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## **REVIEW AND ANALYSIS OF THE STATUS OF ABALONE (*Haliotis midae*) FISHERY IN SOUTH AFRICA**

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### ABSTRACT

The abalone (*Haliotis midae*) fishery is one of the important single species fisheries and is one of South Africa's most valuable fisheries per unit of harvest. Abalone commercial fishing sector in South Africa was formally recognized as one of the official fisheries sectors in 1998 through the Marine Living Resource Act (MLRA) Act 18 of 1998. It is based on the South and West coasts and a TAC of 150 tons is currently allowed since the re-opening of the fishery after it was closed for 2 years from 2008 to 2010. The industry is worth around R70 million per annum with approximately 100 vessels involved. This industry supports about 950 employees. In this paper, a review and assessment of the status of the fishery was done by looking at the abalone policy objectives for the Long Term Fishing Rights Allocation Process and examine the status of those specific policy objectives. In addition, a general assessment of the fishery focusing on important topical issues was conducted. Since the implementation of MLRA, a reasonable progress has been made towards legalizing and management of abalone fishing industry, but the major threat of escalating reports of illegal fishing or poaching has a detrimental effect to the resource. Most of the abalone (legal and illegal) is exported to the Far East. Political changes in South Africa i.e. the end of apartheid regime added both urgency and expectations of broadened access and might have prompted those that were disappointed by the outcome of the process of rights allocation to join illegal fishing. There are currently 303 authorized commercial abalone right holders as opposed to 5 right holders prior to the transformation process, with a further number of people directly depending on this fishery to meet the basic requirements for living.

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## 1. INTRODUCTION

South Africa is located on the southern tip of the African continent. The country is well endowed with marine resources with a 3 623 km coastline and a 200 nm Exclusive Economic Zone (EEZ) (FAO, 2010). For management and administrative purposes, the coastline is divided into West coast region, South coast region, East coast region and KwaZulu Natal (KZN) (Figure 1). The coastline spans two ecosystems, the Atlantic Ocean on the west to the border with Namibia and the Indian Ocean on the east to the Mozambique border (Sowman, 2006). The western coastal shelf has highly productive commercial fisheries similar to other upwelling ecosystems around the world, while the east coast is considerably less productive but has high species diversity (Hutchings, *et al.*, 2009).

The South African coast provides substantial opportunities for economic and social development. However, the resources are at risk from inappropriate developments, pollution, poaching and over use (GCIS, 2012). The most lucrative fish species and industrial fisheries are concentrated on the West coast region. While South Africa (together with Namibia) is considered the largest fishing nation in Africa, it ranks only at 30th place on a world scale with a production of 583 000 tons in 2009 (FAO, 2010). The contribution of the entire industry (fishing, processing and aquaculture) is considered to be less than 1 % of GDP, although in the province of the Western Cape, home to more than 90 % of the fishing industry, the share is higher. The fishing industry has an estimated wholesale value of over R4.4 billion (WWF, 2011). The commercial and recreational fishing industry is valued at approximately R4-5 billion annually and provides employment for an approximately 43 000 people, including seasonal and permanent employment, both land-based and sea-going (FAO, 2010). The annual revenue from commercial fisheries exports from South Africa was estimated at R3.1 billion in 2008 (WWF, 2011).



Figure 1: Geographic location of South Africa with EEZ (dotted line).

At the end of the apartheid era, the need to profoundly change in South Africa's economy and society became the focus of government policy. A key part of this transformation involved redistributing resources more equitably amongst the country's different demographic groups (South African Constitution, 1996). Although access to fishing rights was not officially effected by apartheid, the political system limited majority groups' ability to acquire sufficient capital or expertise to enter the fishing sector or make full use of rights (ANC, 1994). In 1994, less than 1% of the total allowable catch (TAC) for commercial fisheries was allocated to historically disadvantaged persons (HDPs) of black origin (Policy Brief, 2005). With the democracy, HDPs sought greater access to fisheries resources. However, changes to the rights allocation system, which were intended to transform the fishing industry, have caused dissatisfaction among many fishers. The declines in key stocks, in conjunction with small quota sizes and access rights have been alleged to have contributed to growing poverty and unemployment, and a loss of social cohesion in the fishing communities of South Africa (Policy Brief, 2005).

### **1.1 Significance of the research**

This research will contribute towards the review and assessment of the status of South African abalone commercial fishing industry as a result of the development and implementation of Marine Living Resources Act (MLRA), Act 18 of 1998 and abalone fisheries policy. The research will also review the policy objectives that were set in the policy for the allocation of long-term fishing rights in the abalone fishing sector. Sound management actions that are meant to responsibly manage fisheries should also seek to take into account issues of performance in relevant fishing sectors. The current management tools will also be investigated to establish if they are in line with the principle of those objectives. The findings of the overall research will assist fisheries managers to understand how the complexity in the abalone fishing industry was affected by the implementation of the abalone policy

### **1.2 Research strategies, aims and questions**

This study aims to review and assess these following policy objectives that were set in the abalone policy for the allocation of long-term fishing:

- a) Instil a culture of ownership amongst right holders and members of the respective coastal communities;
- b) Encourage right holders and members of the respective coastal communities to co-manage the abalone resource together with the Fisheries department;
- c) Ensure the long-term viability of the South African abalone fishery and;
- d) Sustain the level of employment in the abalone fishery.

The main objective is to look at the progress made with regard to addressing the mentioned abalone policy objectives. Some topical issues of importance in the general fishery will also be covered and analysed.

### **1.3 The organization of the study**

The study begins on **Section 1** by providing an introduction, which includes the significance of research, research strategies, aims and questions and the organization of the study. **Section 2** provides a background of South Africa and importantly gives a description of fishing sectors in South Africa, management of fisheries in South Africa, providing explanation of the concepts of

the determination of the TAC, granting of rights to fish, the allocation of quotas, issuing of permits to fish and an overview of commercial fisheries in South Africa and general fisheries management systems. **Section 3** covers the abalone fishery profile with specific emphases on the general abalone overview, biology of abalone, abalone lifecycle, distribution of abalone in South Africa and harvesting methods. It also describes history of abalone management in South Africa. **Section 4** provides concept of the current management of abalone commercial fishery in South Africa. **Section 5** provides a background on the threat to abalone fishery. **Section 6** provides discussion of the enforcement regime. A summary of the study and recommendations are provided in **Section 7** and **Section 8** concludes.

## 2. BACKGROUND

### 2.1 The fishing sectors of South Africa

The South African marine resources have been exploited on a subsistence level basis for approximately thousands of years (Proudfoot, 2006). The intensity of exploitation has increased over the past decades, greatly as a result of both a concentration of people into coastal areas and a rapid human population growth. In this section, extensive background for the consumption of his or her dependents, including one who engages from time to time in the local sale or barter of excess catch, but does not include a person who engages on a substantial scale in the sale of fish on a commercial basis. Subsistence fishers operate on or near to the shore or in estuaries, live in close proximity to the resource, consume or sell the resources locally, use low technology gear, and the kinds of resources they harvest generate only sufficient returns to meet the basic needs of food security (SFTG, 2000).

**Commercial fishing:** The MLRA (1998) defines a commercial fishery in South Africa as a fishery conducted with the aim of earning money for the entrepreneur, his company and its employees (DEAT, 1997). Branch, May, Roberts, & Clark, (2002a) also define commercial fishers as fishers fishing for profit and earning an income sufficient to meet more than their basic needs of life. The harvesters may employ staff or operate as profit-sharing collective groups, focus on resources that are managed by TAC or total allowable effort (TAE) and which have high value or can be caught in large quantities, and may use capital intensive high-technology gear and methods of processing. The commercial fishing sector is divided into two classes, i.e. small-scale (seaweed, bait organisms, oysters and east coast crustaceans) and industrial-scale (west coast rock lobster, the south coast rock lobster, abalone, line fish, pelagic species such as anchovy and pilchard, and demersal species like hake, which are harvested by trawling). The characteristics of the classes of the fishing sector are mentioned in Figure 2.

**Recreational fishing:** Recreational fishing is defined as fishing for enjoyment, for the sport or the relaxation it offers (DEAT, 1997). While it is difficult to quantify the recreational fishing value, its contribution to the South African economy must be substantial. These fishers receive rights to fishing through permits and there are often high disputes and conflicts arising between them and the other fishers. Recreational fishers often use high technology equipment such as ski-boats and engine boats, which clashes with the traditional fishing methods of subsistence fishers (Kashorte, 2003).

**Illegal fishing:** This refers to any activity, which contravenes industry regulations outlined in the MLRA of 1998. One of the biggest challenges in fisheries management is the control of illegitimate fishing activities that are not part of formal management structures. These activities are collectively termed illegal, unreported and unregulated (IUU) fishing. Illegal operators are more likely to catch undersized fish, or disregard other environmental impacts such as bycatch



levels and habitat destruction. Finally, because they are illegal, they evade paying taxes and levies, and are in effect being subsidized by the environment to absorb the costs of bad fishing practice they can undercut realistic market prices. This can cause instability and loss of revenue from legal and responsible fishers. Once illegal catches have been processed and have entered the formal market it becomes very difficult to distinguish these from legal products, and consumers can unknowingly be contributing to bad environmental impacts (WWF, 2011). Kashorte (2003) gave the synopsis of the characteristics of the fisheries sectors in South Africa as depicted below:

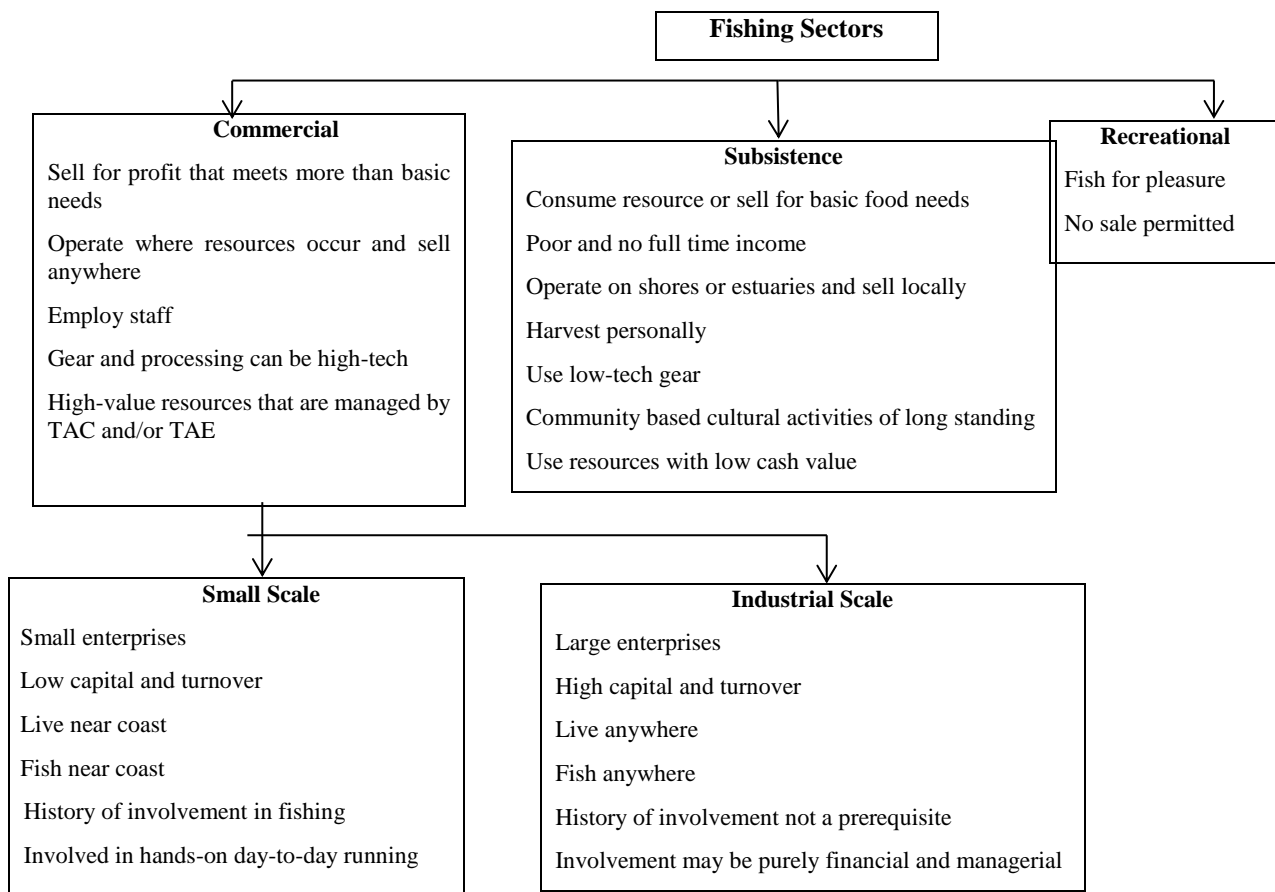


Figure 2: Synopsis of the characteristics of the fisheries sectors in South Africa.

## 2.2 Management of fisheries in South Africa

Management responsibility of South Africa's fisheries is entirely vested in the authority of the Minister of the Department of Agriculture, Forestry and Fisheries (DAFF) and in the Branch Fisheries Management formerly known as Marine and Coastal Management (MCM). MCM however underwent changes that saw the management of fisheries being transferred from the Department of Environmental Affairs and Tourism (DEAT) to the DAFF in 2009. The principal regulatory framework governing fisheries management comprises the Marine Living Resources Act, 1998 (Act No. 18 of 1998), associated regulations and specific permit conditions. The MLRA is rooted in the fisheries management principles of optimum utilization, conservation and endorsement of the precautionary approach.

South Africa is also a member of the Food and Agriculture Organization (FAO) of the United Nations (UN). The country signed the FAO's Code of Conduct for Responsible Fisheries, UN's

Convention on the Law of the Sea (UNCLOS) and UN's Framework Convention on Climate Change. In addition, the Convention on International Trade in Endangered Species (CITES) is another international co-operation and agreement that affect the abalone fishery's management and of which South Africa is a signatory to. Further, during the World Summit on Sustainable Development (WSSD) in 2002, South Africa committed itself to achieve an Ecosystem Approach in Fisheries Management (EAF) (DEAT, 2005). Currently, the country is making strides to implement EAF locally and across the region. The South African fisheries management system is based on a right/quota allocation system.

**Determination of the total allowable catch (TAC) and total applied effort (TAE):** The MLRA empowers the Minister to determine the total allowable catch (TAC), total applied effort (TAE) or a combination thereof.

MLRA (1998), defines TAC as: *the maximum quantity of fish of individual species or groups of species made annually, or during such other period of time as may be prescribed, for combined recreational, subsistence, commercial and foreign fishing in terms of section 14(1).*

MLRA (1998), defines TAE as: *the maximum number of fishing vessels, the type, size and engine power thereof or the fishing method applied thereby for which fishing vessel licences or permits to fish may be issued for individual species or groups of species, or the maximum number of persons on board a fishing vessel for which fishing licences or permits may be issued to fish individual species or groups of species in terms of section 14 (1).*

However, the Minister must be guided by the principles contained in section 2 of the ACT, which include optimal utilization of marine living resources, conservation and the precautionary approach in respect of the management of the marine resources.

**The allocation of quotas:** The Minister must further determine what portions of TAC, TAE, or a combination thereof, is to be allocated in any given year or season to subsistence, recreational, commercial and foreign fishing, in terms of section 14(2).

**Granting of rights to fish:** In terms of section 18 of the MLRA, those that want to engage in fishing, require rights from the Minister to engage in such activities. Applications for rights must be submitted to the Minister and in determining rights allocation procedure, the Minister must have particular regard to the need to permit new entrants, particularly those from the historically disadvantaged sectors of society.

**Issuing of permits to fish:** Right holders under section 18 may not exercise their right unless they have also applied and have been issued permits by the Minister in terms of section 13.

### 2.3 Overview of commercial fishery in South Africa

The South African fishing industry, which was once concentrated in the hands of a few, largely white-owned companies, has undergone intensive transformation over the past few decades (GCIS, 2012). As a result of transformation, 22 commercial fishing sectors were established, ranging from small, less lucrative to large and capital intensive fisheries (Branch *et al.*, 2002b). Following the change of government in 1994, South Africa's market opened substantially with the lifting of international sanctions. As a result, in 2009 South Africa exports of fish and fishery products worldwide amounted to US\$ 75 million, while imports of the same fish and fishery products totaled US\$ 69 million (TRAFFIC, 2010). The South African government currently regards the fishing industry as a sector for employment expansion within the country (WWF, 2011).

South Africa has codified a general overarching fishing policy, as well as the policies for each of the 22 commercial fisheries and those policies also served as key regulatory tool that guided the allocation of long-term fishing rights (Glazewski, 2009). The allocation of long-term commercial fishing rights in South Africa occurred in 2005/2006 for periods ranging between 8 years and 15 years across fisheries (DEAT, 2008). Feike (2008) reported that the policy for allocation of long-term commercial fishing rights was based on the following four core considerations:

**Broad based black economic empowerment:** Applicants were evaluated on their empowerment or transformation credentials. Specific criteria included measuring black ownership and control, representatively of blacks and women at all levels of the organisation, ownership of equity by workers, corporate social investment, affirmative procurement and compliance with employment equity and skills legislation;

**Biological considerations:** The allocation of fishing rights occurred within a biologically determined and sustainable management framework;

**Ecological considerations:** South Africa, together with all other fishing nations are bound by the Johannesburg Plan of Implementation adopted at the World Summit on Sustainable Development to measure the impacts of fishing on marine ecosystems and to mitigate against such impacts; and

**Socio-economic considerations:** There are two important components to this consideration. First, sustainable fisheries management must ensure that the manner of management must sustain an environment that is conducive to growth and investment. Second, fisheries must play a crucial role in fulfilling the socio-economic objectives of job creation, poverty elimination and empowerment along the coast.

The introduction of the MLRA of 1998 required the state to restructure the fishing industry to address historical imbalances and to achieve equity within all branches of the fishing industry (Sauerr *et al.*, 2003). It also required the need to utilise marine living resources to achieve economic growth, human resource development, capacity building within fisheries and mariculture branches, employment creation and a sound ecological balance consistent with the development objectives of the national government. Each commercial fishery sector therefore has a clear policy that provides guidelines for the issuing of fishing rights as well as a strategy designed to secure transformation of the fishing industry through a balance of maintaining an environment in which large companies would continue to invest and small companies would be able to develop (FAO, 2010).

Fisheries policy is founded on two principles: (a) that fisheries resources belong to all of South Africa's people and (b) that these resources should be utilised on a sustainable basis (FAO, 2010). Numerous policy initiatives may influence the governance of fisheries apart from those established for each fishing sector when rights were allocated. Also, fundamental to the governance of fisheries, the allocation of rights is now supported by a Rights Transfer Policy (DEAT, 2008) which allows the right holder to apply to the department for the right to be transferred to another right holder.

In addition to the commercial fishing quotas, authorisations were issued to subsistence fishers who fish for resources such as line fish, mussels, abalone, east coast rock lobster and oysters for purposes of food security (DEAT, 2007). Furthermore, over million people were allowed to fish on a recreational basis for line fish and other game fish species along the South African coast either from the shore or from ski-boats, which are easily launched into the sea from either small landing sites or from the beach into the surf (DEAT, 2009).

South Africa's commercial fisheries are generally well organised and the wild capture fisheries include commercial, recreational and subsistence fisheries, each with their own specific research and management mandates (WWF, 2011). The fisheries are organised into recognised industrial bodies that represent their members' interests on important bodies such as fisheries research and management working groups that advise the Fisheries Management heads of research and fisheries management on a range of matters.

Cabinet introduced the idea of reviews in the sector policies in order to ensure that right holders continued to perform satisfactorily throughout the duration of the rights, some as long as 15 years (Sauer *et al.*, 2003). These sector policies envisage that the department should conduct periodic performance measuring exercises. In light of the sector policies, permit conditions issued to right holders after the long-term rights allocation process (LTRAMP) requires right holders to participate in the review and to co-operate.

The sector policies state that the performance reviews are to ensure that the objectives of the fishery are being met in terms of maintaining or improving transformation, the creation of an environment for investment and job creation, supporting the economic viability and environmental sustainability of the fisheries, and that management methodologies and procedures remain suitable. Out of the 22 commercial fishing sectors, abalone, KZN beach seine, oysters, white mussels, tuna long line and swordfish long line sectors were not part of the performance review process. It is for that reason that it was decided to review and assess the abalone fishing sector on the basis of the policy principles and objectives.

All the fishing sectors are designed to act for the benefit of fishing people, their communities, and fishery and secondary industries thus involving political issues, enforcement of fishing, management rules and regulations (Svavarsson & Kristjánsson, 2006). An appropriate fisheries management regime is therefore a target for all the sectors and should render high profits in the long-term. There are essentially two types of fisheries management systems, biological fisheries management systems and economic fisheries management systems (Arnason, 1996). The characteristics of fisheries management systems are defined in Appendix 2. These are supposed to answer such questions such as: How shall the stock be managed? Should the fishing pattern be changed and if yes, how? Should it aim at more, less, big fish, small fish, mature fish, immature fish etc.?

### **3. THE ABALONE FISHERIES**

Humans around the ocean coasts of the world have exploited abalone. Abalone forms a major fishery in countries such as Australia, South Africa, Mexico, Japan, United States, New Zealand, Korea, Taiwan, Philippines, China, Chile, France and Thailand, which benefit from the great demand and their high price on international markets (Shepherd *et al.*, 1992). Large-scale exploitation of abalone has resulted in the depletion of wild stocks and therefore, the worldwide harvest of abalone has been declining (Glazewski, 2009). Many abalone fisheries had collapsed, and the remaining abalone stocks are put under greater pressure (Gordon & Cook, 2004). The reasons behind stock collapses are varied, but they may be linked to excessive fishing pressure on the resource, inappropriate management regimes, inadequate enforcement policies, pollution, natural recruitment failure, habitat loss and disease (UNU-FTP Course unpublished, 2012/13).

In the last 20 years, the commercial catch of abalone worldwide has declined from 18 000 metric tons to a little over 10 000 metric tons (FishTech, 2009). FishTech (2009) had identified the illegal harvesting as by far the largest and most important reason for the decline. This refers to some people that ignore the regulations enacted to protect abalone. FishTech (2009) also had

listed the 5 more major reasons for the decline of abalone stocks around the world, and they are:

- a) Predation: Sea otters (major abalone predators) expanded their range virtually eliminating fisheries for abalone and other invertebrates.
- b) Mortality of small abalone for many reasons.
- c) Over harvesting: Abalone are easily over harvested because of slow growth and variable reproductive success. Initial high harvests cannot be sustained.
- d) Competition: Sea urchins and other species, utilizing abalone food and living space.
- e) Loss of habitat: Coastal development and pollution have ruined large areas of abalone habitat.

In addition, TACs have gradually been decreasing in almost every remaining abalone fishery in the world (Heasman, 2006). Over-exploitation of abalone, and the resulting threats, is therefore not limited to South Africa.

### **3.1 Abalone commercial fishery profile in South Africa**

The abalone commercial fishery is one of South Africa's most valuable fisheries per unit of harvest and while the fishery is among the smallest in South Africa with respect to yield, it is the most lucrative in terms of unit value (Stuttaford, 2001). The escalation in illegal fishing is having a detrimental effect on the resource (FAO, 2010). The abalone industry is worth approximately R70 million per annum (Van Zyl, 2010). Van Zyl (2010) reports that there are currently about 100 vessels engaged in abalone fishing with a value of approximately R25 million and this industry supports about 950 employees. The abalone fishery contributes towards the livelihood of the coastal communities and also it's an important source of income for the people who live along the coastline of the Western Cape Province. Reductions in the TAC of around 100 tons represent an estimated loss of at least R13 million to the fishing industry (Van Zyl, 2010).

Abalone is a highly prized seafood delicacy and markets have been established over many years of fishing, in the Far East, especially Hong Kong and China where it is exported to (Cook, 2000). The product is very sought after and the recent high price consumers are prepared to pay for the product that creates a perceived value. The sale of abalone yields high economic returns and hence it has attracted the interest of many including poachers.

In general, the economic performance of the global marine fishery is determined by many factors which include, the quality and quantity of fish caught, the price of fish, harvesting costs, and the biological productivity of fisheries (The World Bank, 2009). The demand for the abalone resource explains the huge illegal supply to the market. The poverty and need for food security may have contributed to the illegal fishing. The right holders sell their catch to those processing companies that hold separate processing and subsequently export permits.

### 3.2 Biology of Abalone

Abalone is a common name for a group of small to very large edible sea snails, marine gastropod molluscs in the family Haliotidae. Abalone, a slow growing and late maturing species has about 100 different species, all belonging to the same genus, *Haliotis*. They live attached by their large and well-developed muscular foot to the rocks at the intertidal and subtidal zones (Godfrey, 2003). The foot muscle is also used for locomotion in the form of slow gliding motions over the substrate. The flesh of abalone is widely considered to be a desirable food, and is consumed raw or cooked. Abalone broadcast spawn, releasing their reproductive products into the ocean where eggs or sperm are released into the same area where the gills and anus are located (Godfrey, 2003). The shells of abalone species are rough, flat and ear shaped, which protects them from wave action (Figure 3). On the inside their shells are smooth and shiny to protect the abalone's soft flesh from damage. Abalones expel water that has passed through their gills through the rows of small holes or pores along the edge of their shells (Tarr, 1989). As abalones grow, these holes progressively close-up, with usually only the last four to six holes remaining open when they reach full-size.

Abalone are capable of moving significant distances, but they only move when forced to by space, food limitations or disturbance (Tarr, 1992). They generally live in shallow water, close to the shoreline where their algae is most commonly available, and their natural distribution is unlikely to change rapidly, making them a predictable target (Godfrey, 2003). The larger individuals aggregate in high density beds associated with spawning behaviour, or possibly in response to food availability or other environmental factors (Tarr, 2000).



Figure 3: Live individuals and shells of Abalone *Haliotis midae*.

In South Africa, abalone is an important grazer in the marine ecosystem, especially in the kelp beds of the south-western Cape, where it occurs in highest densities (Tarr, 1989). It is an herbivorous, dioecious broadcast spawner and can reach a maximum age of 30 years on the west coast (Branch *et al.*, 2002b). Being a broadcast spawner and dioecious, it depends on the proximity of conspecifics for successful reproduction (Tarr, 1989). Furthermore, it has a commensal relationship with sea urchins, juvenile abalone acquiring a refuge from predation by fish and rock lobsters under the spines of the urchins (Day, 1998).

### 3.3 Abalone lifecycle

Female abalone can produce millions of eggs each year and the eggs are released into the water, where sperm released by male abalone fertilizes them. The fertilized eggs hatch into organisms called larvae. After about a week (depending on water temperature) the tiny larvae develop into small juveniles often called spat and settle onto rocks. Abalone take about four years to reach

legal size to be collected, which gives females at least two spawning seasons before they can be harvested.

### 3.4 Distribution of Abalone in South Africa

The South African abalone or perlemoen as it is known locally, occurs mainly in the inshore rocky areas from Cape Columbine in the West Coast to Cape Agulhas as well as off the East Coast (Figure 4) (Glazewski, 2009). The biogeographic region of abalone extends to the Eastern Cape Province but the commercial fishery is restricted to the Western Cape Province, with the major resource biomass occurring historically in the area between Cape Hangklip and Quoin Point (Raemaekers, *et al.*, 2011). In this area the resource has been in existence since 1949 as an open access fishery and is characterized by high catch rates and strict regulation (Tarr, 2000).

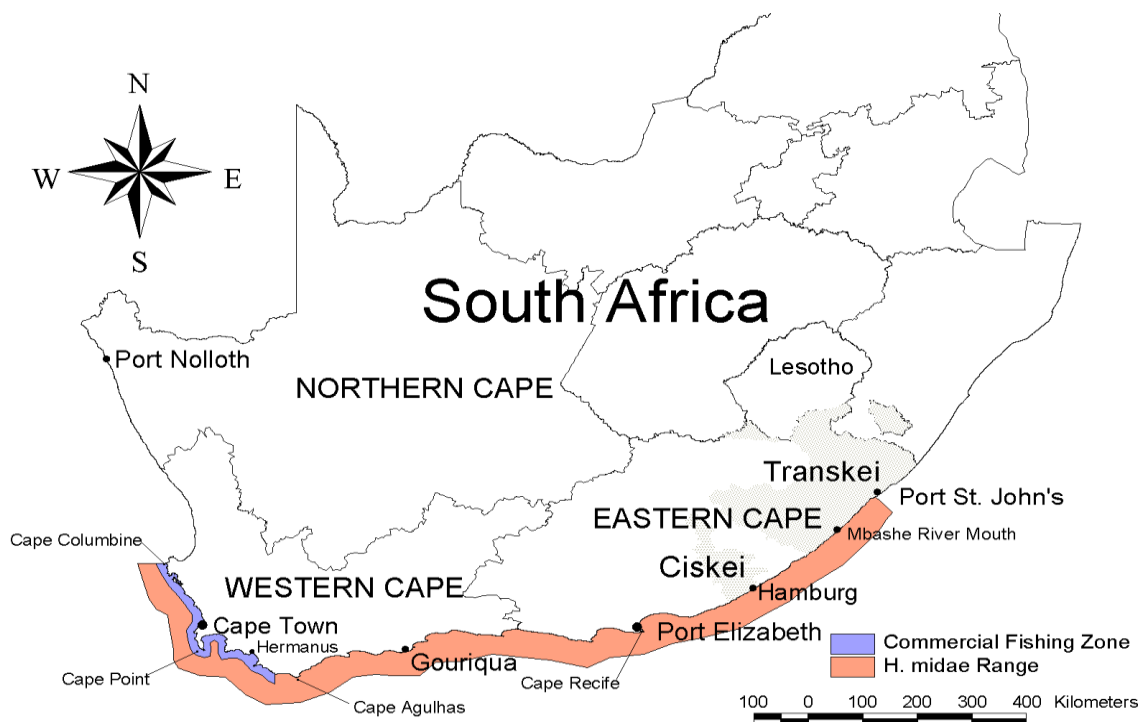


Figure 4: A map of South Africa with provinces outlined.

Sweijd (1999) documented a major genetic discontinuity at Cape Agulhas, which is also seen as an important biogeographic boundary separating the South African coastline into the West and East Coasts. Importantly, the abalone populations in the Eastern Cape Province are considered to be patchily distributed, which is almost certainly dictated by the availability of suitable substrate (Wood, 1993). The length of the Eastern Cape Province coastline, poor access to many parts and unpredictable sea conditions also make diving surveys difficult to perform (Tarr, 2000).

### 3.5 Abalone Harvesting Methods

The current harvest strategy for the South African abalone fishery was designed in accordance with the specific goal to implement a precautionary approach to managing the fishery and to set the TAC at sustainable levels. In terms of the regulations of the abalone fishing sector, authorized divers are permitted to utilize a surface-air supply hookah system, which consists of a breathing pipe feeding compressed air from a compressor on the vessel to harvest abalone. Only the use of an air-hose not exceeding 60 metres in length, is permitted when undertaking commercial fishing of abalone. It is a very simple system with a skipper and two deckhands, assisting the diver, on the vessel. The deckhands monitor the compressor and will indicate air supply to the diver. A new development in the system is a second stage demand valve whereby the diver can control air consumption on demand. Fishers used to dive for abalone from 4 to 6 m fibre-glass rowing boats, but were later replaced by twin-engine ski-boats with a crew of 4 to 6 persons (Raemaekers, *et al.*, 2011). The abalone fishery is primarily a day fishery and vessel launching and landing of catch occur during the day.

### 3.6 History of Abalone Management in South Africa

The South African abalone has been exploited on a commercial scale and an organized fishery has existed for over decades (Tarr, 1992). The commercial fishery is based on a zone system where the area is divided into seven primary zones (Zones A-G) which are further subdivided into secondary zones i.e. A1, A2, A3 (Figure 5). The purpose of splitting the zones into smaller secondary zones is to assist with compliance and monitoring and to instill a sense of ownership amongst right holders over the secondary zone and abalone in that zone, each designated its own TAC (Raemaekers, *et al.*, 2011). Right holders are granted the rights to the specific zones. The most intensively fished areas have traditionally been zones A-D (Figure 5). The history of the fishing sector is complex (Stander, 1995) mainly due to the significant increase in organized black market trade in abalone since the mid-1990s, and the impact of ecological factors that have resulted in the increased predation of juvenile abalone (Cockcroft *et al.*, 2008).

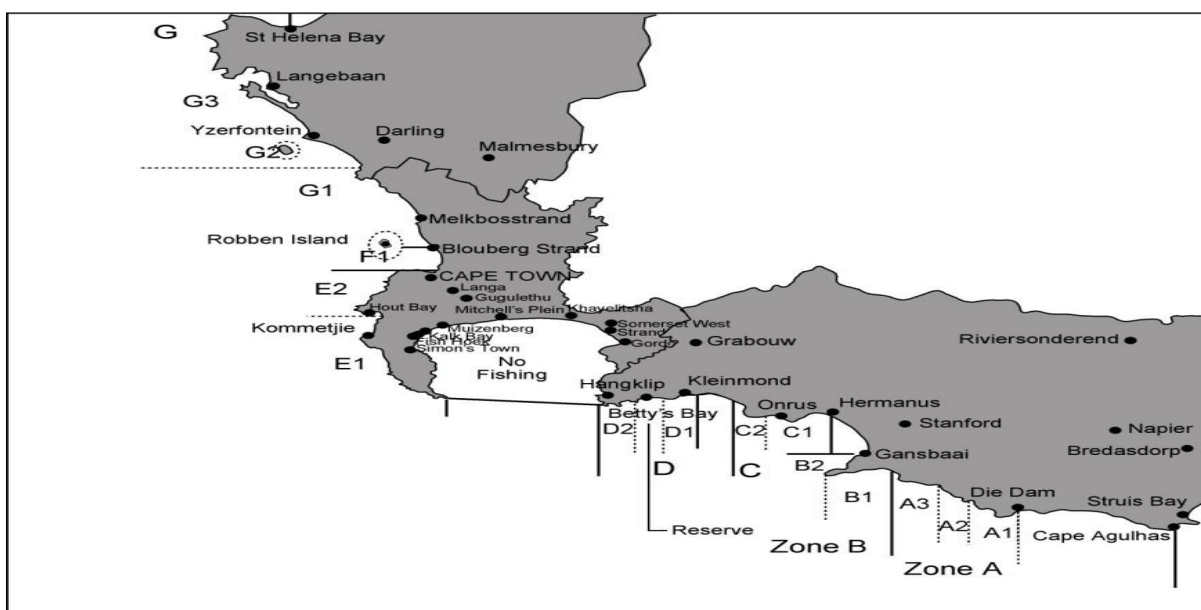


Figure 5: Seven commercial abalone zones (A-G) subdivided into secondary zones.



In South Africa, the management of the abalone resource has been based on several factors such as effort limitations, size limits (shell width of 114 mm), TACs, closed seasons and MPA's (Anon, 1998a). The minimum legal size (MLS) of 10.16 cm shell breadth, which is based on sexual maturity of the local population, allows for 3 to 4 years of protected spawning before recruit into the fishery (Tarr, 1992).

A minimum size limit of 11.43 cm shell breadth was first implemented in 1954 and before that there was unlimited fishing and catches peaked in 1965 with a total catch of 2800 tons (Tarr, 1993). Regulation (except the minimum size limit) of the industry was first introduced in 1970, but prior to that there was no limit on the catch of abalone. In 1983 a TAC system was introduced and the harvest remained relatively stable at around 650 tons until 1995/1996 (Figure 6 & 7). Commercial fishing of the resource has been managed on the basis of annually revised, area specific TACs and the TACs has been systematically reduced in recent years due to sharp declines in the stock and increase in poaching. In the 1996/1997 season, there was a downward adjustment to 550 tons to compensate for over-exploitation and a further reduction to 75 tons in the 2007/8 season, and the complete closure of the fishery in 2008 (Figure 6) (Stuttaford, 1997). Following a closure of about two years, the fishery was conditionally re-opened in 2010 and since then the TAC was set at 150 tons and that has been the case for four consecutive seasons (2009/10, 2010/11, 2011/12 and 2012/13). The major adjustment was effected primarily in zone C and D, where the TAC was set at zero since the re-opening of the fishery.

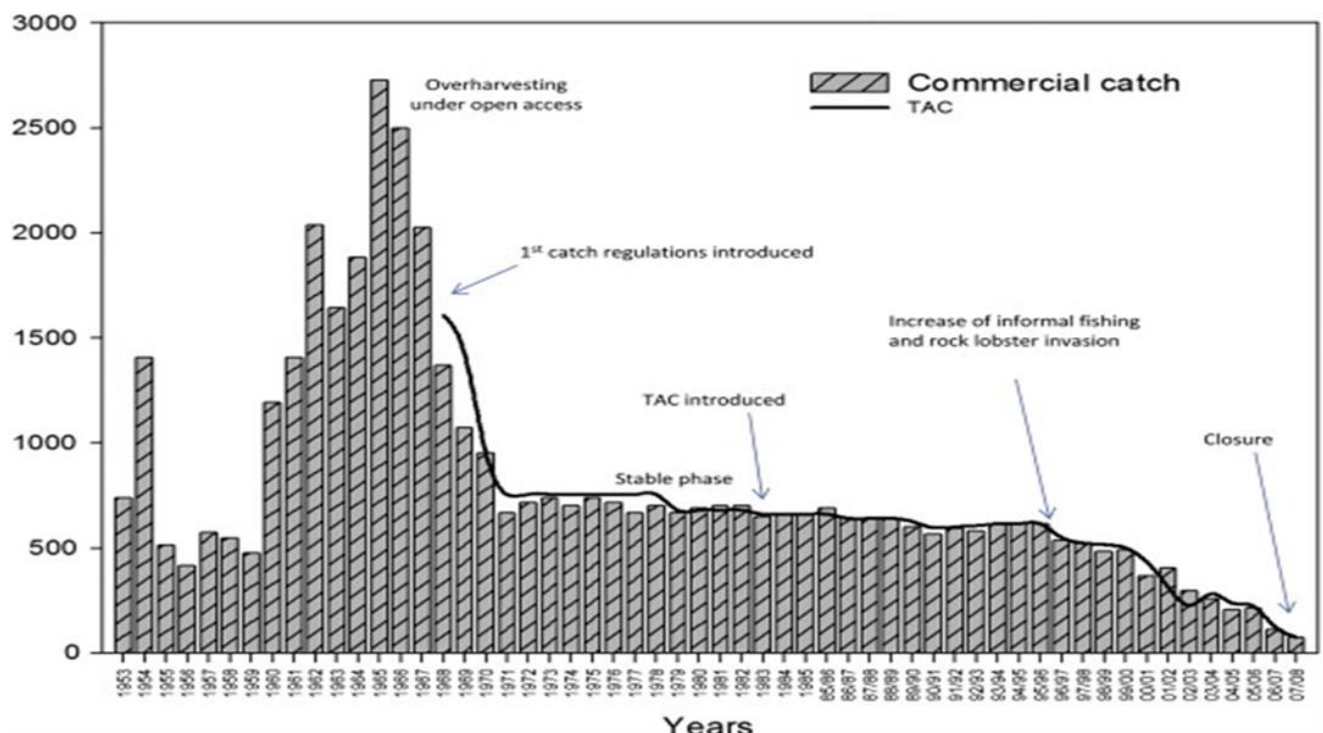


Figure 6: Commercial abalone fishery landings and evolution TAC.

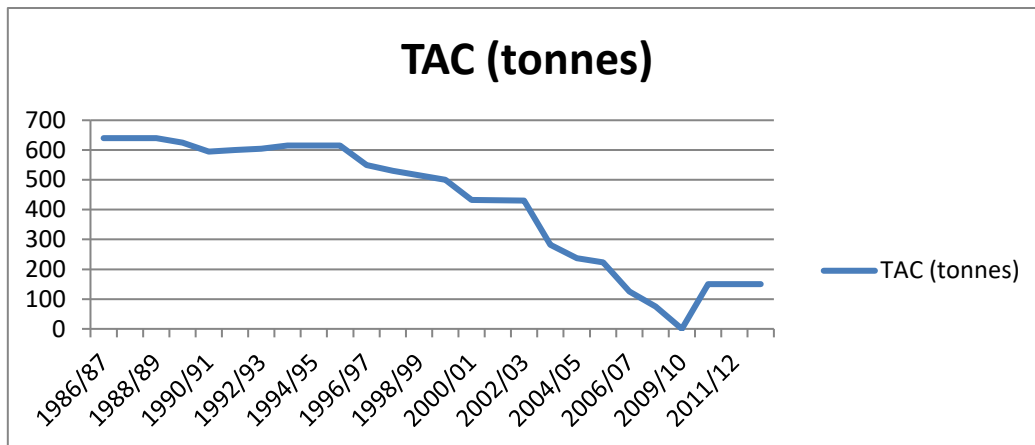


Figure 7: Annual Total Allowable Catch (TAC) for Abalone.

The recreational fishery (which was managed by closed seasons since 1985, and reduced bag limits) was suspended in 2003 due to difficulties in controlling the high levels of illegal fishing and concerns of resource sustainability (Raemaekers *et al.*, 2011).

The centralized nature of government fisheries administration and research facilities, which are situated in the south-western Cape, and its focus on the commercial fishery combined with a lack of funding and manpower has resulted in research effort being concentrated in this area. These contrasts, combined with the paucity of scientific data, particularly on the distribution and abundance of East Coast populations, has resulted in differences developing between the two areas with respect to the commercial and recreational exploitation rates, and the management of the resource.

#### 4. THE CURRENT MANAGEMENT OF ABALONE COMMERCIAL FISHING IN SOUTH AFRICA

##### 4.1 Structure of Fisheries Management Institution

The abalone management falls under the Directorate of Inshore Fisheries Management which also has other supporting Directorates that are working closely with, which are Inshore Fisheries Research (IFR) (conducting research on the stock status and providing scientific recommendations), Monitoring, Control and Surveillance (MCS) (enforces the implementation of the policy and management measures) and support services. The principal regulatory framework governing all fisheries in South Africa is MLRA, Regulations in Terms of the MLRA and abalone permit conditions applied in this fishery sector.

##### 4.2 Abalone Management systems in South Africa

The South African abalone fisheries management system is based on a right/quota allocation system in which the TAC is determined by the Minister who is the final authority on the allocation of fishing rights and issuing of permits although some of the responsibilities are delegated to the employees of the department. Rights are transferable only with the authorization of the department. Figure 6 shows the TAC recommendations from Fisheries Management in recent years. Management measures define the limits for the abalone fishery. These management measures have been classified into four groups; output restrictions, input restrictions, efficiency restrictions and enforcement tools.

**Input restrictions:** Input restrictions are defined in abalone fishery as those related to the level of effort that is permitted in the fishery, e.g. limiting the number and size of vessels (capacity control) and the number of right holders allowed to fish (effort control). Input restrictions such as these have been introduced primarily as the level of outputs from a fishery is difficult to monitor, for instance when a large number of vessels land into a port making effective monitoring of catches and landings difficult. Input restriction has been classified in the following categories: restriction of the fleet size (number of vessels), restriction of effort (days at sea, hours of harvesting), closed seasons (closed from 1 August to 31 October) for a fishery, closed areas and area restrictions and sub-divisions, TURFs and permits.

**Output restrictions:** Output restrictions define the levels of abalone that can be harvested in this fishery. These are defined as quotas in terms of weight of the abalone species. The abalone output restriction has been classified as target species quota, TACs, right holders quotas and minimum legal size limit of 114 mm shell breath (138 mm shell length).

**Efficiency restrictions:** Efficiency restrictions are those management measures that affect the catch per unit of effort of the abalone fishery. They include management measures typically used to protect a vulnerable element of a stock such as juvenile or undersized abalone. Efficiency restrictions have been classified in the following categories: closed areas, gear restrictions, engine size.

**Enforcement tools:** Enforcement tools refer to any vessel (patrol vessel, aircraft), personnel (fisheries inspectors, navy, observers or customs) or tools vessel monitoring system (VMS), land-based landing sites with inspectors (catches tallied) or combination of any of the above that can be used to detect infringements in the control mechanisms used in a fishery.

All commercial divers must complete catch records upon landing their daily catch of abalone. From this point on (that is, from catch through to sale) abalone must at all times be accompanied by conforming documentation (docketing) as proof of its legitimacy. This docketing system allows abalone to be tracked through the market. It also permits comparison of declared amounts along the chain (that is, from landing to delivery to processor to subsequent consignment) to enable detection of any discrepancies. Abalone must be landed and transported whole to processing facilities. Legal and illegal abalone is predominantly intended for export. Detailed quota-management systems exist in the fisheries department which enables reconciliation of diver, processor and export records, and the tracking of catch against quota limits. Compliance monitoring by Fisheries enforcement encompasses the above aspects in relation to the licensed sector, and also includes policing of unlicensed poachers. South African Revenue Services (SARS) Customs also has a role in compliance monitoring at the border.

### 4.3 Rights Allocation Process

As stated in section 18 (1) of MLRA for anyone to be granted a fishing permit, a fishing right should have been issued to them first. In South Africa, the commercial fishing right is considered as a resource management tool and a tool to drive economic development. It is not a property right but a legal permission to harvest marine resources for a specified period (DEAT, 2005). Long-Term Rights (LTR) in the abalone industry refers to 10 year long-term fishing rights which were allocated in the fisheries sectors in 2006 until 2013. The long-term rights process design was detailed and thorough, and guided by a fisheries general including abalone sector policy. Various stakeholders were consulted throughout the process. DEAT (2004, 2005, 2006) report that LTRs are perceived as one of the powerful tools to create jobs and boost economy in South Africa.

#### 4.4 Abalone policy for the Long-Term Rights Allocation Process

The purpose of the policy is to adopt a management regime for the abalone fishery that will result in the substantial reduction in the rate of illegal harvesting (DEAT, 2005). The policy for allocation of long-term abalone commercial fishing rights set sector specific purpose and objectives, which are to:

- *Instill a culture of “ownership” amongst right holders and members of the respective coastal communities;*
- *Encourage right holders and members of the respective coastal communities to co-manage the abalone resource together with the fisheries Department;*
- *Ensure the long-term viability of the South African abalone fishery and;*
- *Sustain the level of employment in the abalone fishery.*

There is generally a wide range of relevant fisheries management objectives, but there is no one combination that will be best for all fisheries at all times. There are, however certain points that are useful in selecting objectives. For most of the part, specific biological objectives are usually not necessary, and may in fact cloud the real issues behind management. For example, an objective to achieve a standing stock of a specific size may be clear and concise, but it begs the important question of why such stock is beneficial. These things are important for the continued commercial success of the fishery and management objectives should address them directly. This does not mean that biology of stock is not important. But achievement of properly stated economic and social objectives will, of necessity, properly maintain the stock. The range of objectives selected and the relative weights assigned to each should be such that the cost in terms of lost economic efficiency for achieving other goals is directly considered. For example, while increased employment may be a valid objective, the gains from increased labour force participation must be weighed against the economic efficiency costs of improper use of other resources due to overcapitalization. Further, while increased employment, which comes at the cost of reductions in total output, may be acceptable, it is likely that after some point the cost of continued increases in employment may become too high. However, in developing countries, the first priority in policymaking is to provide employment and income opportunities (Sterner & Coria, 2012).

After implementing the appropriate management program, the next step is to monitor the fishery under the regulatory program. If the objectives have been stated properly, it will be possible to show in a quantifiable manner the degree to which they have been achieved. The purpose of this step is to monitor those critical elements of the fishery to see how they are changing as a result of the regulatory program. Using the results of the monitoring program, the next step is to determine if the objectives of management are being achieved in the rest of the sections below.

#### 4.5 Transformation process in abalone fishery

Transformation in the abalone fisheries was viewed as one of the major vehicles that was intended to assist in instilling a culture of ownership amongst right holders and in the members of the respective coastal communities. The introduction of a constitutional democracy in South Africa came with some societal reform processes. The implementation of transformation saw rights distributed to a bigger group in the fishery sector. The major purposes of that fisheries transformation process, which was guided by the MLRA, were to redress racial imbalances and inequalities in terms of access to fishing sector (Raemaekers, *et al.*, 2011).

Some traditional fishers who had been marginalized during the apartheid system were afforded opportunities in this process but the general process also raised a lot of expectations (van Sittert *et al.*, 2006). The fishery transformation process was extensive, controversial and with a lot of challenges, as its main aim was the reallocation of rights within the existing industrial fisheries, which in effect excluded marginalized traditional fishers (Sowman, 2006). During that process of restructuring of the abalone fishery, a policy decision was taken to redistribute the fishing rights from a few white owned companies, to individual divers and marginalized traditional fishers from the adjacent communities (Raemaekers, *et al.*, 2011).

Abalone fishing rights had historically been granted to as few companies, which seasonally employed divers from the local communities to catch their quotas. The subsistence rights were granted and 10 percent of the overall abalone TAC to was allocated to subsistence fishers in 1998, as a way of granting formal access to traditional fishers in the adjacent communities (Raemaekers & Britz, 2009). About 236 subsistence fishing rights were allocated to traditional local fishers in the season 1998/1999, and that was representing a total quota of 85 tons of the overall 600 tons TAC (Table 1). In 2001, the abalone subsistence rights were issued as limited commercial rights (DEAT, 2002). In 2002, 273 right holders were allocated diving and marketing rights and 85% of those were allocated to the limited commercial sector (Table 1). There were a lot of management challenges in the subsistence fishery. Long-term commercial rights were allocated in 2003, following the implementation of the abalone fishing policy (DEAT, 2003).

Table 1: Evolution of rights allocation in the abalone fishery.

Seasons	Sectors	No. of Right Holders/Permits	TAC
1992/93	Commercial	6	605
	Subsistence		
	Recreational	34532	664*
1998/99	Commercial	5	515
	Subsistence	236	85
	Recreational	14368	220*
2001/2	Commercial	41	314
	Limited subsistence	232	74.4
	Subsistence	0	0
	Recreational	18777	42.5*
2007/8	Commercial	302	75
2008/9	Commercial	303	0
2009/10	Commercial	303	0
2010/11	Commercial	303	150
2011/12	Commercial	303	150
2012/13	Commercial	303	150

\* Catches of recreational harvesters that were recorded

The increase in the number of right holders that were accommodated resulted in the substantial decrease in quota to commercial right holders and also due to the reduction in the TAC over the years. A greater number of people were included in the formally recognized abalone fishery in the fishery reform process. The credibility of the redistribution of rights had a lot of challenges

and one of those was the unenviable challenge of broadening access to the fishery when the resource was in decline due to the rapidly growing illegal fishing effort. Only 303 rights (divers and legal entities) were allocated (Marine and Coastal Management, Unpublished data) (Table 1). The process of allocation was extensive and cumbersome, with allegations that community elites often benefited at the expense of historically disadvantaged fishers (Sowman, 2006). There were also allegations that there was little stakeholder consultation provided in the rights allocation process, leading to questioning the new governance arrangements.

The transformation brought a lot of expectations and may have contributed to the increase in illegal fishing because of the cut in the amount of quota per individual. There might have been a little understand of the processes involved in order to get a right and that might have caused a lot of disappointment. Management of people's expectations was therefore very crucial and failure to do so might have indirectly led to some societal misbehaviors. Some felt that the government had betrayed them and became outlaws by way of joining illegal fishing. Had the spread of the right accommodated more than 303 people, the amount for quota would have resulted in less value for allocated right holders and that could have still resulted in illegal fishing. There is however no clear plan for government about what would happen in case there were dissatisfactions in the communities. Spreading the access to the abalone fishery might have had good intentions but there is anecdotal evidence, which seem to suggest that the disappointment contributed to illegal harvesting.

#### **4.6 Abalone stock assessment and total allowable catches**

The abalone stock assessment process and the determination of TAC for every fishing season was viewed as core in attempting to ensure the long-term viability of the South African abalone fishery. The management system of South African abalone depends mainly on science to determine sustainable catch levels. Scientists conduct annual research surveys to collect the information necessary to estimate population abundance. The surveys help to give estimates of recruitment and biomass of fish stocks at the time of the survey making it possible to determine a preliminary quota for the coming year. The scientists make a conservative recommendation each year on the amount of abalone that can be harvested on a sustainable basis.

Given the reported declining status of the inshore resources, a need was identified for continuous updated stock assessments to inform appropriate management measures and allow for the implementation of rebuilding strategies (WWF, 2011). At the 2002 WSSD, South Africa undertook to maintain and rebuild fish stocks to levels able to produce maximum sustainable yields by no later than 2015 (McLean & Glazewski, 2009). The management of the South African abalone fishery has however, been informed by very good research and ongoing stock assessment. Abalone Scientific Working Group (ASWG) has been appointed annually by the fisheries authority to provide recommendations on the annual TAC. It comprises of scientists, stock assessment experts, as well as observers, and representatives of the commercial fishery. Several meetings are organized by ASWG each year where the data and stock assessment processes are discussed and a recommendation on the TAC is made. The TAC scientific recommendation is prepared and submitted to Marine Resource Management where a subsequent Management TAC submission is prepared and sent to the Minister, who ultimately makes the final TAC decision.

Various fishery dependent and fishery independent data have been used in the assessment of the abalone resource. The commercial fishery has been monitored by means of catch returns supplied by the right holders and by regular size composition sampling of the catch. The catch per unit effort (CPUE) data historically provided the estimates of resource abundance (Tarr, 2000). Recruitment surveys were undertaken annually from 1988 to 1993 in the main fishing

Zones A to D and Robben Island (Figure 8). These surveys also provided the initial information on the decline in sea urchins and juvenile abalone due to lobster predation in Zones C and D.

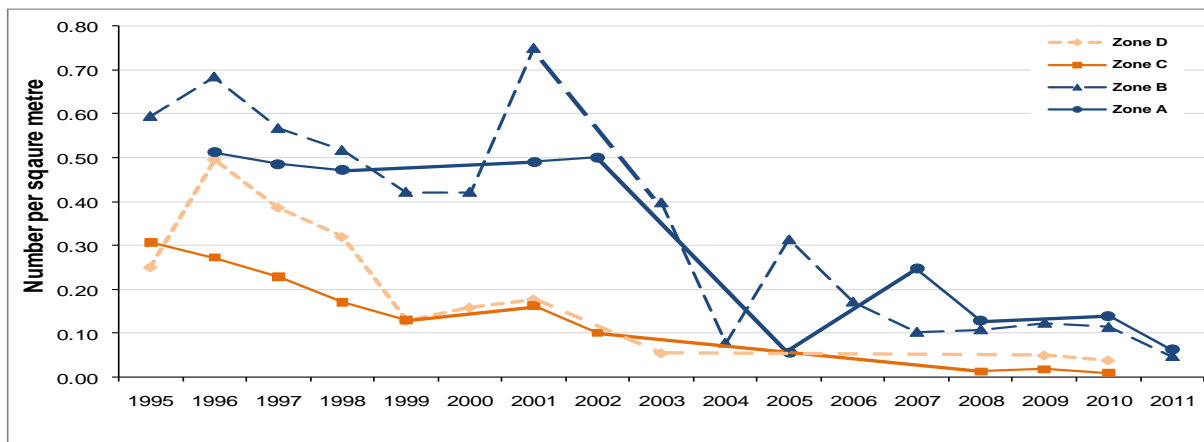


Figure 8: Density of abalone from Fishery Independent Abalone Surveys.

The ongoing monitoring effort and model has provided a valuable indicator of change in the abalone stock in response to increasing fishing pressure, as well as a decision support tool for making future projections based on fishing effort.

#### 4.7 Territorial Use Right Fishery (TURF) in the abalone management system

The Territorial Use Right Fishery is defined as a single fisherman or firm, organized group, community, etc. having an exclusive privilege to fish in a geographically designated fishing ground (DEAT, 2003). These policy decisions were founded on the key objectives of instilling a sense of ownership amongst rights holders, ensuring cooperative management of the abalone resource, ensuring the long-term viability of the fishery and sustaining local employment (DEAT, 2005). It was also viewed as suitable way of encouraging right holders and members of the respective coastal communities to co-manage the abalone resource together with the department. The abalone policy provided guidelines for long-term rights in the commercial fishery and acknowledged that the previous management strategies had failed to effectively deal with illegal fishing. The results of that failure saw the abalone resource as being seriously overfished (DEAT, 2003). TURF system was encouraged and subsequently announced, in the interests of sustaining commercial livelihoods. The co-management approach was clearly stated in the policy and that would be initiated with right holders in each zone in order to manage the resource cooperatively.

The abalone policy embraced a number of principles that were intended to enhance the co-management of the abalone fishery. The absence of exclusivity in the rights was a huge obstacle and that compromised the TURF system due to the sharing of some zones between right holders. This was prompted by that the largest number of abalone fishers was concentrated in over-exploited Zone C, and because of the limited stock in that zone, they were accommodated in adjacent zones. There were attempts made by the fisheries authority to consult on key management issues, but jointly agreed strategy to implement the TURF system was never put in place (Raemaekers *et al.*, 2011). Raemaekers *et al.*, (2011) reported that there was minimal budget and capacity within the fisheries authority to establish co-management arrangements. This lack of institutional capacity and genuine consultation further alienated right holders from the management authority.

The organized crime syndicates were already operating at such a sophisticated level when the long-term policy was implemented and right holders were not equipped to protect their TURFs against armed illegal fishers (Raemaekers *et al.*, 2011). Commercial fishers claimed that the allocation of abalone rights to more community members, combined with cuts in the annual TAC, compromised the financial viability of abalone rights. This, coupled with an uncertain future in the fishery, affected the sense of ownership. There was no broader management strategy that enhanced incentives and many fishers perceived the illegal fishery as means to compensate for an annual decrease of the TAC. Some abalone right holders were therefore working with the illegal fishers in some way, and benefiting from the black market trade (Hauck and Sweijd 2009).

#### **4.8 Employment opportunities and the evolution of number of abalone right holders**

In an attempt to sustain the level of employment in the abalone fishery, 303 right holders (263 divers and 40 legal entities) were granted abalone rights (Table 1). Three year rights were allocated to three abalone processing factories (APFs). All the commercial right holders are based in the Western Cape Province (Doringbaai to Stilbaai) where the 7 abalone fishing zones are found. Fishing is only permitted to take place between Melkbosstrand and Buffelsjagsbaai (Figure 3). The right holders hold the right to harvest and market their catch of the annual TAC. The legal entities may employ qualified divers to catch their allocated quota, whereas individuals were required to catch their own allocations and therefore were all required to have a diving certificate.

The abalone fishing sector is not regarded as a major employer in the fishing industry, mainly because of limited effort needed to fish a TAC of only 150 tons. Furthermore, it does not provide decent employment because of seasonality and the short time period (a few days) needed to catch a right holder's allocation. The abalone fishery sustains approximately 340 jobs at sea, total land based employment of 100 people with an average earning per right holder amounting to approximately R 200 000 per annum (R400/kg x 500 kg) (Van Zyl, 2010). The abalone fishing sector is labour intensive and its infrastructure, established companies that do not have rights to fish dominate marketing and product distribution. Those companies are only permitted to process and export the abalone. The fishery requires specialized divers and gear (diving gear and compressor) that is suitable for commercial fishing, as well as vessels (some catching for more than one right holder's allocation). Total investment on vessels and gear is estimated at R17.85 million (Van Zyl, 2010).

#### **4.9 Marine Protected Areas (MPAs) in South Africa**

In the fisheries management context, a thriving marine protected area (MPA) must provide an environment free from exploitation to protect a part of spawning stocks to ensure recruitment success. Fisheries yields are boosted in adjacent areas via a spillover effect of adult, larvae and eggs. In South Africa the benefits of well-planned MPAs have been proven successful with abalone, linefish species and other vulnerable grounds of fish (Branch, 1998). Fisheries management has therefore made attempts for new MPAs to be proclaimed in areas with important abalone populations in an attempt to among others, preserve abalone populations. The Table Mountain National Park MPA and the Bird Island Group of Islands MPA were declared. The Betty's Bay MPA situated within Zone D was affected by high illegal fishing effort levels and lobster migrations that in turn reduced the habitat area suitable for juvenile abalone (Day & Branch, 2000a). Dyer Island, situated between Zones A and B, was then closed to commercial abalone fishing in the 2003/4 season, with the hope of allowing abalone to move to that area.



However, law enforcement remained questionable in the MPAs and the illegal fishery continued to take place. In Dyer Island, although a closed area, there have been reported cases of boats operating illegally (Marine and Coastal Management, Unpublished data). Within the Bird Island MPA, the South African National Parks rangers stationed on the island regularly reported illegal fishing incidents (SAPS, 1998). An average of four boats and on some days up to twelve boats were visible in the MPA when diving conditions were deemed favorable (Raemaekers & Britz, 2009). Also, within the Table Mountain National Park, and on the reefs surrounding Robben Island, anecdotal reports have suggested illegal abalone fishing activity.

In the light of the serious lack of enforcement capacity within the protected areas, abalone right holders brought the legitimacy of the MPAs and closed areas into question. For example, when Dyer Island was closed to commercial abalone fishing, right holders argued against it and stated that they were being punished while the illegal fishery would merely change strategy and dive at night, when enforcement activity was the lowest. While resource sustainability remained a concern, there were effectively no closed areas for the protection of abalone. Branch (1998) has reported that for South African MPAs to be successful they must have the following characteristics:

- *Be large enough;*
- *Represent all habitats;*
- *Have adequate law enforcement to control poaching; and*
- *Meet the community's financial income, education and recreational rights.*

## **5. THREATS TO THE SOUTH AFRICAN ABALONE FISHERY**

Recorded global landings of commercial abalone species declined from 20 000 tons per year in the early 1970s to only 8850 tons in 2006 (FAO, 2008). However, black market trade of abalone, which is unreported in FAO statistics, is making an increasing contribution to the global supply (Gordon & Cook, 2004). The international trade in abalone *Haliotis* spp. is primarily driven by the high demand and exceptionally high prices in Asia, notably China, Hong Kong, Japan, Taiwan and Singapore. In South Africa, as fisheries management continues to manage the abalone policy, it is confronted with a series of uncertain scenarios, which have the potential to jeopardize the objectives (Hauck, 2009). The high value of abalone, together with the fact that it is found in the shallow intertidal, makes it a prime target for illegal exploitation. With poaching activity continuing unabated in South Africa, important questions and challenges are encountered by the overall fisheries management. Alternative methods of regulation need to be considered, and these have to be embedded in the socio-political context of South Africa and explore the international shift taking place in fisheries management. For example, methods such as co-management, which endorse shared management responsibility between resource users and the state, are encouraged.

Biological and socio-political events have led to changes in resource use and availability of abalone throughout South Africa. The main reasons behind these changes are: 1) illegal fishing of abalone resource and the black market trade 2) migration of rock lobsters occurred in the two traditionally most productive commercial fishing sectors; and 3) the previously unquantified effort levels of recreational divers became better understood (Tarr, 2000). The other threats to abalone fishery include the expansion of rights to a greater number of previously marginalized fishers, the serial reduction in the TAC, and contested closure of the fishery (Raemaekers, *et al.*, 2011).

## 5.1 Migration of rock lobster

Migration of rock lobsters that was observed in the two traditionally most productive zones is believed to have led to an increase in the mortality of juvenile abalone (Day & Branch, 2000a). The relationship between the abalone juveniles, sea urchins and rock lobsters was established. The sea urchins provide protection from predation for the abalone juveniles and thus ensure recruitment success. Rock lobsters feed on the sea urchins cleaning the sea urchin population and as a result, the abalone recruitment will be negatively affected, as there is no protection for abalone juveniles. As rock lobsters do not occur in large numbers on the east coast of South Africa, this only affected abalone juveniles in the south-western Cape.

## 5.2 Unquantified effort levels of recreational divers

Fisheries management had to re-assess the state of the resource and come up with significant changes to the management of the fishery as a whole. The annual recreational catch estimates were nearly the annual catch of the commercial fishery (Table 3). Measures were implemented to limit the recreational take and a recreational TAC was set. The recreational fishery proved to be challenging to manage and was subsequently banned.

## 5.3 Abalone Commercial catches and Licenced Divers

Another potential threat to abalone fishery was the expansion of rights to a greater number of previously marginalized fishers. While the majority of licensed divers operate legitimately within the industry, there may be a few who exploit their position by engaging in quota fraud. This can be done either by harvesting above allocated catches which are then not declared, or by misrepresenting the true amount of abalone caught. Excess abalone may be supplied directly to consumers or to processors for illegal preparation and sale. Unlike organized poachers, licensed divers supplement their legitimate income with illicit activity. The abalone commercial catch have been argued to have contributed minimally to the stock decline as the illegal catch far exceed the annual commercial TAC (Figure 7) and the overall TAC has been drastically reduced over the years. Table 2 shows the allocated quotas and the catches since the re-opening of the fishery and the table suggests that there have been no exceeding in harvesting of the total allocated amounts by both the individuals and legal entities. However the reports of the department show that there are a few individual right holders that have been recorded to have exceeded their annual allocations although the excess amount is not significant to cause any difference in the total annual allocated catches (DAFF unpublished report).

Table 2: Allocated quotas and catches of right holders (in kg).

	2009/10	2009/10	2010/11	2010/11	2011/12	2011/12
	Allocation	Catch	Allocation	Catch	Allocation	Catch
Individuals	125297	123169	121963	117252.6	122462	119284
Legal entities	25291	24995	24545	24097	24832	24641
<b>Total</b>	<b>150588</b>	<b>148164</b>	<b>146508</b>	<b>141349.6</b>	<b>147294</b>	<b>143925</b>

## 5.4 Illegal fishing of abalone

The major threat to the abalone fishery has been identified to be the illegal fishing or poaching of abalone. This is by far the most important threat in the fishery that has had a significant impact on the whole stock and also possesses a serious challenge in the management of the resource (DEAT, 2009). This situation has also been observed around the world; with abalone fisheries in countries such as Australia, Canada, New Zealand and the United States of America all suffering from the impact of organized poaching groups (Heasman, 2006). TRAFFIC (2010) reported that illegal harvesting, which targets many of the inshore resources, is evidently on the rise and has dramatic impacts and considerable threat to the economic viability and sustainability of the fishery and on the environment.

### 5.4.1 *Illegal abalone fishing in South Africa*

Despite the extensive regulatory framework governing South Africa's abalone fishery, illegal abalone harvesting and trading does occur. This refers to any activity which contravenes industry regulations outlined in the MLRA. However, it can also refer to a more serious offence that involves in excess of several hundred kilograms by highly organized poaching syndicates (SAPS, 1998). Illegal take can take a number of forms, such as commercial divers exceeding their quota, recreational fishers exceeding their bag limit, breaches of the MLS, catches in closed areas and catches taken for sale by those without an endorsement to do so (Anon, 1998a). Reports of poaching activities have become a frequent feature in the national press and government reports, and the government decided to close the abalone fishing for almost two years, from 2008 until 2010. There have been a lot of debate, and in a bid to find workable solutions, serious attempts have been made to determine its root causes (Hauck & Sweijd, 1999). Hauck & Sweijd (1999) listed three main reasons have been suggested as to why people became involved in poaching; need, greed and politics. Poverty existing in many coastal communities is seen as a very strong motivator for some people to become involved in illegal activities.

The lucrative nature of poaching has also seen many people joining the poaching activities. The illegal fishing was considered by the public and the police services to be less important, in the context of high crime levels throughout the country, and that law enforcement measures were focused elsewhere, and that has motivated more people to be involved in abalone poaching. The lucrative nature of abalone has led to the formation of poaching syndicates with connections to international organized crime syndicates, who export the abalone through Hong Kong (Raemaekers *et al.*, 2011). The total illegal abalone catch for the period 2001 to 2008 was estimated to be in excess of 300 000 individual pieces of abalone per year making South Africa one the major abalone suppliers (Figure 9).

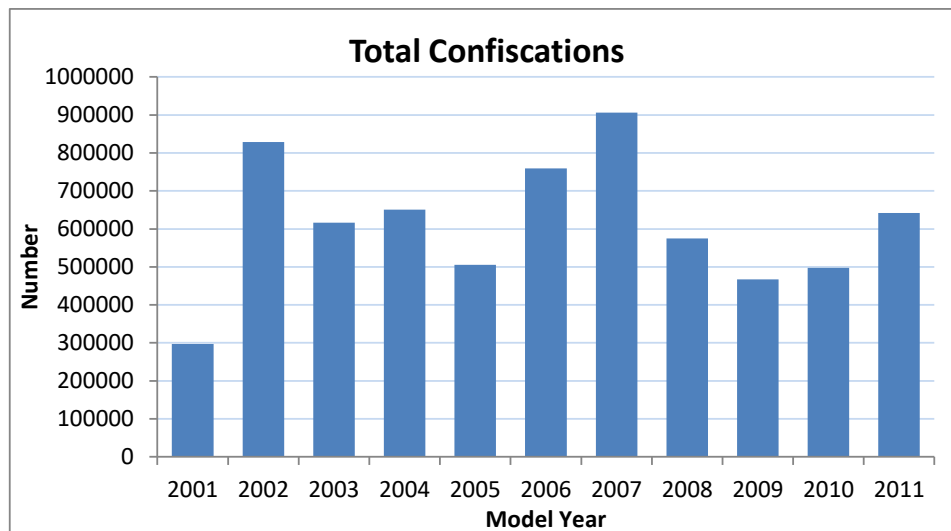


Figure 9: Number of total confiscated abalone in South Africa.

The statistics reveal that for the period 2001 to 2007, between 300 000 and 900 000 pieces of *H. midae* were confiscated annually and majoring of it was destined to Hong Kong, Japan, Singapore, Taiwan and Mainland China.

Corruption within law enforcement agencies has also been reported in the past to have contributed to the levels of illegal fishing (Tarr, 2000). Other social issues include the increased involvement of the youth in poaching activities, and the quality of life being undermined as local residents fear for their lives (Raemaekers *et al.*, 2011). Poaching also poses an economic threat by flooding the international market, so increasing competition for the legitimate industry. If the abalone resource continues to decline towards ultimate collapse, there will be severe economic repercussions in coastal communities. Abalone poachers from the community argue that they have been denied legal access to abalone diving rights unjustly, forcing them to continue poaching rather than to become legitimate members of the industry.

Figure 10 demonstrates the manner in which different forms of illegal harvesting manifest and different stages in the chain until the end user. The abalone poachers are described by their characteristics such as locality of harvest, those doing the harvesting and gear used. All the poached abalone is then taken to the processing factory where it will not be easy to distinguish between the legally and illegally harvested resources unless there is a clear paper trail system.

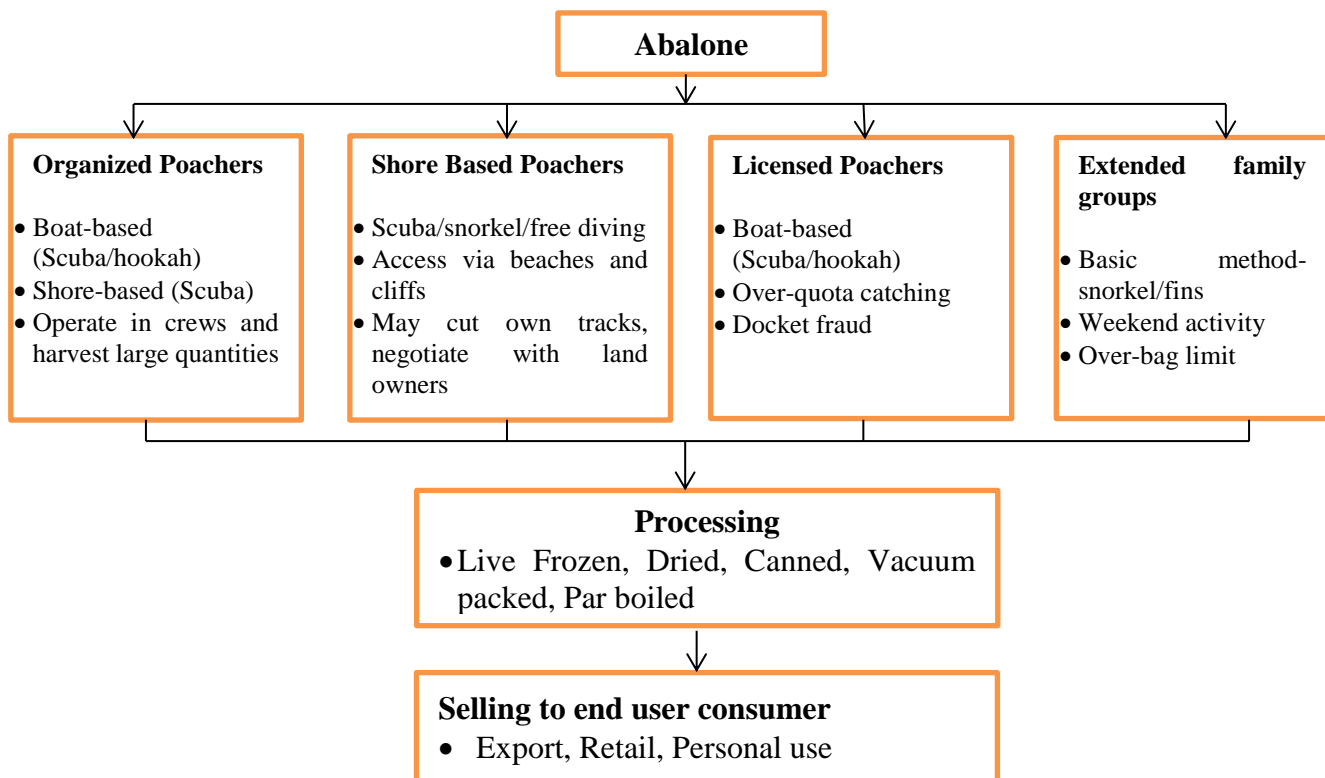


Figure 10: Methods used in each stage of the illegal abalone market.

#### 5.4.2 What makes abalone an attractive illegal commodity?

Some of the factors (not exclusive) that continue to make abalone an attractive illegal commodity are:

Abalone has a high market value and has become a very lucrative resource over the years. It is found in predictable and accessible locations near stands of algal beds and is relatively easy to harvest (often being pried off rocks or from coastal reefs in shallow waters) and requires little capital to undertake successful fishing. It is often fished in remote or secluded areas of the coastline, reducing the chances of fishery management officers catching an illegal fisher. Its high value-to-weight ratio makes it relatively easy to transport in commercial quantities, and it can be easily hidden or smuggled out of the country undetected. Reports show that there have been abalone exported from the neighboring countries even though South Africa is the only country where *H. midae* is found. There is a strong demand for the product in overseas and domestic markets, with many purchasers not questioning how the product was taken.

#### 5.4.3 Possible effects of illegal harvesting

Illegal harvesting may reduce management's ability to increase quotas and, in the long-term, may lead to reduced quotas to maintain a sustainable fishery. This could lead to industry and the government losing legitimate revenue and an overall fall in the value of the quota holdings of legitimate operators. As happens in other types of markets, illegal operators who have few overheads and accept lower prices can undercut legitimate operators. Clandestine harvesting and subsequent poor handling may affect the quality of illegally harvested abalone and create a risk to human health. Mishandling could have a major impact on South Africa's reputation in the international market. The level of illegal activity might have a significant bearing on the future accreditation and export status of the fisheries.

Abalone may be used as a medium of exchange for other illegal substances, such as heroin or marijuana, or to bankroll other illegal activities. Because the illegal abalone industry is so lucrative, there is a risk of government officials being corrupted or compromised. It is not unreasonable to assume that the fisheries officials can be corrupted or compromised as a result of illegal abalone activities in South Africa. The level of expenditure in fishery compliance budgets to tackle this problem significantly affects the amount of funding government and the industry could provide and effectively spend elsewhere. Illegal harvesters will obviously seek to avoid being caught because of the large profits they make and the increasingly harsh sanctions governments are imposing. Their likely resistance raises questions about the safety of fisheries officers, who may be under-equipped or trained to tackle dangerous offenders.

## 6. ENFORCEMENT IN THE ABALONE FISHERY

Successful monitoring and enforcement are essential for any fishery management regime. South Africa's fisheries authority, the DAFF, is the primary agency mandated to undertake fisheries enforcement. In response to the escalating illegal fishing in South African territorial waters, fisheries management restructured and upgraded their Compliance Directorate to a Chief Directorate, Monitoring, Control and Surveillance (MCS). In some cases in other countries monitoring is financed by the fishing industry (Sterner & Coria, 2012). Illegal abalone fishing is not simply a marine resource issue but involves a variety of criminal activities. As a result, law enforcement effort has been intensified over the years in response to the increasingly organised illegal fishing networks. Other agencies of state have played a role in attempting to combat crimes related to illegal abalone fishing, either in partnership with Fisheries Management, or independently (DEAT, 2009).

Hauck & Kroese, (2006) reported that the fisheries authority focussed on increasing its capacity in terms of investigation, establishing partnerships with other law enforcement agencies, devolving compliance responsibility to the local level, and seconding specialised prosecutors to focus on serious marine offences. With the commercial fishery at stake in the Western Cape, resources were largely deployed in this province. Raemaekers & Britz (2009) report that in the Eastern Cape, the first focussed law enforcement strategy targeting the abalone fishery began in 1998. A cooperative policing operation was initiated between the fisheries authority and the SAPS and that was known as Operation Neptune which was initiated tackle illegal activities. Other resources included high-speed patrol vessels, navy divers, abalone sniffer dogs, unmanned aerial vehicles, helicopters and fixed-wing aircraft (Raemaekers & Britz, 2009).

In 2003, the fisheries authority enhanced the law enforcement effectiveness by devolving compliance authority to a local municipality at the centre of the Western Cape illegal fishery. A compliance programme was agreed with the Overstrand local municipality, known as the Management Action for Resources of Inshore and Nearshore Environments (MARINEs) and this grew from a staff contingent of eight in 2003 to 45 in 2005 (Hauck & Kroese, 2006). Their activities involved 24 hour visibility, patrols and rapid response, slipway control, follow-up of cases, awareness-raising, liaison with schools and communities and co-ordination with other departments and organisations (Raemaekers, et al., 2011).

The other initiative was the establishment of South Africa's first two environmental courts in Hermanus and in Port Elizabeth in 2003, driven by DEAT and the Department of Justice, and established primarily to tackle abalone-related offences (Snijman, 2005). A special court was justified by the abalone cases that had a low priority in the justice system, coupled with the conviction rate that was very low and sentences were generally lenient (Snijman, 2005). Raemaekers, *et al.*, (2011) report that in the first 18 months, with the help of two specialist

prosecutors, the court finalised 166 cases, effectively disposing of the previous backlog, with a conviction rate of 75%

A preliminary evaluation of Operation Neptune indicated some great success, but there were also concerns related to corruption, insufficient interaction with broader stakeholder groups (such as fishers) and the lack of a long-term strategy that linked with broader management objectives and mandates (Raemaekers, *et al.*, 2011). A lack of government funding resulted in the highly effective environmental courts being closed in 2005. The MARINEs programme was subsequently terminated in 2006 (Raemaekers & Britz, 2009).

The South African abalone was then listed on Appendix III of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) due to an attention that had to be paid on international trade and market. Through CITES, which is an international agreement between governments to ensure that species are not threatened by international trade, species are listed on one of three Appendices depending on the level of protection that is required (Willock, Burgener, Sancho, 2004). The listing of abalone on Appendix III, came into effect in 2007 and that required that all legal exports to be accompanied by a CITES permit issued by the Department of Environmental Affairs and Tourism. This measure was taken in order to enlist the assistance of other countries in tracking South African abalone in the international trade, and also to strengthen regulatory controls in key importing countries such as Hong Kong, China, Taiwan and Japan. The CITES listing also enabled neighbouring southern African states such as Mozambique, Zimbabwe and Swaziland, countries through which abalone is smuggled, to assist in regulating the international trade (Burgener, 2006). South Africa authorities took a decision to withdraw the CITES listing in 2010, claiming that recent changes to South Africa's CITES implementation legislation had made it too difficult administratively to comply with the requirements for permit endorsement (Burgener, 2010).

## **7. SUMMARY AND RECOMENDATIONS**

The main purpose of fisheries management is to manage the fisheries resources in a sustainable manner, that also increases economic returns from the fishery through contribution to the nation's gross domestic product (GDP) (The World Bank, 2009). The review and assessment of abalone industry indicates that the management arrangements for the South African Abalone Fishery adhere to most of the objectives as set out in the abalone fishery policy for the "Long-term Allocation of Fishing Rights" and in the MLRA. Under existing management arrangements the abalone fishery is a relatively well managed fishery and is unlikely to have an unacceptable or unsustainable impact on the environment in the short term. The current South Africa abalone fishery management regime is documented, publicly available and transparent, and is developed through a consultative process.

The management arrangements are adaptable and underpinned by appropriate objectives and performance criteria by which the effectiveness of the management arrangements can be measured, enforced and reviewed. Periodic review of the fishery should be provided for, as means of enforcing critical aspects of the management arrangements. The management regime takes into account arrangements in other jurisdictions, and adheres to arrangements established under South African laws and international agreements.

## 7.1 Risks identified in the abalone fishery

While the fishery overall is relatively well managed, a number of risks under existing management arrangements have been identified that must be managed to ensure that their impacts are minimized and those risks are:

- a) Substantial declines in catch and available stocks in some zones in recent years;
- b) Uncertainty with stock status across the country;
- c) No definitive stock recovery or rebuilding strategies in place despite evidence of declining stocks;
- d) Significant threat of serial depletion and no specific strategies in place to mitigate these threats;
- e) Understand that the Ecological Risk Assessment or other precautionary strategies is currently developed but it must be in place to assess the impacts of fishery on the entire environment and to address the topical issues that have been identified; and
- f) Absence of appropriate documented and understood performance indicators.

## 7.2 Illegal harvesting or poaching of abalone

In the abalone fishery, the major concern is the presence and persistence of illegal fishing or poaching of abalone which exert pressure of the effort. If the rate of illegal activities stays the same or increases at the current alarming rate, it appears that the biomass will be negatively affected or depleted. Given that poaching could be reduced to economically efficient levels, the abalone fishery is capable of generating substantial net present value of economic benefits. The fisheries authorities implemented a number of measures to manage the illegal harvesting and most were developed to meet the MLRA's objectives and in response to the growing illegal fishery. Some of the strategies that were initiated were good on paper but do not appear to have a long-term success and required a long-term financial support. There needs to be a strong plan aiming to strengthen significantly the enforcement arrangements required to reduce abalone poaching. Enforcement will be improved through better strategies, a planning and cost recovery process in which industry must participate in, and through the quantification and monitoring of enforcement targets.

The illegal harvesting is generally a key issue for compliance and enforcement activities and that illegal harvest of abalone is a significant national issue, with the potential for significant adverse impacts on the overall sustainability of abalone fisheries across South Africa. The considerable work is being done in other jurisdictions, including Fisheries Management, to address the problem of abalone poaching. Fisheries Management should cooperate more with other jurisdictions, to ensure that a continuing priority is given to the accurate reporting of illegal harvesting and the development of appropriate management responses to reduce poaching.

While illegally obtained abalone bound for export can be detected through random searches, road blocks and scans of luggage, passengers and consignments, Customs is also in an ideal position to fight illegal abalone out of South Africa. Given competing enforcement and policing priorities for Customs in terms of other illicit goods, however, the interception of illegal or suspect abalone at the border may not be as high a priority. Timely intelligence sharing from fisheries authority and SAPS concerning illegal product headed for export serves to facilitate border interceptions. Similarly, consideration of the inclusion of abalone as a scheduled export item under Customs legislation may provide additional legislative backing for the interception of illegal abalone exports. To date there have been a number of jurisdictional operations



targeting the black market in abalone which have succeeded due to strong cooperation between fisheries, state police and agencies such as Customs.

### **7.3 Listing of abalone in the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)**

Recent progress has been made towards prohibiting the export of any abalone except for Fisheries Management Authority approved product. Despite efforts by the South African government as a whole, to address the poaching problem, the international nature of the trade means that there is a need to secure the assistance of other countries. This is most effectively achieved through the CITES listing. An attempt should be made for the South African abalone to be listed on Appendix III of CITES due to an attention that has to be paid on international trade and market. The listing of abalone on Appendix III, will require that all legal exports to be accompanied by a CITES permit.

### **7.4 Compliance and enforcement**

Compliance and enforcement tools in the fishery must be strengthened and involve checking all the landings which includes monthly reconciliation sheets, along with periodic patrols and inspections. Additionally, abalone divers should be strictly required to sell their product through a registered processor, which must be registered by the fisheries authorities. A Strategic Plan for Abalone Compliance should also be in place for the fishery and aims to minimize the number of offences committed by divers and abalone processors. These compliance measures should contain the means of enforcing critical aspects of the management arrangements for the abalone commercial fishery. Further discussion of the illegal harvesting and measures to address it should be conducted with various stakeholders including other Governments Departments. Some fishery independent information should also be collected and discussion of the information collection system should be established.

### **7.5 Abalone stock assessment**

A sound stock assessment process is being done for the abalone fishery, based on fishery dependent and fishery independent data. An annual stock assessment program is undertaken and presented to the Abalone Scientific Working Group Committee for discussion to form the basis of the Scientific TAC recommendation for each subsequent fishing period. The stock assessment process draws on basic catch information for the fishery (obtained through recording the catches) and available biological survey data. Other fishery dependent data, including size composition of commercial catch and catch and effort data, are utilized with the results of the fishery independent abundance survey data in a length-structure model, used to inform TAC decisions.

Illegal abalone catch is the most significant issue contributing to the uncertainty in the longer term ecological sustainable abalone yields from the fishery. The recent assessment of Illegal Catches of South African abalone, noted that, quantifiable data derived from sound scientific estimates of abalone theft are around 10 times more than the commercial TAC. Estimates of illegal take, although uncertain, are factored into the stock assessment process.

Significant concern was raised in public comments on the ERA over the decline in stock abundance, evident in a further decrease of the TAC to 150 tons in recent years. High priority should be given to addressing the causes of this decline and in forming a more accurate picture of the current stock status of abalone across the entire fishery, rather than just the sampling sites

used for the current annual review. Due to the selective nature of harvest in the fishery and the management regulations that restrict landing of species apart from the target abalone species, no bycatch species are taken in the abalone fishery.

The management regime in the abalone fishery is appropriately precautionary and provide for the fishery to be conducted in a manner that does not lead to over-fishing in the short to medium term. The information collection system and stock assessment and management arrangements generally are sufficient to ensure that the fishery is conducted at catch levels that maintain ecologically viable stock levels. To promote recovery to ecologically viable stock levels, the fishery should be managed to promote recovery ecologically viable stock levels within nominated timeframes.

## **7.6 Regional and international management regime**

The prime international regime affecting the abalone fishery is the United Nations Convention on the Law of the Sea (UNCLOS). The management regime should comply with this and in particular comply with precautionary approach, and other international regimes are applicable to fisheries management but do not explicitly involve this fishery, for example the 1992 Convention on Biological Diversity and in particular the 1995 Jakarta Mandate requiring that, in relation to the sustainable use of marine and coastal biological diversity, the precautionary principle should apply in efforts to address threats to biodiversity. The application of the International Convention for the Prevention of Pollution from Ships (MARPOL) to vessels operating in the fishery is also relevant. A thorough understanding of the framework of national, regional and international agreements should be developed and citing their applicability to export-based fisheries.

## **7.7 Environmental Risk Assessment (ERA) and Environmental Impact Assessment (EIA) processes**

The Environmental Risk Assessment (ERA) is currently being finalized under South Africa's Environmental Impact Assessment (EIA) process for the Abalone Fishery with the aim of identifying and addressing some of the issues to further enhance the sustainable and responsible management of the fishery. The existing management regime of TACs and other output and input controls, sound stock assessment process and other mode of fishing operations suggests that the fishery is being managed in an ecologically sustainable way and is working to address existing problems and minimize environmental risks.

The operation of the fishery is generally consistent and managed in accordance with the policy regime described in the Abalone Policy for the Allocation of Long-term Right Process. Given the management arrangements already in place and the intent to introduce further measures in the final EIA once the current ERA process for the fishery is completed, it is considered that the management of the fishery will not be detrimental to the survival or conservation status of the fishery in the short term. Similarly, it is not likely to threaten any relevant ecosystem in the short term. The effort has been taken to maintain a certain number of right holders (fishing effort) with the current management measures.

## 8. CONCLUSION

This paper has focused on the reviewing and assessment of the status of abalone fishery and the analysis of those issues was matched against stated objectives of the abalone management.

- The priority for enforcement should be the targeting of syndicated illegal fishing operations and processors and response includes intelligence collection and analysis, sophisticated planning and operations. Often police assistance is required, particularly when there is a high safety risk to participating officers.
- A second order of priority is the routine enforcement of legal commercial divers' activities. The enforcement department should set down performance targets. The enforcement response should include routine patrols as part of the wider marine fisheries enforcement effort directed at commercial users. Local police officers may be involved, as would be the case if it were necessary to have roadblocks.
- If there are any breaches, a report, outlining mitigation strategies, must be provided. There should be a commitment made to the development of recovery strategies with timeframes linked to management responses, in the event that abalone stocks fall below sustainable levels.

The fishery is classified as fully exploited, however the increases in catch should be possible through a reduction in illegal catch and the recovery of heavily depleted populations. Right holder's comments raised concern about the closed areas for legal harvesting while there is a lot of illegal catches reported in those closed area. This is what appears to be benefiting illegal harvesters and punishing the legal harvesters. These concerns should be taken into account before any closed areas to harvest could be declared. There should be more precautionary management approach to declining abalone stocks. Despite the recent substantial reductions in catch limits and uncertainty with the status of stocks and reasons for biomass declines across the fishery, there is no evident stock recovery strategy in place across the fishery. A more definitive recovery strategy should be developed in conjunction with other abalone fishery stakeholders which include appropriate management actions within set timeframes. The recovery strategy should also address appropriate monitoring measures and management responses and proposed timelines for recovery of overfished and depleted stocks.

When the rights are about to expire, it is logical/ normal to start seeing some misbehaving in the fishery. The current right holders have not guarantees that they will be accommodated in the next round of right allocation. The policy emphasizes that the minister must give a chance to the new entrants in the fishery. That could possibly explain why the people are misbehaving.

Based on the investigation that was done on the management of abalone exports and attempts to curb the illegal exportation of abalone in Australia, it was discovered that the methods that are implemented in the Australian abalone fishery are similar to those used in South Africa abalone fishery. However, there are a number of areas that can be learnt from Australian management system that can also be used in South Africa such as attempting to list the abalone on CITES. Illegal harvesting of abalone places additional stresses in the high value of this resource and in the management of the fishery in both these countries. The fisheries authorities and abalone industries must continue to vigorously address issues regarding enforcement of regulations, permits and illegal fishing in the abalone fishery.

South Africa fisheries management system can also learn a lot from the enforcement theory as there are already some of the measures in place that could ensure the complete implementation. However, a strengthened cooperation and commitment by various agencies will be a key requirement to the success of this theory.

In conclusion, the causes of the abalone fishery problem are now fairly well understood, and a window of opportunity has been opened to reconfigure the governance and management arrangements in the fishery. Options for biological, social and financial solutions have been identified but they will require considerable public sector support and commitment to implement. While the political will appears to exist to rebuild the abalone fishery for the benefit of coastal communities, the major challenge will be the creation of the required public sector developmental capacity to support the various implementation processes. Another way to fight abalone poaching could be strengthened by the development of national information and reporting systems for fisheries intelligence.

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## Appendix 1: The main sectors of the South African fishing industry

Sector	Description
<b>Recreational</b>	This includes angling, spear fishing, cast-netting and marine aquarium fishing
<b>Subsistence</b>	This is based on low catch value, easily accessible and cheap to harvest resources such as oysters, mussels, limpets, winkles, red bait and estuarine crabs. There are about 28,300 fisher households and 29,200 individual subsistence fishers in South Africa.
<b>Small-scale commercial</b>	This includes small-scale fishing activities that do not qualify for subsistence criteria. Fishers of this sector operate at the lower end of the commercial fishers. Inshore west rock lobster, line fish, abalone, octopus, kelp and sea weeds form the basis of this sector.
<b>Medium-scale commercial</b>	This is based on squid, inshore pelagic, hake long line and hand line, tuna pole, demersal shark and offshore west coast rock lobster fishing for local and international markets.
<b>Large-scale commercial</b>	This is based on hake trawling, offshore pelagic, Patagonian tooth fish, south coast rock lobster and prawn trawling. Resources harvested in this sector are hardly accessible, fishing thus requires substantial capital and technology. Large vessels and few but strongly vertically integrated companies participate in this sector mainly for international markets.

## Appendix 2: The different types of fisheries management systems

Type of fisheries management System	Purpose	Methods	Common Measures	Summary
<b>Biological fisheries management systems</b>	Increase the biological yield of the resource	Protect young fish, spawners and habitat	TAC, area closures, seasonal closures, gear and pollution restrictions	May conserve the resource, may increase the sustainable yield, and probably generates a net economic loss.
<b>Direct economic restrictions</b>	Enhance the economic yield from the resource	Constrain fishing effort and capital	Limited fishing effort (days at sea, fishing etc.), capital restrictions (vessel size, power, shape, type, equipment), investment restrictions, gear restrictions.	May conceivably conserve the resource, may increase catches, will most likely result in long-term economic loss.
<b>Indirect economic restrictions: Taxation</b>	Obtain economic rents	Induce industry to reduce effort (in a wide sense) by making it less profitable	Variants include tax on the volume of the landings, tax on the value of the landings, tax on inputs	In practice it is virtually impossible to calculate the "correct" taxes, socially unpopular, taxes are likely to entail a painful adjustment period. The tax revenue should represent pure fisheries rents.
<b>Indirect economic restrictions: Property rights</b>	Obtain economic rents	Reduce or eliminate the common property externality and private incentives coincide with public objectives.	Variants include: licences, sole ownership, TURF's, IQ's/ITQ's, communal property rights	The efficiency depends on the quality of the right (the higher the quality of the property right the more efficient the fishery), the property rights have important attributes viz., security, exclusivity, permanence and transferability.