

Analysis of the chokka squid; *Loligo reynaudi* d`Orbigny, 1845; log-book data in South Africa

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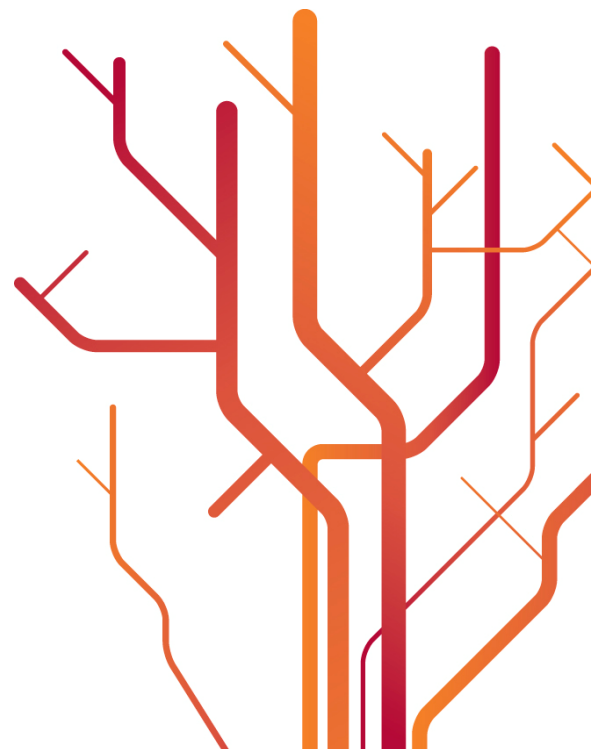


Table of contents

Table of contents	2
List of figures	4
List of tables	5
Acknowledgements	6
Abstract	7
1. Introduction	8
1.1 Biology of the chokka squid	8
1.2 The chokka squid fishery in South Africa	12
1.3 Management overview	14
1.3.1 Historical chokka squid management	14
1.3.2 Current chokka squid management	15
1.4 Research Problem	17
1.5 Approach	18
2. Materials and methods	19
2.1 Study area	19
2.2 Data type	19
2.3 Data collection	19
2.4 Data selection	20
2.5 Analysis of the survey data	20
2.6 Analysis of the logbook data	21
2.6.1 Total annual landings	24
2.6.2 Annual CPUE	24
2.6.3 Catch in years by areas	24
2.6.4 Comparison of the standardized CPUE and survey biomass	25

3. Results	26
3.1 Description of the data	26
3.2 Total annual landings	28
3.3 Annual CPUE	29
3.4 Catch by areas	31
3.5 Statistical analyses	33
3.6 Comparison of the standardized CPUE and surveys biomass	36
4. Discussion	38
4.1 Total annual landings	38
4.2 Variation in the CPUE	39
4.3 Standardized annual CPUE as the biomass measure	41
4.4 Comparison of the standardized CPUE and surveys biomass	42
5. Conclusion and recommendation	44
6. References	45
7. Appendices	50

List of figures

Figure 1. The indication of the chokka distribution resembled by the main spawning grounds of the chokka squid and paralarvae distribution in the Agulhas Bank	9
Figure 2. An example of the mating methods of the <i>Loligo reynaudi</i>	11
Figure 3. Histogram showing the vessel frequency by number of crew and by five vessel size group	21
Figure 4. The study area, Agulhas Bank stretch. Localities used in the analysis (bold) and range of localities (regular) in each of the eight areas (Area 1-8)	23
Figure 5. The annual total catch of chokka squid. FAO total capture production. Primary logbook data and reduced data where outliers (catch > 5000 kg and distance > 162 nm) are excluded	28
Figure 6. The annual CPUE (kg/hr) $\pm 95\%$ confidence interval box plots of the chokka squid by a) year, b) month, c) size group and d) area	30
Figure 7. Chokka Ln catch (kg) ± 95 confidence interval box plots by years in regions (Region 1 in the left and region 2 in the right)	31
Figure 8. The standardized Ln CPUE (kg/hr) ($\pm SE$) of the chokka in years	35
Figure 9. The standardized Ln CPUE (kg/hr) ($\pm SE$) and survey biomass ($\pm SE$) index of the chokka in autumn and spring of the chokka in autumn (quarter 1-2), spring quarter (3-4). autumn and biomass index	37
Figure 10. Chokka squid catch (kg) ± 95 confidence interval box plots by years in eight fishing areas	51

List of tables

Table 1. Defining the vessel size groups with their estimated sizes in meters	22
Table 2. Frequency distribution table describing the primary data, the reduced data and the aggregated dataset	27
Table 3. Annual standardized effort in the jig fishery expressed in terms of man-hours	32
Table 4. Results of a simple ANOVA and GLM model using the Ln CPUE of the chokka squid as a dependant variable	34
Table 5. Results of the Spearman rank correlation between the standardized Ln CPUE and surveys	35
Table 6. The different types of the vessels utilized to catch squid during the early 1980s	50
Table 7. Vessel category types currently utilized to catch the chokka	50

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Abstract

The total annual catch from the log-book statistics and the landing statistics of the Food and Agriculture Organization were compared. Annual catch per unit effort of the *Loligo reynaudi* was investigated by selecting the relevant variables in the log-books. The Squid Policy of 2005 was used as a guideline to group the vessels into five size groups. The grouping of vessels by size was done by using the crew number distribution. There were eight fishing areas identified from the localities that had more than one percent of the observation use. The data were aggregated by year, month, size and area. Four quarters, and two regions were identified. A simple Analysis of Variance was used to test the effect of the year, quarter, size group and region and a General Linear Model was used to standardize the annual CPUE. The trend in the annual biomass from the surveys and the standardized CPUE were examined and compared.

The log-book data had the highest annual catch in 2004 and lowest in 2001. While FAO statistics had the highest record in 2005. Closed season imposed from October to November and different peaks in the spawning periods had an influence on the monthly CPUE. Vessel size group 5 had the highest CPUE, while, size group 1 had the lowest. Areas also exhibited differences in the CPUE with Port Alfred showing higher and Seal Bay lower CPUE. The relationship between the survey biomass and standardized annual CPUE revealed an increase in the biomass in the surveys and a fluctuation in the CPUE.

Key words: Catch per unit effort, *Loligo reynaudi*, size groups, areas, closed season and biomass.

1. INTRODUCTION

The cephalopods fishery has increased worldwide in the past decades. Jereb *et al.* (2005) reported in Food and Agriculture Organization (FAO) the catch increase of the cephalopods from about 1 million in 1970 to more than 3 million metric tonnes in 2001. This has been caused by a substantial entry growth of the cephalopod species on the commercial fisheries (FAO, 2008). Among the cephalopods, the squid catches from 1982 to 2002 have ranged between 1,1 and 2,6 million tonnes (Japp, 2004). The Ommastrephids, *Illex argentine*s and *Todarodes pacificus* dominated these squid catches. FAO¹ recorded 12,4 to 288,9 metric tonnes of the *Loligo* species from 1950 to 2001. According to FAO (2004), *Loligo gahi* was the dominant specie in the *Loligo* species.

1.1 Biology of the chokka squid

Squid is classified under the phylum Mollusca, class Cephalopoda. *Loligo reynaudi* belongs to a Loliginidae family (Hanlon *et al.*, 2002). There are four species of commercial significance recorded in South African waters. Namely, *Loligo reynaudi*, *Uroterthis duvarceli*, Angola flying squid *Todarodes angolensis* and lesser flying squid *Todaropsis eblanae*. During the 1980s, it was uncertain whether the *Loligo vulgaris* in the European and West African waters was distinct from the populations in South Africa. The subsequent investigation determined that South African squid was distinct, and that the genetic differences were at the sub species level (Augustyn *et al.*, 1992). The European and West African sub species was termed as the *Loligo vulgaris vulgaris* hence the South African sub-species was termed as the *Loligo vulgaris reynaudii*. A further investigation on the *L. v. reynaudii* nomenclature was carried out. *L. v. reynaudii* was re-named as *Loligo reynaudi* (d'Orbigny, 1845) which is the present name being used (Olyott *et al.*, 2007).

Loligo reynaudi is the most abundant species in South African waters as it counts for about 95% of the total squid catch. It is locally and commonly known as the chokka squid in South Africa, and commonly known as the Cape Hope squid by FAO. It is distinguished from other loliginid squids by its relatively long grayish diamond fins, which cover more than half the length of their mantle.

¹ Jereb *et al.* (2005). **Table 1** Total world cephalopods catch in thousand tonnes since 1950, by major species.

The chokka squid is distributed only in South Africa (Rodhouse, 2005²). It is mainly distributed in the eastern Agulhas Bank (Figure 1). It is found also along the extension of the Cape Point continental shelf to the southern Namibia on the west coast (DEAT: 2005b). Apparently, the west coast population of *Loligo reynaudi* that consists of immature and sub adult squid is an extension of the main population, which is concentrated on the east coast of Cape Agulhas Bank.

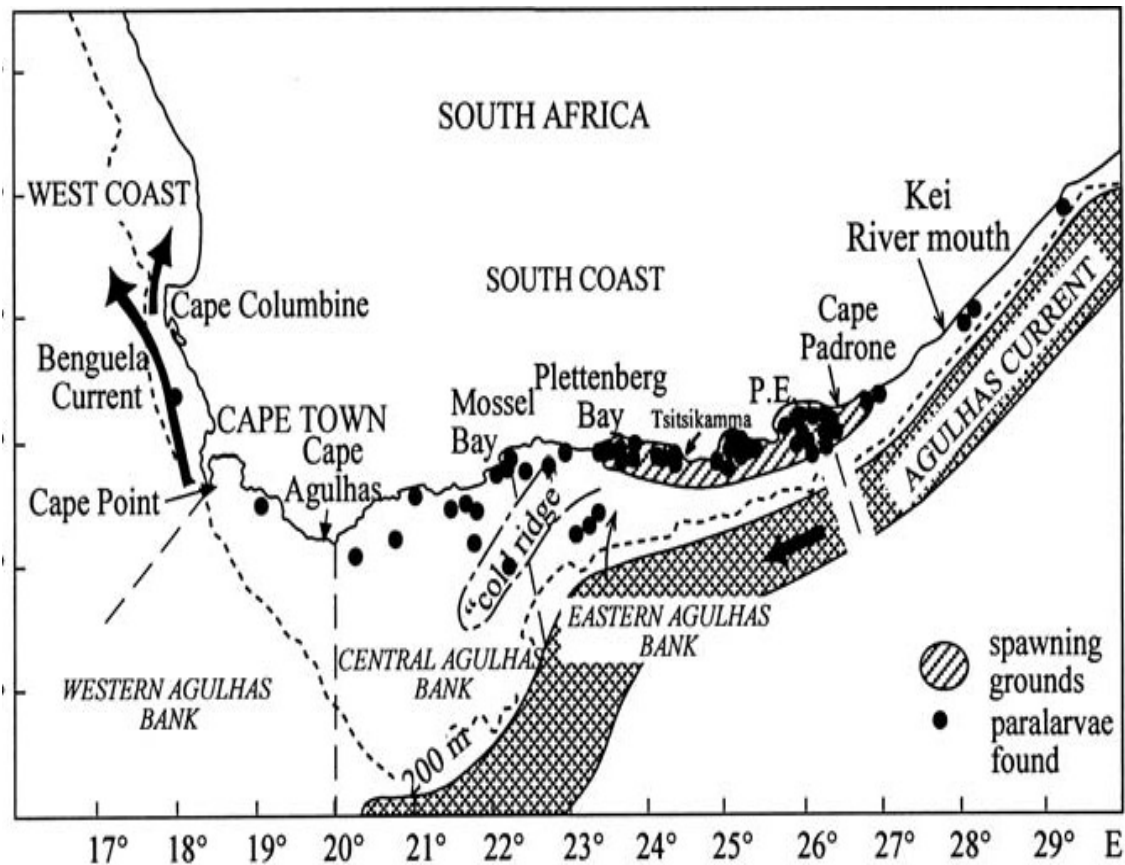


Figure 1³ The indication of the chokka distribution resembled by the main spawning grounds and paralarvae distribution in the Agulhas Bank.

² Rodhouse (2005). Figure C2.1 – Distribution of the world’s major squid stocks exploited by commercial fisheries and reported at species level by FAO. Figure C Lolignidae.

³ The figure was directly taken from Roberts & van den Berg (2002).

The temperature, dissolved oxygen, turbidity and wind currents are the major abiotic factors that the squid distribution depends on. In South Africa, chokka is found mostly in shallow inshore areas and in deep water of the Agulhas Bank (Olyott, 2007). Most squid prefer the east of the Agulhas Bank, due to the high temperature and well oxygenated bottom water. In most instances the chokka squid is not found along the west coast. Due to the fact that the west coast region has abundant primary and secondary production that may lead to low levels of dissolved oxygen.

Loligo reynaudi squid is a fast growing coastal cephalopod. The life cycle (embryonic development) lasts from few weeks to few months and the post-hatching life cycle is approximately equal to a year. During the embryonic development, the embryo remains attached on the hard substratum or in the algae on the bottom of the coastal sea (Augustyn & Roel, 1998). Chokka squid reach sexual maturity at the mantle length of 125 mm for males and at 160 mm mantle length for females. The growth of *L. reynaudi* is highly variable due to aspects of the biology and abiotic factors. Normally, males grow larger than females reaching a mantle length of about 46 cm, while females reach a mantle length of 28 cm (DEAT, 2005b). The age of the chokka is determined by counting the rings in the statoliths increments. Their life span is approximately two years (Roel & Butterworth, 2000). Chokka specie is semelparous and its population is typically unstable, responding rapidly to changes in environmental conditions.

The type of food that the chokka squid feeds on differ with the depth, location, weather conditions, season and time of the day. Zooplankton copepods, namely, *Calanoides carinatus* and *Calanus agulhensis*, are the most important diet of the chokka paralarvae (Olyott *et al.*, 2007). The adult chokka squid prey mainly on small fishes, crustaceans and other cephalopods. There are two vertebrate marine mammals that belong to Cetacea order, found feeding on the chokka squid. Those are killer whales, *Orcinus orca* and dusky dolphin, *Lagenorhynchus obscurus* (Augustyn *et al.*, 1992). Chokka squid serve as an important food for benthic sharks, namely, spinydog fish shark, *Squalus acanthias*, smooth-hound shark, *Mustelus mustelus*; pyjama cat shark, *Poroderma africanus* (Sauer, 1995) and leopard cat shark, *Poroderma pantheriu*. Some teleost fish, rays and *Thalassarches* albatross seabirds prey also on the chokka squid.

L. reynaudi mates by using three ways which are: Head to head mating where the male and female face each other and entangle their arms and males place spermatophores in females bursa copulatrix (pouch for storing sperms) (Figure 2). This mating method is usually observed in the offshore areas. Male parallel mating occurs when the male swims beneath the female, grasp her with his arms and passes spermatophores to the mantle cavity near the oviduct (Hanlon *et al.*, 2002) (Figure 2). The last mating method is the male “sneaker” mating. In this method, the male jet quickly and grasp females near the base of the 1st or 2nd arms to place spermatophores amidst the arms where the single egg strands are held and fertilized (Figure 2). The chokka squid normally spawns on depths of about 200 m in inshore waters along the southern east coast (Olyott *et al.*, 2007), between Port Alfred next to Port Elizabeth (P.E.) and Plettenberg Bay (Figure 1). The chokka spawning occurs throughout the year with the higher peak between September and December. Egg masses are laid on underside of rocky overhangs attached to hard substratum or branched sessile organisms on the sea bottom, where they form large masses (Figure 2). The paralarvae turn to migrate offshore to feed, mature, and then return to the spawning grounds to complete their life cycle. The chokka squid do not have several larval phases after hatching, but hatch into paralarvae that become planktonic and hence it becomes susceptible to predation (Roberts & van den Berg, 2002).

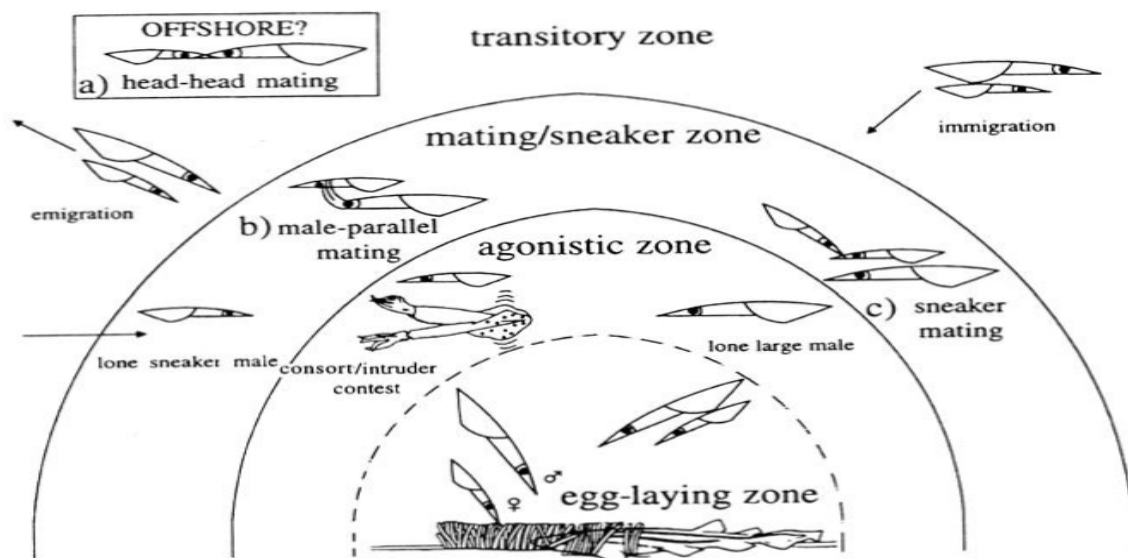


Figure 2⁴ An example of the mating methods of the *Loligo reynaudi*.

⁴ The figure was directly taken from Hanlon *et al.* (2002).

1.2 The chokka squid fishery in South Africa

The South African chokka squid fishery is based on a single species namely, *Loligo reynaudi*. The chokka fishery started in the early 1960s. During that time, foreign fleets dominated the chokka fishery in South African waters. The South African demersal trawl fleets caught the chokka as a by catch when targeting the Cape hake (*Merluccius* species) and Agulhus sole (*Austroglossus pectoralis*) (Roel *et al.*, 2000; Glazer & Butterworth, 2006). The line-fishermen were catching the chokka for bait purposes. The chokka fishery began to expand in the late 1970s when the calamari became a popular restaurant dish. In 1984, the costal handline chokka squid jig industry was established (Sauer, 1995). The fishery became chaotic as there were no management measures imposed. The foreign fleets were phased out in the late 1980s when the management controls measures were initiated. At present, only South Africans are allowed to catch the chokka.

The South African chokka handline jig fishery is undertaken on the south east coast in the coastal waters of the Eastern Cape Province. Historically the fishery was performed on the inshore spawning grounds of the chokka between the Plettenberg Bay and Port Alfred (below Cape Padrone in Figure 1). Most of the currently used fishing grounds were used in the past but now vessels may move further offshore. Particularly during the day, the majority of the chokka are caught over egg begs while actively spawning (Sauer, 1995). The fishery occurs through-out the year. In most instances, chokka squids are commercially exploited during the most critical period of their life cycle during reproduction. The fleet aggregate in the inshore areas. During the winter months when the chokka are scarce in the inshore spawning areas fleet move to fish further offshore.

During the development of the squid fishery in South Africa, Japanese plastic hand-held jigs were used (Augustyn & Roel, 1998). As the fishery progressed, the local fishermen made varieties of the jig types that appeared on the local markets. On each line, there were 2 jigs attached with a plastic floater (Sauer, 1995). Squid were line caught by large spiny hooks that were jigged up and down in the water. In the current fishery, the jigs are attached with parachute sea anchors to reduce the jig drift (DEAT, 2005a). During the night fishing operation, chokka fishers use open bulbs and spotlights to attract and catch the chokka squid. In the past chokka, squid vessels were divided into vessel categories and maximum number of crew was set for each vessel. The vessels that participated in the chokka fishery during the

1980s were categorized into three groups (Table 6 in appendix 1). According to Mather *et al.* (undated), the ski-boats were powered by a twin outboard motor but because they were not able to handle the large amount of squid quantities, in 1985 the large deck boats with freezers began to arrive. The squid fishery fleet has changed due to the technological improvement on the vessel. Yet there are still some ski-boats operating. Currently the vessels operating in the squid fishery are categorized into group sizes based on the crew number (Table 7 in appendix 1).

Almost all the squid caught in South Africa is frozen in trays at sea and packed to a maximum of 10 kilograms for the export primarily to Europe. According to Rodhouse⁵ (2005) the nominal catch amounts to approximately 8 000 t per year, which is 0.2% of the global trade in *Loligo* species. Chokka is also exported to Japan, Spain and Italy. The Japanese land more squid than any other nation, including good catches of lolignids species such as *Loligo bleekeri* and *Loligo edulis* (Sauer, 1995). However, the South African squid fishery contributes directly to the local economy of the Eastern Cape Province as it provides a high level of the employment opportunities (Glazer & Butterworth, 2006). Prior the export, the chokka are sorted according to size.

The chokka stock assessment in South Africa was initiated in 1986, when the squid management started. The swept area method was introduced and is still used to provide the biomass estimates of the chokka squid. The Department of Environmental Affairs and Tourism (DEAT) conduct the biomass surveys through the Marine and Coastal Management (MCM) branch. These surveys are performed with the primary aim to estimate the biomass and abundance of the deep water hake, *Merluccius paradoxus* and a shallow water hake, *Merluccius capensis* (Augustyn & Roel, 1998). The areas are surveyed by a stratified bottom trawl surveys conducted in spring and in autumn. Although the surveys are designed for the demersal fish species, they provide estimates of the chokka squid that are used to determining the biomass trends.

⁵ C2-FAO (2005). On table C2.1. Summary of the world squid catch in 2002 (FAO 2003).

The surveys do not give the exact biomass because they do not cover the entire area of the species distribution. The model fitted on the squid biomass index is a “*revised biomass dynamic model that uses an observation error estimator*” (Roel & Butterworth, 2000; Glazer & Butterworth, 2006). DEAT⁶ (2005) further reported, “*A biomass dynamic model using an observation-error estimator was developed in 1997-1998 to assess the status of the chokka resource. This model is therefore currently being revised and other alternative models are also being investigated.*” The catch and effort data submitted to DEAT in MCM by the squid fishing industry serve as the second method for the chokka biomass index assessment. Due to the fact that demersal fish surveys are not considered reliable in determining the Total Allowable Effort (TAE). The nominal catch per unit effort (CPUE) calculated from the catch and effort data, is standardized by the General Linear Model (GLM) (Glazer & Butterworth, 2006). The variables used include the year, area, vessel, length, water depth and target species.

1.3 Management overview

1.3.1 Historical chokka squid management

Ever since the start of the chokka squid jigging fishery in 1984 in South Africa, various control management measures had been initiated. The squid fishery management began towards the end of 1986 when it was realized that there were hundreds of the line fishing boats involved in the chokka fishery (Sauer, 1995). During that time, the squid fishery was a chaotic adventure. As a result, the catch and product quality was poor with much of the resource being wasted as the local markets became saturated. The South African government initiated in 1986 the TAE input control management measure (Augustyn *et al.*, 1992) and a public bag limit of 20 squid per person per day to the sport anglers. At the beginning of 1987, a six weeks closed season management measure from December to January was added with the aim of reducing the squid fishing pressure on the spawning grounds. This seasonal closure did not apply to the sport anglers. The fleet size was limited and there was a restriction on the vessel size. The fishers were prohibited to transfer or sell their squid fishing license for a period of 3 years. In 1988, the government in collaboration with Southern Cape Commercial

⁶ DEAT. (2005c). TAE for 2005 Squid Season. See under annexure B1 page 1 and annexure B2 page 1. Reference: V1/29/5/1.

Available at: http://www.mcm-deat.gov.za/tae_tac/tae_2005_squid.pdf (Accessed on 01 February 2010).

Line Fishing Association (SCCLFA) moved the closed season from December - January to October – November (DEAT, 2005c annexure B2). This was done because of the high spawning peak between September to December. The Tsitsikamma National Marine Park (TNMP) (Figure 1) located within the main spawning grounds were totally closed for all fishing industries in South Africa. By that time, the squid fishery was regulated by the Sea Fishery Act of 1988 (Act No. 12 of 1988) (White Paper, 1997). Institutions⁷ that were involved in the squid management include the Sea Fisheries Advisory Council which was responsible to advise the Minister on the determination of the annual effort. The Quota Board⁸, which had to recommend and give advice on the effort allocations. The Sea Fisheries Research Institute which was responsible for conducting the research and to support the decision-makers on the optimal utilization of South Africa marine living resources. SCCLFA formulated in 1988 that was later altered to South African Squid and Line Industrial Association (SASLIA) and to South African Squid Management Industrial Association (SASMIA) in 1990 was a non-governmental institution involved also in the squid management. Alterations following the 1994 first democratic elections were initiated to fisheries in South Africa. The Fisheries Policy Development Committee in 1995 was formulated and published a White Paper on Marine Fisheries Policy in 1997. In 27 May 1998, the Sea Fisheries Act (Act No. 12 of 1988) was replaced by a Marine Living Resource Act (Act No. 18 of 1998).

1.3.2 Current chokka squid management

The squid fishery is regulated by the Marine Living Resource Act (MLRA) of 1998 *with a goal of transformation and provides equal access to rectify historical imbalances* (Olyott, *et al.*, 2007). MLRA has 3 main pillars equity, sustainable resource use and industrial stability. Institutions that are currently participating in the squid management include the Consultative Advisory Forum that performs the past Quota Board function, SASMIA, squid research working group, squid management working group, Monitoring, Control, Surveillance (MCS) control officers. At the international level, South Africa aligned itself with the FAOs Code of Conduct Responsible for Fisheries to manage the chokka squid fishery in a sustainable manner.

⁷ Institutions are defined as people involved in the management, this includes the governmental, non-governmental, interested and affected parties (White Paper, 1997).

⁸ Quota Board were 5 members appointed by the Minister which had no direct or indirect interest in the fishing industry (White Paper, 1997).

It also made a commitment of introducing approaches such as Ecosystem Approach to Fisheries management by 2010 (DEAT: 2005c). Chokka fishery is also managed by following the Squid Policy of 2005 guidelines. The purpose of the policy is *to set out the considerations that will apply to the allocation of long-term commercial squid fishing rights*. The sectoral management plans formed in accordance with the White Paper (1997) being used include the Draft Squid Fishery Management Plan of 2006.

The squid fishery from 2006 is managed by granting a 10 years commercial fishing rights to each Right Holder⁹. The other management measure is the TAE input control measure that is determined in accordance of section 14 of the MLRA (DEAT¹⁰, 2005a). TAE is an effort control measure whereby the number of fishermen and vessels permitted to participate in the squid fishery are limited. It is set based on the historical catch return reports, squid scientific research surveys and is revived annually. The TAE of this year (2010) is maintained at the same level as in 2009 being 136 vessels and 2422 crew members (DEAT¹¹, 2010). Recreational fishers are allocated a bag limit of 20 chokka per person per day. An annual eleven weeks closed season *as stipulated in the Government Gazette Notice 9047 dated 06th March 2009* (DEAT¹², 2009) is the additional squid management control. The closed periods are from 19 March-09 April, 23 July-13 August, 19 October-23 November. However, the closed periods except from October to November are being altered this year (2010) though not yet gazetted to 11 August-22 September. TNMP is a totally closed area. There are no output control measures imposed. For instance no minimum landing size or specifications for by-catch or discards are stated in the Squid management plan and Policy. MCS is also involved in the management. Their aim is to monitor, control and enforce the effort control in the squid fishery. MCS insists on the utilization of the Vessel Monitoring System (VMS) during fishing operation, but this is not implemented by fishers.

⁹ Right Holder is a person who is permitted and granted the commercial rights to fish in South African waters.

¹⁰ DEAT. (2005). General Fisheries Policy.

¹¹ DEAT (2010). TAE for the squid fishing season.

¹² DEAT (2009). Squid Permit Conditions Amendment. Paragraph 10 (10.1).

1.4 Research Problem

In South Africa, the squid fishery is based only on chokka as mentioned previously. The fishery is considered being important, as it provides direct employment and increases the economy of the country. Management of the chokka fishery is based on the TAE that is set based on the historical catch returns determined from the log-book and biomass estimates from the surveys. Managers face a challenge on setting the TAE. This is because, the log-books are inaccurate as some information on the effort is not recorded. In addition, the surveys are not conducted in all years. Hence, in some years they are conducted but only once instead of twice a year.

The study of Roel *et al.* (2000) identified a declining trend in chokka squid *Loligo vulgaris reynaudii* South African catches. Hence, the results in this study based on the jig data revealed a fluctuation. Therefore it is necessary to analyze a larger dataset from 1985 to 2008 to catch potential dramatic changes in the 1980`s and 1990`s. The short time series of 10 years selected in this study was not able to catch previous change. It is now hard to judge if the stable state is due to a healthy stock or a stock on low levels.

The aims of this study were to:

1. Study the total annual catch from 1999 to 2008, by comparing the annual catch recorded in log-books and FAO annual landings.
2. Examine the annual CPUE in years, months, vessel size groups and in areas.
3. Standardize the annual CPUE.
4. Use the standardized annual CPUE as a measure of stock biomass.
5. Compare the standardized annual CPUE and biomass index from the surveys.

1.5 Approach

Due to the limited time “4 months” given for a write-up, compromises had to be made in the large amount of the data collected. The analysis was based only on 10 years, 1999 to 2008. The approach used for the analysis was inductive research strategy at which the log-book data of the chokka was described.

It is very much important to mention that, “doing a study on a secondary data is not an easy task.”

2. MATERIALS AND METHODS

The use of the CPUE data as a measure of the stock abundance index involved the selection of specific logbook data to be utilized. After the data selection as described in section 2.4, the vessels were grouped into five size groups and the localities into eight fishing areas. The principles utilized for the vessel size grouping and area aggregation are outlined in 2.6. The CPUE indices were examined after the primary dataset was aggregated by years, months, size groups and areas. A simple Analysis of Variance and GLM were used to test the effect on the CPUE and to standardize the CPUE. The standardized CPUE and the survey indices were finally compared (3.6).

2.1 Study area

The study area is determined according to the fishing areas utilized by the jiggers fishing chokka squid. The study area extends from 20⁰E to 27⁰E in the Agulhas Bank that stretches along the South African coast (Figure 4).

2.2 Data type

The data used in this study were secondary data that were kindly provided by MCM. The data were fishery independent data from surveys and fishery dependent data from logbooks. The data of FAO reported in FishBase were a tertiary data (<http://www.fishbase.org/Country/CountrySearchList.php>, accessed on 25 March 2010).

2.3 Data collection

Fishery independent data – Survey data

These data were collected by means of a stratified random sampling. The areas of the species distribution were surveyed by stratified bottom trawl surveys, which were conducted twice a year (Roel & Butterworth, 2000). These surveys were performed with the aim of estimating the biomass and abundance of the demersal species such as hake, *Merluccius paradoxus*, *M. capensis*, Cape Agulhus sole (*Austroglossus pectoralis*) and squid. The surveys did not provide the exact biomass because they did not cover the entire area of the species distribution and the catchability of the survey trawl is likely to be below one. Yet the surveys provide an estimate of the squid abundance as a biomass index.

Fishery dependent data – Logbook data

The chokka squid fishing jiggers collected the fishery dependent data. The chokka squid fishers carefully register catch and effort in logbooks daily and submit them on a monthly basis to MCM.

2.4 Data selection

The survey data and logbook data were selected for a period of ten years from 1999 to 2008, and FAO capture production statistics from 1999 to 2007 were included. In the logbook statistics dataset, the following variables were selected for the analyses.

1. Catch in kilograms
2. Crew number
3. Hours of fishing
4. Distance to the shore in nautical miles
5. Locality number
6. Year and
7. Month.

The selection was done because it was seen necessary to include only the variables relevant to the topic of this study.

2.5 Analysis of the survey data

Scientists at MCM follow the method described by King (2006) when analyzing the biomass survey indices. The area sampled was calculated (equation 1).

$$a = W \times TV \times D \quad (1)$$

Where a is the area swept by the bottom trawl, W -width of the trawl, TV -towing speed and D -duration of the bottom trawl tow. The total estimated squid stock size per area was analyzed (equation 2).

$$N = n (A/a) \quad (2)$$

Where N is the total estimated stock size, n -is the mean catch of the fish, A is the stock size area and a is the swept area. Finally the biomass of each strata were summed up (Lipinski, 2010, personal communication). The method used to estimate the final biomass was not specified in the survey report. Only survey indices namely the stratified swept area estimate are available (MCM/2009/JUL/SWG-SQ/6 report).

2.6 Analysis of the logbook data

The raw logbook dataset called “the primary dataset”, were reduced by identifying and eliminating the outliers to a “reduced dataset”. Outliers are the observation points that are far away from the other observation points in the data (Berk & Carey, 2004). The following definitions were used to exclude the outliers, catch > 5000 kg, distance > 162 nautical miles. Five vessel size groups were identified following the Squid Policy (2005) guidelines. Grouping was done by using all the crew numbers observation records and the approximate size in meters of each vessel size group were estimated (Figure 3, Table 1). Crew numbers were chosen for the size grouping because it was not possible to use the vessel numbers since the vessel numbers of the fishing vessels vary in years.

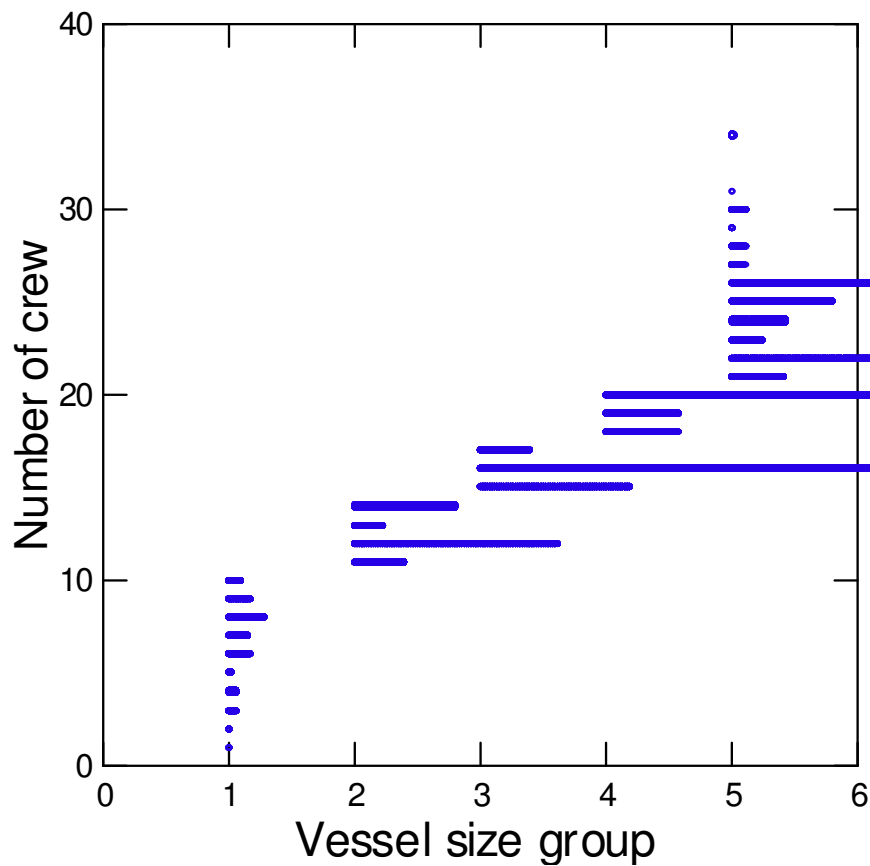


Figure 3. Histogram showing the vessel frequency by number of crew and by the five vessel size group.

Table 1. Defining the vessel size groups with their estimated sizes in meters.

Vessel size group	Crew number	Approximate size (m)	Number of observations	Percent
1	1-10	5-12	6 041	4.134
2	11-14	13-15	18 175	12.436
3	15-17	15-17	42 447	29.044
4	18-20	17-19	29 233	20.002
5	21-34	Over 19	33 8790	23.175
Total	Missing values		16 381	11.209
Grand total			451 067	100

The localities were grouped by using the locality codes book guideline (MCM, 2009) to identify which of eight areas each locality belonged to. Localities were allocated to eight areas. Because of the huge amount data (N=164 159), reductions in the dataset had to be made. Therefore, the localities with few records (< 1%) were deleted from the primary data. The data were then aggregated by “year”, “month”, “size” and “area” and the sum for the variables “catch” and “effort” were to be included in further analyses. The five most important fishing areas were later further identified as two regions “region”= 1 in the east, consisting of areas 2, 3, 4 and “region”=2 in the west consisting of areas 6 and 7. A new variable “quarter” (=1-4) summarising every three months, was introduced to reduce the cells with zero observations.

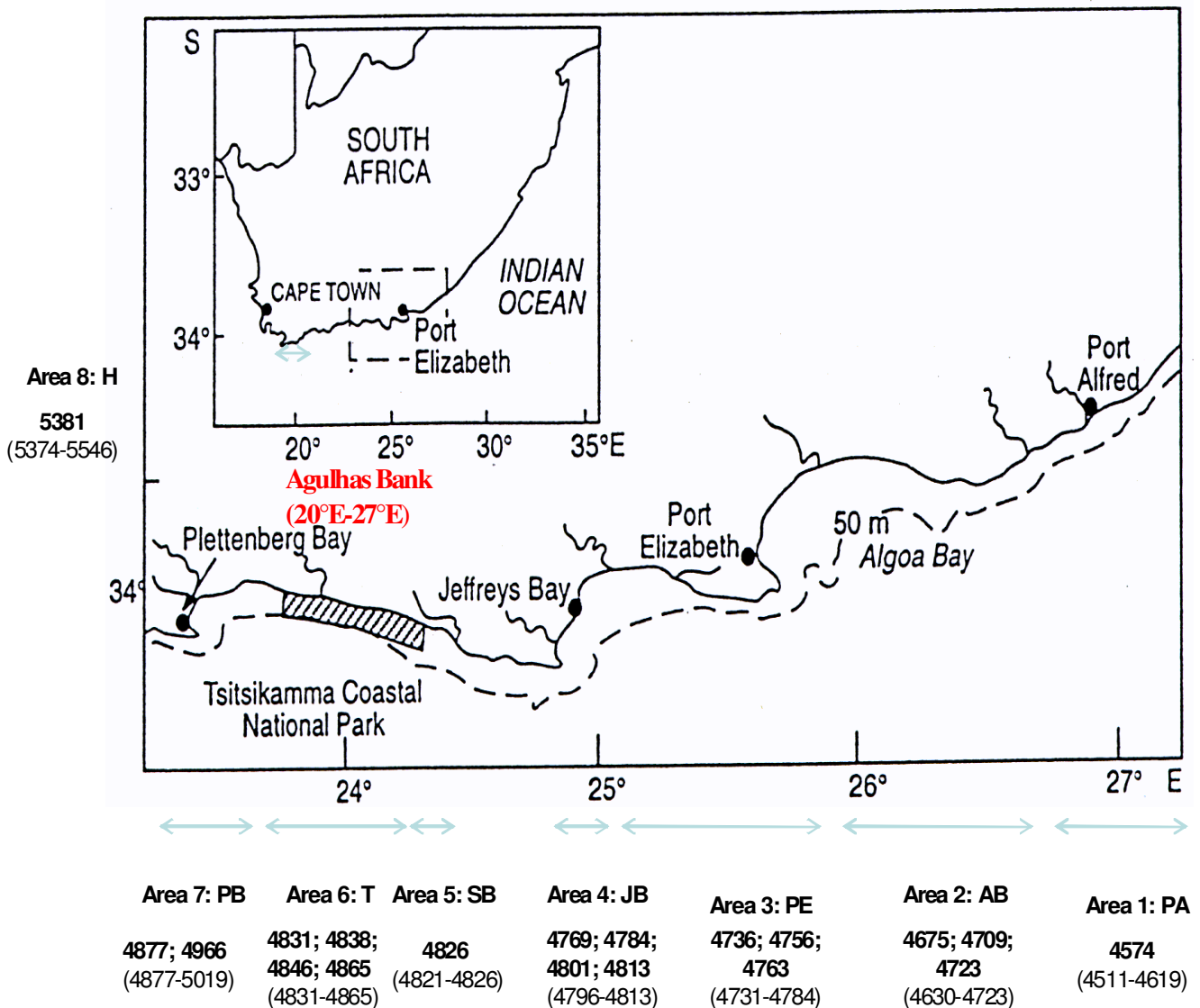


Figure 4. The study area, Agulhus Bank stretch (indicated by name & co-ordinates). PA-Port Alfred, AB-Algoa Bay, PE-Port Elizabeth, JB-Jeffreys Bay, SB-Seal Bay, T-Tsitsikamma, PB-Plettenberg Bay and H-Hermanus. Localities used in the analysis (bold) and range of localities (regular) in each of the eight areas (Area 1-8).

2.6.1 Total annual landings

The total annual catch was calculated from the primary and reduced logbook data and compared with the FAO annual capture statistics

(<http://www.fishbase.org/Country/CountrySearchList.php> , accessed on 25 March 2010).

2.6.2 Annual CPUE

The annual CPUE was examined by plotting the Ln CPUE (kg/hr) box plots against years, months, size groups and areas.

2.6.3 Catch in years by areas

Catch assessment in areas was investigated by plotting the box plots of the catch (kg) by the years in the areas. The catch of the years by areas of area 1, 5, 8 box plots were eliminated when defining the eastern and the western region. This was done by following the recommendation of excluding the areas with less catch records observation though they are significant (Punt *et al.*, 2000).

Fishing effort

Scientists in MCM obtained fishing effort from the chokka vessel logbook database. It was presented as the annual values of the standardized effort. Standardized effort was given as man-hour and calculated by dividing the total annual catch by the combined standardized CPUE indexes derived from the included areas (DEAT, 2005c, annexure B1). The standardized CPUE indexes were calculated using GLM (Glazer & Butterworth, 2006; Roel & Butterworth, 2000). The variables included for standardizing the annual CPUE indexes were year, area, vessel length, water depth and target species.

A simple Analysis of Variance (ANOVA)

A simple ANOVA was utilized to test the effect of year, quarter, size and region on the Ln CPUE of the chokka. Ln CPUE was treated as a dependent variable and year, quarter, region were treated as the categorical variables, while vessel size was treated as the covariate variable.

General Linear Model (GLM)

It is essential to standardize the CPUE data for squid fisheries in order to obtain the appropriate abundance index because the catch efficiency of the fleet may change due to technological creep (Battaile & Quinn, 2004; Dobby *et al.*, 2008) and the catchability may vary between areas and season. The model used for the standardization of the Ln CPUE in years, quarter, size and region was a GLM with multiplicative approach. This model is a linear combination of the explanatory variables and it assumes a log-normal error (Campbell, 2004; Maunder & Punt, 2004). In the equation (3), the response variable was the independent variable, Ln CPUE and the explanatory input variables were the year, quarter, size group and region.

$$\begin{aligned} \text{Ln CPUE} = & \beta_c + \beta_y(\text{year}) + \beta_q(\text{quarter}) + \beta_s(\text{size}) + \beta_r(\text{region}) \\ & + \beta_{y*q}(\text{year}*quarter) + \beta_{y*s}(\text{year}*size) + \varepsilon \end{aligned} \quad (3)$$

Where Ln CPUE is the standardized CPUE

β_c is the constant co-efficiency

β_y is the co-efficiency of the year

β_q is the co-efficiency of the quarter

β_s is the co-efficiency of the size group,

β_r is the co-efficiency of the region

β_{y*q} is the co-efficiency of year interacting with the quarter

β_{y*s} is the co-efficiency of year interacting with size group

ε is the error

2.6.4 Comparison of the standardized CPUE and biomass surveys

Finally, the annual standardized CPUE was compared with the survey indexes. This was done by plotting the line graph of the standardized CPUE and biomass indexes.

All data treatment and statistical analysis were done on SYSTAT (SYSTAT 12, 2010) and Excel.

3. RESULTS

The results outlined below were obtained after the analyses of the logbook data.

3.1 Description of the data

The primary dataset is very large and consisted of 164 159 cases recorded from 1999 to 2008. The reduced dataset where outliers were excluded had 146 147 cases and the aggregated dataset had 3966 cases (Table 2). The number of cases was evenly distributed between the years. In the primary and reduced datasets, 2001 had less number of cases, while the year 2004 had the highest number of cases. The aggregated dataset had less record in 2005 and 2008, indicating a relatively lower activity in areas and months in these years, while 2000 had high records indicating higher distribution of fishing activity between areas and months.

Table 2. Frequency distribution table describing the primary data, the reduced data and the aggregated dataset.

Year	Primary dataset		Reduced dataset		Aggregated dataset	
	Number of cases	Percent	Number of cases	Percent	Number of cases	Percent
1999	17 962	10.942	15 312	10.477	404	10.187
2000	17 509	10.666	14 777	10.111	445	11.220
2001	12 468	7.595	10 277	7.032	427	10.767
2002	15 306	9.324	13 337	9.126	439	11.069
2003	16 038	9.770	14 009	9.586	416	10.489
2004	19 506	11.882	17 770	12.159	406	10.237
2005	15 207	9.264	14 066	9.625	328	8.270
2006	15 628	9.520	14 917	10.207	368	9.279
2007	19 433	11.838	17 710	12.118	405	10.212
2008	15 102	9.520	13 972	9.560	328	8.270
Total	164 159	100%	146 147	100%	3966	100%

3.2 Total annual landings

The annual FAO catch statistics of chokka (*Loligo reynaudi*) reported in FishBase and registered in the logbook varies over the years. FAO records report the total capture landed by all the fleets. That includes the landings of trawlers catching chokka squid as by-catch (about 5%) and the landings from the jiggers. As previously explained the logbook records presented in this study are from the jig fleets only. FAO records have the highest value of 10362 t in 2005, while low landings of 3373 and 3578 t for the FAO and logbook data respectively were recorded in 2001 (Figure 5). The highest catch is 11028 t in 2004 in the primary logbook data. A comparison of the primary logbook data with the FAO landings over the years reveal higher catch values for the primary logbook data. The reduced logbook data, where outliers are excluded is well correlated with the FAO capture production statistics, yet there is a great difference in annual catch in 2004 and 2005.

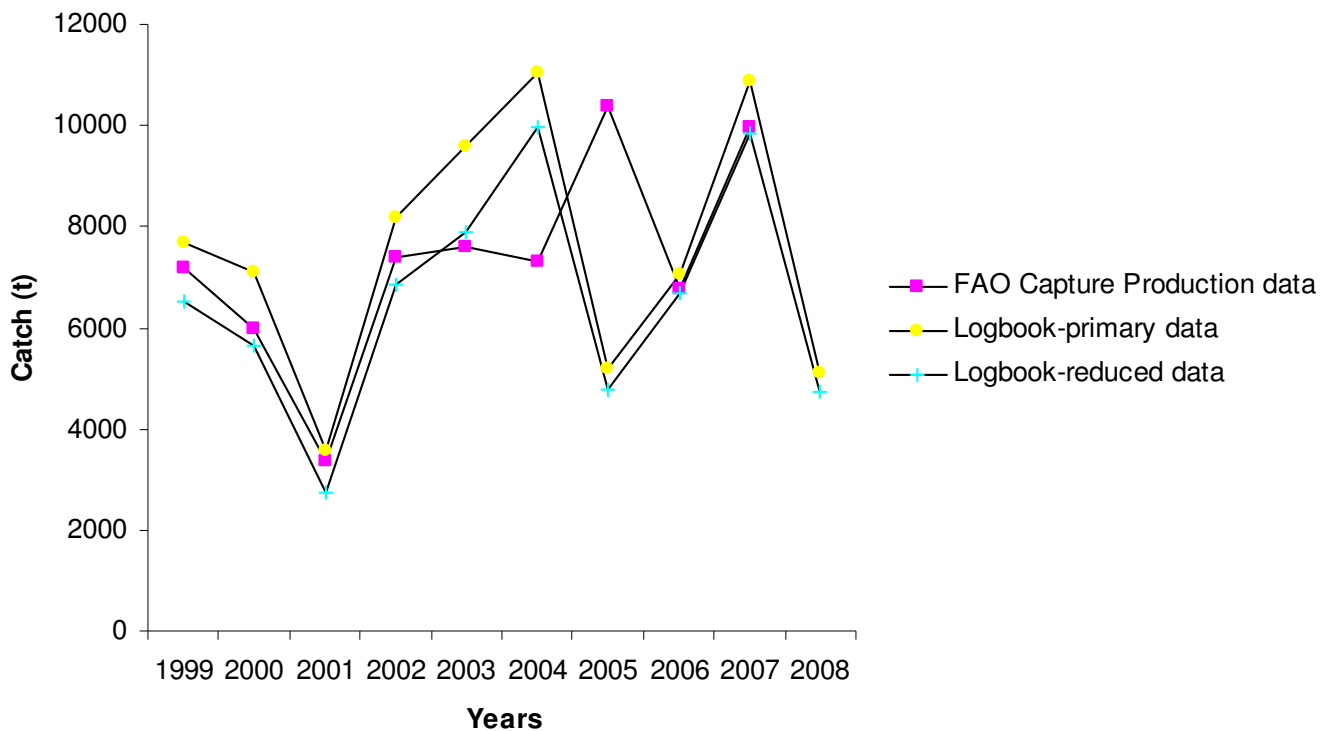


Figure 5. The annual total catch of chokka squid. FAO total capture production (<http://www.fishbase.org/Country/CountrySearchList.php>, accessed on 25 March 2010). Primary logbook data and reduced data where outliers (catch > 5000 kg and distance to the shore > 162 nm) are excluded.

3.3 Annual CPUE

The annual CPUE exhibits a fluctuating pattern over the years. Values declined from 1999 to 2001, afterwards a continuous fluctuation was observed (Figure 6a). Over the months, the Ln CPUE revealed a convex declining slope from February to October and increase from November to January (Figure 6b). The Ln CPUE increased with vessel size, but the increase is not very prominent between the largest size groups (Figure 6c). The CPUE also varies between areas. Areas 5 and 8 had the lowest Ln CPUE value (Figure 6d).

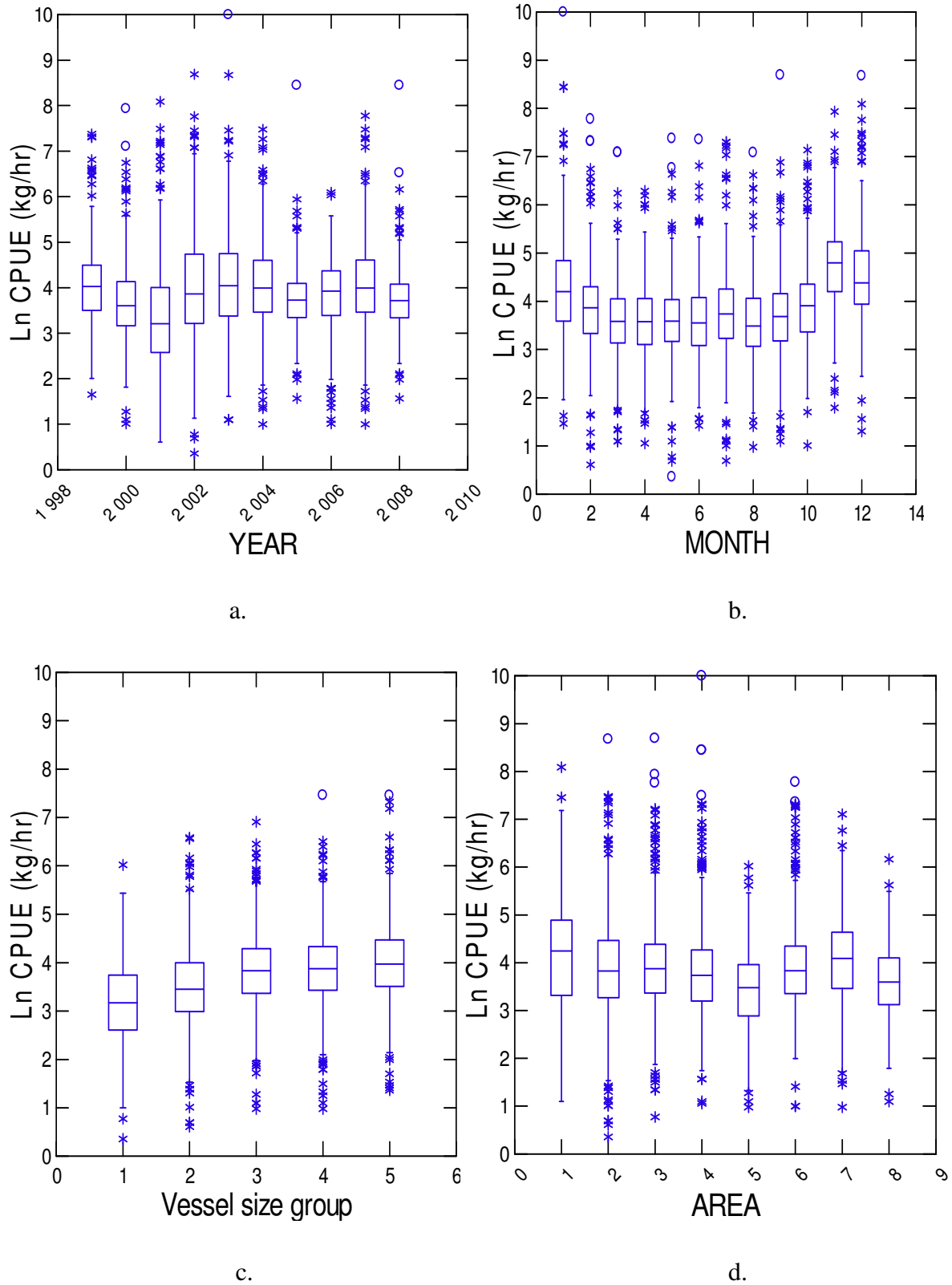


Figure 6. The annual CPUE (kg/hr) ± 95% confidence interval box plots of the chokka squid by a) year, b) month, c) size group and d) area.

3.4 Catch by areas

The annual catch (kg) in the eight areas showed the lowest catches in areas 1, 5 and 8 (Appendix 2). The catches in region 1 (areas 2-4) declined from 1999 to 2001 with an increase between 2002 and 2004 and a slight fluctuation afterwards (Figure 7 left). The same trend as in region 1 was observed in region 2 from 1999 to 2001. However, between 2002 and 2004, the catch remained relatively stable (Figure 7, right).

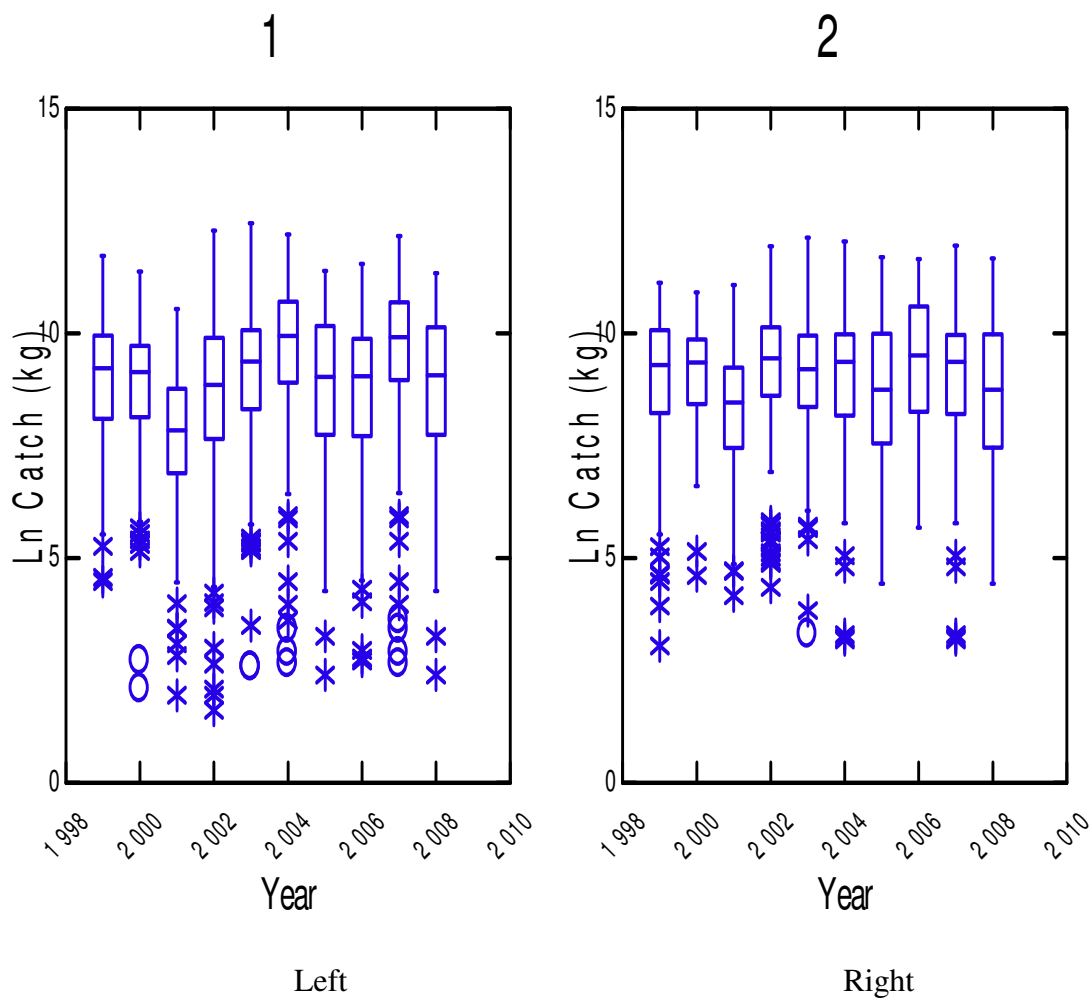


Figure 7. Chokka Ln catch (kg) \pm 95 confidence interval box plots by years in regions (Region 1 in the left and region 2 in the right).

The standardized effort has been increasing in the years (Table 3). The highest effort was observed in 2004 followed by a slow decline.

Table 3. Annual standardized effort in the jig fishery expressed in terms of man-hours (The table was directly taken from the DEAT document. **Reference:** V1/29/5/1. Annexure B)

Year	Effort ('000 man-hours)
1999	255
2000	320
2001	240
2002	260
2003	270
2004	350
2005	310
2006	250

3.5 Statistical analyses

In the ANOVA, size was run as the covariate since the variable has highest and most significant effect on the CPUE. The ANOVA identified year, quarter, and region as highly significant variables (Table 4). The multiplied variables year*quarter, year*region were also significant, while the quarter*region, year*quarter*region did not have significant effect on the CPUE. The year effect reflects the change in stock abundance and causes significant differences between the years. The significant variables were further tested in the GLM. Variables that were not significant in the ANOVA were excluded in the model. Results of the model showed the highest significant in year, quarter within the year, region, size (Table 4). The multiplied variable, year*region was also significant. The Aicake values for the GLM were slightly lower than for the ANOVA indicating a slightly better fit or the model to the data. The standardised CPUE estimated by the selected GLM model showed a drop in 2001 and slight decline in 2005 (Figure 8). There was no significant correlation between survey and standardized CPUE in Spearman correlation (Table 5).

Table 4. Results of a simple ANOVA and GLM model using Ln CPUE of the chokka squid as dependent variable (*denotes significant difference at $p < 0.05$).

Source	ANOVA			GLM		
	df	F-ratio	p-level	df	F-level	p-level
Year	9	39.777	0.000*	9	6.175	0.000*
Quarter	3	118.347	0.000*	3	126.777	0.000*
Region	1	36.097	0.000*	1	35.539	0.000*
Year*quarter	27	12.651	0.000*	27	13.304	0.000*
Year*region	9	2.472	0.008*			
Quarter*region	3	1.885	0.130			
Year*quarter*region	27	1.304	0.0416			
Size	1	457.705	0.000*	1	474.139	0.000*
Error	2 497			2 527		
AIC	5 172.354			5 127. 992		

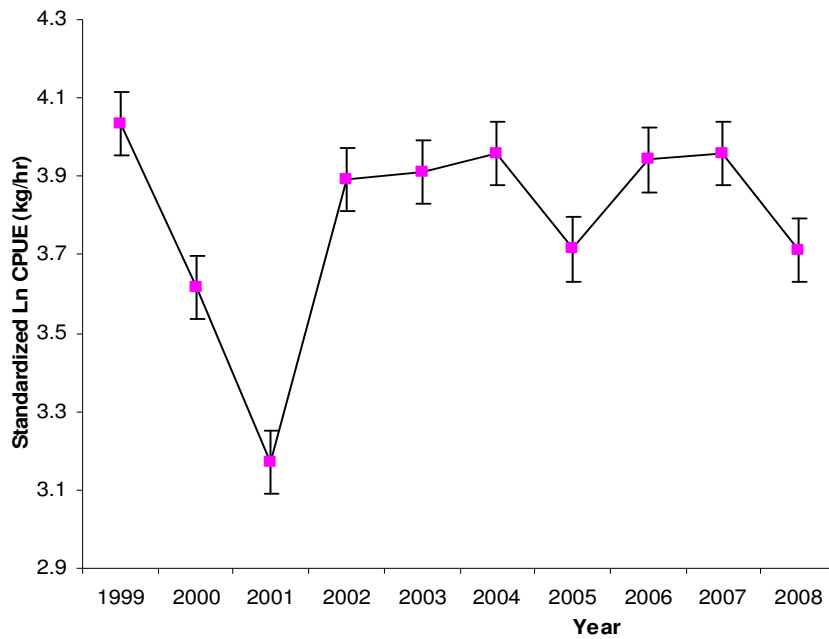


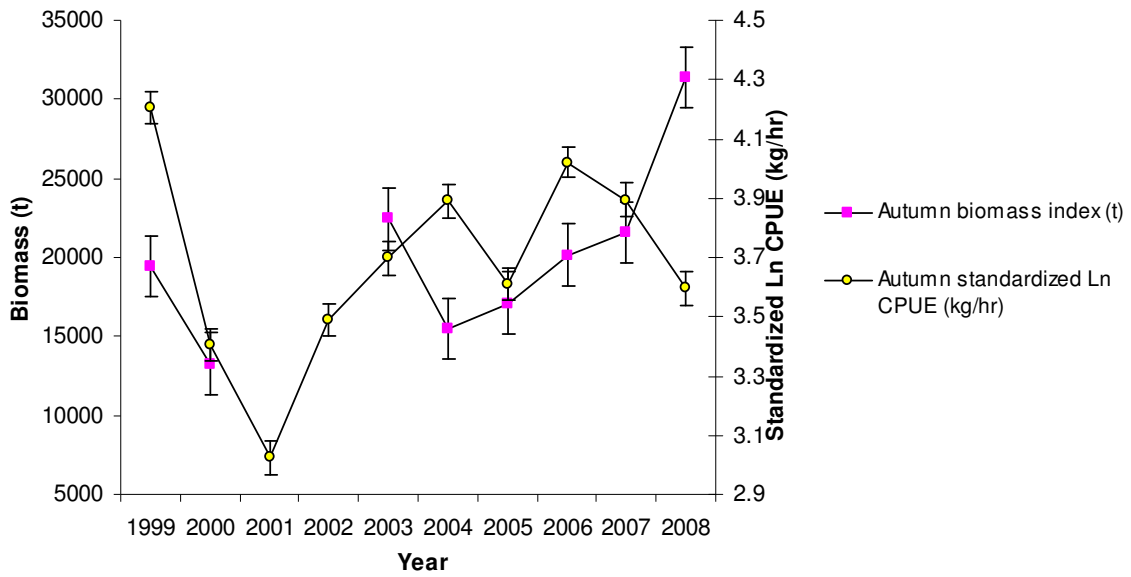
Figure 8. The standardized Ln CPUE (kg/hr) (\pm SE) of the chokka in years.

Table 5. Results of the Spearman rank correlation between the standardized Ln CPUE and surveys.

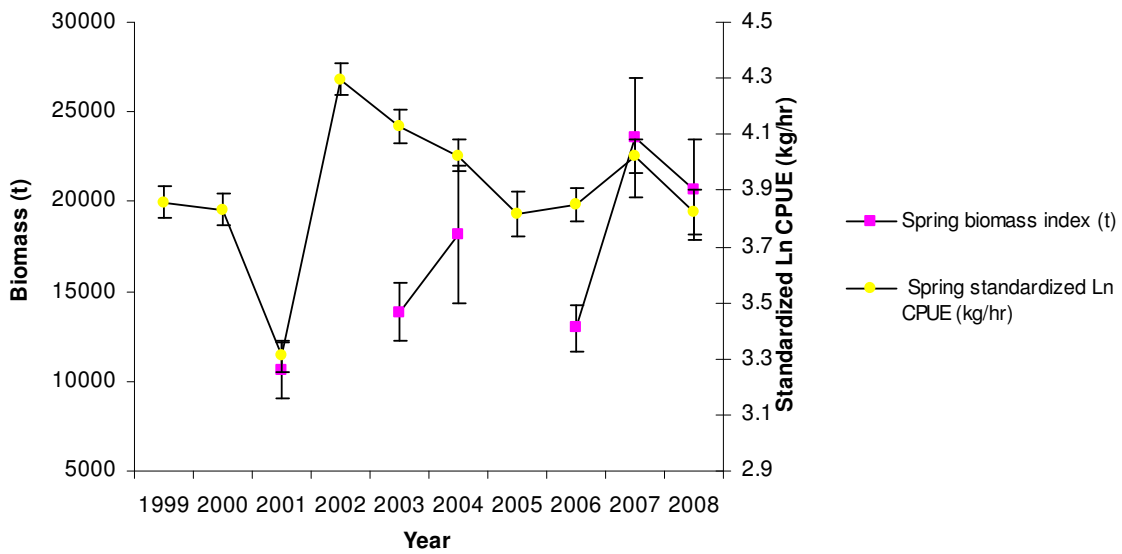
	Survey in Autumn (t)	Standardized Ln CPUE in Autumn (kg/hr)	Survey in Spring (t)	Standardized Ln CPUE in Spring (kg/hr)
Survey in Autumn (t)	$\rho=1$ $n=8$		$\rho=1.000$ $n=6$	
Standardized Ln CPUE in Autumn (kg/hr)	$\rho=0.119$ $n=8$	$\rho=1.000$ $n=8$		
Survey in Spring (t)	$\rho=0.300$ $n=5$		$\rho=1.00$ $n=6$	
Standardized Ln CPUE in Spring (kg/hr)		$\rho=0.358$ $n=10$	$\rho=0.314$ $n=6$	$\rho=1$ $n=6$

3.6 Comparison of the standardized CPUE and biomass index

From 1999 to 2002, both surveys and standardized CPUE show the same declining trend in autumn (quarter 1-2). Yet from 2004 to 2008 the surveys biomass increase by 100% while the standardized CPUE is relatively stable (Figure 9a). Due to high variation in annual surveys estimates, it is not possible to identify a trend similar to the standardised CPUE in spring (quarter 3-4) (9b).



a.



b.

Figure 9. a) The standardized Ln CPUE (\pm SE) and survey biomass (\pm SE) index of the chokka in autumn (quarter 1-2) and b) The standardized CPUE (kg/hr) (\pm SE) and survey biomass index. (\pm SE) of the chokka in spring quarter (3-4).

4. DISCUSSION

4.1 Total landings

As previously mentioned, the annual total landings in the log-books are for the jiggers only. In the FAO record jiggers contribute to about 95% of the catch and 5% comes from the trawlers where chokka is taken as a by-catch. FAO and reduced log-book data seemed to be well correlated though FAO had slightly higher records, that may be explained by the above mentioned additional catch from trawlers. The annual catches of the chokka from 1999 to 2001 declined to about 3000 t. While in 2002, 2003 the total landings increased to a value of about 8000 t in the log-book data and the FAO statistics. Log-book data had much higher records in 2004, while, the FAO registered landings had extremely higher records in 2005 (Figure 5). This difference may be caused by high catches caught and registered in the log-books in the end of 2004 that were recorded as landings early in 2005 by the FAO. From 2006 to 2008, the log-book catch is almost the same as the FAO landings.

There was an inaccuracy in the log-book data. This was seen in the cases where the number of crew and hours of fishing were missing. The use of the log-book data in the chokka management may cause a mis-management of the fishery and therefore the log-book data need to be improved.

The chokka squid has been used in South Africa in the local restaurants for a popular calamari dish (Augustyn *et al.*, 1992; Sauer, 1995). It has also been used ever since the early 1960s by the line fishermen for bait (Glazer & Butterworth, 2006). This could be the cause of high annual catch records in the log-books reported to MCM, but not in the final landing statistics reported by FAO. Roel *et al.* (2000) report that sometimes the trawlers turn to discard the chokka catches due to their poor quality. Nevertheless, these discards are reported in the log-books. Fox & Starr (1996) concluded that discards of fishes in the commercial fishery provide a potentially major discrepancy between log-book statistics and research estimates of fish abundance. The problem is especially difficult to address if discards occur at different rates in different locations. They concluded that log-book data need to be thoroughly error checked.

My study reveal that there is a relatively good correlation between reported catch in log-books and reported landings, yet discarding and misreporting seem to occur. Keeping the latter in mind log-books still provide valuable data for the management.

4.2 Variation in the CPUE

The present study indicates high Ln CPUE in November followed by December and January (Figure 6b). From February to October, the Ln CPUE is low and almost the same. High Ln CPUE in November may be obtained from the high squid abundance in November. The ANOVA also showed a significant difference ($p < 0.000$) in the monthly Ln CPUE. In South Africa, chokka spawning prevails in the inshore spawning grounds (Sauer, 1995) in all months. Peak spawning is in October to November and the fishery is closed from October to mid November. Good catches are obtained in November though the effort applied is low compared with the other months, thus increasing the CPUE in November.

Jiggers target the chokka most of the time when they are aggregated in their spawning grounds. An increase in fishing pressure on an aggregation of the spawning chokka squid would ultimately lead to a decrease in spawning intensity and cause a reduction in the CPUE. Sauer (1995) proposed an avoidance of the chokka spawner's depletion and stressed that the decrease in spawning intensity because fishing pressure may lead to a decline in the threshold number of animals that are needed for continued spawning. Then high Ln CPUE in November could also be obtained due to the high concentration of squid in the inshore areas.

Chen & Chiu (2009) concluded that changes in the CPUE of *Illex argentinus* may be related to the feeding characterizes of the specie. Augustyn & Roel (1998) reported that, chokka migrate to the offshore to feed. During the winter season when the food is scarce in the inshore areas (Roel *et al.*, 2000), and after their reproduction the chokka migrate to the offshore during their developmental life cycle (Olyott *et al.*, 2007). Variation on the food availability over the seasons might cause mortality. For instance, if there are insufficient amounts of zooplankton, the chokka paralarvae may starve and die. Yet, abundant food availability alone does not promise survival of the chokka (Roberts & van den Berg 2002).

It may be possible that chokka was available at sea but because of fishing technical problems, the fishers were not able to catch them. The effect of factors such as turbidity and sea current may also have disturbed the fishing, thereby causing the variation in the chokka CPUE over the months (Campbell & Tuck, 1998; Shon *et al.*, 2002).

Vessel size group 5 displayed a slightly higher Ln CPUE, followed by vessel group 4, 3 then 2 and lastly 1. The highest Ln CPUE in size group 5 was due the largest storage capacity compared with the other vessel groups and many crew members (21-34) (Figure 6c). Some small ski-boats in the chokka fishery are made-up of a wooden material (Mather undated *et al.*). This prevents them for fishing under any sea and weather conditions. On big vessels weather and sea conditions are not problematic, because most of them are made of steel. In the chokka fishery, vessel 5, 4 and maybe 3, are able to go further offshore than the ski-boats. This is because they have more engine power (Wallace *et al.*, 1998; Worthington *et al.*, 1998). Yet, these big vessels might not reach the inshore spawning areas at which the chokka squid is concentrated, while, the ski-boats can (Sauer, 1995). This means that the size of a vessel does not guarantee access and higher CPUE and the annual CPUE may be equal between vessel groups over a period of time (LePape & Vigneau, 2001).

Port Alfred displayed higher Ln CPUE among the areas and was followed by Algoa Bay, Plettenberg Bay. Other areas Port Elizabeth, Jefferies Bay and Tsitsikamma showed the second highest and the lowest was observed in Seal Bay and Hermanus (Figure 6d). Variation in the Ln CPUE in these areas may be caused by the technical fishing methods. This is because all these fishing areas, except for the Hermanus, are located in the chokka squid main spawning grounds. These areas are also located in the eastern part of the Agulhas Bank, which has less turbidity (Olyott *et al.*, 2007). The difference in the Ln CPUE between areas was further confirmed by combining the catch of areas into regions (Figure 7). In 1999 to 2001, both regions showed a decline in catches. Between 2002 and 2004, catch in region 1 increased but declined in region 2. Since region 2 has the TNMP, chokka were expected to spill over into the nearby areas. Variation in the Ln CPUE is then associated with the depth of the spawning grounds in these areas. Fishermen may also select the fishing areas that are next to the harbours to minimize fuel costs and duration of fishing (Fox & Starr, 1996).

These factors have an influence on the expected harvest and on the management. Therefore, CPUE of the area may not be indicative of the population over a large area. This significant difference in the Ln CPUE in areas may be associated also with the Traditional Ecological Knowledge (TEK) of knowing the spawning grounds (Ota & Just, 2007; Schaefer & Reis, 2008).

TEK is associated with the experience of the skippers and the communication of the skippers who know the best spawning grounds. The experienced fishermen therefore target spawning aggregations while inexperienced fishers search for boat aggregations (Schon *et al.*, 2009). Physical conditions of an area are the determinant of the area productivity (Prellezo *et al.* 2009). The Agulhas Bank exhibits variability in depth, oxygen, temperature as well as in the abundance of a species food and predators. This may cause the areas to produce different harvest (Christensen & van Thin, 2008; Dobby *et al.*, 2008) which can lead to different CPUE. Fishermen therefore usually turn to identify and select the areas, which are more productive.

4.3 Standardized annual CPUE as the biomass measure

In 1999 to 2001, the standardized Ln CPUE declined followed by an increase in 2002. Between 2003 and 2008, CPUE fluctuated with a slight drop in 2005 (Figure 8). The annual fluctuation observed indicates that the stock biomass was fluctuating. However, there is no guarantee that the index of abundance measured as the standardized CPUE is proportional to the stock abundance. But still the standardized CPUE may be used as an index of the stock abundance and the state of the stock.

One of the most important factors that perhaps caused a variation in the CPUE of the chokka in years, is a non-random distribution of the fishing effort. In 1999 to 2001, the CPUE declined, while the fishing effort increased from 1999 to 2000 and dropped in 2001 (Table 3). The chokka squid abundance surely recovered in 2002. Therefore, the CPUE increased, but it dropped in 2005 and fluctuated afterwards. The slight drop in the CPUE in 2005 seems to be caused by a high fishing effort in 2004. If, nevertheless, fishing effort is increased in a less productive year, a fall in CPUE can be observed (Wallace *et al.*, 1998).

Apart from the change in fishing effort, the chokka fishing industry itself has changed dramatically over the past decades (Sauer, 1995; DEAT, 2006), as the fleet also improved the technology onboard (DEAT, 2005b). The fishing capacity of the squid fleet has been increased because fishermen upgraded their fishing vessels, thus creeping up the effort. This has been achieved by installing processing equipment and freezers (Japp, 2004), as well as fish finding devices and light system onboard the vessels. The fishing jig gear has also been changed and vessel engines power has been increased.

Chokka turns to reproduce a large amount of offspring each year (Olyott *et al.*, 2006). Nevertheless, this does not guarantee an obvious increase in the CPUE. It depends on the species ability to withstand the other natural factors apart from the fishing mortality (Quirijns *et al.*, 2008). Adult chokka are therefore represented by one cohort and characterized by a Beverton-Holt stock recruitment relationship (Augustyn & Roel, 1998; Glazer & Butterworth, 2000). The CPUE of each year is therefore highly dependent on the successful recruitment of the cohorts. This means that an adequate number of spawners should survive each year to prevent recruitment over-fishing (Roberts & van den Berg, 2002).

4.4 Comparison of the standardized CPUE and surveys

In autumn, both the standardized Ln CPUE and biomass declined from 1999 to 2001. An increase in the standardized Ln CPUE from 2002 was observed, where after it fluctuated between 2003 and 2008. In contrast, the survey biomass declined in 2003 and increased from 2004 to 2008. It was difficult to observe any correlation between the standardized Ln CPUE and survey biomass index in spring, because in 1999, 2000, 2002, 2005 the surveys were not conducted (Figure 9a&9b). However, the standardized Ln CPUE from 1999 to 2000 was relatively stable and dropped in 2001. Between 2002 and 2008, standardized Ln CPUE showed a slow decline. On the other hand, biomass from the surveys increased with 100%. The spearman rank correlation test exhibited no significant correlation between the standardized Ln CPUE and spring survey biomass and in autumn the correlation value (ρ) was even lower (0.0119 & 0.314) (Table 5). The assumption of the proportionality between the standardized Ln CPUE and biomass from the surveys was thereby violated.

The overall results therefore, illustrated fluctuating abundance chokka abundance from the surveys and in the standardized Ln CPUE over time. This difference can be explained by differences in the gears utilized (Walsh, 1996). For instance, surveys used the bottom trawl when sampling (Augustyn *et al.*, 1992) and chokka fishers used the jig. Augustyn & Roel (1998) argued that surveys are designed for the hake species stock assessment but are used also to determine the squid biomass. Thereby surveys did not cover the entire area of the squid distribution. It may therefore be possible that chokka were aggregated in the selected areas where the survey-trawl wiped them (Sauer, 1995). This would then cause high chokka abundance estimation from the surveys. In other years the spawning aggregations of chokka

may be located at the edge or outside the surveyed area. Although there are uncertainties connected to the log-book statistics it is therefore better to use the standardized CPUE as an annual biomass estimate when assessing the chokka. This is because the squid fleet turns to fish almost in all areas of the species distribution.

As the surveys are designed to cover the hake species distribution, a big size research vessel is used. This size of vessel is prevented from entering inshore areas (Glazer & Butterworth, 2006), and a trawl may damage the chokka spawning grounds (Sauer, 1995), yet that is where the chokka squid is concentrated. Walsh (1996) addressed also that trawl sampling may not accurately reflect abundance of a species. It is also expensive to conduct the surveys (Hanchet *et al.*, 2005; Tian, *et al.*, 2009). As a result, in some years for some stocks, including the hake and the chokka, surveys are not conducted.

In South Africa, the chokka stock is subsequent to variability (Rodhouse, 2005). Their population is typically unstable, responding rapidly to changes in environmental conditions. This causes difficulties in the stock assessment (Augustyn & Roel, 1998). Fox & Starr (1996), Harley *et al.*; (2001) and Hanchet *et al.* (2005) have described the aspect of using the standardized CPUE and biomass index from the surveys for the stock assessment. These authors agreed in their conclusions that if the results reveal slightly the same abundance, standardized CPUE should be used for the stock assessment. Their assumption was that the standardized CPUE would be proportional to the survey biomass. Walsh (1996) reported that, if the surveys are carried out within some random sampling framework, then one would hope that this assumption would hold.

5. CONCLUSION AND RECOMMENDATION

The results of this study exhibited almost the same annual variation in the total landing statistics of FAO and catch registered in log-books. The exception was 2004 and 2005 when catches late in 2004 seem to have been registered as landings early in 2005. Over the months, November produced the highest Ln CPUE. This was attributed from the closed season imposed from October to mid November and the spawning aggregations. The main aim of the closed season was to allow fertile individuals to spawn and reduce disturbance on spawners. CPUE differed between areas. Vessel size is the most important variable determining the CPUE and should be corrected for when using CPUE as measure for stock size. The standardized Ln CPUE fluctuated over the years with a sharp drop in 2001. There was no correlation between standardized Ln CPUE and biomass indices from surveys, which is due to different area coverage and different gear used by the jiggers and researchers.

In order to fully monitor and estimate the chokka abundance, stock assessment should be performed in the chokka inshore distributional areas. Therefore, research vessels that can be able to assess the inshore areas are needed. The uncertainties in the CPUE of *Loligo reynaudi* have implications for conservation management. Fishers need to be sincere and accurate when recording the catch and effort data in the log-book.

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7. APPENDICES

APPENDIX 1

Table 6¹³ The different types of the vessels utilized to catch squid during the early 1980s.

Vessel type	Vessel size (m)	Average no. of crew	Operational fishing time	Average annual catch (tons)	Points of landing
Ski-boat (non-freezer)	6 – 8 m	6-9	Only day	19–102 tonnes	Beach or river
Deck boat / Catamaran	10-15m	12-18	Day and / or night	38-152 tonnes	River
Deck / freezer vessel	15-20m	18-24	Day and night	90-201 tonnes	Harbours

Table 7¹⁴ Vessel category types currently utilized to catch the chokka.

Category of vessel	Maximum persons per vessel
Ski boat or non freezer vessel	7 persons
Vessels up to 13 metres	12 persons
Vessels from 13 to 15 metres	16 persons
Vessels from 15 to 17 metres	20 persons
Vessels from 17 to 19 metres	22 persons
Vessels over 19 metres	26 persons

¹³ The table was adapted from Sauer (1995).

¹⁴ The table was taken from DEAT: Squid Policy. (2005).

APPENDIX 2 Chokka squid catch (kg) \pm 95 confidence interval box plots by years in eight fishing areas.

