BAITED REMOTE UNDERWATER SURVEY OF CHONDRICHTHYANS IN FALSE BAY, SOUTH AFRICA

By

Ralph Gareth Andrew Watson

Supervisor: Associate Professor Colin Attwood

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University of Cape Town

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ABSTRACT

Worldwide, numerous shark populations are in rapid decline due to chronic overfishing. Their slow reproductive capacity make them susceptible to extinction. To monitor the status of chondrichthyan species, the method or combination of methods used should be non-selective, applicable in a variety of habitats and under most environmental conditions. Baited Remote Underwater Video (BRUV) surveys have shown major benefits over traditional capture-based survey methods in multiple areas. They have been shown to be non-extractive, causing no major disturbance to the substrata and its epibenthos. Large, mobile animals that avoid divers and active fishing surveys are detected. The recorded video removes the need for specialist observers to conduct all the fieldwork. The video allows impartial and repeatable measurements and standardizes data collection and training in association with remote taxonomists. The method is also cheaper than alternatives.

Ninety-five sites were sampled with 60 minute video recordings across the whole of False Bay during the period of June-July 2012. Fifteen species of chondrichthyans were recorded, of which *Haploblepharus edwardsii* was the most abundant, being observed at 83 of 95 sites. One hour was sufficient to capture all the chondrichthyans within the observed area as the average time of arrival was about half an hour into the recording. The distribution of the chondrichthyan population was remarkably uniform across the bay. Depth, habitat and substrate type were significant predictors of species composition ($P = 0.004$, 0.025 and 0.001 respectively). Opportunistic encounters (one individual observed) included *Carcharodon carcharias, Squalus megalops, Rhinobatos annulatus* and *Myliobatis aquila.*

The results obtained during this study showed similarities with other underwater surveys performed in False Bay. The BRUV survey showed similarities with SCUBA censuses and rotenone surveys due to being underwater visual surveys and to longlining and linefishing due to the

involvement of bait. The BRUV survey was the 4th most diverse survey and is a viable way of monitoring the chondrichthyan population across False Bay.

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CHAPTER 1 - LITERATURE REVIEW

Chondrichthyans

Worldwide marine diversity is under threat from over-harvesting, pollution and climate change (Field et al 2009). Numerous shark populations are in rapid decline due to chronic overfishing and slow reproductive life-history features making them susceptible to extinction (Baum et al 2003, Baum & Meyers 2004, Brooks et al 2011, Field et al 2009, Myers et al 2007, Stevens et al 2000).

Chondrichthyans are made up out of 1 141 species (http://www.catalogueoflife.org; as of 15 October 2012), 55 families and 165 genera (Compagno 1990). Currently there are two major groups, the small subclass Holocephalii and the predominant subclass Elasmobranchii. The Holocephalii encompasses the order Chimaeriformes, has three families, six genera and 31 to 50 species of chimaeras, ratfishes and elephantfishes. The Elasmobranchii contains the superorder Selachii (sharks) and Batoidea (skates and rays).

Sharks include approximately 500 species (Ferretti et al 2010) in eight orders, thirty-four families and 100 genera (Compagno et al 2005) (See appendix I, p. 56). The most dominant orders (containing 56% of all shark species) are the ground sharks (Carcharhiniformes), followed by dogfish sharks (Squaliformes comprising 23% of the sharks), carpet sharks (Orectolobiformes, 8%), mackerel sharks (Lamniformes, 4%), angel sharks (Squatiniformes, 4%), bullhead sharks (Heterodontiformes, 2%), frilled and cow sharks (Hexanchiformes, 1%) and saw sharks (Pristiophoriformes, 1%) (Compagno 1990).

The Batoidea contain approximately 600 species (Compagno et al 2005, Ferretti et al 2010) in four orders, eighteen families and 59 genera. The two dominant orders are skates (Rajiformes) and Rays (Myliobatiformes) comprising respectively 44% and 47% of the species. The two other orders are electric rays (Torpediniformes, containing 9% of the species) and sawfishes (Pristiformes, 1%) (Compagno 1990).

Chondrichthyans are entirely predatory and situated, as a group, high in the food-web. They feed on most marine animals, from plankton and small benthic invertebrates to whales (Compagno 1990). Inhabiting coastal, demersal and pelagic habitats in all oceans, sharks range in sizes from 0.2 to over 20 meters in length. A majority of large sharks and some batoids are predators situated at, or near, the top of marine food webs (Field et al 2009, Stevens et al 2000), while there is a high diversity of mesopredatory elasmobranchs that fall prey to larger sharks (Field et al 2009). Many sharks feed on a wide variety of prey, resulting in a high connectivity of sharks in food-web models (Bascompte et al 2005). With their wide distribution and predatory role, large sharks in particular can have a substantial influence across different ecosystems. Large sharks exert a strong top-down control on ecosystems, thereby shaping marine communities over large spatial and temporal scales. The decline of large predatory sharks reduces natural mortality in a range of prey, causing changes in abundance, distribution, and behavior of small elasmobranchs, marine mammals, and sea turtles that have few other predators (Ferretti et al 2010, Field et al 2009). Compared to bony fish, the majority of chondrichthyans are set apart by their K-selected life-history strategy, which is characterized by slow growth, late attainment of sexual maturity, long life spans, low fecundity and natural mortality, and a close relationship between the number of young produced and size of the breeding biomass (Compagno 1990, Field et al 2009, Stevens et al 2000). These characteristics makes them vulnerable to fishing mortality and their ability to recover after depletion is generally low (Ferretti et al 2010).

The loss of sharks could also result in complex community changes, including trophic cascades, meso-predatory release, and consequent declines in some commercial fish (Ferretti et al 2010).

Despite having relatively short coastline of 3300 km, South Africa is a diversity hotspot with all orders of Chondrichthyans represented. Forty-seven families and approximately 210 species are known to occur in South Africa (Compagno 1999), of these, roughly 79 species are ‘area endemic’ (Kroese et al 1996).

While worldwide the number of skates and ray species outnumber shark species, this is not the case in South Africa, where more shark species are present. The shark subdivisions Squaliformes, Hexanchiformes, Carcharhiniformes and Lamniformes have shown a higher number of species in South Africa compared to worldwide shark biodiversity, with Orectolobiformes showing a lower relative number of species. The chimaera in SA show a similar number of species compared to the worldwide biodiversity (Compagno 1999).

South Africa has a high number of endemic and near-endemic shark species, as well as species with a wide distributions, making the chondrichthyan fauna zoogeographically complex. The endemism lies notably in members of catshark (Family Scyliorhinidae), finback catsharks (Proscylliidae), houndsharks (Triakidae), sawsharks (Pristiophoridae), dogfish (Squaliformes), skates (Rajoidei) and chimaeras (Chimaeriformes) (Compagno 1999).

Chondrichthyans can be divided by habitat into species of the continental shelves (intertidal to 200m), the continental slopes (200m to ocean floor) and the oceanic zone (beyond the shelves and above the slopes and sea floor). South Africa has an astoundingly rich slope fauna of sharks with 38% of the species present and 33.7% of the species on the continental shelves. Only 1% of these species (incl. Bluntnose sixgill and White sharks) range in habitat from inshore to the continental slopes and oceanic waters. Species on the continental shelf can be further divided into cool-temperate, warm-temperate and subtropical species with overlapping distributions (Compagno 1999).

Exploitation & Conservation

Many fisheries around the world are experiencing a crisis. A high number of stocks of large predatory fish have been depleted, resulting from both targeted fisheries and fisheries that generate by-catch (Pauly et al 1995). It has been suggested that the current greatest threat to the diversity and abundance of shark and ray populations is harvesting, with the risk from industrial and commercial fisheries out-weighing the artisanal and subsistence harvest (Field et al 2009). With over 90% of elasmobranch species inhabiting demersal ecosystems on continental shelves and slopes (Compagno 1990), sharks and rays are highly vulnerable to trawl fishing (Shepherd & Myers 2005). Rising from approximately 270 000 t in the 1950s to 810 000 t in 2004, the global catch of chondrichthyans had a peak of 881 000 t in 2003 (Field et al 2009). In South Africa the pelagic purse-seine, squid (*Loligo* spp.) jigging, tuna poling, traditional fish trap and pilchard beach seine net fishery have shown a negligible impact on elasmobranchs (Kroese et al 1996). Shark catches in gill and seine net fisheries appear to be low, and catches in 1993 included 309 t of St Joseph, 2 t of Soupfin sharks, 26 t of rays and 9 t of other shark species (Japp 1999). On average, 4 000 t of sharks were landed every year of which two thirds were by-catch (e.g. tuna and swordfish longline fisheries), in contrast to targeted (demersal shark longline) fisheries. Concentrated around Mossel Bay and Port Elizabeth, inshore trawl fisheries were responsible for the highest catch of demersal sharks and other chondrichthyans. In 2010, over 4 800 t of chondrichthyans were caught in the trawl fisheries (DAFF 2012).

While the potential for shark fishing in South Africa was first documented in the early 1930s, it was the Second World War (WWII) that stimulated shark fishing by creating demand for vitamin A as health supplements, this was continued to be produced until 1975 (Kroese et al 1996). Between 1975 and 1990 the demand for shark meat fluctuated noticeably. Since then there has been a steady increase in the demand for shark meat and fins, with approximately 18 ton of soupfin shark (*Galeorhinus galeus)* fins exported from South Africa in 1993 (Kroese et al 1996, Stuttaford 1995).

Fishing for *G. galeus* was mostly done off the south western tip of South Africa (Van Zyl 1993/4, Kroese et al 1996).

Sharks and rays are of relatively low economic value, making them a low priority resource when it comes to research and conservation. This conflicts with the demand for some of their products, such as shark fins, which is tremendously high and encourages increasing exploitation (Bonfil, 1994). An estimated 26-73 million sharks have been caught globally per annum, due to the increasing demand for their fins (Clarke et al 2006). Consequently, several populations have been reduced to less than 10% of their pre-exploitation levels (Gulf of Mexico: Baum & Myers 2004; Mediterranean: Ferretti et al 2008). As a result of a lack of baseline data, underreporting of catch and widespread illegal fishing, the exact degree of the decline remains unclear (Clarke et al 2006; Lack & Sant, 2006). For most species of chondrichthyans, even the most fundamental ecological information is lacking. This has caused about 46% of chondrichthyan species to be listed as 'Data Deficient' on the IUCN Red List of Threatened Species (IUCN 2012, Brooks et al 2011). Of the 52% of Chondrichthyans being Red-listed by the International Union for Conservation of Nature (IUCN), about 17% are threatened with extinction (10.6% Vulnerable, 3.7% Endangered, 2.3% Critically Endangered), 12.2% are Near Threatened and 25.1% are considered Least Concerned (http://www.red-list.org).

At the Great Barrier Reef local fisheries have been suggested as the main cause of population reductions in and around conservation areas (Robbins et al 2009, Field et al 2009). This results in a number of difficulties accompanying the design, implementation and management of marine protected areas (Field et al 2009). The high mobility of many species, some even involving trans-boundary migrations, causes another level of complexity to their assessment and highlights the need for proper knowledge about stock delimitation and dynamics if proper management is to be implemented (Bonfil 1994).

A number of countries have in recent years initiated protective legislation or regulations for a limited number of shark species due to an increasing concern regarding the threats to these species. White shark (*Carcharodon carcharias)* has been under varying levels of protection in South Africa, Australia, Israel, Namibia and the United States (Camhi et al 1998).

Shark Monitoring ~ Traditional Methods

Coastal ecosystems have been exploited throughout history and few have remained unaffected by human activities (Lotze et al 2006), making the reconstruction of pre-exploitation abundances and historical changes of coastal sharks difficult (Ferretti et al 2010). For the development of effective management and conservation initiatives, elementary ecological information relating to the diversity, distribution and abundance of sharks is essential (Brooks et al 2011).

First developed in South Africa and Australia, shark netting programs were developed to protect swimmers. These programs have been a valuable source of data on coastal ecosystems and provided long-term series of shark Catch Per Unit Effort (CPUE) within a region. At least 14 species are commonly caught in netting programs within South Africa (Dudley & Simpfendorfer 2006). Shark netting in South Africa started in the early 1950s, and 32 kilometers of nets were installed along 267 kilometers of coastline in 1975. This was sufficient to affect large sharks across the whole region (Van der Elst 1979) as from 1961 to 1972 species-specific catch rates declined between 27% to over 99%. Yet, anecdotal evidence indicated that severe declines had already taken place before systematic data collection (Ferretti et al 2010).

To monitor the status of chondrichthyans species, the method or combination of methods used should be non-selective, applicable in a variety of habitats and under most environmental conditions. While SCUBA dive transects is a non-destructive and broad spectrum technique, it is dependent on environmental conditions, covers only certain parts of a target area, is limited by depth (Best 2012) and the results are biased through the presence of the diver (Watson et al 2010). By inflicting various degrees of physical trauma and physiological stress on chondrichthyans, controlled angling can result in a high mortality rate (Brooks et al 2011). Other methods, such as spearfishing and poisoning, are potentially destructive and too selective for chondrichthyans (Best 2012). Considering the destructive properties of these traditional methods, a method that overcame these problems was developed.

Baited Remote Underwater Videos

The use of Baited Remote Underwater Videos was first developed in Australia for the assessment of reef fish (Cappo et al 2003) and length assessment of Southern Bluefin Tuna (Harvey et al 2003).

Many traditional methods are size selective, whereby hook or mesh size are only effective for a certain size range. BRUVS work to the contrary and the standardized surveys can be replicated at any depth, in a variety of habitats, and by staff with relatively low levels of training (Brooks et al 2011, Cappo et al 2006). A study by Brooks et al (2011) and Willis et al (2000) has shown that BRUVS generate relative abundance and species diversity estimates similar to those generated by scientific longline surveys. BRUVS are a viable, less invasive and more cost-effective alternative to longline surveys depending on the specific research question. They are especially suited for long-term monitoring of species richness and relative abundance over wide geographical and temporal scales, as they are easily replicated by relatively untrained personnel without specialized equipment (Brooks et al 2011). Being able to record the large, and rare predatory species (Watson et al 2005), has caused BRUVS to become the standard approach for monitoring the larger-bodied, more cautious reef fish, including sharks (Brooks et al 2011, Meekan & Cappo 2004, Meekan et al 2006, Malcolm et al 2007).

BRUVS has shown major benefits over traditional capture-based survey methods in three main areas. Firstly, baited video approaches are non-extractive and do not cause major disturbance to the substrata and its epibenthos (Brooks et al 2011, Cappo et al 2006). Secondly, large, mobile animals that avoid divers and active fishing surveys are detected (Cappo and Brown 1996, Cappo et al 2004, 2006) and all animals attracted to the activity around the vicinity of the bait are 'captured', independent of whether or not they are attracted to the bait (Armstrong et al 1992, Brooks et al 2011). Thirdly, the acquired permanent digital record resolves the need for specialist observers to conduct all the fieldwork, allows impartial and repeatable measurements, standardizes data collection and training in association with remote taxonomists, and supplies a sensational format to communicate science to the public (Cappo et al 2006).

A reduction in field time and the number of staff required to deploy the remote underwater videos, has shown that even with the costs of the video equipment and time associated with analyzing the video images, the use of this technique for repetitive studies of an area can be more efficient than Underwater Visual Census (Watson et al 2005).

The underwater video techniques does have biases like the reliance on good visibility, conservative relative density measures and complexities in determining areas sampled when using bait (Priede and Merret 1996; 1998, Sainte-Marie and Hargrove 1987, Bailey and Priede 2002), but these techniques do appear to be the best way to obtain recordings of large number of species and individuals, regardless of relief type or location with the least sampling effort (Watson et al 2005). As there is no single technique that is able to measure changes in fish assemblages accurately and precisely without introducing its own biases (Watson et al 2005), the underwater video techniques weren't able to sample small cryptic fish families like gobies and blennies, and a combination of survey techniques was recommended for comprehensive surveys of fish assemblages for biodiversity inventories (Cappo et al 2006, Watson et al 2005).

It has been shown that bony fishes, sharks and rays, and seasnakes don’t come to the bait just to feed, but are also attracted by the general activity in the field of view. Large sharks and rays accompanied by schools of species of Carangidae and Scombridae will often investigate the bait and their attendant species are identified and counted (Cappo et al 2006). A reason why video transects record fewer average species and individuals than baited remote video might be the fish behavior, particularly of the larger targeted and/or predatory fish, towards a SCUBA diver (Watson et al 2005). The probable avoidance behavior of large predatory species towards divers has also been reported by Davis and Anderson (1989).

BRUVS have successfully been used to monitor sharks in the Western Indian Ocean (the Red Sea, Bassas da India, Europa, Aldabra and the Maldives) (Clarke et al 2012), Australia (Meekan & Cappo 2004), Florida, the Cayman Islands and Belize (Brooks et al 2011).

CHAPTER 2 - CHONDRICHTHYAN BRUV SURVEY IN FALSE BAY

INTRODUCTION

Fishing in South-Africa has been recorded since 1652 with the arrival of Jan van Riebeeck (Thompson 1913). Commercial fishing in False Bay has been dated back as early as the 17th century. While False Bay has the longest history of fishing in Southern Africa, it also has the longest record of protection from certain fishing methods, with bottom trawling being prohibited in 1928 and purse-seine fishing in 1982. Beach-seine catches of Yellowtail (*Seriola lalandi*), White Steenbras (*Lithognathus lithognathus*), Elf (*Pomatomus saltatrix*) and silver kob (*Argyrosomus* species) form a significant part of False Bay catches, but are minor compared to national line catches (Penney 1991). False Bay has also been recognized as a popular angling destination (Day 1970). The long history of exploitation and high density of people living on its shores were the reasons False Bay was chosen as study site.

In 1996, the metropolitan area of Cape Town had a population of 2.56 million, rising to 2.89 million in 2001 and 3.50 million in 2007 (Wright 2010). With an increase in population comes an increase in utilization of False Bay. This results in a number of threats to the chondrichthyan population and range from fishing (targeted and by-catch), habitat loss and degradation associated with pollution and recreation (Stevens et al 2005).

To assess trends in chondrichthyan populations in False Bay, Best (2012) used catch data spanning from 1897 to 2011, covering amongst others: trawling, angling (recreational/competition), linefishing, and beach seine. This resulted in 38 chondrichthyans being recorded, of which 14 species (37%) were considered to be of primarily Atlantic origin, and seven species (18%) were predominately from the Indo-Pacific region (Smith & Heemstra 1986, Compagno et al 2005). Of the chondrichthyans with restricted distributions eight (21%) were endemic to Southern Africa and four (11%) to South Africa. The remaining five species (13%) were cosmopolitan pelagic sharks found across the world (Best 2012).

If under the assumption that top predators maintain the structure and function of ecosystems, the 'health' of chondrichthyan populations should equate to the 'health' of the ecosystem or food chain as a whole. When such top-down control is removed through fishing, then the structure and function of the ecosystem could be severely impacted (Jackson 2008).

The possible implementation of shark nets, due to the threat of shark attacks, would further reduce the already vulnerable shark population. Yet shark nets have not only shown to impact their target species, but also impact the populations of smaller sharks, skates and rays, seabirds, whales, cetaceans and sea turtles (Dudley & Simpfendorfer 2006).

Despite the concern over shark exploitation, it is not impossible to protect these species from the impacts of fisheries. It has been suggested that it is essential to increase the knowledge of diversity in the appropriate fisheries, the species exploited, the size of the catches, the harvesting practices involved, to establish the current state of chondrichthyans (Bonfil 1994). Effective management and protection of chondrichthyans can only be established through improved knowledge of these species.

Aim of the Study

The purpose of this thesis is twofold: Firstly to gain a description of the shark fauna in False Bay through the use of Baited Remote Underwater Videos, and secondly to assess this novel monitoring method on chondrichthyans, in relation to existing methods.

Study Area

False Bay (34°04’-34°16’S, 18°26’-18°51’E), measuring over 1000 km^2 and 90 m at its deepest point, is the largest true bay in South Africa (Spargo 1991) and lies in the southwestern Cape immediately south of the city of Cape Town, approximately 150 km to the west of Cape Agulhas, Africa’s southernmost tip (Figure 1). Located between Cape Point and Cape Hangklip and with a width of 32 km, the mouth opens south into the Atlantic Ocean (Spargo 1991).

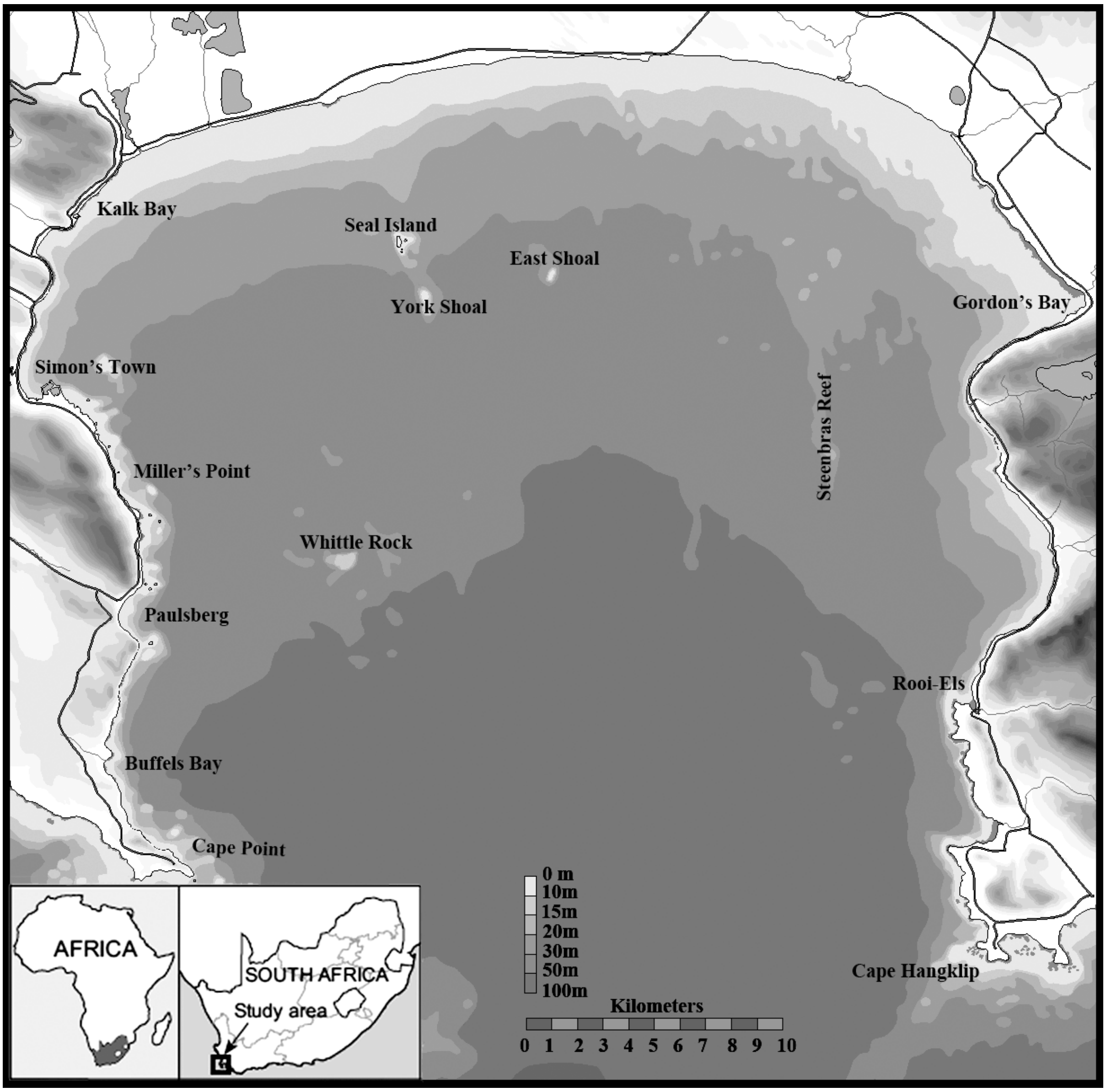

Figure 1: False Bay with Africa and South Africa in insets.

The bay is deepest at the entrance with a depth of around 80-90 m. The bottom slopes upwards from south to north with a depth of 40-60 m at the centre (Spargo 1991). The bottom of False Bay is generally smooth, covered by a variety of sediments ranging from very fine to very coarse, khaki-colored sand over a large area and green mud at the entrance (Spargo 1991, Day 1970). The depth averages to 20 m further north and the sediments become more patchy with large areas of coarse sand and broken shell and smaller areas of fine white sand. With the exception of Whittle Rock, most of the larger reefs are found in the eastern half of the bay (Du Plessis and Glass 1991).

Flanked by two ranges of mountains, to the west of the bay lies the Cape Peninsula Mountain Chain, ranging from Table Mountain in the north to Cape Point in the south, and to the east lies a complex set of mountains, dominated by the Hottentots-Hollands mountains. Both sets of mountains consist principally of three rock types: Table Mountain sandstone, Malmesbury and grey-wacke shales, and granite (Spargo 1991).

The western part of False Bay is underlain by granites and according to seismic profiles weathered rock of varying thickness (0-40 m) covers the unweathered granite surface (Figure 2). Whittle Rock and Roman Rock are made up of unweathered granite. The eastern part of False Bay is underlain by Malmesbury Group rocks (Du Plessis and Glass 1991).

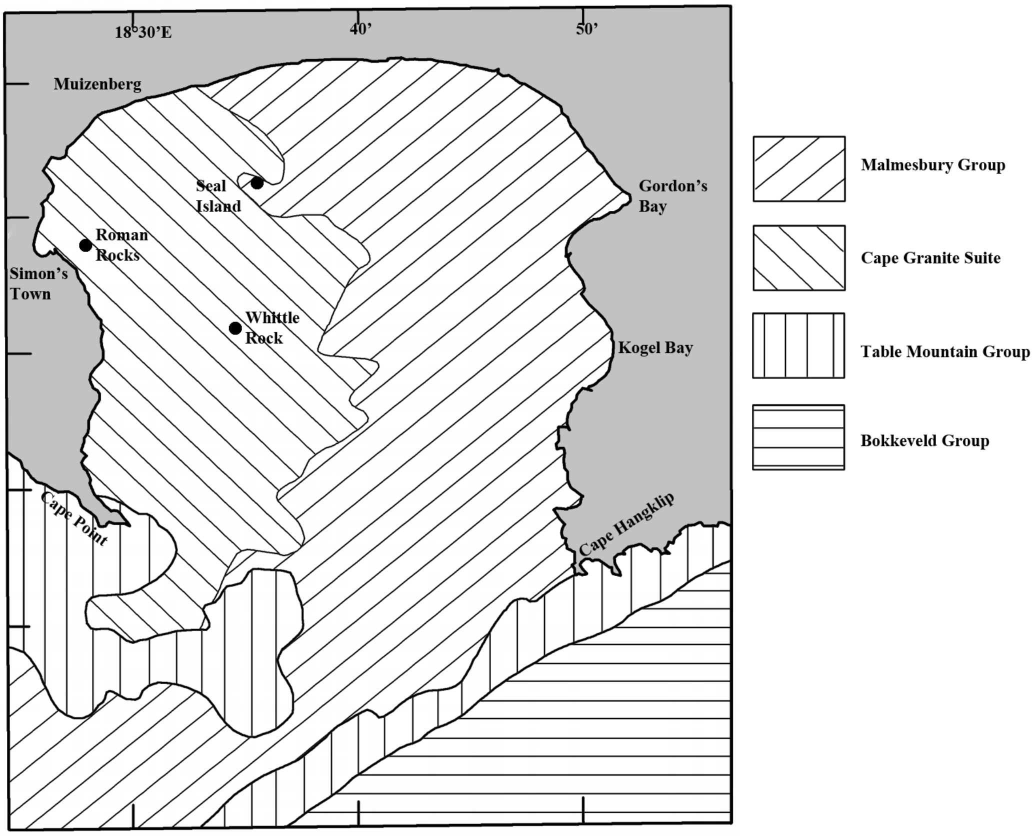

Figure 2: Geology map of False Bay showing with distribution of ground-type (redrawn from Du Plessis & Glass 1991)

Midwinter the whole bay is relatively cold and uniform with surface and bottom temperatures of 13-14°C (up to 50 meters depth) and 10-12°C in deeper parts. During spring warmer surface water of 16°C drifts from the Agulhas Bank into the bay, slowly circulating clock-wise and reaching temperatures of 17-18°C when reaching Gordon's Bay. During the summer surface waters reach temperatures of 19-20°C. In late summer, the shallow waters along the northern shores are heated by the sun, developing a marked thermocline and a layer of warm water (16-20°C) that may extend to depths of 20 meters (Day 1991).

The water in False Bay is derived from both the Agulhas and the Benguela currents, which is reflected in the nature and composition of the benthic fauna. False Bay contains a mixture of warm water and cold water species (Day 1991).

METHODS

The random stratified survey was performed between the 14th of June and 18th of July 2012, whereby 98 BRUV samples were taken across False Bay in 9 pre-determined zones (Figure 3). The location of the sites were selected to include sand and reef sites, shallower than 40 m and in clusters of four to facilitate field work. The sites within a cluster were further than 250 m apart to ensure the bait plumes didn't overlap.

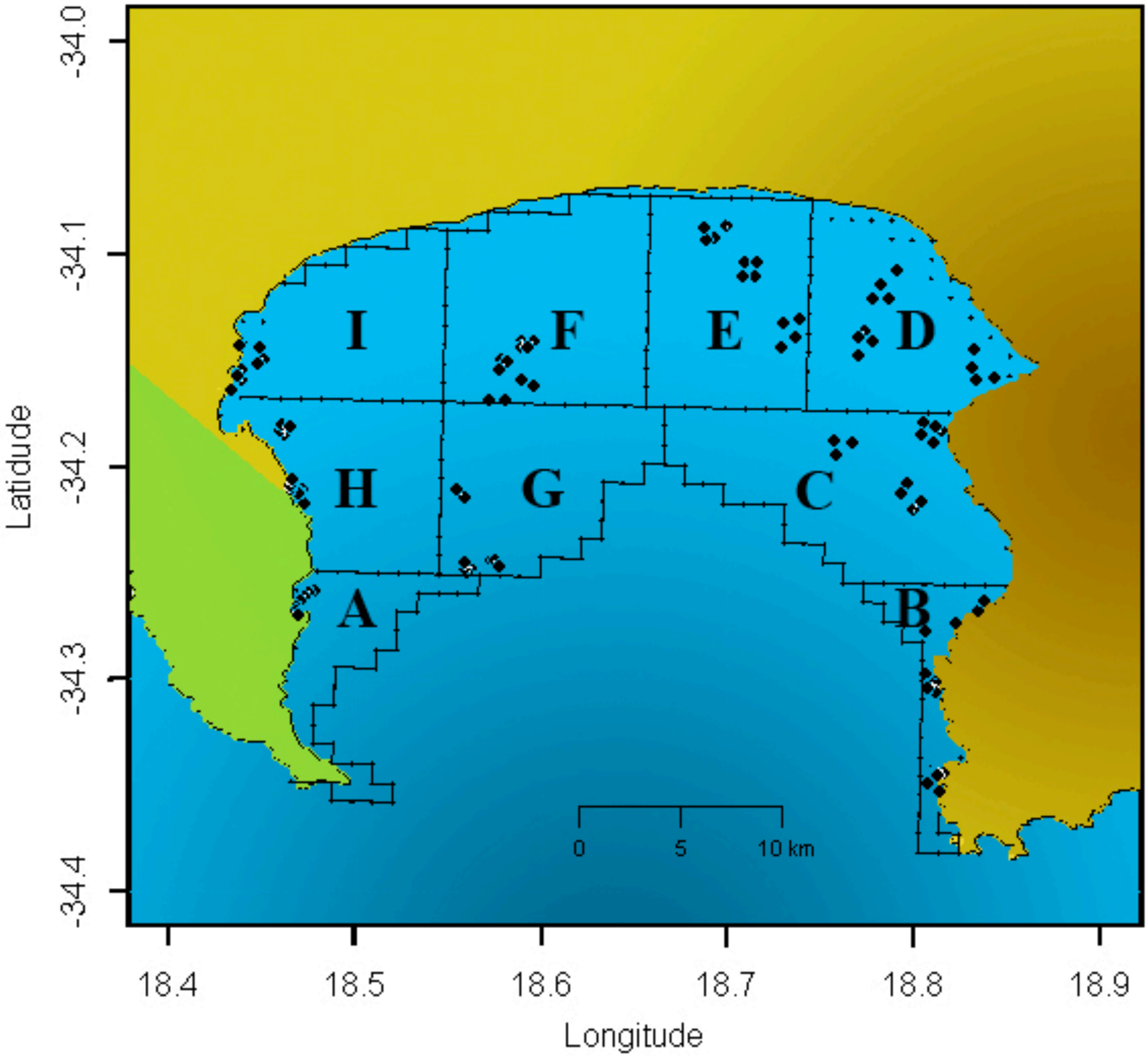

Figure 3: Map of False Bay with established zones and sites locations.

The Baited Remote Underwater Video Rig

A GoPro Hero2 HD camera in an underwater housing was attached to a long steel rig, 30 cm off the ground. A temperature logger was attached to the rig on top of the camera, held in place by zip-ties. A perforated PVC bait canister (130 mm by 110 mm with 10 mm perforations) was attached to the other end of the steel rig, 1 m away from the camera lens. A horizontal crossbar was fixed to stabilise the rig (Figure 4). A short chain and a substantial amount of rope connected the rig on the side of the bait canister to a buoy on the surface. The camera was adjusted to ensure that the bait canister was in the centre of the field of view. This rig differed from conventional rigs, as there was no live feed to the boat. The exact habitat could not be selected and only became evident once the video was screened.

Figure 4: BRUV rig deployed on a sub-tidal granite reef in False Bay, 2012. Three *Poroderma africanum* swim as if in formation.

Data Collection

BRUV deployment

The bait canister was filled with 1 kg of chopped sardines (*Sardinops sagax*). The camera was switched on at the surface, after which the rig was gently lowered to the seafloor. The start and end time of each deployment was noted and GPS coordinates were taken. The rig was retrieved after one hour and the video recording was terminated.

Habitat assessment and classification

Temperature was measured in °C using the temperature logger attached to the top of the GoPro Camera. Temperature was logged every five minutes during the full length of each deployment and at each cluster of sampling sites, the median sea temperature was noted. Depth (m) was determined from the boat's echo sounder.

Reef profile and bottom sediment-type were assessed during video analysis. Sediment was classified as either 'reef' or 'sand'. 'Reef' was subjectively ranked as 'high' or 'low' profile.

Data analysis

Video analysis

The videos were analysed using VLC media player 2.0.2. Species were recorded at the time they were first seen in the video (First Sighting), to gauge their proximity to the bait, and the time when the maximum number of individuals of a single species were seen in the video (Maximum number, MaxN) to assess their maximum presence within an area (Willis et al 2003). A Kruskal-Wallis test was carried out to determine wether the arrival times of the different species were statistically significant.

Species evaluation

The number of sites in which a species was positively observed was recorded and labeled as 'Frequency', whereas the complete sum of MaxN was labeled as 'Abundance'. The 'Mean MaxN' of each species was calculated by dividing the sum of 'MaxN' across all sites by the number of sites where they were present, to determine the level of aggregation per species. The standard deviation assessed the level of variation from each 'Mean MaxN' value and was calculated for each species. Relative abundance was calculated by taking the sum of 'MaxN' and dividing it by the total number of sites sampled (Colton & Swearer 2010), as a measure of relative density within the study site. The probability of encounter was calculated by dividing the sites with positive observations of a species by the total amount of sites to determine the chance of observing a species. A species accumulation curve was constructed according to the cumulative percentage of relative abundance, to judge the degree of dominance of chondrichthyans.

Habitat association

Depth was split into three factor levels: 'shallow' (0-15 m), 'medium' (16-30 m) and 'deep' (31-45 m). Habitat sorted as 'sand', 'low-profile reef' or 'high-profile reef' and reef-type was classified as either 'granite', 'Malmesbury shale' or 'Table Mountain sandstone', based on geographical knowledge and GPS coordinates.

To evaluate the similarity of species composition across the sites, a cluster analysis and MDS plot were generated using Primer E version 6. A fourth-root transformation was applied to MaxN values to down-weight the influence of abundant species.

To determine the importance of depth, habitat and rock-type on the species composition, a one-way ANOSIM test was preformed separately on these variables. A PERMANOVA test was performed on these variables to assess their contribution to explaining variance in species composition. The three random effect variables were assessed individually, while depth was also assessed in combination with habitat-type and in combination with rock-type. A SIMPER analysis was carried out to establish which species' presence contributed to the differences in species composition among the two different habitat types, and which species were typical for each habitat type.

Comparison between BRUV and prior surveys performed in False Bay

The results gained from this survey were compared to other surveys previously preformed in False Bay and analysed by Best (2012). The history of shark exploitation was reconstructed using historical and contemporary fisheries records. The fishing and sampling methods subsequently analysed were trawl surveys, demersal longline catch returns, commercial linefish catch returns, beach seine scientific surveys and commercial catch returns, recreational angling, SCUBA diving underwater census, spearfishing and rotenone (poison) surveys. Historical trawl survey records from False Bay were extracted from the Director of Fisheries, Marine Biological Survey Reports, while demersal longline data were provided by C. Da Silva, Department of Agriculture, Forestry and Fisheries. Commercial linefish data were extracted from the National Marine Linefish System (Penny 1994; Penny et al 1997) and the catch in kilograms were converted to number of individuals using an average individual weight. Beach seine data were provided by S. J. Lamberth, Department of Agriculture, Forestry and Fisheries, and survey records were extracted from published sources (Clark et al 1996, Lamberth et al 1995). The data were divided into commercial seines (1974- 2003) and scientific surveys (1990 - 1993), and analysed separately. Recreational angling records were collected from unpublished club records and provided by Thys Kemp from the Western Cape Shore Angling Association. Lastly, SCUBA census (Cliff 1983; Lechanteur 1999; Lechanteur & Griffiths 2001) and poison surveys (Prochazka 1998), as well as spearfishing records (Lechanteur 1999), were also found in published literature.

To compare the results gained from this BRUV survey to other surveys preformed on chondrichthyans in False Bay, the data was fourth root transformed, standardised and a Bray-Curtis similarity analysis was carried out.

RESULTS

Habitat Association

Of the 98 BRUV samples taken in False Bay, three failed due to technical issues. The depth of the 95 successful samples ranged from 4.8 meters to 40.0 meters, with an average of 22.56 meters (Table 1).

Table 1: Number of BRUV deployments in False Bay June/July (2012) per zone per depth category.

		Zone								
		A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
Depth Category (m)	**1-15**	7	7	0	6	2	0	1	2	4
	16-30	0	4	5	3	9	5	5	8	4
	31-45	0	1	7	0	1	6	6	2	0
	Total	7	12	12	9	12	11	12	12	8

The bottom temperature ranged from 11.86°C to 14.49°C, with a mean of 13.30°C (± 0.6 SD). 45.3% Of the sites were classified as 'sand', 40% were classified as low-profile reef and 14.7% were classified as high-profile reef. Of the 54.7% assigned as reef sites, 34.6% were located on granite reef, 59.6% on Malmesbury Shale and 5.8% on Table Mountain sandstone (Figure 5).

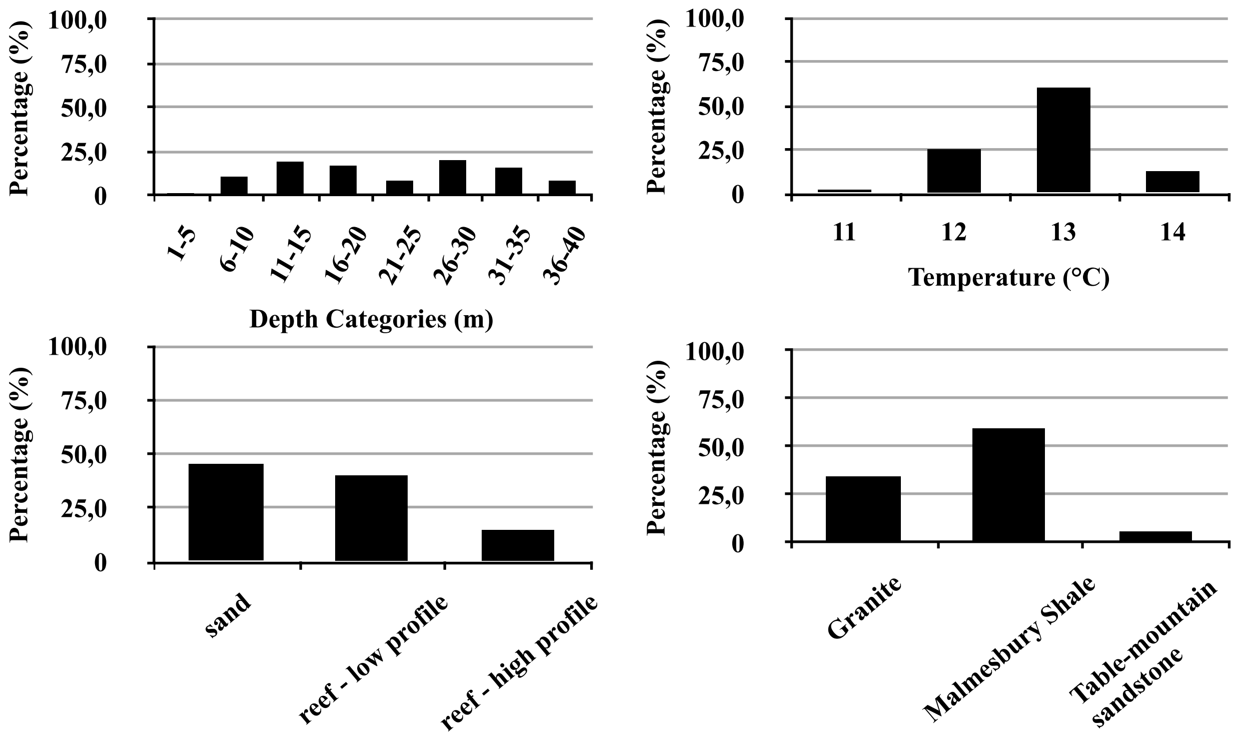

Figure 5: Environmental variables (a) depth (m), (b) water-temperature (°C), (c) bottom habitat-type and (d) rock-type of BRUV deployment sites in False Bay, South-Africa (2012).

Diversity

Fifteen species of chondrichthyans belonging to 10 families and 3 taxa were recorded in False Bay (Table 2). The identification of species was difficult in some cases. The darker coloured *Haploblepharus edwardsii* and *H. pictus* showed a lot of similarity and were distinguished by the presence or absence of the darker margins around the saddle and the presence of numerous white spots on *H. edwardsii* (Appendix II, p. 61). *Galeorhinus galeus* and *Mustelus mustelus* showed a lot of similarity on the videos and were distinguished by the length of their second dorsal fin, whereby *M. mustelus'* fin is almost as long as the first dorsal fin, compared to *G. galeus'* which is less than half the length of the first dorsal fin. While *Raja straeleni* showed similarities to *R. miraletus, R. straelenis* spots were more oval and lacked the blue spot.

Out of the 95 successful sites, 3 showed no presence of chondrichthyans. *Haploblepharus edwardsii* and *Poroderma africanum* were recorded the most often with a frequency of 83 and 47 respectively. *Haploblepharus edwardsii*, *P. africanum* and *P. pantherinum* appeared in the highest numbers at any one site with a 'Mean MaxN' and 'Maximum MaxN' of 3.05 and 9, 1.70 and 5, and 1.50 and 4 respectively. *Haploblepharus edwardsii* was the most abundant species with a 'Relative Abundance' of 2.67.

A species accumulation curve created from the percentage of relative abundance showed that *H. edwardsii*, *P. africanum* and *P. pantherinum* together made up 80% of the total chondrichthyan abundance (Figure 6). Ninety percent of the total abundance was achieved with only 5 species, with *H. natalensis* being the 5th most abundant species. Single contributions were made by *C. carcharias, S. megalops, R. annulatus* and *M. aquila*.

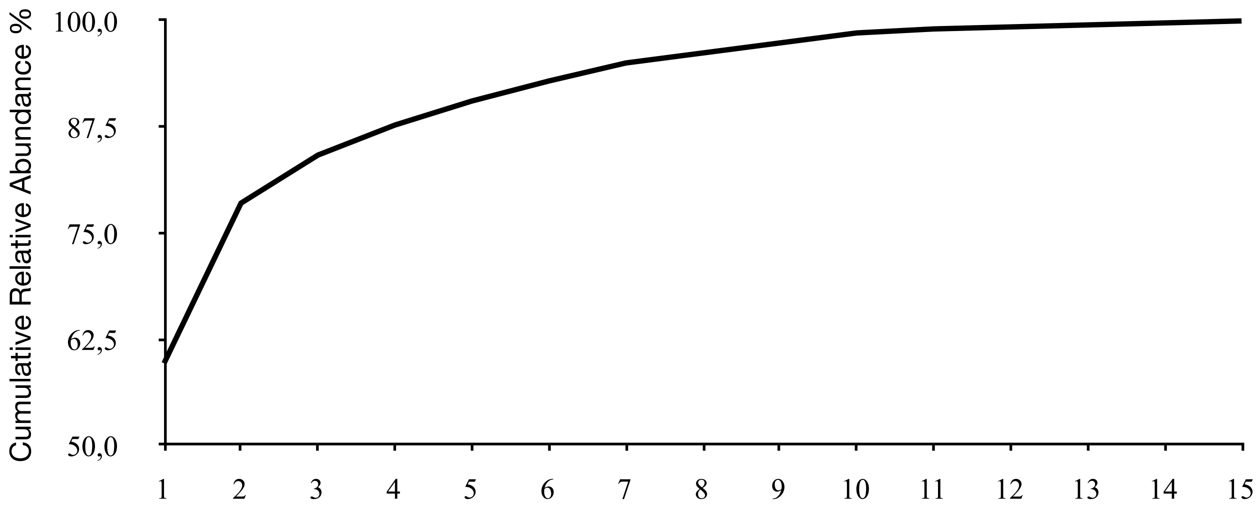

Figure 6: Species accumulation curve of recorded chondrichthyan species in False Bay according to increasing percentage of Relative Abundance. [1 = *Haploblepharus edwardsii*, 2 = *Poroderma africanum*, 3 = *Poroderma pantherinum*, 4 = *Haploblepharus pictus*, 5 = *Halaelurus natalensis*, 6 = *Galeorhinus galeus*, 7 = *Mustelus Mustelus*, 8 = *Raja straeleni*, 9 = *Notorynchus cepedianus*, 10 = *Dasyatis brevicaudata*, 11 = *Callorhinchus capensis*, 12 = *Carcharodon carcharias*, 13 = *Squalus megalops*, 14 = *Rhinobatos annulatus*, 15 = *Myliobatis aquila*]

Table 2: Chondrichthyans recorded in False Bay during June-July 2012 using BRUV. Species arranged according to descending relative abundance.

Family	Species	Scientific Name	Frequency	Abundance	Max N				Relative Abundance	Probability of encounter
					Mean	SD	Max	Min		
Scyliorhinidae	Puffadder Shyshark	*Haploblepharus edwardsii*	83	253	3.05	1.93	9	1	2,663	0,87
Scyliorhinidae	Pyjama Catshark	*Poroderma africanum*	47	80	1.70	0.88	5	1	0,842	0,49
Scyliorhinidae	Leopard Catshark	*Poroderma pantherinum*	16	24	1.50	0.89	4	1	0,253	0,17
Scyliorhinidae	Dark Shyshark	*Haploblepharus pictus*	14	15	1.07	0.27	2	1	0,158	0,15
Scyliorhinidae	Tiger Catshark	*Halaelurus natalensis*	11	12	1.09	0.30	2	1	0,126	0,12
Triakidae	Soupfin Shark	*Galeorhinus galeus*	10	10	1.00	0	1	1	0,105	0,11
Triakidae	Smoothhound Shark	*Mustelus mustelus*	9	9	1.00	0	1	1	0,095	0,09
Rajidae	Biscuit Skate	*Raja straeleni*	5	5	1.00	0	1	1	0,053	0,05
Hexanchidae	Broadnose Sevengill Shark	*Notorynchus cepedianus*	5	5	1.00	0	1	1	0,053	0,05
Dasyatidae	Short-tail Stingray	*Dasyatis brevicaudata*	5	5	1.00	0	1	1	0,053	0,05
Callorhinchidae	St. Joseph Shark	*Callorhinchus capensis*	2	2	1.00	0	1	1	0,021	0,02
Lamnidae	Great White Shark	*Carcharodon carcharias*	1	1	1.00	NA	1	1	0,010	0,01
Squalidae	Spiny Dogfish	*Squalus megalops*	1	1	1.00	NA	1	1	0,010	0,01
Rhinobatidae	Lesser Guitarfish	*Rhinobatos annulatus*	1	1	1.00	NA	1	1	0,010	0,01
Myliobatidae	Eagle Ray	*Myliobatis aquila*	1	1	1.00	NA	1	1	0,010	0,01

Relative abundance across the different zones (Figure 7) shows that *H. edwardsii* dominated the biodiversity. Zone G showed an exception, whereby *P. africanum* appeared more frequently than *H. edwardsii*. *Poroderma pantherinum* also showed a higher abundance in this zone compared to other zones.

An analysis of the time taken for the first appearance of the four most frequently occuring species showed that *H. edwardsii* appeared on average at 10:49 min after the start of the deployment. The two *Poroderma* species and *H. pictus* took on average a lot longer to arrive. Correspondingly, *H. edwardsii* attained on average MaxN values between 15 and 20 min. Whereas for the remaining three species the MaxN was achieved on average at 32:52, 31:00 and 25:47 respectively (Figure 8). *Poroderma africanum* showed a sharp increase at the end of the MaxN time series. A Kruskal-Wallis test showed a significant difference between the arrival times of the different species (χ^2= 43.9306, df = 3, p = 1.561^{-09}).

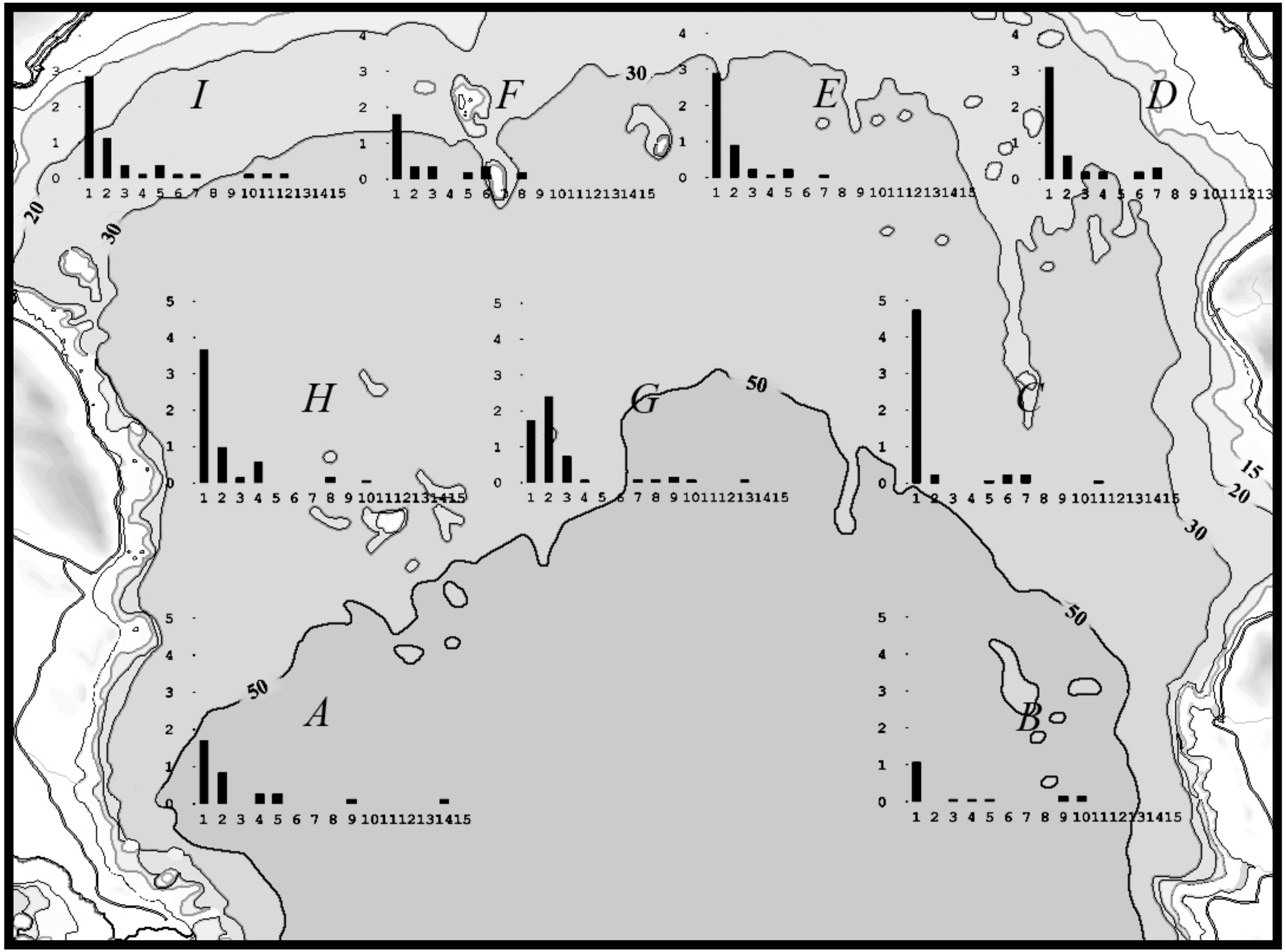

Figure 7: relative abundance per zone. Y-axis represents relative abundance, with X-axis representing species [1 = *Haploblepharus edwardsii*, 2 = *Poroderma africanum*, 3 = *Poroderma pantherinum*, 4 = *Haploblepharus pictus*, 5 = *Halaelurus natalensis*, 6 = *Galeorhinus galeus*, 7 = *Mustelus mustelus*, 8 = *Raja straeleni*, 9 = *Notorynchus cepedianus*, 10 = *Dasyatis brevicaudata*, 11 = *Callorhinchus capensis*, 12 = *Carcharodon carcharias*, 13 = *Squalus megalops*, 14 = *Rhinobatos annulatus*, 15 = *Myliobatis aquila*]

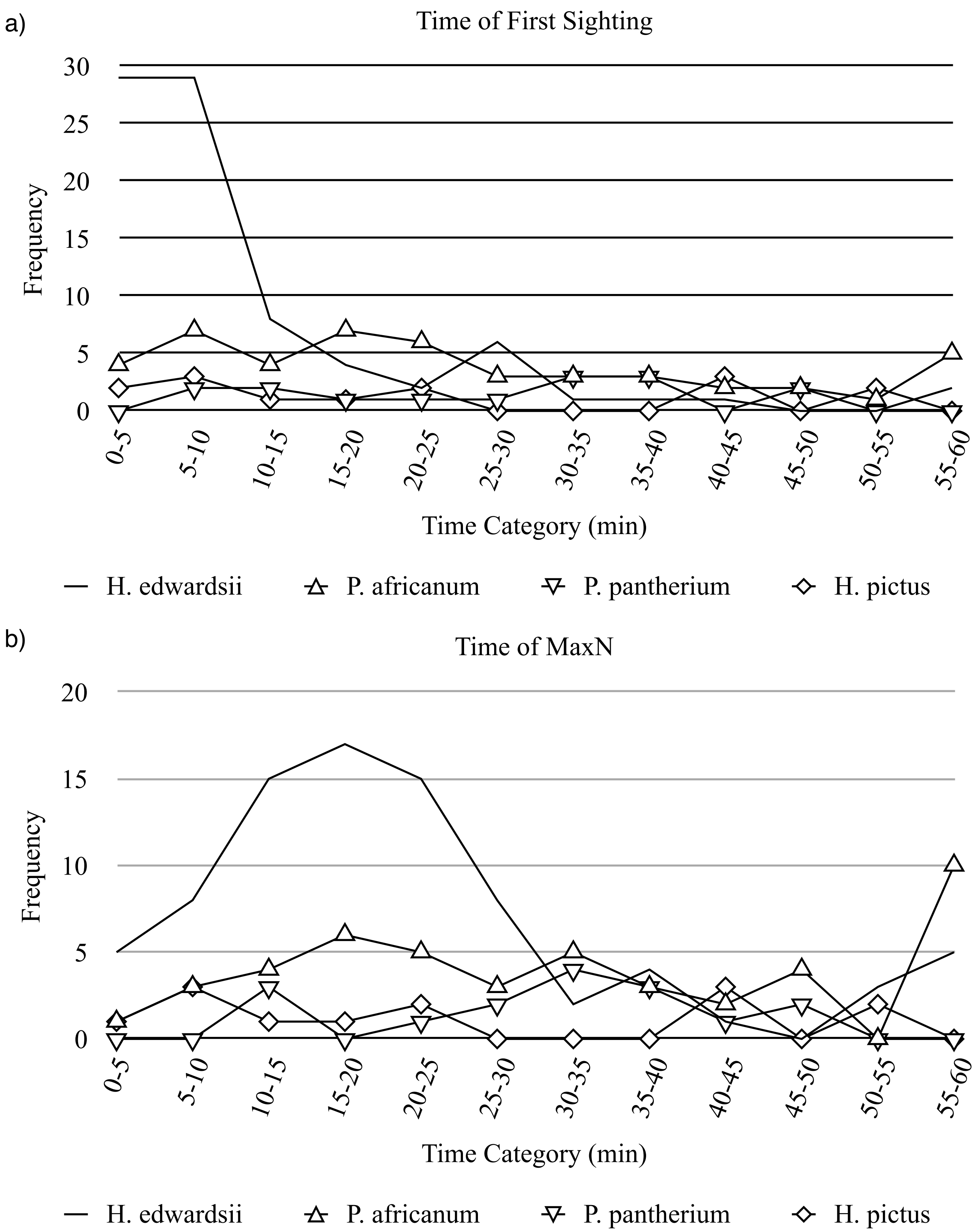

Figure 8: frequency of a) 'Time of First Sighting' and b) 'Time of MaxN' of *Haploblepharus edwardsii, Poroderma africanum, Poroderma pantherium* and *Haploblepharus pictus* from all BRUV sites in False Bay (June 2012). Time was categorized in sections of 5 min.

Similarity in species composition

The dominant group was characterised by a presence of either *H. edwardsii* and/or *P. africanum* (Figure 9). Sites located outside the main cluster were set apart by an absence of both these species. Site A was represented by *R. straeleni*, site B by *H. natalensis,* site C by *H. natalensis*, *G. galeus* and *R. straeleni,* Site D and E (overlapping on MDS plot) were represented by a single *G. galeus*, and site F was represented by *N. cepedianus*.

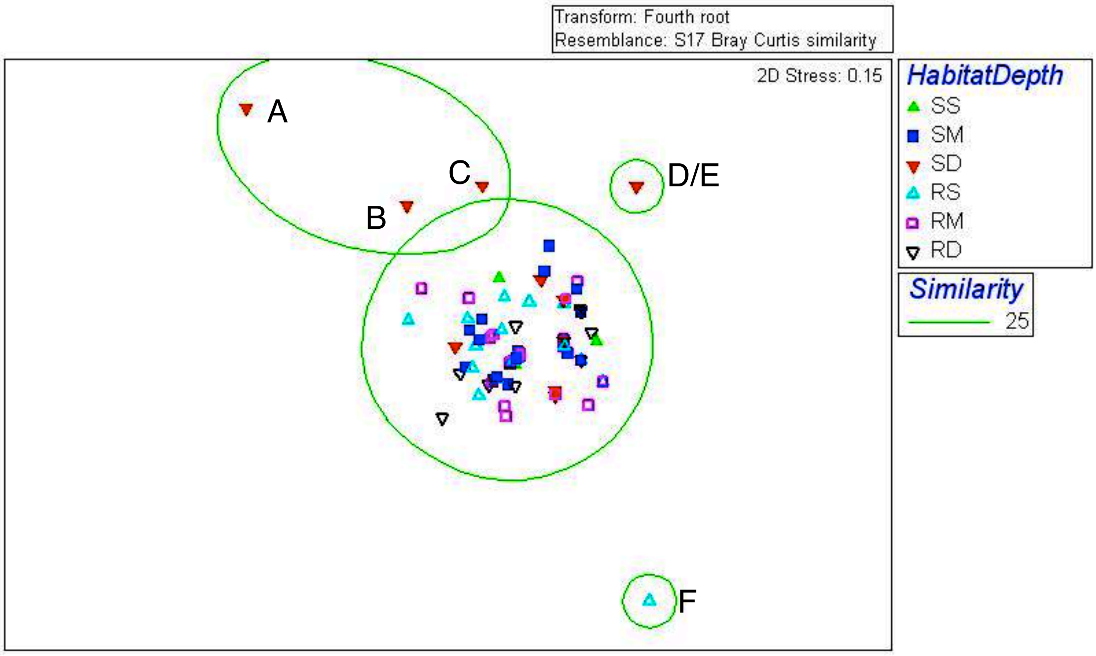

Figure 9: A Bray-Curtis similarity multi-dimensional scaling plot of species composition among sites in False Bay (June/July 2012) obtained through BRUV surveys. Sites are characterised according to habitat-type [S=Sand, R=Reef] and depth-strata [S=Shallow (0-15m), M=Medium (16-30m), D=Deep (31-45m)]. Ellipses designate groupings at similarity level of 25%. Site A is *Raja straeleni,* B is *Halaelurus natalensis*, site C is *H. natalensis*, *Galeorhinus galeus* and *R. straeleni*, D and E is *Galeorhinus galeus* and F is *Notorynchus cepedianus*.

An ANOSIM test revealed significant differences in species composition across depth categories ($R=0.068$, $P>0.01$), whereas an ANOSIM on habitat type revealed a weaker pattern of species composition with respect to habitat type (R=0.030, P=0.07). A test of species composition across a finer delineation of habitat including the three rock types was not significant (R=0.022, P=0.24).

One-way PERMANOVA analyses of depth, habitat and rock-type (tested separately) showed all three to be significant factors in species composition with P-values of 0.004, 0.025 and 0,001 respectively. While individually depth and habitat were significant factors, a two-way PERMANOVA analyses of these factors showed no significance (P=0.109), as none of the factors could be distinguished as dominant. The combination of depth and rock-type did show a significant correlation for chondrichthyan composition (P=0.038) (Table 3).

Table 3: Table of results of 5 PERMANOVA models of environmental factors, Depth (m), Habitat and Rock-type on species composition in False Bay (2012) based on BRUVs.

Source	df	Pseudo-F	P(Perm)
Depth	2	3,0118	0,004
Res	89		
Total	91		
Habitat	1	2,715	0,025
Res	90		
Total	91		
Rock	3	3,5998	0,001
Res	88		
Total	91		
Depth	2	1,8021	0,309
Habitat	1	1,7217	0,361
Depth x Habitat	2	1,697	0,109
Res	86		
Total	91		
Depth	2	1,7294	0,162
Rock	3	3,112	0,181
Depth x Rock	4	1,3456	0,038
Res	87		
Total	92		

A one-way SIMPER analysis showed that *H. edwardsii* and *P. africanum* dominated the communities in both sand and reef environments (Table 4), the different depth strata (Table 5) and different rock-types (data not shown). While *P. africanum* and *H. edwardsii* were present in higher abundance in reef environments, *G. galeus* and *H. natalensis* showed a preference for sand environments. *Galeorhinus galeus* and *P. pantherinum* distinguished deep communities from shallow and medium communities, whereas *P. africanum* differentiated medium depths from shallow and deep communities.

Table 4: List of chondrichthyan species dominating different a) habitat and b) depth types in False Bay obtained from BRUVs in 2012 (June/July) (shaded diagonal boxes), and species differentiating communities among the different habitat and depth types (shown in the unshaded boxes). Differentiating species are common in the habitat and depth type listed in the row but rare in the habitat type listed in the column.

A)

		Rare	
		Sand	**Reef**
Common	**Sand**	*Haploblepharus edwardsii* *Poroderma africanum*	*Galeorhinus galeus* *Halaelurus natalensis*
	Reef	*Poroderma africanum* *Haploblepharus edwardsii*	*Haploblepharus edwardsii* *Poroderma africanum*

B)

		Rare		
		Shallow	**Medium**	**Deep**
Common	**Shallow**	*H. edwardsii* *P. africanum*	*H. pictus* *P. pantherinum*	*H. edwardsii* *P. africanum*
	Medium	*P. africanum* *H. edwardsii*	*H. edwardsii* *P. africanum*	*H. edwardsii* *P. africanum*
	Deep	*P. pantherinum* *G. galeus*	*G. galeus* *P. pantherinum*	*H. edwardsii* *P. africanum*

Comparison between BRUV and prior surveys performed in False Bay

Comparing the BRUV survey results to other chondrichthyan surveys preformed in False Bay over the 20th century (Table 6) shows that the results gained from this BRUV survey are comparable to results gained from SCUBA surveys and poison surveys using rotenone (43.51% similarity) (Cluster-analysis, data not shown). The BRUV survey results were least comparable to those gained from long lining and line fishing (13.67% similarity). A MDS-plot shows the BRUV survey displaying similar results (40% similarity) to SCUBA census and Rotenone surveys and a 20% similarity to spearfishing (Figure 10). Three other groups could be distinguished with 40% similarity, namely: deep water fishing surveys, shallow water surveys and trawling as a separate group. Out of the 34 species gathered in previous surveys, this BRUV survey found 44.1% of species. This is only surpassed by Recreational Angling (73.5%), Survey Beach Seine (55.9%) and Linefishing (52.9%).

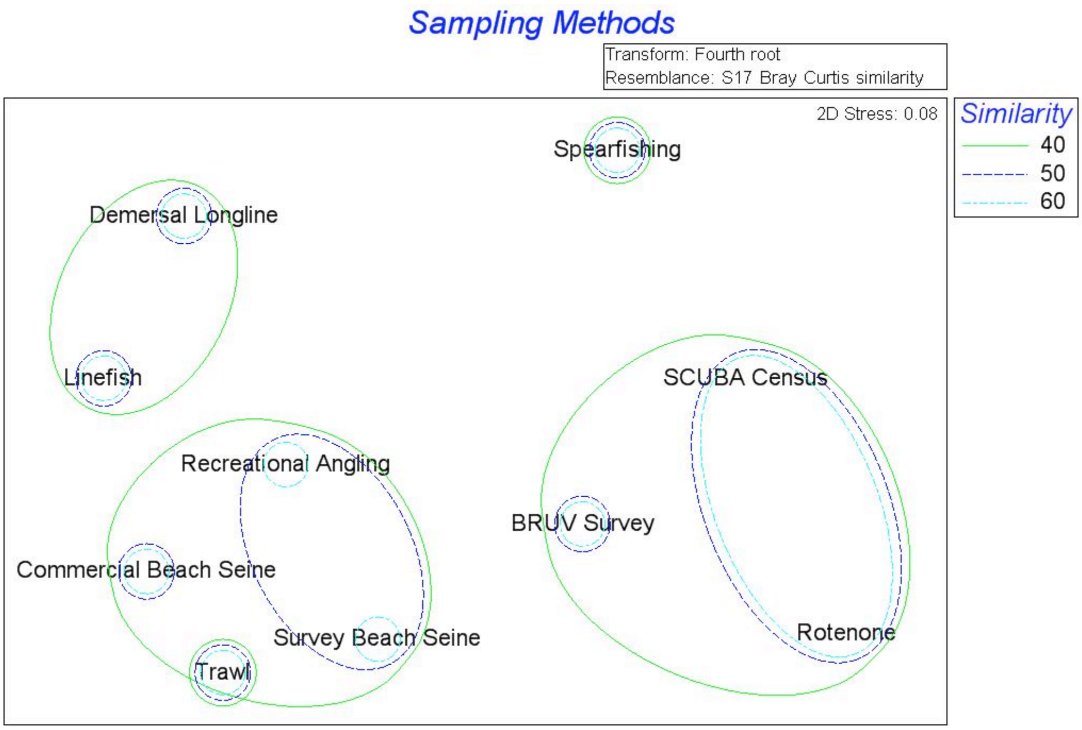

Figure 10: A Bray-Curtis similarity multi-dimensional scaling plot of fish survey methods used in False Bay from 1897 - 2012. Ellipses designate groupings at similarity level of 40, 50 and 60%.

Table 5: Chondrichthyan species recorded in each fishing- or sampling method occurring in False Bay (1897 - 2012), South Africa, for which records exist, in the 20th century and the total number identified.

Species	Commercial Beach Seine[1]	Survey Beach Seine[2]	Linefish[3]	SCUBA Census[4]	Recreational Angling[5]	Trawl[6]	Demersal Longline[7]	Rotenone[8]	Spearfishing[9]	BRUV survey
Year (combined)	1974 - 2003	1990- 1993	1985 - 2010	1978 - 1980, 1993 - 1996	1969 - 1986	1897 - 1903, 1920, 1927 - 1932 (exl. 1989 - 1901, 1928 and 1930)	1992, 1996 - 2003, 2007 - 2011	1994	1992 - 1996	2012
Alopias vulpinus			5,2		11,0					
Callorhinchus capensis	3 146,0	1 716,0	14,5		35,0	7,0				2,0
Carcharhinus brachyurus	27,0	100,0	612,4		1 352,0				1,0	
Carcharhinus brevipinna			38,2							
Carcharhinus limbatus					2,0					
Carcharias taurus	1,0	2,0			66,0					
Carcharodon carcharias	2,0	1,0	10,2		2,0					1,0
Dasyatis brevicaudata		3,0			2,0					5,0
Dasyatis chrysonota		1 076,0			487,0	13,0				
Dasyatis thetidis					3,0					
Elasmobranch spp.*	650,0		72 819,6		985,0	881,0	5,0			
Etmopterus granulosus						6,0				
Galeorhinus galeus	65,0		16 692,8		362,0		7 965,0			10,0
Gymnura natalensis	24,0	18,0			150,0					
Halaelurus natalensis		1,0								11,0
Haploblepharus edwardsii		21,0		21,0	39,0			23,0		83,0
Haploblepharus pictus		1,0		1,0				12,0		14,0
Isurus oxyrinchus	2,0		303,8				93,0			
Mustelus mustelus		1 442,0	12 950,6	1,0	359,0	7,0	3 298,0		30,0	9,0

Table 5 continued: Chondrichthyan species recorded in each fishing- or sampling method occurring in False Bay (1897 - 2012), South Africa, for which records exist, in the 20th century and the total number identified.

Species	Commercial Beach Seine[1]	Survey Beach Seine[2]	Linefish[3]	SCUBA Census[4]	Recreational Angling[5]	Trawl[6]	Demersal Longline[7]	Rotenone[8]	Spearfishing[9]	BRUV survey
Myliobatis aquila	30,0	1 589,0	98,8		172,0	233,0				1,0
Narke capensis		6,0								
Notorynchus cepedianus	1,0		3 228,1	2,0	301,0		170,0		5,0	5,0
Pliotrema warren						3,0				
Poroderma africanum		3,0		4,0	9,0	2,0		4,0		47,0
Poroderma pantherinum			34,5	1,0	3,0					16,0
Prionace glauca			128,4				17,0			
Pteromylaeus bovinus		4,0			103,0					
***Raja* spp.**	27,0	93,0			184,0	1 395,0	1 063,0			
Raja straeleni										5,0
Rhinobatos annulatus	9,0	5 388,0	7,5		876,0	105,0				1,0
***Scyliorhinidae* spp.**	2 000,0		21,0			1,0				
Sphyrna zygaena	4,0		27,9		11,0					
Squalus acanthias						1 166,0				
Squalus megalops			1 298,0		237,0	113,0	1,0			1,0
Torpedo fascomaculata		1,0								
Torpedo marmorata					7,0	95,0				
Triakis megalopterus		5,0	793,4	2,0	1 537,0				9,0	

Source: [1] S. J. Lamberth (Best, 2012); [2] Lamberth (1994), Clark et al (1996), Lamberth et al (1995); [3] National Marine Linefish System (Best, 2012); [4] Cliff (1983), Lechanteur (1999), Lechanteur & Griffiths (2001); [5] Cape Peninsula Club records, Ocean's 50 Club records, Northern's Club records (Best, 2012); [6] CGH (1898, 1899, 1903, 1904), Gilchrist (1921), Von Blonde (1929a, b, 1932a, 1933); [7] C. Da Silva (Best, 2012); [8] Prochazka (1998); [9] Lechanteur (1999).

DISCUSSION

Results of this project represents the first Baited Remote Underwater Video survey which was conducted across 98 sites in False Bay, and was the most comprehensive survey performed covering all habitat types, with the exception of the pelagic zone.

Environmental Factors

Depth of sampling was limited to 40 m, below which the amount of light was limiting. There was also concern about the capacity of camera housing to withstand pressure (Woodman Labs 2009). Despite these concerns, the majority of False Bay could be sampled. Adjustments to facilitate a light source would have to be made to the rig and further analyses would need to incorporate the presence/absence of this light source (Pers. Comm. De Vos, 2013). The addition of a light source could influence species behaviour. Additionally, depth was limited at the surface as well, sampling not shallower than 5 m. This negated the subtidal and surfzone, as the swell and surf could further limit visibility. This restricted the area of False Bay which could be sampled. BRUVs is the most complete method as no other methods sampled all habitats and ranges to depths of 40 m.

Visibility was not assessed in this study as no successful way to properly assess this environmental factor was found, nevertheless previous studies have shown it to be an insignificant element in species composition (De Vos 2012).

Biotic Factors

All fish surveys are inherently biased. No single method is capable of sampling each fish in their true proportion (Solano-Fernández et al 2012). However, the BRUV survey compares favourably with the best existing survey methods, and its biases appear to be intermediate between those of the underwater methods (SCUBA/Rotenone) and the capture methods involving bait (longline and linefishing). The BRUV survey species composition were closest to those achieved by SCUBA and rotenone surveys. Combined with spearfishing, all four rely on underwater visual observations. Trawling was located close to the shallow water surveys in all likelihood as it sampled over soft sediment.

Of the 37 chondrichthyan species found in the other surveys of False Bay, three were classified to the genus level or higher (i.e. *Elasmobranch* spp. *Raja* spp. and *Scyliorhinidae* spp.). Nine of the species were found using one method only, of which 7 had less than 10 specimens each (Best, 2012). The BRUV survey was shown to produce the 4th most diverse survey, only surpassed by recreational angling, survey beach seine and linefishing. The two months of data from this BRUV survey also surpassed the level of biodiversity captured by data was composed over several years (commercial beach seine with 29 years, demersal longlining with 12 years and trawling with 7 years).

The shark community in False Bay were shown to be uniform across the bay shallower than 40 m. *Haploblepharus edwardsii* and *P. africanum* were shown to be the most dominant species in abundance across False Bay. *Haploblepharus edwardsii* showed in a majority of sites within the first 10 minutes, while the maximum frequency of MaxN lay around 15 minutes, implying that they are present within a short distance of the BRUV rig, not having to travel far to reach the bait. While the lighter individuals of *H. edwardsii* were easily recognisable, but dark specimens were difficult to distinguish from *H. pictus*. The two species were set apart from one another by the presence or absence of the darker margins around the saddles and the presence of the numerous white spots on *H. edwardsii*. The high 'Mean MaxN' for *H. edwardsii* corresponds with the social behaviour of the species, as they have often been seen congregating at night in captivity, sleeping in groups (Compagno, 2005).

Poroderma africanum's frequency of first appearance remained stable over the first 25 minutes, while no peak in the frequency of MaxN was reached, implying that while the species is abundant across False Bay, they are more dispersed than *H. edwardsii*, needing more time to reach the bait. The appearance of *P. africanum* became less frequent further in the video sequence. Incongruously, the frequency with which MaxN was reach for *P. africanum* increased at the end of the time series, but because the time series was terminated after 60 min, it is unclear if this trend would have continued. The cause of this sudden increase of maximum number of occurrences is uncertain without extending the time series, and considered being likely due to chance.

Poroderma pantherinum and *H. pictus* showed no discernible patterns relating to time of appearance nor time of reaching a maximum number. *Poroderma pantherinum* is usually discerned by the presence of rosettes. *Poroderma pantherinum* was on occasion difficult to distinguish from *P. africanum* as no discernible rosettes were present. Instead solid dark spots lined in a horizontal pattern were present, causing them to look similar to either *Poroderma marleyi* or *P. africanum*. In the absence of horizontal black bands, ambiguous *Poroderma* individuals were taken to be *P. pantherinum*. *Poroderma marleyi* does not occur in the Western Cape (Van der Elst 1993) and was therefore ruled out as a possibility.

Halaelurus natalensis was shown to be one of the species differentiating sand communities from reef. This corresponds with the knowledge that *H. natalensis* prefers sand environments over reef (Van der Elst 1993). The head of *H. natalensis* is spatula-shaped and used for grubbing in sediments and unearthing prey.

The frequency of arrival time for *G. galeus* and *M. mustelus* were too low to determine any noticeable pattern. Differentiating between *G. galeus* and *M. mustelus* was also problematic on occasion. Showing similar body structure, the species were differentiated based upon the length of the second dorsal fin. If the second dorsal fin was in similar height to the first dorsal fin, the individual was determined to be *M. mustelus,* whereas if the second dorsal fin was half the size of the first dorsal fin, the individual would be established as *G. galeus.*

The abundance of *G. galeus* and *M. mustelus* in this study were very low compared to the numbers found in other studies (especially compared to Demersal Longlining). A large bodied species, *G. galeus* occurs over a wide range, explaining why they don't arrive immediately. The mean MaxN for this species was low, contradictory to what would be expected for a shoaling species.

Notorynchus cepedianus is known to be abundant in False Bay, yet the number of individuals found in this study were low. Their near-absence in this study is most likely explained by seasonal variation as shown in other parts of the world (Barnett et al 2010). *Notorynchus cepedianus* was one of the few species of chondrichthyans in this study who feeds on other sharks, stingrays, eagle-rays and some bony fish.

Raja straeleni was the only skate observed in this study. While easily confused with *Raja miraletus, R. straelenis* spots were more oval and lacked the blue spot in the centre. Smith and Heemstra (2003) noted that *R. straeleni* was only found deeper than 80 m, yet Compagno et al (2005) observed a minimum depth of 24 m. *Raja straeleni* was found between 12 and 40 m in this study, providing the shallowest record of this species. It is noteworthy that *Raja* species have not been adequately separated in previous studies in False Bay, because the species are often by-catch in most fisheries, thus lumped together, making it difficult for species comparisons among surveys.

Dasyatis brevicaudata is most common between depths of 182 and 476 m, but this species is sometimes found closer to shore. *Dasyatis brevicaudata* aggregate in large numbers and is found on both sand and rock habitats (Hennemann 2001).

Less frequent encounters included *C. capensis, C. carcharias, S. megalops, R. annulatus* and *M. aquila*. *Callorhinchus capensis* was observed twice in the whole study, whereas the other four were only observed once. Of these species, *C. carcharias* was observed most fortuitously, as the camera was moved by *P. africanum* and consequently aimed higher into the water column where the apex predator was observed.

The question whether *C. capensis* and *M. aquila* were chance encounters can be clarified by their diet. Both species are known to eat primarily invertebrates (Smith & Heemstra 1986, Van der Elst 1993; *C. capensis:* Freer & Griffiths 1993) and thus unlikely to have been attracted to the bait.

Squalus megalops is more commonly found in deeper waters along trawl grounds (Pers. Comm. C. Attwood, 2013). The specimen in this study was consequently found at the shallow end of its distribution. Opposed to the single individual found, the species also occurs in large aggregations (Heemstra & Heemstra 2004). *Rhinobatos annulatus* on the other hand is a surfzone species and thus found on the deeper end of its distribution.

Notable absences from this survey are amongst others, *Raja alba*, a species once common in False Bay, now completely absent from the area (Pers. comm. C. Attwood 2013). Other species absent from this survey are *Gymnura natalensis* (Backwater Butterfly Ray or Diamond Ray), *Carcharhinus brachyurus* (Bronze whaler), *Triakis megalopterus* (Spotted gully shark) and *Dasyatis chrysonata* (Blue stingray), but these are known to be in the area during summer and are thus expected to appear in surveys performed during these months.

Despite this being the only BRUV survey in False Bay, it is apparent that there is an unusual abundance of catsharks and shysharks, compared to other surveys in False Bay. BRUV surveys performed in other parts of the world noted no species from the Scyliorhinidae family. BRUV surveys of chondrichthyan populations in other parts of the world have shown a higher number of species at high trophic level (Brooks et al 2011, Clarke et al 2012).

The high number of Shysharks and Catsharks in this study might be attributed to the disappearance of large predatory sharks which feed on them. This process were medium-sized vertebrate predator populations increase due to the removal of their predators is known as mesopredator release (Baum & Worm 2009). One of the major species which has been reduced by fishing is *G. galeus* (DAFF 2012).

Another reason for the high number of mesopredatory sharks might be due to the low height of the camera (± 30 cm of the ground), resulting oversampling of the benthic species and under sampling of pelagic species.

Depth, habitat and rock-type were weak predicators of species distribution and abundance. In fact chondrichthyans composition is remarkably uniform across False Bay. Both *H. edwardsii* and *P. africanum* dominated the chondrichthyan community structure across all depth factors, habitat and rock types.

The role of depth could be explained by the preferred egg laying habitat of the catsharks. Although *H. edwardsii* can be present up to depths of 288 m and is most commonly found between depths of 30 and 90 m (Compagno 2005), it lays its eggs between depths of 8 m and 34 m, showing no preference for what substratum it attaches its eggs to (Pretorius 2012). The reason for placing their eggs above their preferred depth can be attributed to temperature, as higher temperatures stimulate egg production and decreases the incubation period (Pretorius 2012). *Haploblepharus pictus* is found only up to a depth of 35 m, and lays its eggs at an average depth of 3.9 m, preferring to attach their eggs to one specific alga (*Bifurcariopsis capensis*) (Pretorius 2012). While *P. africanum* is found from the intertidal zone all the way to depths of 282 m (Compagno 2005), it lays it's eggs along depths from 7 m to 26 m. *Poroderma pantherinum* can be found up to depths of 256 m (Compagno 2005) and 80% of its eggs are laid at a depth of 8 to 20 m (average of 15.7 m). Both species preferred to attach their eggs to seafans (Pretorius 2012).

While *H. edwardsii* and *P. africanum* dominated the species community across reef and sand habitat types, *G. galeus* and *H. natalensis* were the species that differentiated the sand environment from reef. This conforms with the general knowledge as both species are found commonly in sandy environments (Van der Elst 1993)

BRUV surveys do have drawbacks that make using them troublesome. While one has some influence in the placements of BRUV rigs, when generally placing them in reef environments, the field of view can become blocked by boulders or obstructed in other ways. The video survey is also heavily dependent on suitable visibility conditions, making studies in highly turbid waters problematic. Due to this inconvenience the number and diversity of sharks at affected sites is thought to be underestimated. Another issue already addressed is the difficulty regarding the identification and differentiating of certain species.

In spite of the drawbacks, BRUV is a low impact survey, known to be able to survey a high range of depths and habitat types. As a large amount of sharks species are threatened, the need for non-invasive methods are increased. Another non-invasive method, SCUBA, is inadequate as this survey is limited by the divers ability and due to sharks being dangerous and relatively rare. An additional benefit is that the video footage can be stored and re-analysed at a later time.

BRUV surveys have been shown to be a viable measure of survey sharks in other parts of the world (Brooks et al 2011). Since this survey was only performed over nine days in winter (2012), deriving conclusions to whether this BRUV survey serves as an effective measure to survey sharks in False Bay should be delayed until seasonal variation can be incorporated.

CHAPTER 3 - STUDY REVIEW

CONCLUSION

The benthic shark community is uniform across False Bay. Depth, habitat and rock type are weak indicators of the community structure. Of the benthic chondrichthyan community, species of the Scyliorhinidae family are the most abundant. It is unclear whether this is due to mesopredatory release or the location of the BRUV rig on the benthic ground. If the former of these explanations is valid, it would indicate a potential shark conservation problem for False Bay, in terms of the depletion of top predators and ecosystem disruptions.

While no method is inherently perfect for analysing community structure, the BRUV survey method is a viable improvement over others. The technique has shown to be non-invasive, non-extractive and usable across a majority of habitat types, with the potential to include the whole of False Bay. When compared to the biodiversity found through other surveys used in False Bay, BRUV showed a 44.5% diversity, the 4th most diverse method behind recreational angling, survey beach seine and linefishing. It is likely that with summer sampling the diversity will be comparable to the best of the other surveys. Additional surveys should be performed in summer months to compare with this winter survey. This would allow for the sightings of more species (*G. natalensis*, *C. brachyurus*, *T. megalopterus* and *D. chrysonata*), plus include seasonal variation. Increasing the sample size would ensure sightings of more rare species in False Bay.

TECHNICAL RECOMMENDATIONS AND FUTURE RESEARCH

Additions could be made to the rig to assure that the rig lands horizontally on the bottom. This could be in the form of small floats or buoys which sole purpose is to make sure the rig stays up during the whole descent.

While the BRUV set up is sufficient to monitor the chondrichthyan community in False Bay, additions to the rig could extend the range of monitoring. Despite the depth restriction established for this study, BRUV surveys are capable in extending to 300 m depths. Upgrading the underwater housing would be necessary to allow for greater pressure resistance. Adding a light source would facilitate the viewing process. To assure that species are attracted to the bait and not inquisitive about the light source, it is suggested that the light source provides a red luminescence, a colour undetectable to a majority of the species. The addition of a light source would also allow the monitoring of the area during night time. This would enable the viewing of nocturnal species and their behaviour. The addition of an underwater microphone would permit the recording of shark sounds. The improvements and fixtures of these additions would extend the surveys to other habitats, e.g. deeper and surf-zones, thus sampling of the entire False Bay ecosystem.

The problem of viewing only benthic species with this rig, could be solved with the development of a rig that would float in mid-waters. This allows for the viewing of species in the pelagic zone. An anticipated problem would be stability and alterations should be considered to ensure a steady view.

A dual camera set-up would allow the measure of species length, provided that necessary software is available. GoPro Hero2 HD cameras have been found unsuitable for this task, as the underwater housing distorts the image.

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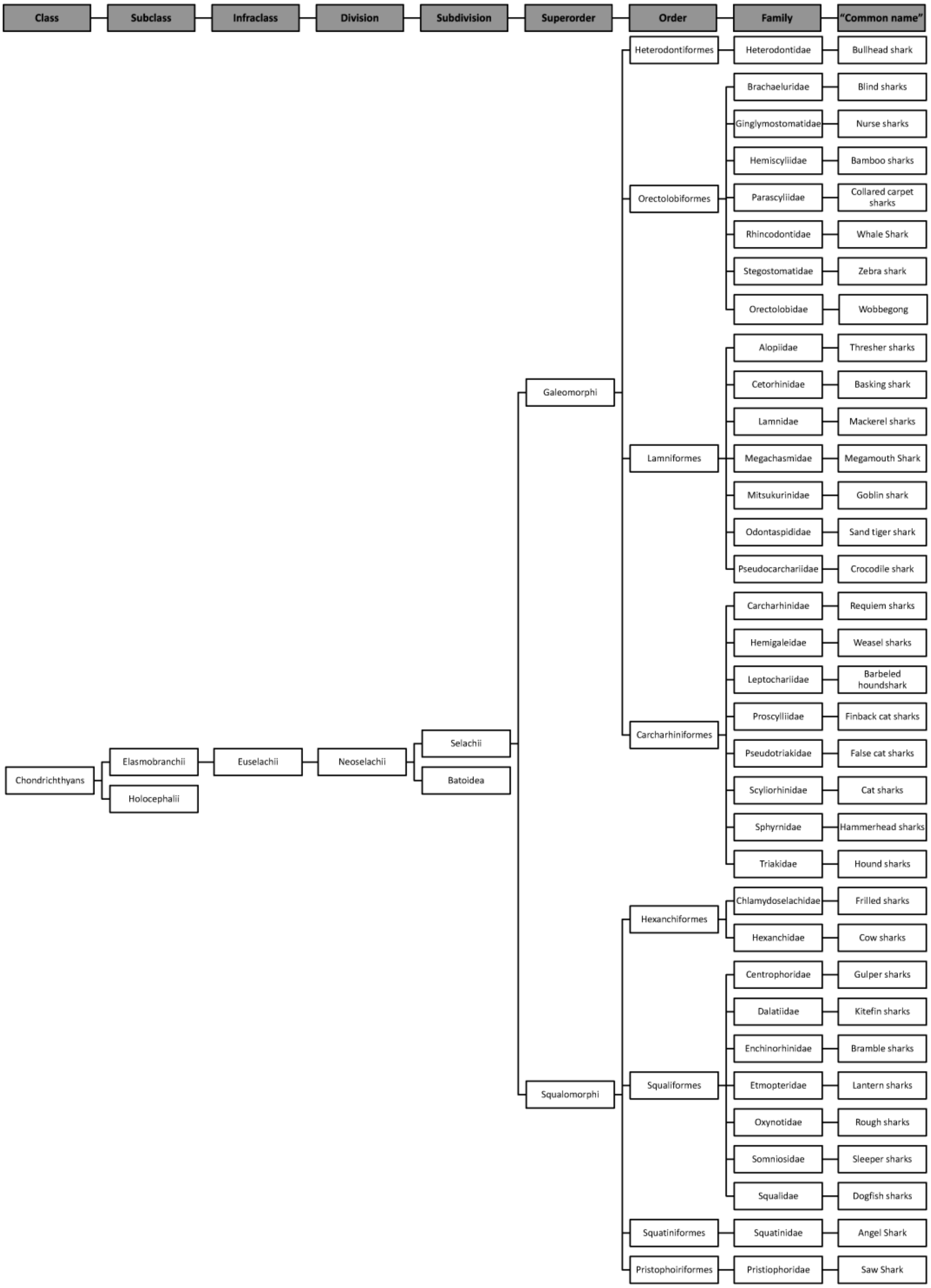
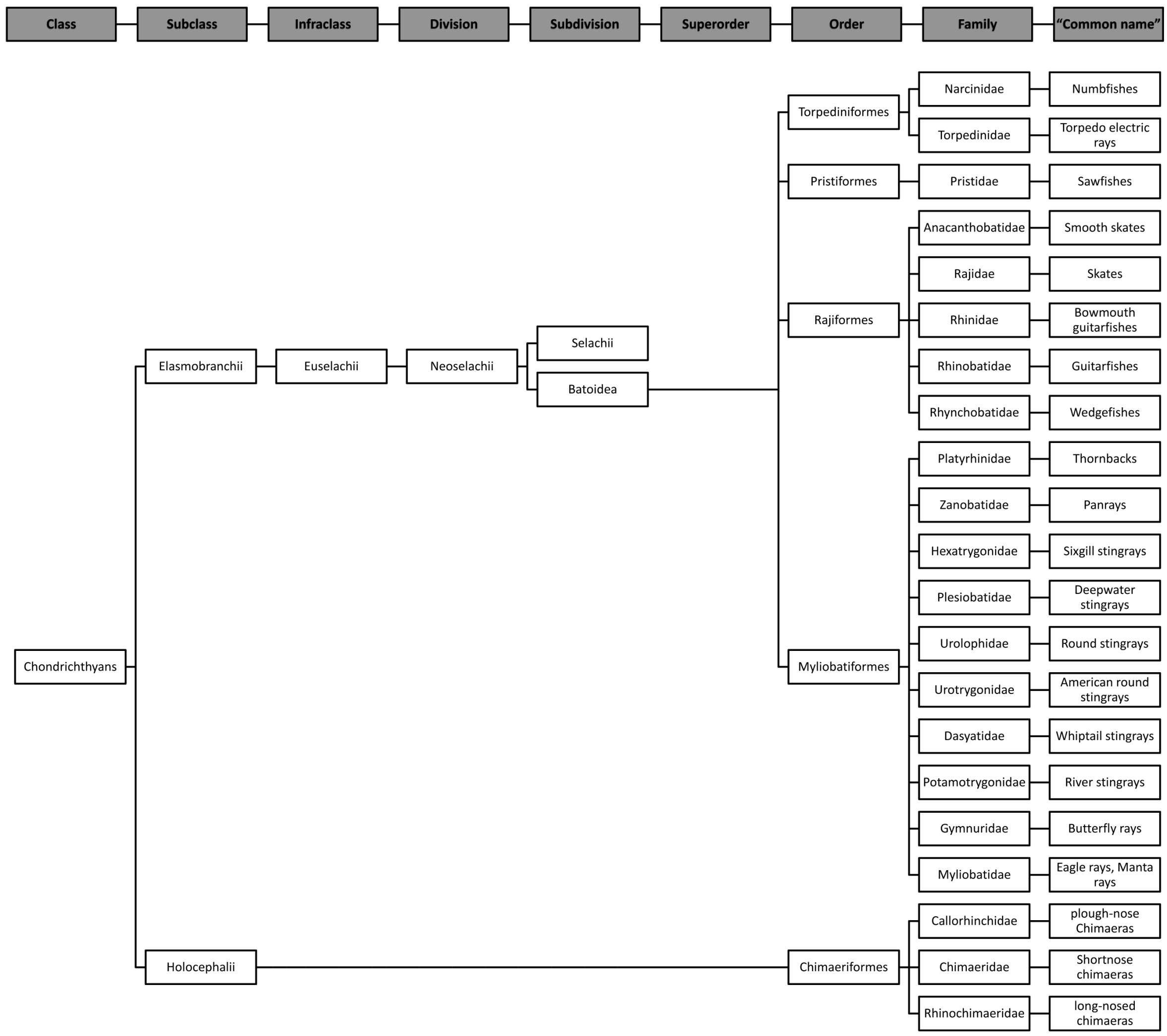
APPENDICES

Appendix I

Taxonomy tree of sharks (subdivision: Selachii), classified from class to family including the family's "common name". Sources: NCBI (www.ncbi.nlm.nih.gov), Encyclopedia of Life (http://eol.org), Intergrated Taxonomic Information System (ITIS) (http://www.itis.gov), World Register of Marine Species (WoRMS) (http://www.marinespecies.org/), Compagno (2005).



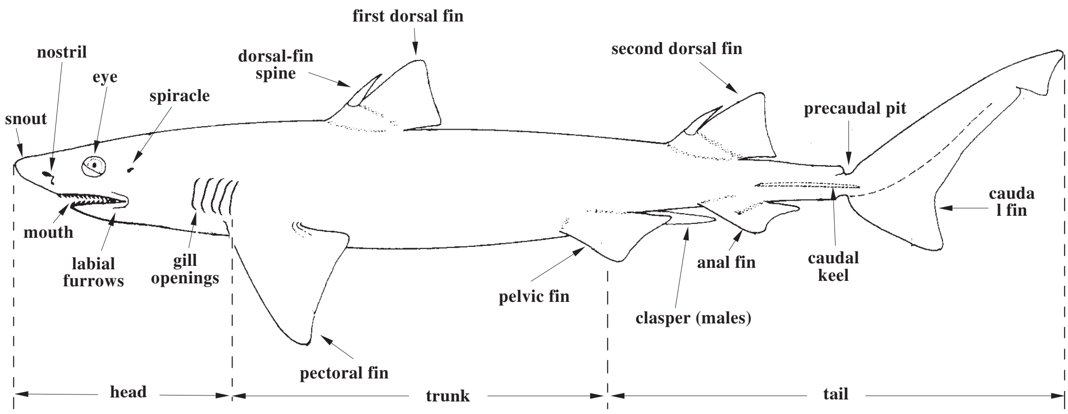
Taxonomy tree of skates and rays (subdivision: Batoidea) and Chimaeras (subclass: Holocephalii), classified from class to family including the family's "common name". Sources: NCBI (www.ncbi.nlm.nih.gov), Encyclopedia of Life (http://eol.org), Intergrated Taxonomic Information System (ITIS) (http://www.itis.gov), World Register of Marine Species (WoRMS) (http://www.marinespecies.org/), Ebert & Compagno 2007.



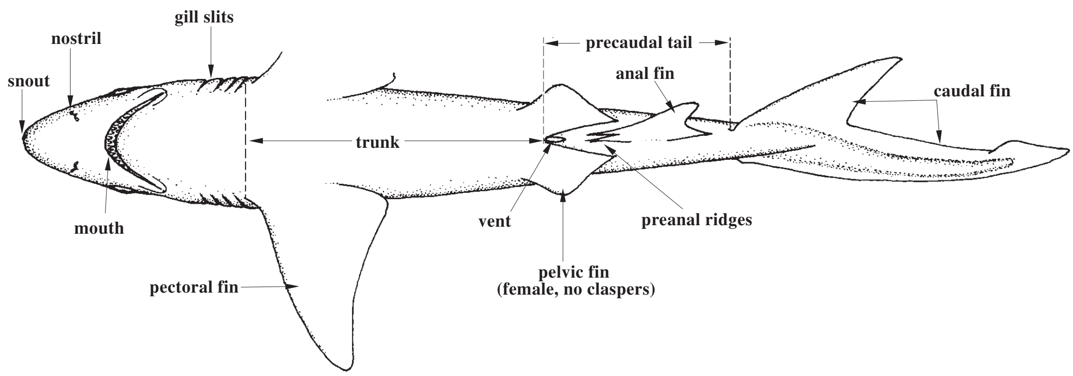
Appendix II

Picture Guide to External Terminology of Sharks - Technical Terms and Measurements.

1. Lateral View

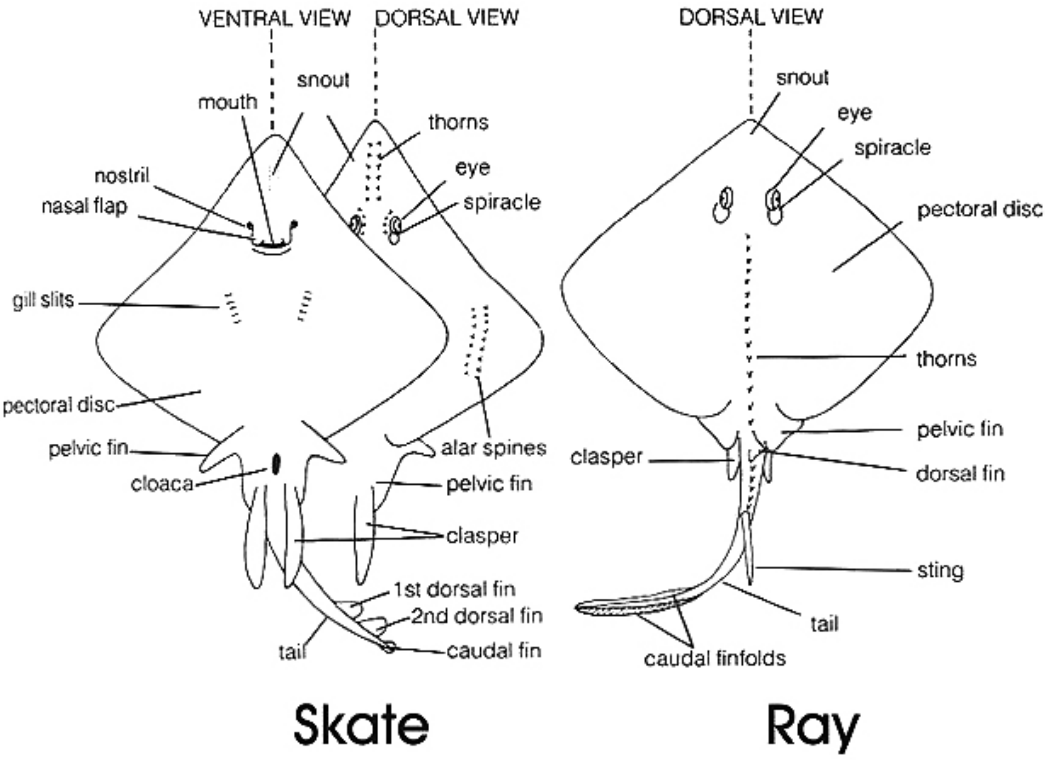


2. Ventral View



Source: Compagno L.J.V. 2002. Sharks of the World, Volume 2. FAO Species Catalogue for Fishery Purposes

Picture Guide to External Terminology of Skates and Rays - Technical Terms.



Source: www.ajilbab.com/skates/skates-and-rays.htm

Order *CARCHARHINIFORMES*

The typical shark with 2 spineless dorsal fins, an anal fin, 5 pairs of gill slits, a movable lower nicitating eyelid, a long mouth extending behind the eyes. The largest group of sharks with inshore, oceanic and deep-water benthic species in all temperate and tropical seas. A few species enter freshwater.

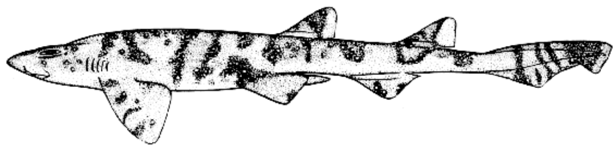
Family *Scyliorhinidae*

This family has two dorsal fins without spines. The first dorsal axil is located either over or behind pelvic origin. An anal fin is present.

The genera *Poroderma* is the only one with nostrils with conspicuous barbels. The genera *Haploblepharus* and *Halaelurus* are defined from other genera by the presence of both upper and lower lip grooves. *Haploblepharus* is further defined by nostrils connecting to the mouth by grooves, while with *Halaelurus* the nostrils are separate from the mouth. *Halaelurus* is further defined by the origin of the anal fin located behind the tip of the first dorsal fin. *Haploblepharus* are known as ‘shysharks’ for covering their eyes with their tails when caught.

Puffadder Shyshark (*Haploblepharus edwardsii*) Near Threatened

Also known as: Happy Eddie



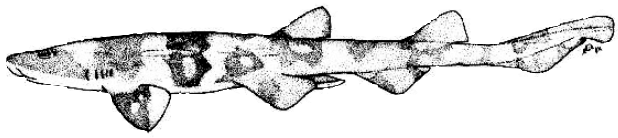
Size: Eggcase: ~3.5-5 x 1.5-3 cm. Hatch: ~10 cm TL. Adolescent: 26-40 cm ♂, 39-44 cm ♀. Mature: 37-60 cm ♂, 39-69 cm ♀. Max: 69 cm TL.

Description: Coloured yellow-brown with clearly visible saddles. The saddles have noticeably darker margins, both front and back, and numerous pale spots can be seen on the saddles.

Distribution: Endemic to South-Africa and found in shallow inshore waters of False Bay and eastwards (past Algoa Bay).

Dark Shyshark (*Haploblepharus pictus*) N/A

Also known as: Pretty Happy



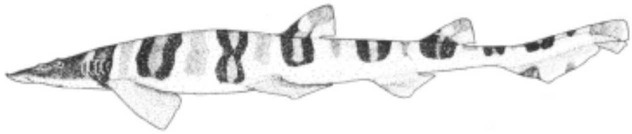
Size: Adolescent: 50-54 cm ♂. Adult: 55-69 cm ♂, 60-63 cm ♀. Max: 69 cm TL.

Description: Coloured dark brown, sometimes obscuring the saddles. Compared to *Haploblepharus edwardssi*, the saddles don't have darker margins, and lacks numerous pale spots.

Distribution: Located from the Namibian coast to the western Cape (including False Bay). Found in shallow waters.

Tiger Catshark (*Halaelurus natalensis*) N/A

Also known as: -



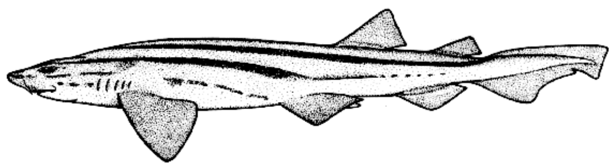
Size: Eggcase: ~4 x 1.5 cm. Adolescent: 29-35 cm ♂, 30-44 cm ♀. Adult: 35-45 cm ♂, 37-50 cm ♀. Max: 50 cm ♀ TL.

Description: The snout of the Tiger Catshark is pointed and slightly turned upward. The distance between the two dorsal fin bases is approximately 2.5-3 times the first dorsal fins height and the lower edge of the caudal fin is almost straight. Coloured yellow-brown with a cream-colour below and 7 dark brown dorsal saddles.

Distribution: Endemic in South-Africa from Saldana Bay to Algoa Bay. From the shore out to at least 125 m.

Pyjama Catshark (*Poroderma africanum*) N/A

Also known as: Striped Catshark



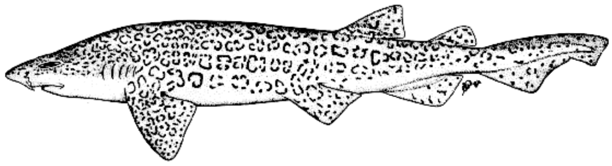
Size: Hatch: 14-15 cm TL. Mature: 58-76 cm ♂, 65-72 cm ♀. Max: 95 cm TL.

Description: The Pyjama Catshark has a creamy background colour with dark brown, almost black, horizontal bands with pale centre stripes. Very short nose barbels.

Distribution: In South-Africa from the southwestern Cape to Algoa Bay, where they are less common, and scarce in East London. Found in shallow water down to 100 meters.

Leopard Catshark (*Poroderma pantherinum*) N/A

Also known as: -



Size: Mature: 54-58 cm ♂, 58-61 cm ♀. Max: 74 cm TL.

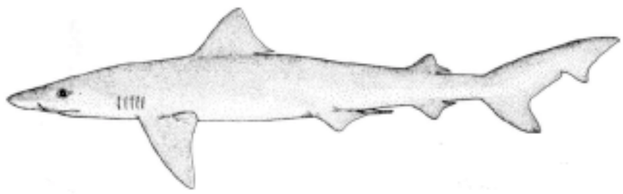
Description: Colour pattern of pale-centered spots or open rings. The basic stripe pattern of *P. africanum* is also present, but breaks up with growth (>30 cm) into small rosettes. Traces of the original pattern may disappear in largest specimens. Nose barbels equal to nasal length.

Distribution: In South-Africa common in East London and abundant in Algoa Bay. Less common along the south-west coast.

Family: *Triakidae*

With over 40 species it's one of the largest family of sharks. Distributed world-wide in warm and temperate coastal seas.

Soupfin Shark (*Galeorhinus galeus*) Vulnerable



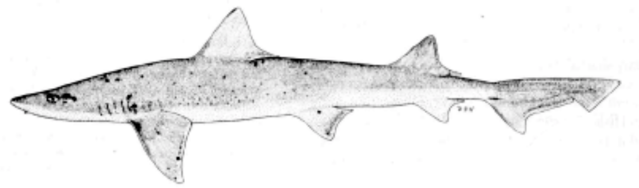
Also known as: Tope Shark, School Shark.

Size: Varies between regions. Born: 30-40 cm TL. Mature: ~120-170 cm ♂, 130-185 cm ♀. Max: 175 cm ♂, 195 cm ♀ TL.

Description: Dark grey above, paler below. The snout has a milky colour below. The height of the second dorsal fin is about equal to the height of the anal fin and less than half the length of the caudal fin tip.

Distribution: Common in eastern North Atlantic and Mediterranean, reported in Pacific Ocean. In Southern African from Angola to East London. Abundant in southern and western Cape. Shallow inshore waters down to 200 meters.

Smoothhound (*Mustelus mustelus*) Vulnerable



Also known as: Common Smoothhound.

Size: Born: ~39 cm TL. Mature: 70-74 cm ♂, ~80 cm ♀. Max: >110 cm ♂, >164 cm ♀.

Description: Dorsally uniform grey, sometimes with a few irregular darker spots. Has a cylindrical body with the head and anterior part flattened ventrally. The second dorsal fin is larger than the anal fin and almost as big as the first dorsal fin. The pectoral fin's length is around 12-17% of the Total Length.

Distribution: Found from the Mediterranean and west coast of Africa to Namibia and around the south coast of Africa to fish river.

Order LAMNIFORMES

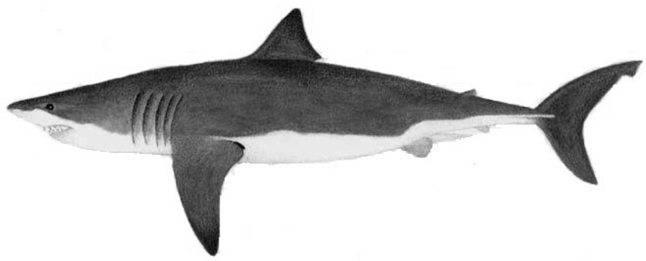
A typical order of sharks with 2 spineless dorsal fins, an anal fin, 5 pairs of gill slits and a long mouth extending behind the eyes. Contrary to the order Carcharhiniformes, Lamniformes species have no movable necessitating eyelid. These shark are inshore, oceanic and in deep-water benthic species and species in all seas, with a limited distribution in the Antarctic and Artic oceans.

Family: *Lamnidae*

The pectoral fin originates behind the last gill slit. The Anal and second dorsal fins are minute compared to the first dorsal fin.

White shark *(Carcharodon carcharias)*

Vulnerable



Also known as: Great White Shark, White Death.

Size: Born: ~110-160 cm TL. Mature: 350-400 cm ♂, ~450-500 cm ♀. Max: ~600 cm TL.

Description: Coloured dark grey or blue grey on top and white below. The first dorsal fin starts in front of the pectoral fin's inner corner. The anal fin starts under or behind the second dorsal fin's axil.

Distribution: Found inshore in all oceans, yet rarely in the open ocean. In South-Africa they're concentrated in the western and southern Cape. In the winter and spring young specimens (<3 meters) are found along the KwaZulu-Natal coast as well.

Order *HEXANCHIFORMES*

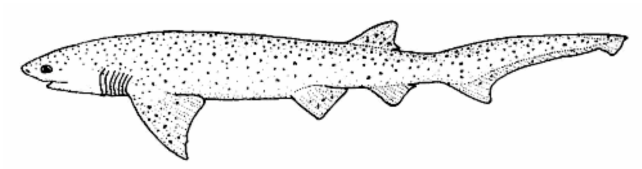
The only order of sharks combining a single dorsal fin with 6 or 7 pairs of gills.

Family *Hexanchidae*

Also referred to as Cow sharks, this family has one dorsal fin, the anal fin is present, and lacks fin spines. Depending on genera, this family has either 6 (genera: *Hexanchus*) or 7 (genera: *Heptranchias* and *Notorynchus*) pairs of gill slits.

Broadnose Sevengill Shark (*Notorynchus cepedianus*) Near Threatened

Also known as: -



Size: Born: 34-45 cm TL. Mature: ~130-170 cm ♂, ~200 cm ♀. Max: ~290 cm (possibly 300-400 TL).

Description: *Notorynchus* has a blunter snout (snout length 1.1-1.3 times internostril distance) compared to *Heptranchias* (snout length 1.6-2.0 times internostril distance). Pale grey dorsally, white below. Dorsal surface of body and fins speckled with black spots.

Distribution: All oceans (except North Atlantic and Mediterranean Sea), apparently non-tropic. In Southern Africa from Algoa Bay to Namibia.

Order *SQUALIFORMES*

A normal cylindrical shark, without an anal fin, and with 2 dorsal fins. The dorsal fins may have small to large spines on their front margins. 5 pairs of gill slits.

Family *Squalidae*

2 dorsal fins without an anal fin, and 5 pairs of gill slits are present.

Spiny Dogfish (*Squalus megalops*) N/A

Also known as: Bluntnose spiny dogfish

Size: Born: 23 cm TL. Mature: ~42 cm ♂, ~55 cm ♀. Max: ~55 cm ♂, ~70 cm ♀.

Description: The first dorsal spine is located over or in front of the inner pectoral fins corner. Has a dark brown or grey colour above, paler below and without white spots.

Distribution: Found around the South African coast on the continental shelf from depths of 50 to 450 m.

Order CHIMAERIFORMES

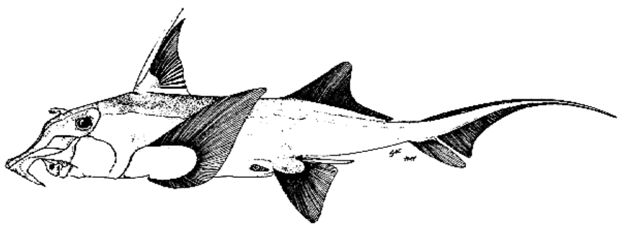
Cartilaginous fishes with a single external gill opening on each side. The first dorsal fin is erect with a strong, mildly toxic spine. Delicate and slow-moving bottom fishes found in deep water on the upper continental slopes down to at least 2600 meters. Some species occur in shallower waters. Males have a pair of prepelvic claspers in front of the pelvic fins and a doorknocker-like frontal tentaculum or head clasper on the forehead used to grasp the female during copulation.

Family: *Callorhinchidae*

This family has a snout with a recurved, hoe-shaped projection. The first dorsal fin is erect with a strong, curved and serrated spine. The second dorsal fin is higher anteriorly and the length of its base is about equal to the distance from the first dorsal fin. The caudal fin has a raised axis. *Callorhinchidae* has a high anal fin and its base is narrow and adjoined to the caudal fin.

St. Joseph Shark (*Callorhinchus capensis*) Least Concern

Also known as: Cape Elephantfish



Size: Eggcase: ~23 cm. Born: 15 cm. Mature: 44 cm ♂, 50 ♀ cm FL. Max: 90 cm FL.

Description: Silvery coloured with dusky brown markings and brown fins.

Distribution: Found only in southern Africa, from Namibia to KwaZulu-Natal. Rarely found in warmer waters. Common in inshore waters up to 200 meters.

Order RAJIFORMES

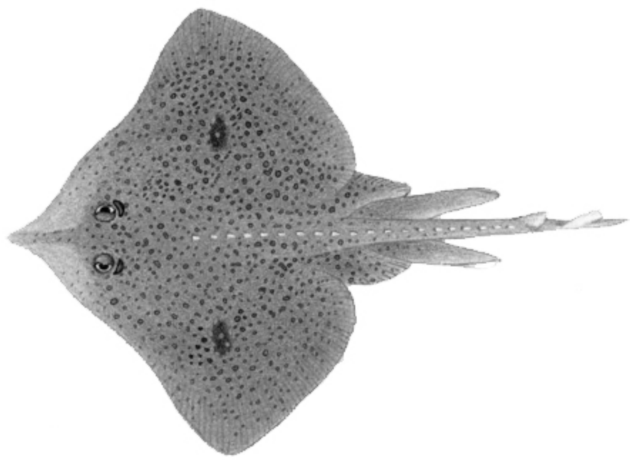
Flattened Batoid species with greatly expanded pectoral fins fused to the head and trunk, forming a disc. Nostrils located close to the mouth, with the nasal flaps expanded posteriorly, overlapping the mouth. Pelvic fins with anterior ends expanded as distinct lobes, occasionally entirely separate from posterior lobes. The tail is slender (but not whip-like), with a reduced caudal fin and 2 small dorsal fins usually located close to the tip of the tail (sometimes absent).

Family: *Rajidae*

The disc is quadrangular to rhomboidally shaped with a snout ranging from long and acutely angled to short and obtusely rounded. The tail has lateral folds, 2 dorsal fins and a caudal fin. *Rajidae* have five pairs of ventral gill slits.

Biscuit Skate (*Raja straeleni*) Data Deficient

Also known as: -



Size: Max Width: ~ 49 cm, Max Length: ~ 67 cm.

Description: The body is 1.2 to 1.5 times as broad as long. The snout is not produced nor sharply pointed. One row of thorns is present on the tail. Dorsally brown to grey with scattered dark spots and two larger oval spots present.

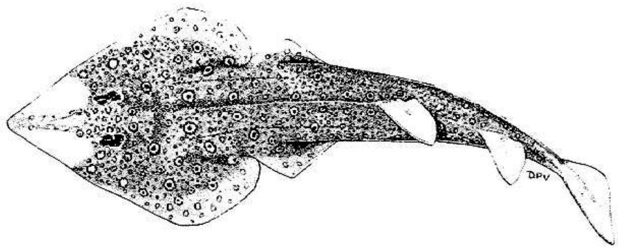
Distribution: Common on the continental shelf of southern Africa and especially South Africa, at depths of 80–690 m, yet also found from 24 m deep (Compagno et al, 2006).

Family: Rhinobatidae

The body is elongated and shark-like with a much depressed front and the tail is stout. The snout is wedged shaped or broadly rounded. Two large dorsal fins and a well-developed caudal fin.

Lesser Guitarfish (*Rhinobatos annulatus*) Least Concern

Also known as: -



Size: Mature: ~ 59 - 70 cm, Max length: ~ 140 - 183 cm.

Description: The snout margin is slightly convex behind an angular snout tip. The length from the snout tip to mouth is 2.5 to 3 times the mouth width. The eyes are slightly larger than the spiracles and the length from snout tip to eyes is 2 to 3 times the distance between spiracles. Buff to dark brown above. The body and tail with brown spots or brown and white annular rings. Ocelli consists of a dark spot surrounded by light spots and dark rings.

Distribution: East Atlantic from West of the British Isles, the Mediterranean down to KwaZulu-Natal, South Africa.

Order MYLIOBATIFORMES

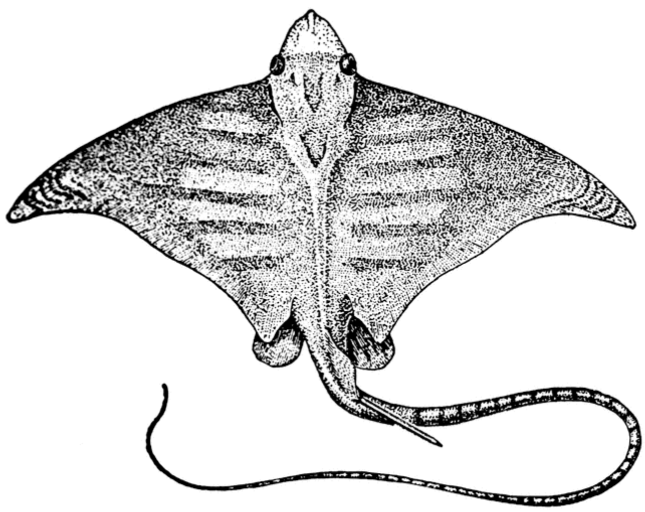
A flat batoid with pectoral fins expanded and fused with head and trunk to form a disc. The snout is angular, broadly rounded or bilobed. Either with one dorsal fin or none. The tail is fairly thick or more or less elongated and whip-like, usually with a stinging spine near base of tail.

Family: Myliobatidae

Head, body and pectoral fins form a strongly angular disc, almost twice as wide as long. Head and snout strongly marked off from rest of disc with the snout forming a single lobe or a pair of broadly rounded lobes separated by a median notch with a bilobate shelf overhanging snout. Five pairs of gill openings are located on the underside of the disc. No caudal fin or fin-folds; tail slender (whiplike), as long as disc or longer.

Common Eagle Ray (*Myliobatis aquila*) Data Deficient

Also known as: -



Size: Max width: ~ 150 cm.

Description: The snout is broad and short, connected to the pectoral disc by a broad ridge under each eyes and projected as a single lobe. The forehead doesn't overhang over the snout. Chocolate-brown to black above, white below, no prominent markings.

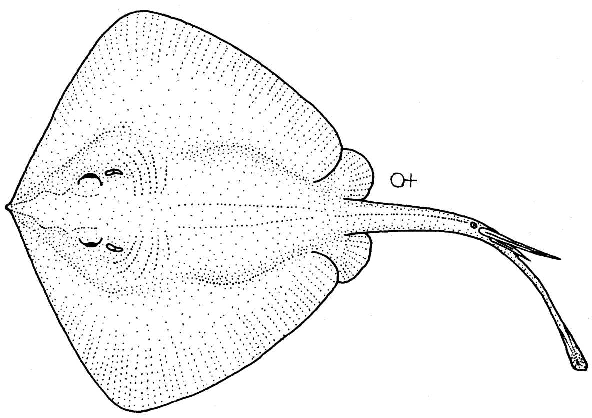
Distribution: From the Mediterranean and East Atlantic around the Cape to Kwazulu-Natal. Coastal and often found in shallow lagoons and estuaries.

Family: Dasyatidae

The head, body and pectoral fins form a rounded or angular pectoral disc (1-2x as wide as long). The snout is broadly to narrowly angular or rounded with a length less than half the width of the disc. Five pairs of gills are located on underside of the disc. Tail moderately slender to very slender (whip-like), varying from somewhat shorter than disc to several times disc length, generally with a large, venomous sting on its dorsal surface well behind its base.

Short-tail Stingray (*Dasyatis brevicaudata*) Least Concern

Also known as: -



Size: Max width: ~ 2.1 m; Max length: ~ 4.3 m.

Description: The disc and tail are relatively smooth without enlarged stellate denticles. Disc slightly wider than long, no medial row of thorns or enlarged denticles. A short dorsal fin-fold above ventral fold. Grey-brown above, white below. Tail length slightly shorter than disc with scattered small stellate denticles. The sting ends close to the tail tip. No markings on disc or tail.

Distribution: From False Bay to Maputo. Also known in Australia and New Zealand. Probably most abundant in depths of 182 to 476 m, but occasionally found close inshore.

Unless noted otherwise, source: Smith, M. M., and P. C. Heemstra. 1986. Smith's sea fishes. 1st edition. Southern Book Publishers, Johannesburg.