was overfished and catches were about 10% higher during 2008–2010 than in 2007. ICCAT has recommended that no additional effort be exerted on the Atlantic yellowfin stock, as production model has indicated that increased catches will slow or reverse rebuilding of the stock. The high catches in the Indian Ocean in the period 2003–2006 (average catch of 464 000 t) may have led to a decline in the biomass of the stock. A stock assessment conducted in 2012 suggested that the stock is currently not overfished and is not experiencing overfishing. The IOTC Scientific Committee recommended that the catches in the Indian Ocean do not exceed the current estimate of Maximum Sustainable Yield (MSY) of 300 000 t (catches of yellowfin in 2011 were 302 939 t) and that improvements in the status of the stock are dependent on future recruitments reaching previous higher levels and the control of fishing pressures (catch and effort).

Albacore

A full southern Atlantic albacore stock assessment was conducted by ICCAT in 2013, using a broad range of methods and data up to 2011. The results of the stock assessment suggest there is a 57% probability that the stock is both overfished and experiencing overfishing. The large confidence intervals reveal uncertainties in the status of the stock. Consequently, the TAC was maintained at 24 000 t in the South Atlantic region with Contracting Parties receiving hard-limit quotas. South Africa received a catch limit of 4 400 t for 2014. The IOTC conducted an albacore stock assessment in 2011. At current effort levels the Indian Ocean stock is considered at risk and catches are most likely above MSY (29 900 t).

Swordfish

A swordfish stock assessment conducted by ICCAT in 2013 revealed conflicting results between the models. The stock could be in an overfished state and experiencing overfishing. Until improved scientific information is available, in the form of more consistent indices, tagging studies to estimate fishing mortality or abundance, or other improved information, this uncertainty may remain. South Africa's TAC was maintained at 1 001 t for 2014–2016. The outlook for the swordfish stock in the Indian Ocean is more optimistic with signs of reductions in catch and effort that have brought down mortalities. These conditions are suitable for stock recovery and rebuilding to the level of MSY.

Bigeye tuna

The latest stock assessment of bigeye tuna in the Atlantic Ocean was conducted in 2010, using catch data up to 2009, and it indicated that the stock is optimally exploited. The total catch in 2009 increased to 86 011 t, higher than the targeted TAC of 85 000 t recommended by the ICCAT (Standing Committee on Research and Statistics) to promote stock growth. The total catch of bigeye tuna in the Indian Ocean reached 40 700 t in 1999, but the average catch for the period 2005–

2009 has been 114 600 t. The stock assessment in 2006 used four assessment models and the results showed that the stock was fully exploited. Current catches (2011) of bigeye tuna in the Indian Ocean (87 420 t) are below the range of the estimated MSY levels of between 100 000 t and 115 000 t, indicating that the stock is not overfished and it is not experiencing overfishing.

Southern bluefin tuna

A model assessment of the southern bluefin stock was not conducted in 2013 at the Extended Scientific Committee of CCSBT. The indicators continue to support previous evidence that this tuna resource is still overexploited. The stock assessment also indicated that the spawning stock biomass (SSB) is at a very low fraction of its original biomass (4.6% of unfished levels) as well as below the levels that could produce maximum sustainable yield (15% of SSBMSY), and these results were consistent across all possible scenarios. However, the global TAC has been increased to 12 449 t for 2014 and it is estimated to be increased to 14 647 t for the years 2015–2017. These increases are less than the 30 000 t set in the Management Plan and are a result of recent positive trends in the CPUE and aerial surveys indices. Catches at the current TAC are expected to achieve rebuilding of the stock.

Pelagic sharks

Stock assessments of pelagic sharks, conducted by ICCAT in 2008, were inconclusive due to widespread under-reporting of shark catch-and-effort data. Despite this, there is international concern regarding the stock status of pelagic sharks, due to the biology of these species and the current high fishing capacity worldwide. As a precautionary measure, 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

Stock status	Unknown	Abundant	Optimal	Depleted	Heavily depleted
Fishing pressure	Unknown	Light	Optimal	Heavy	

Introduction

The West Coast rock lobster fishery is the most important rock lobster fishery in South Africa due to its high market value (more than R260 million per annum) and its importance in providing employment for over 4 200 people from communities along the West Coast. West Coast rock lobster is a cold water temperate spiny lobster species occurring from Walvis Bay in Namibia to East London in South Africa. In South Africa, the commercial fishery operates between the Orange River Mouth and Danger Point. 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 from 'bakkies' in the nearshore region up to one nautical mile offshore and 80% by offshore trap vessels operating to water depths of greater than 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 months.

The invasion by West Coast rock lobsters of 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 in 2001/2002. However, the fishery on the West Coast, which historically landed the bulk (60%) of the lobster catch, now lands only 40% of the total catch annually. This decline in catch has had a devastating effect on the coastal communities, with economic hardships experienced by most fishers on the West Coast. In the face of resource decline, an Operational Management Procedure was developed which aims 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 44). Lobsters were predominantly caught with hoop nets prior to the 1960s and from 1965 more efficient traps and motorized 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, over-exploitation, 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), 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 carapace length 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 carapace length was implemented. In 1979 the tail-mass production quota was replaced by a whole lobster quota, which led to the introduction of the Total Allowable Catch (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 45, 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 is exclusively harvested by hoop net fishers operating in the nearshore region.

Other management controls applied included protection of

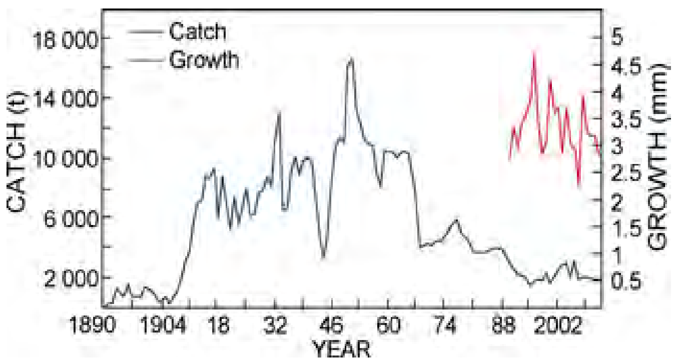

Figure 44: Historical catches of West Coast rock lobster, with the associated trend in growth indicated for the period post-1960.

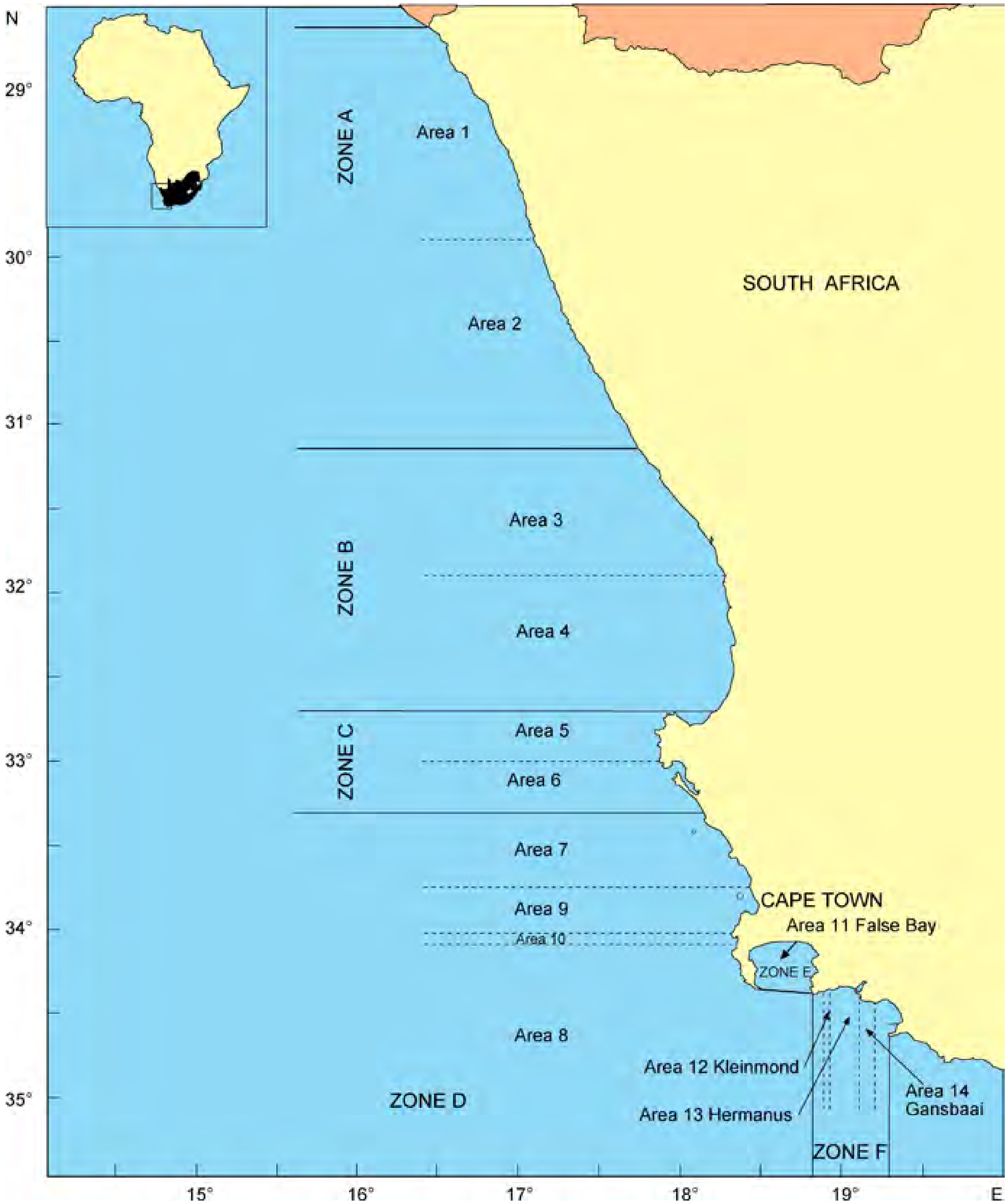

Figure 45: West Coast rock lobster fishing zones and areas. The five Super Areas used in the Operational management Procedure (OMP) corresponds to Zone A, Zone B, Zone C, Area 7 and Area 8 combined with Zone F.

Table 10: Input data for the 2011 OMP TAC calculations for Super Areas 1-8+. (FIMS-Fisheries Independent Monitoring Surveys)

Year	Trap CPUE	Hoop CPUE	FIMS CPUE	Somatic growth of 70 mm male lobster (mm/year)
		Super Area 1+2		
2005	-	1.372	-	2.74
2006	-	1.303	-	2.833
2007	-	1.41	-	3.841
2008	-	1.152	-	3.526
2009	-	1.583	-	7.014
2010	-	1.053	-	4.487
2011	-	0.853	-	4.196
2012	-	0.862	-	4.029
		Super Area 3+4		
2005	-	0.503	1.712	3.25
2006	-	0.402	0.239	3.2
2007	-	0.813	0.267	2.344
2008	-	1.33	1.548	4.095
2009	-	1.414	0.009	3.464
2010	-	1.307	3.863	3.372
2011	-	1.692	1.23	3.381
2012	-	0.886	0.41	3.081
		Super Area 5+6		
2005	-	0.809	0.241	3.972
2006	-	0.894	0.119	4
2007	-	1.105	1.267	3.066
2008	-	1.39	0.756	4.817
2009	-	1.153	0.706	4.141
2010	-	1.429	0.59	4.05
2011	-	1.543	2.32	4.058
2012	-	1.46	2.11	3.759
		Super Area 7		
2005	0.652	-	15.790	3.301
2006	0.801	-	13.960	3.084
2007	0.486	-	21.880	3.351
2008	0.392	-	9.67	4.632
2009	0.617	-	5.09	2.984
2010	0.99	-	3.27	4.143
2011	0.344	-	2.89	4.222
2012	0.322	-	1.59	3.241
		Super Area 8+		
2005	0.945	1.07	62.71	2.572
2006	0.829	0.965	79.18	2.523
2007	0.746	0.839	106.65	1.667
2008	0.839	0.891	101.43	3.417
2009	0.844	1.025	101.02	2.64
2010	0.975	1.122	94.41	2.549
2011	0.996	1.008	105.61	2.557
2012	0.783	0.924	247.06	2.258

females with eggs (berried females) and soft-shelled lobsters, a closed winter season, and a daily bag limit for recreational fishers. Catches stabilized around 3 500 to 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 carapace length, to reduce mortalities resulting from

Table 11: The resource indices for each super-area calculated using the data in Tables 1a-e and the critical values below which the Exceptional Circumstances (EC) rule would be invoked.

Super-area	The gear-combined index of abundance	The critical values below which EC would be declared
1+2	0.76	0.7
3+4	1.22	0.85
5+6	1.43	0.7
7	0.60	0.8
8+	1.19	0.7

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 Operational Management Procedure (OMP) was implemented in 1997 to rebuild the resource to more healthy levels (defined as those pre-1990). The initial target for the OMP developed in 1997 was to increase resource abundance to 20% above the 1996 level by 2006. By 2003, the resource had improved to 16% above the 1996 level. However, 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 2003/04. The commercial TAC was decreased by 10% for the subsequent three consecutive seasons (2006/07, 2007/08 and 2008/09) in an attempt to rebuild the stock to the new target of 20% above 2006 levels by 2016. The OMP adopted in 2011 aims to rebuild the resource by 35% by 2021 i.e. B^{75m}.

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 Catch-Per-Unit-Effort (CPUE) derived from fisheries-independent monitoring surveys 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.

Catch 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 carapace length, 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 is also recorded during fisheries independent monitoring surveys and ship-based observer monitoring surveys on board commercial vessels, to derive abundance indices of sub-adult, 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 fisheries-independent survey data and analysis methods have been recently re-checked, and changes in weather conditions have been identified as a source of variation in CPUE. The associated effects of changes in bottom oxygen concentrations, 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 lobster have been initiated to establish a long-term index of pre-recruit 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

The OMP adopted in 2011 is empirically based. This means that it uses data collected from the fishery directly for calculating the TAC. No population model is fitted to input data as for previous OMPs. Four indices are used as input data to the OMP in order to set the TAC – trap CPUE, hoop net CPUE, abundance estimates from Fisheries Independent Monitoring Surveys (FIMS), and somatic growth. Recent trends in these indices are given in Table 10.

Results obtained from the analysis of these data indicated that the “Exceptional Circumstances” threshold had been breached for Super Area 7 under the low abundance rule of the OMP (Table 11). In line with the OMP provisions, an immediate OMP review was commenced, together with updated assessments that took into account recent catches and revisions of poaching level estimates. These new assessments showed that the status of the resource in Super Area 7 was alarmingly low. However, given the time constraints, a full revision of the OMP was not possible for the 2013/14 season TAC recommendation. In light of these circumstances, an interim approach for one season only was developed to provide the TAC recommendation for 2013/14, which was consistent with the intent of the rebuilding plan. This resulted in a Global TAC of 2 167 t for 2013/14, a decrease of 259 t compared to the previous season.

Catch estimates reported from recent telephone surveys have indicated that the annual recreational catch has not decreased substantially since 2000, but rather has remained in the vicinity of its estimated level for earlier years of some 300 t. However, over recent years there have been indications of some catch decrease, with catches in the 2011/12 season estimated at 125 t. This is in line with the intended decrease in recreational catch brought about by a severe reduction in recreational season length.

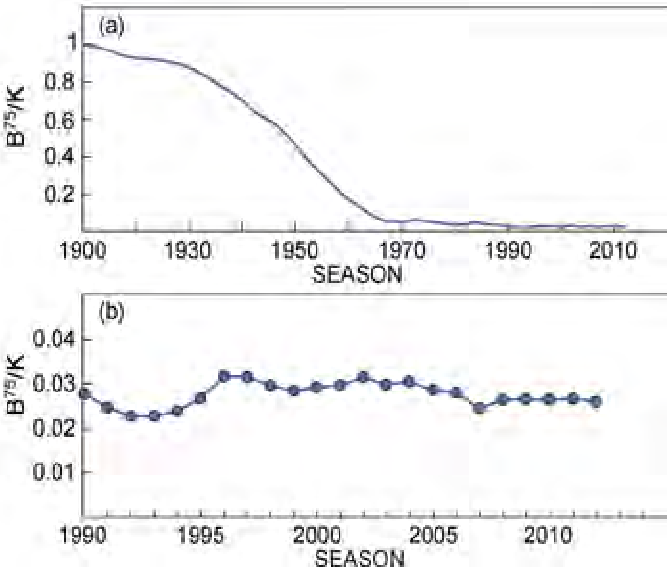

Figure 46: Current biomass in relation to pristine (B^{75}/K) values for the resource as a whole (i.e. summed over the five Super Areas). The bottom plot shows values for 1990+ only. The 95% confidence intervals are shown for 1996 and 2000+ years.

The biomass of male West Coast rock lobster above the 75 mm CL minimum size limit is currently at 2.6% of pristine levels (B^{75m}/K =0.02 6) (Figure 46). If the recovery target of 35% is met, the resource biomass will increase to 4.8% of pristine by 2021. Every effort to reduce illegal harvesting, including substantially improved compliance with permit conditions for reporting of catches, should be instituted to ensure that sound resource management and resource rebuilding are not compromised.

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Notes