National Accounts

Environmental Economic Accounts

Fishery Accounts for South Africa: 1990–2008

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List of abbreviations and acronyms

DEA	Department of Environmental Affairs (Department of Environmental Affairs and Tourism prior to July 2009 (President's Minutes No. 690 of 2009))
EEA	Environmental Economic Accounts
MARAM	Marine Resource Assessment and Management
MCM	Marine and Coastal Management
MPA	Marine Protected Areas
OMP	Operational management procedure
SADCO	Southern African Data Centre for Oceanography
SASSI	Southern African Sustainable Seafood Initiative
SEEA	System of Integrated Environmental and Economic Accounts
SEEAF	System for Integrated Environmental and Economic Accounting for Fisheries
Stats SA	Statistics South Africa
TAC	Total allowable commercial catch
UCT	University of Cape Town
1993 SNA	1993 System of National Accounts

Executive summary

The fishing industry in South Africa is very critical for many people who rely on it for both formal and informal employment. The stocks of fish that support the industry need to be monitored and measured, to prevent over-fishing. Current stocks are so low that further stock depletion will necessarily reduce economic harvests (catch per unit effort will decrease) and as the fishing industry becomes uneconomical employment is likely to drop. The small scale fishers and subsistence fishers whose ability to seek out fish offshore will be particularly vulnerable.

Fishery satellite accounts capture stock assessments based on modelling and monitoring of the resource. Such estimates can help managers and administrators to manage the fisheries sustainably; and ensure the future of the fishing industry and the fish resources themselves. The fishery accounts can provide estimates of the stock in physical units (e.g. as tons of fish available (exploitable biomass)) or in monetary units (e.g. values of the physical stocks). This discussion document will concentrate on the physical accounts for hake (*Merluccius paradoxus and M. capensis*) and west coast rock lobster (*Jasus lalandii)* fisheries for South Africa as the data for these two commercial species are of a high quality and they contribute about 80% of the economic contribution to the fishing industry in South Africa. Monetary estimates will not be provided at this stage.

Key findings

Hake (*M. paradoxus and M. capensis*) closing stock (exploitable biomass) showed that combined species experienced a steady but controlled decline from 622 thousand tons[1] in 1990 to 575 thousand tons in 2008. Total catches consisted mostly of offshore trawl that has shown a decline from 126 thousand tons in 1990 to 117 thousand tons in 2008. This decline is largely attributable to the decrease of the total allowable commercial catch (TAC) by eight thousand tons in 2006 and 15 thousand tons for 2007, in an attempt to manage the declining stocks.

West coast rock lobster (*J. lalandii)* closing stock (exploitable biomass) experienced a steady decline from 26 062 tons in 1990 to 19 461 tons in 2008. The commercial catches have also shown a decline from 2 996 tons in 1990 to 2 083 tons in 2008 for commercial catches.

1. Introduction

The purpose of this discussion document is to present physical fishery accounts for South Africa, more specifically for hake (*M. paradoxus and M. capensis*) and west coast rock lobster (*J. Lalandii)*. The document will begin with a brief background description of the fishing industry in South Africa. Section 3 will give a brief discussion on the natural pressures confronting marine resources in South Africa. In section 4, details regarding the data sources used to compile the physical fishery accounts will be discussed. Section 5 will present the actual physical fishery accounts for hake (*M. capensis* and *M. paradoxus*) and west coast rock lobster (*J. lalandii)* and an analysis of the data will also be given. Section 6 will discuss the policy implications of the

[1] Tons are measured in metric units.

fishery accounts. In Annexure 1, a detailed description of the methodologies used to compile the physical fishery accounts found in section 5 will be presented.

2. Overview of the fishing industry in South Africa

The users of marine resources are divided into three major groups, recreational, subsistence and commercial. The recreational users collect or catch fish and other marine species as part of leisure activities. These include shore anglers, underwater fishers, shellfish and bait collectors and recreational boat anglers. Subsistence fishers are largely individuals located in remote rural areas who collect fish for own consumption. The commercial fisheries make up the formal fishing industry and range from relatively small-scale and labour intensive inshore fisheries to the highly industrialised deep-water trawls. There are 18 recognised commercial fisheries which are divided into four clusters which are presented in Table 1 below.

Table 1: Commercial fishing industry clusters

Cluster A	Cluster B
• Hake (*M. paradoxus; M. capensis*) deep water bottom trawl; • Hake (*M. paradoxus; M. capensis*); sole (*Austroglossus pectoralis*) inshore bottom trawl; • Horse mackerel (*Trachurus* spp.) mid-water trawl; • Small pelagics purse-seine; • Patagonian toothfish (*Dissostichus eleginoides*) long-line; • South coast rock lobster (*Palinurus gilchristi*) trap long-line; and • KwaZulu-Natal prawn (*Metapenaeus monoceros*) bottom trawl.	• Hake long-line (*M. paradoxus; M. capensis*); • West coast rock lobster (*J. lalandii*), off-shore traps; • Squid (*Loligovulgaris reynaudii*) jigging; • Seaweed (*Ecklonia maxima*, *Laminaria pallida* and *Gracilaria* spp.) harvesting; • Tuna Albacore *(Thunnus alalunga)* pole; and • Demersal shark long-line.
Cluster C	**Cluster D**
• Handline hake (*M. paradoxus; M. capensis*); and • West coast rock lobster (*J. lalandii*), near-shore hoop-nets.	• Net fish (gillnets, beach seine and KwaZulu-Natal beach seine); • Oysters (*Crassostrea gigas*); and • White mussels (*Donax serra*).

Source: *The Southern African Sustainable Seafood Initiative*

According to the Marine and Coastal Management (MCM) branch of the Department of Environmental Affairs (DEA), South Africa allocates fishing rights for the exploitation of 21 different commercial fisheries, including:

- Hake (*M. paradoxus; M. capensis*) inshore trawl;
- Hake (*M. paradoxus; M. capensis*) handline;
- Hake (*M. paradoxus; M. capensis*) long-line;

- South coast rock lobster (*P. gilchristi*);
- West coast rock lobster (*J. lalandii)*;
- Abalone *(Haliotis midae)*;
- Large pelagics (tunas – *Thunnus sp.*; and swordfish – *Xiphias gladius*);
- Small pelagics (anchovies – *Engraulidae capensis*; and pilchards – *Sardinops sagax*);
- Traditional linefish (which includes some 150 species of fish);
- Net fishing;
- White Mussels (*Donax serra*);
- Oysters (*Crassostrea gigas*);
- Seaweed (*Ecklonia maxima*, *Laminaria pallida* and *Gracilaria* spp.);
- Squid (*Loligo vulgaris reynaudii*);
- Prawn trawl (*Penaeus indicus,* and *Penaeus monodon)*;
- Horse mackerel *(Trachurus trachurus capensis)* (mid-water trawl);
- Patagonian Toothfish (*Dissostichus eleginoides*);
- Tuna Albacore *(Thunnus alalunga)* handline (pole); and
- Mariculture.

3. Pressures and impacts on marine resources

Many marine species are subject to natural population fluctuations. This section will address naturally occurring factors that might influence the fish stock in South Africa. The factors that will be discussed are red tides, climate change and sea surface temperature changes.

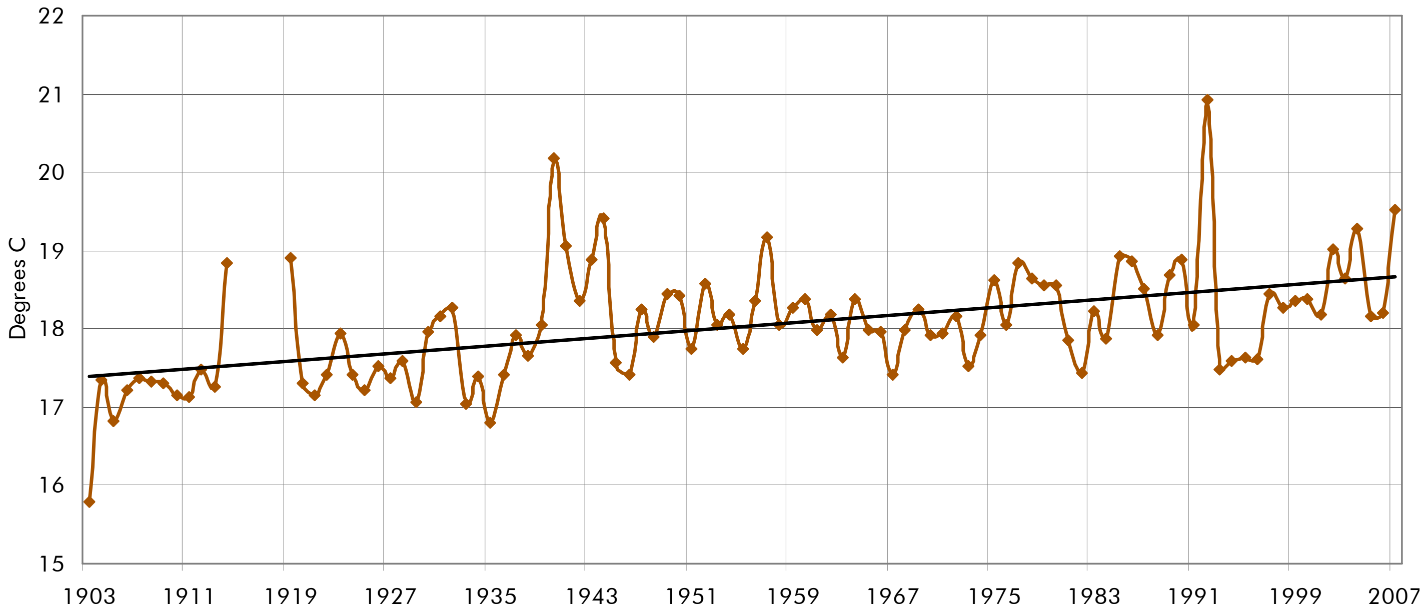
3.1 Climate change

Climate change is becoming a well recognised global issue. It encompasses host of impacts that affect all levels of the environment. Within the bounds of this document there will only be a discussion regarding the change in global average temperature and the change in the annual average precipitation and the manner in which these changes can impact on fish resources.

The fluctuations in rainfall result in the change in the amount of freshwater runoff. Any reduction in freshwater flow will have a direct impact on estuaries and the marine biota that utilise these systems, such as estuarine dependent fish species. A reduction in freshwater flow will also decrease the level of dilution of wastewater discharge before reaching estuaries. This could adversely affect the quality of estuarine habitats which will in turn have negative consequences for fisheries targeting estuary associated species (DEAT, 2005).

Another negative effect of climate change is the variations in sea surface temperatures. According to DEAT 2005, sea surface temperatures off Southern Africa appear to have increased by about 0,25°C per decade for the last four decades. With increasing sea surface temperatures, marine species are expected to shift their distribution patterns in response to the changing temperature regimes. This is most likely having the greatest effect on those species that are most sensitive to temperature fluctuations.

Figure 1: Mean annual sea surface temperatures, 1903–2007



Notes: Collected from Voluntary Observing Ships data, between Knysna and Struisbaai up to 60 nautical miles offshore
Source: Southern African Data Centre for Oceanography (SADCO)

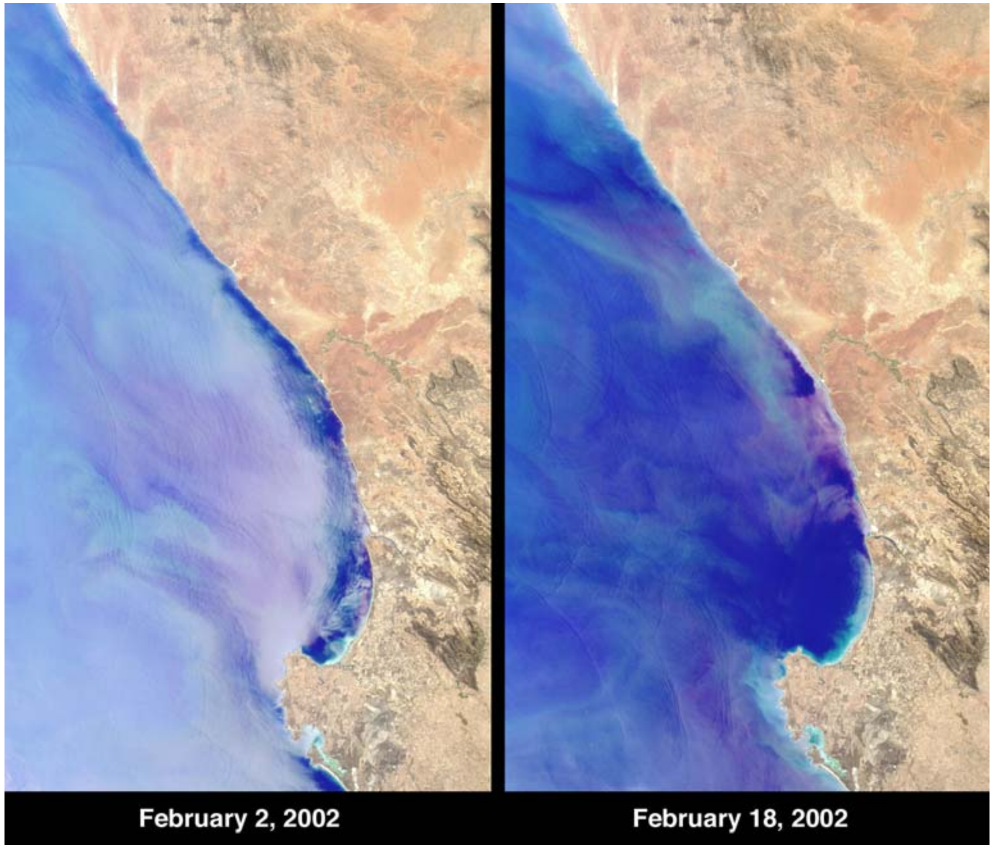
3.2 Red tides

Red tides are caused by blooms of certain phytoplankton species which are characterised by an abundance of micro-algae that can lead to discoloration of water. Red tide blooms can become toxic and lead to mass mortalities of fish and invertebrates.

Once the nutrient supply is depleted, the phytoplankton bloom begins decaying. This uses up oxygen in the inshore waters, leading to oxygen depletion or anoxic conditions (DEAT, 2005).

This is a particular problem for managers of inshore species such as west cost rock lobster. At Elands Bay in Western Cape, about 1 000 tons of rock lobsters beached themselves during February 2002, when the decay of dense blooms of phytoplankton caused a rapid reduction in the oxygen concentration of near shore waters. The lobsters moved toward the breaking surf in search of oxygen, but were stranded by the retreating tide[2]. Figure 2 is a satellite photograph of the red tide.

Figure 2: Red tides observed from space, Elands Bay in the Western Cape



Source: National Aeronautics and Space Administration (NASA): http://earthobservatory.nasa.gov/IOTD/view.php?id=2251

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[2] National Aeronautics and Space Administration (NASA) Earth Observatory: http://earthobservatory.nasa.gov/IOTD/view.php?id=2251

4. Data availability

This section discusses the data sources that were used to compile the physical fishery accounts.

4.1 Data sources utilised

To compile the physical fishery accounts the data was sourced from the MCM and University of Cape Town's (UCT) Marine Resource Assessment and Management (MARAM) programme. The model used for the data compilation is briefly discussed below.

Marine and Coastal Management

MCM is one of the branches within the DEA and is the regulatory authority responsible for managing all marine and coastal activities which includes:

- Allocation and management of fishing rights;
- Regulation of recreational fishing;
- Management of South Africa's marine protected areas;
- Protection and monitoring of South Africa's costal and estuarine resources;
- Control of vehicle use on beaches;
- Promotion of fish farming or mariculture; and
- Research into fish stocks and advises on the status of fish stock.

MCM employs scientists and technicians who conduct research on more than 200 species of fish each year. This data is used to advise MCM and the Minister of Environmental Affairs on how much fish may be harvested by each of the 21 commercial fisheries/species (refer to Section 2).

MCM also has the operational management procedures (OMP) database. According to Leiman & Harris (2009), MCM manages the major marine fisheries using the OMP. The OMP approach is based on the precautionary principle, and derives TAC using simulations run in Bayesian models[3] that explicitly allow for scientific uncertainties. In each fishery, a non-tradable quota is allocated as a share of the species TAC which is annually adjusted in accordance with projections from the models. Data are perpetually inputted, thus iteratively improving estimates of historic fish stocks and allowing conditional estimates of current stocks and sustainable harvests. Such models have been in place for the major commercial species for some time:

- Hake (modelled jointly for the two sub-species, *M. capensis* and *M. paradoxus*) since 1990;

[3] In statistics, Bayesian model comparison is a method of model selection based on Bayes factors. It is commonly interpreted as an alternative to hypothesis tests.

- Small-pelagics (modelled jointly pilchard (*Sardinops sagax*) and anchovy (*Engraulidae capensis*)) since 1991; and
- West coast rock lobster (*J. lalandii*) since 1997.

South Coast Rock Lobster (*Palinurus gilchristi*) and Patagonian Toothfish (*D. eleginoides*) OPM models are in the process of being developed.

An advantage of the system is that each OMP is rooted in an annual meeting at which modellers, scientists and commercial fishermen exchange views while working towards consensus on the estimates for the year. These figures go into the model which is then further fine-tuned over the season. The longer the system runs, the more robust it becomes, provided the quality of the data input is maintained (Leiman & Harris, 2009).

Estimates of stocks and catches suited to use in the physical fishery accounts can be obtained through the OMP models run for all major commercial species. The OMP uses the most comprehensive and verifiable data. More to the point, these models operate over long periods, and permit backward induction to estimate pre-exploitation stock levels. They thus offer insight into the health of these resources, and into potential yields, which short period stock and harvest figures would not provide (Leiman & Harris, 2009).

University of Cape Town

MARAM a research unit within the Department of Mathematics and Applied Mathematics at the UCT carries out the quantitative analyses upon which scientific advice for catches levels, for all of the major South African fisheries are based. MARAM runs the OMP for MCM.

5. Physical accounts for the South African fishing industry

This section presents the physical fishery accounts for hake (*M. capensis* and *M. paradoxus*) and west coast rock lobster (*J. lalandii*). These physical accounts have been compiled accordance with the System for Integrated Environmental Economic Accounts for Fisheries (SEEAF) recommendations. For this discussion document it was decided to only present physical account for hake (*M. capensis* and *M. paradoxus*) and west coast rock lobster (*J. lalandii*) as these two commercial species contributes about 80% of the economic contribution to the fishing industry in South Africa and the data for these two commercial species is of high quality.

5.1 Hake

Table 2 below presents the physical accounts for hake (*M. Paradoxus and M. Capensis*) closing stock (exploitable biomass). The closing stock (exploitable biomass) for the combined species experienced a steady but controlled decline from 622 thousand tons in 1990 to 575 thousand tons in 2008. The total catches (mostly of offshore trawls) have also shown a decline from 126 thousand tons in 1990 to 117 thousand tons in 2008 for offshore trawl catches. This decline is due to the decrease of the global TAC by eight thousand tons in 2006 and 15 thousand tons for 2007 in an attempt to manage the declining stocks.

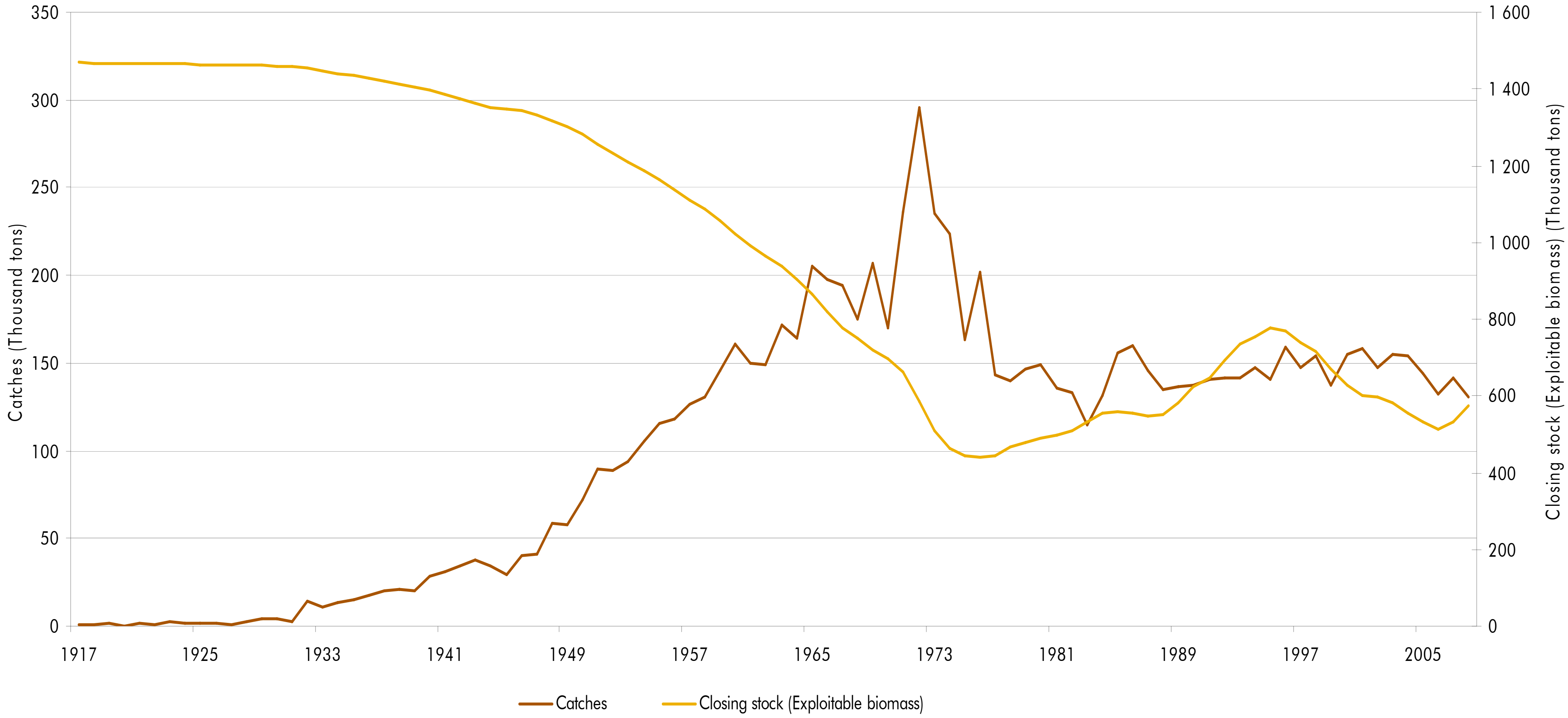
A better picture of the available stock can be seen by analysing the stock levels for an increased time series. Figure 3 present the hake (*M. Paradoxus and M. Capensis*) exploitable biomass and catches from 1917 to 2008. The data in Figure 3 illustrates the relationship between the closing stock (exploitable biomass) and catches. In 1917 the closing stock (exploitable biomass) was 1 469 thousand tons and the catches was only at one thousand ton. As the level of catches increased, the level of closing stock (exploitable biomass) decreased. The level of catches increased reaching a high of 295 thousand tons in 1972. However, even as the catch levels started to decrease the closing stock (exploitable biomass) continued to decline to its lowest level of 441 thousand tons in 1976 when is started to recover, but then managed to recover to 768 thousand tons in 1996 as it started to decline again until 2007/2008, where there has been a small recovery along with a drop in the catch levels. Figure 4 takes a closer look at the relationship between exploitable biomass and catches for the reference period of 1990 to 2008. The closing stock (exploitable biomass) dropped as the catches increased, however the catches began to drop from 2007 and the closing stock (exploitable biomass) began to recover.

Table 2: Hake: physical accounts for South Africa, 1990–2008

Year	Opening stock	Catches: Offshore trawl	Catches: Inshore trawl	Catches: Long-line	Catches: Handline	Other volume changes	Closing stock (exploitable biomass): Merluccius paradoxus	Closing stock (exploitable biomass): Merluccius capensis	Closing stock (exploitable biomass): Species combined
	Thousand tons								
1990	583	126	10	0	0	176	169	453	622
1991	622	129	8	3	1	167	169	479	648
1992	648	130	9	2	1	187	179	514	693
1993	693	132	9	0	0	185	193	543	737
1994	737	135	10	2	0	166	198	558	755
1995	755	128	11	2	1	163	221	556	777
1996	777	142	11	4	2	151	221	548	768
1997	768	133	9	4	1	119	206	534	740
1998	740	142	8	2	2	131	206	511	717
1999	717	119	9	7	3	92	186	485	671
2000	671	131	11	7	6	111	171	457	628
2001	628	134	12	6	7	133	170	432	603
2002	603	124	10	11	4	141	174	423	596
2003	596	130	10	12	3	141	169	414	583
2004	583	133	10	10	2	125	162	392	554
2005	554	125	8	11	1	121	158	373	531
2006	531	117	6	9	0	115	147	366	514
2007	514	126	6	8	0	160	163	369	533
2008	533	117	6	8	0	173	191	384	575

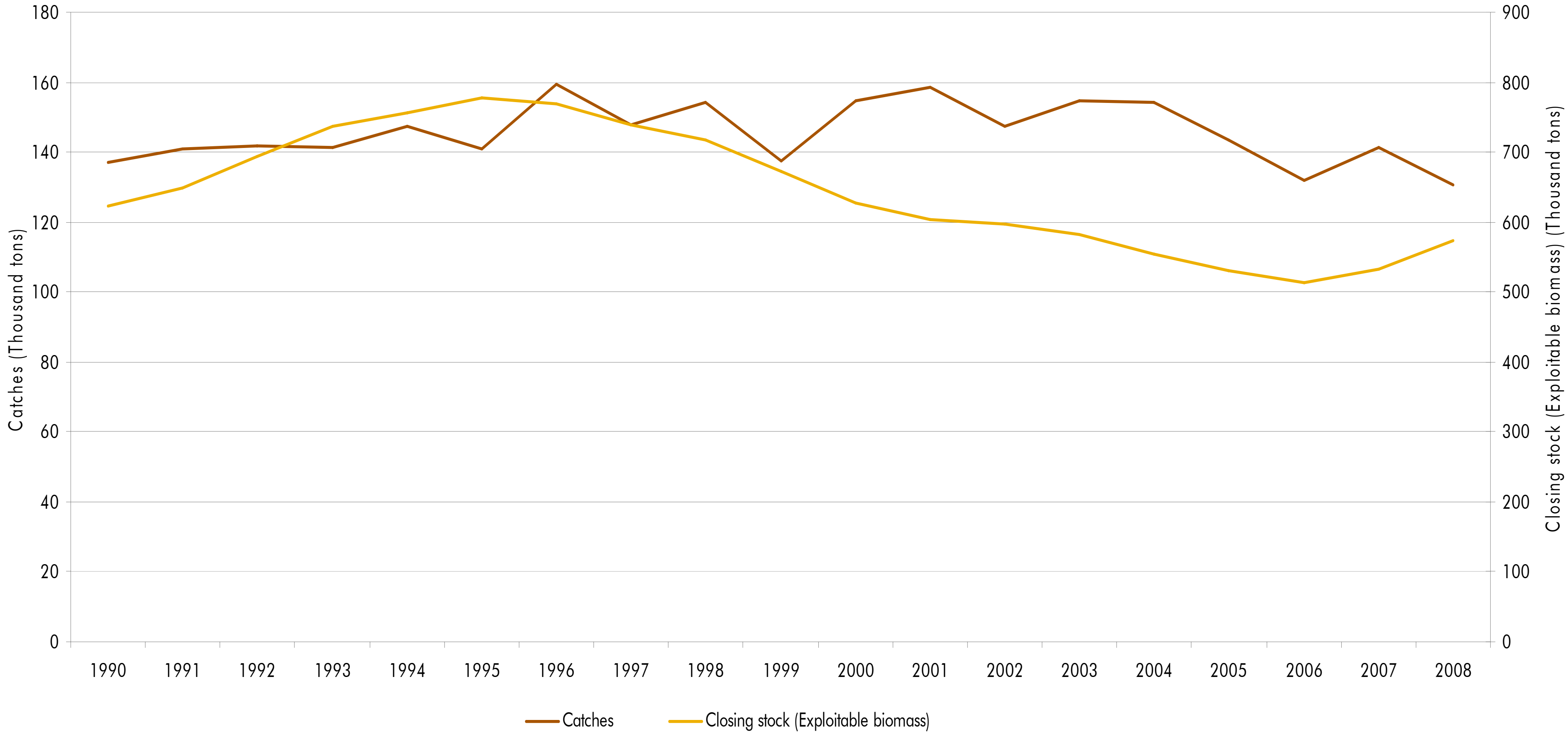
Source: Marine and Coastal Management and Marine Resource Assessment and Management Group

Figure 3: Hake: closing stock (exploitable biomass) and catches, 1917–2008



Source: Marine and Coastal Management and Marine Resource Assessment and Management Group

Figure 4: Hake: closing stock (exploitable biomass) and catches, 1990–2008



Source: Marine and Coastal Management and Marine Resource Assessment and Management Group

5.2 West coast rock lobster

Table 3 presents the physical accounts for west coast rock lobster (*J. lalandii*) closing stock (exploitable biomass). The closing stock (exploitable biomass) for the west coast rock lobster experienced a steady decline from 26 062 tons in 1990 to 19 461 tons in 2008. Commercial catches have shown a decline from 2 996 tons in 1990 to 2 083 tons in 2008. The drop in the catch level can also be attributed to the reduction of the global TAC by 317 tons in 2006 and 286 tons in 2007, brining the global TAC level to 2 571 tons for the 2007/2008 season.

Table 3: West coast rock lobster: physical accounts for South Africa, 1990–2008

	Tons					
Year	Opening stock	Commercial catch	Recreational catch estimate	Poaching estimate	Other volume changes	Closing stock (exploitable biomass) (>75mm)
1990	29 999	2 996	441	500	0	26 062
1991	26 062	2 480	455	500	-80	22 547
1992	22 547	2 176	469	500	199	19 601
1993	19 601	2 197	391	500	1 810	18 323
1994	18 323	1 966	336	500	2 182	17 703
1995	17 703	1 516	379	500	3 333	18 641
1996	18 641	1 674	496	500	6 483	22 454
1997	22 454	1 918	340	500	2 609	22 305
1998	22 305	1 792	249	500	1 426	21 191
1999	21 191	2 315	360	500	2 839	20 855
2000	20 855	1 609	404	500	4 836	23 178
2001	23 178	2 073	468	500	3 820	23 957
2002	23 957	2 462	583	500	4 521	24 933
2003	24 933	2 918	320	500	1 284	22 480
2004	22 480	3 205	320	500	3 253	21 707
2005	21 707	2 875	320	500	1 144	19 156
2006	19 156	2 207	300	500	888	17 037
2007	17 037	2 314	257	500	3 207	17 173
2008	17 173	2 083	257	500	5 128	19 461

Note: Poaching estimates remains constant due to lack of data.
Source: Marine and Coastal Management and Marine Resource Assessment and Management Group

6. Policy analysis

The commercial fisheries employing the highest number of people are the line, squid, hake (*M. capensis* and *M. paradoxus*) trawl, and west coast rock lobster (*J. lalandii*) fisheries. In terms of earnings however, the deep-sea hake fishery pays the highest wages (DEAT, 2007).

According to the DEA, the deep-sea hake (demersal offshore trawl) lands the highest value catch, contributing 44% to the total revenue of South African fisheries (whilst the pelagic and line fisheries contribute 20% and 11%, respectively). In the 1960s, the demersal trawl fishery contributed as much as 90% of South Africa's overall fish landings by value, but this contribution declined to 60% during the 1990s because of a shift in focus to mixed-species fisheries and increased landings of the by-catch from this fishery. Demersal trawling (dragging) is a non-selective fishing method, yielding a high proportion of by-catch and causing extensive environmental degradation to the seabed. Long-line fishing is less destructive of the marine environment (although more dangerous to seabirds) by not affecting the seabed, targeting demersal trawl species more successfully and discards only a limited amount of by-catch. Currently, hake stocks are targeted by demersal trawl (deep-sea and inshore), long-line, and handline (from ski-boats) fishing efforts, which place considerable pressure on this resource. Since 1999, the hake resource has shown early warning signs of depletion and as a precautionary measure, the TAC has been reduced by between two thousand and three thousand tons each year since 2003. According to MCM, in 2006, the TAC was reduced by eight thousand tons with a further reduction of 15 thousand tons for 2007 and about five thousand tons for 2008. The status of the stocks and the associated environmental parameters are being carefully monitored.

The west coast rock lobster (*J. lalandii*) fishery is one of the country's oldest fisheries, dating back to at least 1875, when the first commercial processing plant was established. Commercial, subsistence and recreational fisheries target the west rock lobster (*J. lalandii*) and are managed by using combinations of TAC quotas allocated for zones along the coast, a minimum size limit, closed seasons, daily bag limits, and restricted fishing (08h00–16h00) during seasonal fishing days.

The annual commercial landings of rock lobster have decreased since the 1960s, indicating that the high landings of earlier years were unsustainable. According to DEA, during the 1990s, rock-lobsters showed a decrease in somatic growth rates, and numbers of juvenile lobsters in the population seemed insufficient to sustain a healthy fishery in the immediate future. Consequently they further reduced the total rock lobster quota, reducing the TAC to about half that of the 1980s. Currently, the exploitable biomass (all rock lobsters with carapace length greater than 75mm) is estimated to be only 5% of pre-exploitation levels and the spawning biomass approximately 20% of pristine levels. Despite this significant depletion on the west coast, the population has now stabilised and sufficient to implement a stock rebuilding strategy[4].

Compiling the physical fishery account also assists in decision-taking and policy-making. The physical accounts can track the changes in stock (exploitable biomass) over time, which indicates the effect of fisheries policy on the stock when depletion is occurring. As the stock of the various fisheries becomes depleted so will the catches also decrease with the implementation of TAC. With the use of the physical accounts when TAC is included in the fishery accounts trends in catch, stock (exploitable biomass) and TAC could be compared to see how fisheries managers have responded to changes in fish stocks.

[4] Department of Environmental Affairs and Tourism, 2007. South Africa Environment Outlook, a report on the state of the environment.

With time trends from the various components measured and presented in the physical accounts, an understanding of a fishery from an economic perspective can develop. For example, a highly volatile stock of a particular fishery will often have a highly volatile catch or TAC, which in turn can make the industry unattractive for investment, affecting the economic efficiency of fishing[5].

A possible future tool for the enhancement of measuring the economic effects of fisheries through the analysis of fishery accounts is to make use of Supply and Use Tables. For fisheries stock (exploitable biomass), it is important to be able to translate the impact of a change in final demand into a change in inputs (for example catch) rather than translating this impact into changes of output. For example, if there is an increase in the final demand of fishing produced, it would be useful for decision-taking and policy-making to quantify the effect it will have on the fish stock coming into the market.

Further studies need to be conducted in this area to strengthen the links between the National Accounts and the fishery accounts.

7. Conclusion

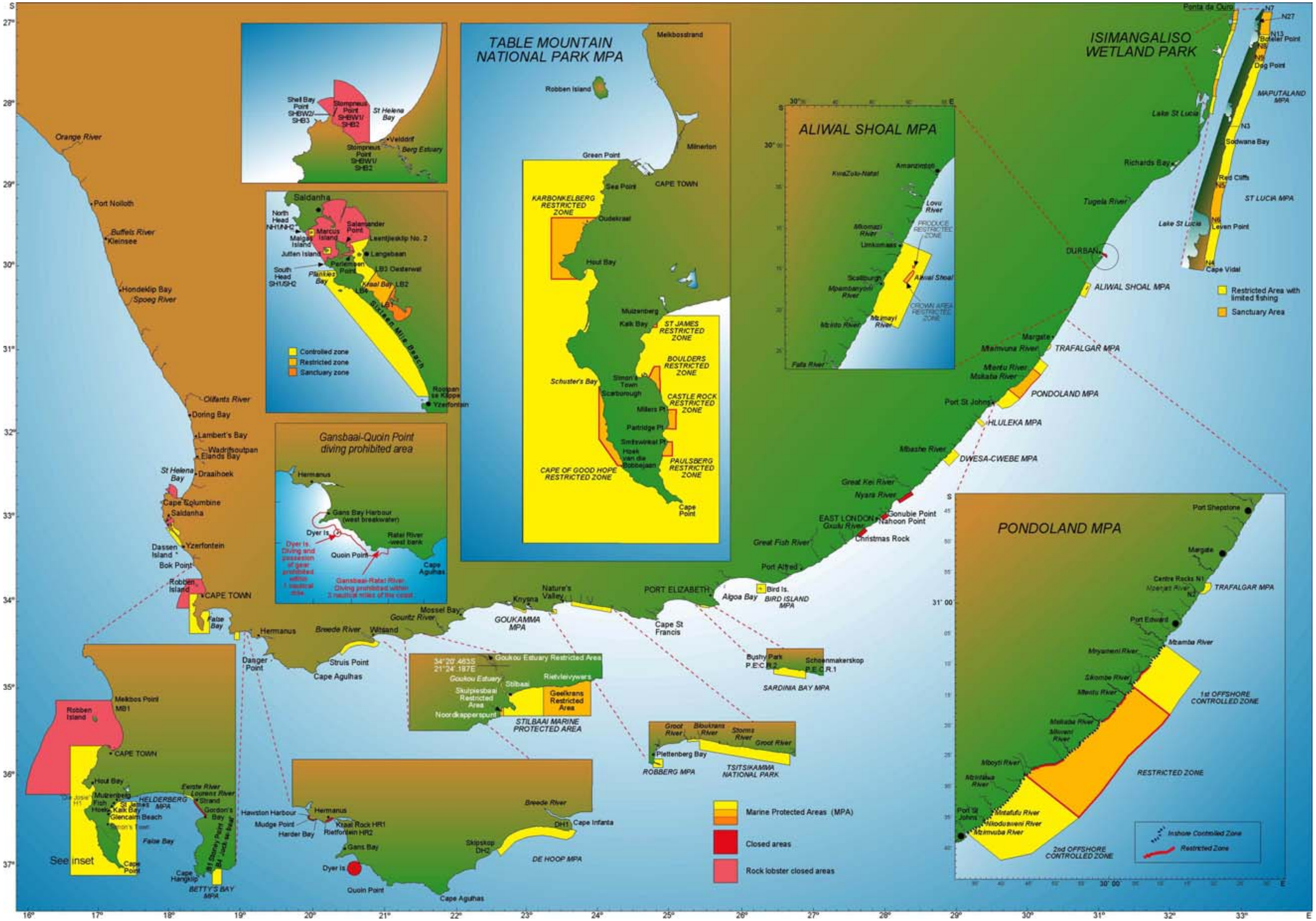
According to DEA, at an international level, the marine and coastal environment of South Africa is considered to be in a moderately healthy state, mostly because of strong management measures implemented in the past decade. Important management measures recently introduced to South Africa's marine conservation include:

- Improvements in many of the regulations governing the marine environment;
- Allocation of long-term (8 to 15-year) fishing rights;
- Transformation (that is, redistribution of fishing rights to historically disadvantaged individuals);
- Legislation preventing vehicles from driving in the coastal zone;
- Proclamation of four new Marine Protected Areas (MPA) and the proposal for a fifth (refer to Figure 5);
- Purchase of four new marine patrol vessels to improve protection of the marine environment; and
- Greater emphasis on public awareness and education.

There are 21 MPA that were declared (refer to Figure 5) along with Walker Bay Sanctuary that is operational for 5 months of the year only. Nineteen of these MPA were declared[6] in 2000 along with four added in 2004 (Aliwal Shoal, Table Mountain, Pondoland and Bird Island). Stilbaai was included in 2008. For management purposes the Malgas, Jutten and Marcus Islands are seen as one MPA. Mkambati falls under the Pondoland MPA and Castel Rock falls under the Table Mountain MPA.

[5] United Nations Statistics Division, 2004. Integrated environmental and economic accounting for fisheries.
[6] Government Gazette, 29 December 2000: No. 21948

Figure 5: Marine Protected Areas (MPA)



Source: Marine and Coastal Management

Implementation of such management measures has directly and indirectly benefited the marine environment, with overall improvement in some industries of the marine and coastal environment since the 1999 National State of Environment report. The pelagic resource, particularly sardines, appears to have recovered from a depleted state in the late 1960s; several mariculture ventures are proving to be potentially successful; and awareness and demand has increased for access to non-consumptive marine resources (whale and shark viewing). Certain fish species, however, particularly linefish and abalone, continue to decline dramatically, and they require immediate intervention. Other issues of concern for the marine environment have recently arisen or continue to pose severe threats, namely:

- Increasing uncontrolled coastal development leading to habitat degradation and changing land-use patterns;
- Substantial increases in the amount of wastewater discharged into the marine environment; and
- Reduced freshwater flow having a harmful effect on estuaries and the associated species dependent on this sheltered environment.

As already discussed in section 3.1 there is increasing evidence that global climate change is beginning to affect South Africa's marine environment. Over-exploitation of natural resources (wild stocks) from the ocean and coastal zone is still, by far, the single greatest threat to the marine environment. Exploitation of marine resources started to increase in South Africa in the mid-1960s, peaking in the mid 70s (refer to Figure 3). Catch rates at this level were unsustainable and have declined considerably since then. With decreasing catch rates, alternative marine resources have been sought, including squid, octopus, and seaweed, and marine 'farming' (mariculture) has developed more intensively (DEAT, 2007).

Improved regulations governing the marine and coastal environment now require focused enforcement efforts, to assist in rebuilding stocks and maximising the long-term, sustainable potential of its socio-economic contribution. The physical fishery accounts can be used most successfully in complementing the monitoring and managing of the South African fish resources. With further development, the accounts can be expanded to include other fisheries of South Africa and along with further studies into the use of the Supply and Use Tables to measure the economic effects of the fisheries and this will improve the usefulness of the fisheries accounts as a policy document.

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Glossary

Term	Description
Account	An account is a tool which records, for a given aspect of economic life, (a) the uses and resources or (b) the changes in assets and the changes in liabilities and/or (c) the stock of assets and liabilities existing at a certain time; the transactions accounts include a balancing item which is used to equate the two sides of the accounts (e.g. resources and uses) and which is a meaningful measure of economic performance in itself.
Bayesian model	In statistics, Bayesian model comparison is a method of model selection based on Bayes factors. It is commonly interpreted as an alternative to hypothesis tests.
Commercial fishing	Commercial fishing refers to the harvesting of fish, either in whole or in part, for sale, barter or trade.
Crustaceans	A group of mainly aquatic invertebrates with a hard exoskeleton, two pairs of antennae and jointed, double-branched limbs. Crustaceans grow by moulting (or shedding) their hard exoskeleton and forming a new one. Most crustaceans have gills, although smaller forms breathe directly through their exoskeleton. Examples are crabs, lobsters, prawns, sea lice and barnacles.
Echinoderms	Exclusively marine invertebrates with an internal skeleton of calcareous plates that often bear spines. Echinoderms have a unique hydraulic water vascular system which operates tube feet used for feeding and locomotion. Their bodies are generally radially symmetrical with the body divided into five parts around a central axis. Echinoderms are nearly all bottom dwelling. Examples are star fish, feather stars, brittle stars, sea urchins and sea cucumbers.
Elasmobranchs	Fishes, whose internal skeleton is mainly cartilaginous, sometimes calcified but never ossified. Their skull is without sutures. Elasmobranchs have placoid scales and their upper jaw is not fused to the cranium. They have numerous teeth that are not usually fused to the jaws and are replaced serially. Elasmobranchs have a spiracle (respiratory pore) and five to seven separate gill openings on each side, no swim bladder and males bear claspers for internal fertilisation. Examples are sharks, skates and rays.
Environmental Economic Accounting (EEA)	EEA brings together economic and environmental information in a common framework to measure the contribution of the environment to the economy, and the impact of the economy on the environment.

Term	Description
Environmental indicator	An environmental indicator is a parameter, or a value derived from parameters, that points to, provides information about and/or describes the state of the environment, and has a significance extending beyond that directly associated with any given parametric value. The term may encompass indicators of environmental pressures, conditions and responses.
Exploitable biomass	Refers to that portion of a stock´s biomass that is available to the fishing gear.
Molluscs	A group of mainly aquatic invertebrates with a soft, unsegmented body and often a shell. Most have a radula, a large muscular foot and a fleshy mantle covering the internal organs which, in some forms, secretes a thin shell. Most forms possess one or two gills. Examples are oysters, scallops, abalone, periwinkles, limpets, cuttlefish, squid and octopus.
Monetary accounts	Provide a basket of measures that describe the economic and welfare impacts of water supply and use.
National accounts	National accounts are a coherent, consistent and integrated set of macroeconomic accounts, balance sheets and tables based on a set of internationally agreed concepts, definitions, classifications and accounting rules. National accounts provide a comprehensive accounting framework within which economic data can be compiled and presented in a format that is designed for purposes of economic analysis, decision-taking and policy-making.
Natural Resource Accounting	Natural Resource Accounting is an accounting system that deals with stocks and stock changes of natural assets, comprising biota (produced or wild), subsoil assets (proved reserves), water and land with their aquatic and terrestrial ecosystems. It is frequently used in the sense of physical accounting as distinguished from monetary (environmental) accounting.
Natural resources	Natural assets (raw materials) occurring in nature that can be used for economic production or consumption. The naturally occurring assets that provide use benefits through the provision of raw materials and energy used in economic activity (or that may provide such benefits in future) and that are subject primarily to quantitative depletion through human use are subdivided into four categories: mineral and energy resources, soil resources, water resources and biological resources.
Pelagic	Relates to communities of marine organisms that belong to the open sea, living free from direct dependence on the sea bottom or shore.

Term	Description
Physical accounting	Natural resource and environmental accounting of stocks and changes in stocks in physical (non-monetary) units, for example, weight, area or number. Qualitative measures, expressed in terms of quality classes, types of uses or ecosystem characteristics, may supplement quantitative measures. The combined changes in asset quality and quantity are called volume changes.
Satellite accounts	Satellite accounts provide a framework linked to the central accounts and which enables attention to be focused on a certain field or aspect of economic and social life in the context of national accounts: common examples are satellite accounts for the environment, tourism or unpaid household work.
Spawning biomass	The total weight of all sexually mature fish in a population.
System of Integrated Environmental and Economic Accounting (SEEA)	Satellite system of the System of National Accounts (SNA) proposed by the United Nations (1993a) for the incorporation of environment concerns (environmental costs, benefits and assets) into national accounts.
Teleosts	Fishes whose internal skeleton is constructed mainly of true bone. Their skull is sutured and the teeth are usually fused to the jaw bones. The posterior tip of their vertebral column turns upwards and terminates in a bony plate. Their scales are usually thin and bony. Teleosts have external nostrils, a single gill opening on each side, and usually have a swim bladder or lung. Examples include sardines, eels, bream and tunas.
Trawl	A conical fishnet dragged through the water at great depths.
1993 System of National Accounts	The revised (1993) system adopted worldwide for conventional economic (national) accounting (Commission of the European Communities and others, 1993).

Annexure 1: Methodological notes

This section focuses on the methodology for compiling physical fishery accounts according to the System for Integrated Environmental and Economic Accounting for Fisheries (SEEAF).

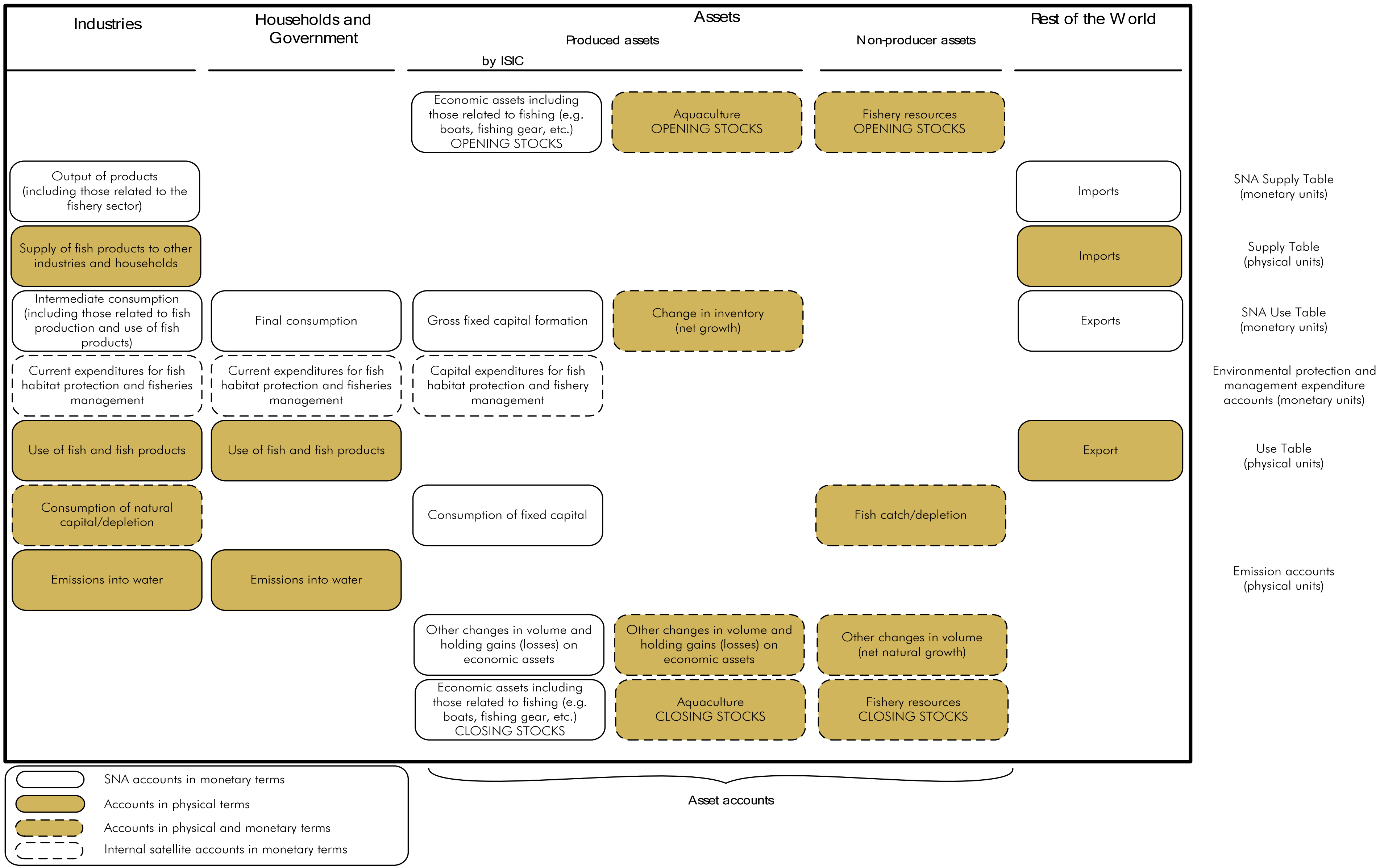
1.1 The System for Integrated Environmental and Economic Accounting for Fisheries

The SEEAF was developed with the purpose of expanding the System of Integrated Environmental and Economic Accounts (SEEA). The main objectives of the SEEAF are to:

- clarify the 1993 System of National Accounts (1993 SNA) and SEEA concepts and expand them for fisheries and related resources;
- harmonise accounting practices for fisheries so that accounts are comparable across all countries;
- promote accounting for the fisheries industry; and
- provide a guide and a training tool.

Figure 6 gives a simplified representation of the SEEAF accounting framework for fishery resources.

Figure 6: Framework for Integrated Environmental Economic Accounts for Fishery resources



Source: *Integrated Environmental and Economic Accounting for Fisheries*

Figure 6 displays how the horizontal supply and use accounts overlap with the vertical asset accounts, where supply and use constitute part of the changes in stocks of the assets.

The fishing industry has several unique characteristics that are relevant to the construction of SEEAF accounts:

- Wild stocks might migrate between different countries' exclusive economic zones and the open seas, which are international waters. These straddling and migratory stocks pose special challenges for management and accounting since they do not occur exclusively in one country's economic territory.
- The treatment of catch differs according to whether the stock is cultivated or non-cultivated.
- The abundance and health of wild fish stocks are increasingly affected by water pollution and by the degradation of fish habitats so that fisheries management requires some accounting for these related resources.

1.2 Asset classification for aquatic resources

The SEEA asset classification for aquatic resources covers fish, shellfish and other aquatic resources such as sponges and seaweeds as well as aquatic mammals such as whales as follows:

- EA.143 Aquatic resources;
- EA.1431 Cultivated
  - EA.14311 For harvest
  - EA.14312 For breeding; and
- EA.1432 Non-cultivated.

The SEEAF focuses mostly on accounting for fisheries resources and only briefly touches upon ecosystem accounts.

Aquatic resources distinguish between cultivated assets and non-cultivated assets. The SEEAF considers all farmed aquatic organisms to be cultivated assets, and all types of wild, enhanced and ranched fish stocks as non-cultivated, also known as 'capture fisheries'.

A cultivated asset is a result of a production process, which in the 1993 SNA context does not consist of just legislative control. Examples of production are:

- Control of regeneration (for example, controlling the fertility of the fish); and
- Regular and frequent supervision of the fish, attending to illnesses, or restrict the area over which fish might roam to be within a supervised or otherwise designated area.

The process of production should be classified to the fishing industry. It is not sufficient that it only be part of government administration. Further, the level of this production activity has to be significant relative to the value of the resource and directly connected with the fish stock in question.

Like the 1993 SNA, the SEEAF separates cultivated resources into those used exclusively for breeding and those raised for harvest, although it is not very common to keep fish purely for breeding purposes. Fish-for-harvest that mature over more than one year are treated as inventories, a work-in-progress.

1.3 Physical asset accounts

The physical asset accounts show the fish stocks at the beginning and end of the accounting period and changes therein.

Structure of physical asset accounts

The components of stock accounts for each category of fishery resources are shown in Table 4.

Table 4: Framework for physical asset accounts for aquatic resources in the Integrated Environmental and Economic Accounting for Fisheries[7]

EA. 1431 Cultivated aquatic resources		EA. 1432 Non-cultivated aquatic resources
EA. 14311 For harvest	EA. 14312 For breeding	
Opening stocks	Opening stocks	Opening stocks
Change in inventory/growth	Net growth of breeding stock	Catch
Other changes in volume of assets (catastrophic losses)	Other changes in volume of assets (catastrophic losses)	Other changes in volume of assets (net natural growth + catastrophic losses)
Closing stocks	Closing stocks	Closing stocks

Source: *Integrated Environmental and Economic Accounting for Fisheries*

The accounting period is typically one year, corresponding to the accounting period for the national accounts. 'Opening stocks' record the volume in tons at the beginning of the accounting period, and 'Closing stocks' record the volume at the end of the accounting period. Changes in stocks during the year are divided into:

- Changes that result from economic activity (changes in inventory, net growth of stock, or catch); and
- Changes due to other factors (other changes in volume).

[7] Measured in tons or other physical units.

The role of economic activity is different for cultivated and non-cultivated fisheries, so the treatment of common items such as 'catch' and 'natural growth' differs for the two categories of fish.

For cultivated assets, stock raised for harvest over a period more than one year is treated as work-in-progress, so the changes in stocks are recorded as 'changes in inventories'. For cultivated assets kept as breeding stocks, annual changes are measured as the 'net growth of the breeding stock', which is equivalent to gross fixed capital formation minus consumption of fixed capital (losses of breeding stock). 'Other changes in the volume of assets' include catastrophic losses due to, for example, environmental events or disease, uncompensated seizure, and other factors that are not directly related to economic activity.

For non-cultivated (wild) assets, the source of change resulting from economic activity is the annual 'catch'. 'Other changes in volumes of assets' include: catastrophic losses but also the net natural growth of the stock (births or recruitment minus natural mortality). The reason for including net natural growth as part of 'other changes in volume' is that this growth is not under the control or management of economic agents, in contrast to cultivated fish stocks.