IOTC-2017-WPEB12-14

African Journal of Marine Science
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/tams20

The current status and management of South Africa's chondrichthyan fisheries

C da Silva[ab], AJ Booth[c], SFJ Dudley[ad], SE Kerwath[abe], SJ Lamberth[af], RW Leslie[ab], ME McCord[g], WHH Sauer[c] & T Zweig[g]

[a] Branch: Fisheries Management, Department of Agriculture, Forestry and Fisheries, Cape Town, South Africa

[b] Department of Biological Sciences, University of Cape Town, Cape Town, South Africa

[c] Department of Ichthyology and Fisheries Science, Rhodes University, Grahamstown, South Africa

[d] KwaZulu-Natal Sharks Board, Umhlanga Rocks, South Africa

[e] Department of Animal Sciences, Stellenbosch University, Stellenbosch, South Africa

[f] South African Institute for Aquatic Biodiversity, Grahamstown, South Africa

[g] South African Shark Conservancy (SASC), Hermanus, South Africa

Published online: 24 Jul 2015.

To cite this article: C da Silva, AJ Booth, SFJ Dudley, SE Kerwath, SJ Lamberth, RW Leslie, ME McCord, WHH Sauer & T Zweig (2015) The current status and management of South Africa's chondrichthyan fisheries, African Journal of Marine Science, 37:2, 233-248, DOI: 10.2989/1814232X.2015.1044471

To link to this article: http://dx.doi.org/10.2989/1814232X.2015.1044471

African Journal of Marine Science 2015, 37(2): 233–248
Printed in South Africa — All rights reserved

AFRICAN JOURNAL OF
MARINE SCIENCE
ISSN 1814-232X EISSN 1814-2338
http://dx.doi.org/10.2989/1814232X.2015.1044471

The current status and management of South Africa's chondrichthyan fisheries[§]

C da Silva[1,2]*, AJ Booth[3], SFJ Dudley[1,4], SE Kerwath[1,2,5], SJ Lamberth[1,6], RW Leslie[1,2], ME McCord[7], WHH Sauer[3] and T Zweig[7]

[1] *Branch: Fisheries Management, Department of Agriculture, Forestry and Fisheries, Cape Town, South Africa*
[2] *Department of Biological Sciences, University of Cape Town, Cape Town, South Africa*
[3] *Department of Ichthyology and Fisheries Science, Rhodes University, Grahamstown, South Africa*
[4] *KwaZulu-Natal Sharks Board, Umhlanga Rocks, South Africa*
[5] *Department of Animal Sciences, Stellenbosch University, Stellenbosch, South Africa*
[6] *South African Institute for Aquatic Biodiversity, Grahamstown, South Africa*
[7] *South African Shark Conservancy (SASC), Hermanus, South Africa*
* *Corresponding author, e-mail: charlened@daff.gov.za*

Chondrichthyans (sharks, skates, rays and chimaeras) are captured in many marine fisheries. Management and research efforts directed at chondrichthyan fishing are often neglected because of low product value, taxonomic uncertainty, low capture rates, and harvesting by multiple fisheries. In South Africa's diverse fishery sectors, which include artisanal as well as highly industrialised fisheries, 99 (49%) of 204 chondrichthyan species that occur in southern Africa are targeted regularly or taken as bycatch. Total reported dressed catch for 2010, 2011 and 2012 was estimated to be 3 375 t, 3 241 t and 2 527 t, respectively. Two-thirds of the reported catch was bycatch. Regulations aimed at limiting chondrichthyan catches, coupled with species-specific permit conditions, currently exist in the following fisheries: demersal shark longline, pelagic longline, recreational line, and beach-seine and gillnet. Limited management measures are currently in place for chondrichthyans captured in other South African fisheries. Catch and effort dataseries suitable for stock assessments exist for fewer than 10 species. Stock assessments have been attempted for five shark species: soupfin *Galeorhinus galeus*, smoothhound *Mustelus mustelus*, white *Carcharodon carcharias*, spotted ragged-tooth *Carcharias taurus*, and spotted gully *Triakis megalopterus*. Fishery-independent surveys and fishery observer data, which can be used as a measure of relative abundance, exist for 67 species. Compared with most developing countries, South African shark fishing is relatively well controlled and managed. As elsewhere, incidental capture and bycatch remain challenges to the appropriate management of shark species. In 2013, South Africa's National Plan of Action for the Conservation and Management of Sharks (NPOA-Sharks) was published. Implementation of the NPOA-Sharks should help to improve chondrichthyan management in the near future.

Keywords: bycatch, fisheries management, shark fisheries, shark trade, stock assessment

Introduction

Chondrichthyans, fishes that include sharks, batoids and chimaeras, are captured in most marine fisheries either as directed catch or as bycatch (Dulvy et al. 2008; FAO 2012; Worm et al. 2013). They are harvested for their meat, fins, skin, cartilage, liver (for oil and squalene) and teeth (Kroese and Sauer 1998; Vannuccini 1999). After the development of advanced fishing technologies in the 1920s chondrichthyans were harvested on an industrial scale, and by the 1950s global catches of 270 000 t were reported (FAO 2005). Global shark catches reported to FAO tripled between 1950 and the end of the century, with 893 000 t caught in 2000. Since then, a downward trend has been observed, with catches 15% lower at 766 000 t in 2011 (FAO 2014).

Most chondrichthyan-directed fisheries are characterised by a history of overharvest, stock decline and limited recovery, if any, with several species demonstrating significant declines in recent decades (Bonfil 1994; Pauly et al. 1998; Stevens et al. 2000). However, sustainable harvesting of chondrichthyans has been documented, especially in cases where targeted species are somewhat resilient to fishing pressure or where timely management interventions were introduced (Stevens et al 2000; Prince 2005; Barnett et al 2012).

Several factors have contributed to the historic mismanagement of chondrichthyan fisheries. These include: (i) K-selected life-history traits that include *inter alia* longevity, slow growth, low natural mortality rates and low fecundity, which collectively render chondrichthyans particularly vulnerable to overfishing (Smith et al. 1998; Stevens et al. 2000; Field et al. 2009); (ii) the comparatively low economic value of chondrichthyan fisheries (estimated global value approaching US$1 billion per year, compared with teleost fisheries at

[§] This article is based on a paper presented at the 'Sharks International 2014' conference, held 2–6 June 2014, Durban, South Africa, and is part of a special issue 'Advances in Shark Research' edited by DA Ebert, C Huveneers and SFJ Dudley

US$129.8 billion in 2012) (FAO 2014), resulting in a lack of baseline landing and catch data required for basic resource assessments (Baum et al. 2003; Lack and Sant 2009; FAO 2014); and (iii) poor species identification protocols, whereby chondrichthyan catch data are usually reported by family or by grouping of morphologically similar species. For example, in 2007 only 20% of landed chondrichthyan catches worldwide were identified to species level (FAO 2011). Assessments by the International Union for the Conservation of Nature (IUCN) estimate that one quarter of chondrichthyans are threatened due to targeted and incidental overfishing (Dulvy et al. 2014).

Interventions available to fisheries managers are dependent on the availability (and quality) of information on the status of the resource being investigated (Hillborn and Walters 1992). This information is usually provided in the form of a resource assessment. Chondrichthyan resource assessments are limited by the lack of basic data such as annual landings, catch rate, and bycatch/discard level (Anderson 1990; Walker 1998; Cortés 2007). This problem is especially relevant to species harvested by multiple or multi-species fisheries. Until these basic data are collected accurately, resources cannot be assessed adequately and appropriate management interventions cannot be implemented. These shortcomings exist in South Africa but are not unique to the country.

Commercial-scale exploitation of chondrichthyans in South Africa was initiated in the 1930s (von Bonde 1934). Increased demand for natural vitamin A (from shark liver) after the Second World War saw a concomitant increase in shark catches, with annual landings exceeding 4 000 t (van Zyl 1993). Although the fishery targeted several species, soupfin shark *Galeorhinus galeus* was the most heavily fished, particularly in fishing villages in the Western Cape. Although it was not until the synthesis of vitamin A in 1967 that demand for shark products decreased, catches of soupfin shark were already declining by the late 1940s (Davies 1964; Kroese and Sauer 1998). Catches have not returned to pre-war levels (McCord 2005).

By 1992 there was renewed interest in sharks and a shark-directed longline fishery was established (Kroese and Sauer 1998). The fishery initially targeted both demersal and pelagic sharks, but shifted toward pelagic sharks when further industrialisation and motorisation enabled fishers to fish further offshore for longer periods of time (Smale 2008). Annual landings have fluctuated dramatically since the fishery's inception due to variations in demand and price (da Silva and Bürgener 2007).

Despite a long history of chondrichthyan research in South Africa, much of the research has focused on the distribution, abundance and movement patterns of large, charismatic, non-harvested species such as the white shark *Carcharodon carcharias* and the spotted ragged-tooth shark *Carcharias taurus* (e.g. Smale et al. 2012; Towner et al. 2013; Weltz et al. 2013). Fisheries research, by contrast, has been patchy and has been focused primarily on the biology and life history of the larger targeted and marketable species, or those caught in large quantities in research surveys (e.g. Freer and Griffiths 1993a; Watson and Smale 1998; Wintner et al. 2002; Ebert et al. 2008; Benavides et al. 2011; Jolly et al. 2013).

Since 1994, fundamental changes in the governance and management of South African fisheries have resulted in a management approach focused on target species, with little attention paid to the development of management interventions for lower-priority species captured across fishery sectors (Kroese et al. 1996; Kroese and Sauer 1998; Sauer et al. 2003). Consequently, limited information is available regarding the impact of fisheries on chondrichthyan populations in this country. Herein, we therefore provide an updated overview of fisheries that capture chondrichthyans as either targeted catch or bycatch. Additionally, we describe estimated catch and effort data and relevant management interventions for these fisheries. Furthermore, following a review of economic considerations and resource assessments, suggestions are made for improved management of chondrichthyans in South Africa.

Sources of catch data

The study area includes the South African exclusive economic zone (EEZ) and, for the purpose of this study, excludes the sub-Antarctic Prince Edward Islands (Figure 1). Chondrichthyan landed-catch data for 2010, 2011 and 2012, both targeted and bycatch, were obtained from fisheries (logbooks, landing declarations and catch return forms) and observer databases (catches, length-frequency data) from the South African Department of Agriculture, Forestry and Fisheries (DAFF) and the KwaZulu-Natal Sharks Board (KZNSB).

Due to uncertainties in data quality and reporting rates, catch-per-species was reported within the following categories: <1 t, 1–10 t, 11–100 t, 101–200 t, 201–300 t, 301–400 t, 401–500 t, 501–600 t, 601–700 t, 701–800 t and 801–900 t (Appendix). In cases where the minimum and maximum reported catch spanned multiple categories, the ranges were reflected instead. Catches inferred from logbooks (where species names were reported) are indicated by a symbol representing percentage contribution by that fishery to the total catch of a given species. In some fisheries, similar species frequently were recorded to genus level only (e.g. smoothhound sharks, *Mustelus* spp. or dog sharks *Squalus* spp.). In others, they were identified to family (e.g. requiem sharks, which may be listed as 'bronzies' after the most common species, the bronze whaler *Carcharhinus brachyurus*), or even to superorder (e.g. Batoidea – skates and rays). In these cases, estimates of relative contribution per species in a given fishery were obtained from the corresponding observer database for that fishery and used to apportion the catch among species. Note that this method results in the omission of species not recorded in the observer database. However, these estimates are nevertheless useful as a preliminary attempt at elucidating the effect of both targeted catch and bycatch of chondrichthyans across all fisheries.

The availability of fishery-independent data from research surveys per fishery was also investigated. Instances where limited data were available are indicated (Appendix). To account for misidentification and for identification of only high-value species, chondrichthyans thought to be caught as bycatch were investigated separately for each fishery. For the commercial linefishery, a literature review was

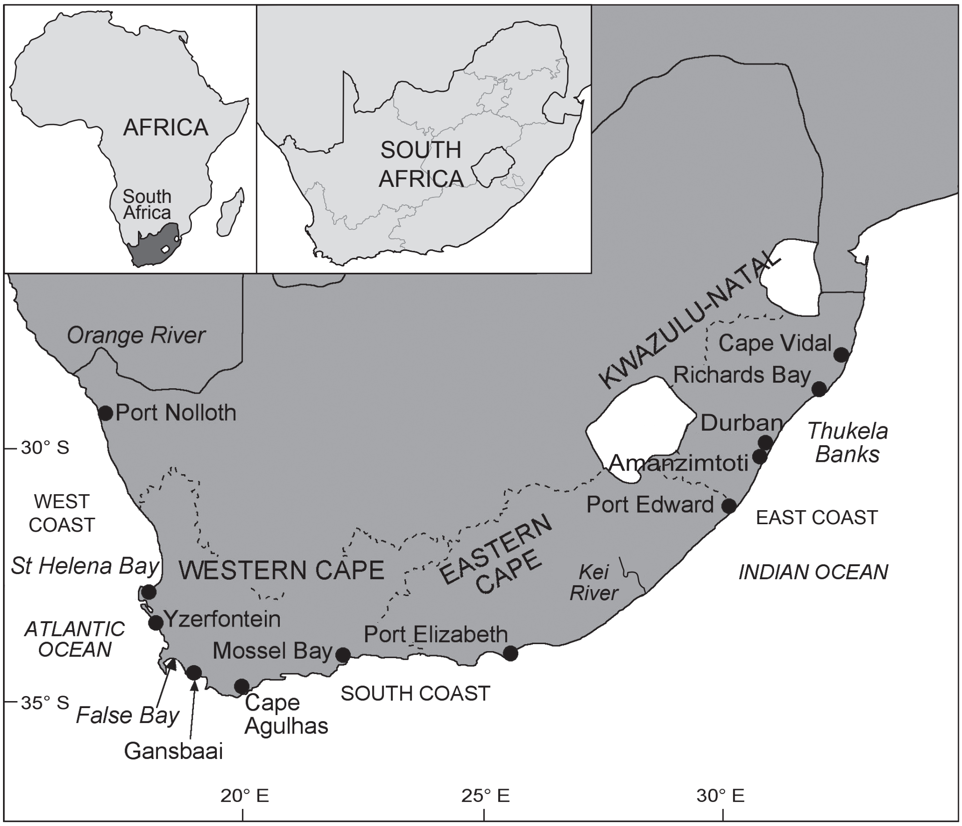

Figure 1: Map of South Africa indicating fishing localities named in the text where chondrichthyans are harvested or landed

undertaken and chondrichthyans known to occur close inshore were highlighted as species likely to be caught by this fishery. The recreational linefishery does not report catch data; therefore chondrichthyans assumed to be caught in this fishery were selected in similar manner to those in the commercial linefishery. Species reported by the Oceanographic Research Institute's Cooperative Fish Tagging Project were regarded as confirmed catches. For the demersal shark and pelagic longline fisheries, chondrichthyans caught as bycatch were confirmed by comparing catches with those recorded in DAFF fishery-independent surveys. To verify catches by the gillnet and beach-seine fisheries, we used information provided by Lamberth (2006). For the inshore- and offshore trawl, hake longline, and prawn trawl fisheries, chondrichthyan species were confirmed via a literature review of species occurring in the areas and at the depths in which each fishery operates. Actual catches by the prawn trawl fishery were verified using Fennessy et al. (1994a).

Description of South Africa's chondrichthyan fisheries

South African chondrichthyans are captured in eight of 16 commercial fisheries. Commercial fisheries include those targeting chondrichthyans or harvesting them as bycatch. Chondrichthyans are also caught by bather protection nets and drumlines in the KwaZulu-Natal (KZN) province and are targeted by an increasing number of recreational anglers around the entire coast (da Silva 2007; DAFF 2012).

Kroese et al. (1996) provide a detailed account of the historical information available on shark fisheries in South Africa. Fishery-dependent data for chondrichthyans were first collated in 1989, with an estimated landed catch of 2 595 t (dressed weight). Primary target species included soupfin shark, St Joseph *Callorhinchus capensis*, and biscuit skate *Raja straeleni*, with landed catches of 506 t, 716 t and 1 197 t, respectively (Kroese et al. 1996).

Directed fisheries include the demersal shark longline fishery, pelagic longline fishery, boat-based and shore-based linefisheries, beach-seine net ('treknet') fishery, gillnet fishery and the KZN bather protection programme (a shark-fishing operation but not strictly a fishery in the conventional sense). Non-directed fisheries include the demersal trawl fisheries (inshore and offshore), hake longline fishery, prawn trawl fishery, and small-pelagic and midwater trawl fisheries. The bather protection programme was included in the analysis because it has the objective of catching certain shark species, and takes a bycatch of other shark species as well as rays (Cliff and Dudley 2011). Infrequent chondrichthyan bycatch is taken by the tuna pole, small invertebrate and rock lobster trap (West Coast and South Coast) and squid fisheries, but the catch is seldom retained.

Ninety-nine species of chondrichthyans were reported between 2010 and 2012 (Appendix), comprising 49% of southern Africa's known chondrichthyan fauna (Ebert and van Hees 2015). Total reported dressed catch was estimated to be at least 3 375 t, 3 241 t and 2 527 t for

2010, 2011 and 2012, respectively (DAFF unpublished data). Extrapolation of actual catches from those observed in shark-processing factories suggests that fisher reporting rates of chondrichthyan landings can be as low as 25–50% (da Silva 2007). Chondrichthyans discarded (dead or alive) at sea are not recorded in the catch data. Furthermore, the ratio of total- to dressed-weight varies between species; hence reporting of dressed weight provides only a conservative estimate of total chondrichthyan catches.

Directed fisheries

Demersal shark longline

The demersal shark longline fishery operates in coastal waters from the Orange River on the West Coast to the Kei River on the East Coast (Figure 1). As a precautionary measure, vessels are prohibited from fishing north of the Kei River (DAFF 2014a) due to increased biodiversity on the narrow continental shelf (Lutjeharms et al. 1989). Fishing vessels are <30 m in length and use nylon monofilament Lindgren Pitman spool systems to set weighted longlines that are baited with up to 2 000 hooks (average 1 000 hooks) and deployed at depths of 50–100 m. In the 1990s, over 30 permits to target chondrichthyans were issued, but most permits were unutilised because many rights-holders held permits in other (more lucrative) fisheries (DAFF 2012). As a result of poor fishery performance, permit numbers were decreased. The fishery is managed on a total allowable effort (TAE) basis, with six vessels currently targeting shark. All landings are monitored independently and skippers are required to complete logbook entries per longline set. Vessels are tracked by a vessel monitoring system (VMS). Eleven chondrichthyan species have been recorded, with an additional 12 species expected to be caught by this fishery (Appendix). Estimated landings of 408 t, 175 t and 88 t of shark were reported in 2010, 2011 and 2012, respectively. This apparent drop in landed-catches may be attributed to a combination of effort displacement towards more lucrative fisheries, target availability or a general decline in abundance. However, the relative importance of these factors could not be disaggregated. Common species reported include smoothhound *Mustelus mustelus*, white-spotted smoothhound *M. palumbes*, soupfin, bronze whaler, and dusky *Carcharhinus obscurus* sharks, and unidentified skates (DAFF 2012).

Pelagic longline fishery

The pelagic shark longline fishery and the tuna and swordfish fishery were recently amalgamated into the pelagic longline fishery for management purposes. Pelagic longline fishing is permitted within the entire South African EEZ, except within 12 nautical miles of the coast (20 nautical miles within KZN) (Figure 1). The fishery uses a drifting nylon monofilament line, set with a Lindgren Pitman spool system and with an average of 1 000 hooks per set (Sauer et al. 2003). All vessels are monitored by VMS and all landings are weighed and independently monitored. Logbooks are completed by fishers for each longline set.

Domestic pelagic longlining for tuna began in the 1960s, but the fishery declined rapidly due to the low-quality product landed by South African fishers. In 1997, following a joint venture with a Japanese vessel, renewed interest in tuna longlining led to the issuing of 30 experimental tuna longline permits. This fishery was formalised in 2005, when 18 and 26 long-term rights, respectively, were issued for the swordfish-directed and tuna-directed fisheries. The shark-directed vessels were amalgamated into the tuna and swordfish longline fishery to increase catches of swordfish. However, participants in the former pelagic shark-directed fishery were granted exemptions from the permit conditions, allowing them to continue targeting sharks. These vessels were restricted to a landed catch of sharks that comprised less than 10% of the total landed catch of the sector. In April 2011, the rights-holders fishing under the exemption were fully amalgamated into the tuna and swordfish fishery (DAFF 2012).

Currently, shark landings in the tuna and swordfish fishery are managed according to a precautionary upper catch limit (PUCL) of 2 000 t dressed weight per annum (DAFF 2014b). This is based loosely on shark catch ratios obtained during the early exploratory phase of the fishery when no shark bycatch restrictions applied. Should this target be reached, the fishery would be closed immediately for the remainder of the year. Should 60% (1 200 t) of the PUCL be reached, the use of wire traces within 50 cm of the hook would be prohibited, to limit the potential to catch additional sharks.[1] Should 80% of the PUCL be reached, the remaining 20% would be subdivided amongst active right holders (DAFF 2014b). Stainless steel hooks are prohibited for all vessels other than those fishing under the previous exemption, and foreign-flagged vessels are not permitted to use wire leaders attached to, or within 50 cm of, the hook (DAFF 2014b).

Estimated landings for 2010, 2011 and 2012 were well below the PUCL at 926 t, 1 220 t and 661 t, respectively. Current permit conditions prohibit finning (the removal and retention of shark fins only, with the trunk discarded). Fins may, however, be removed provided the trunks are retained. Owing to the large inter- and intra-specific variation in fin-to-trunk ratios, the total weight of retained fins may not exceed 8% and 13% of the total weight of the trunks for shortfin mako *Isurus oxyrinchus* and blue sharks *Prionace glauca*, respectively (DAFF 2014b).

The use of fish aggregation devices is prohibited in South African waters (RSA 1998). In 2011, retention of oceanic whitetip *Carcharhinus longimanus*, thresher *Alopias* spp., and hammerhead sharks *Sphyrna* spp. was prohibited. The silky shark *Carcharhinus falciformis* was added to the prohibited list in 2012 due to international concern over stock declines (DAFF 2014b). The fishery targets mainly shortfin mako and blue sharks, with six other species of sharks and rays also reported. A further 13 species are expected to be represented as bycatch in this fishery (Appendix), but misidentification of most requiem sharks as 'bronze whalers' makes disaggregation of catches to species level difficult.

The KZN bather protection programme

The bather protection programme consists of shark nets and drumlines that are deployed off selected beaches along the KZN coastline from Richards Bay to Port Edward (Figure 1). Nets were first deployed at Durban in 1952 as a measure to

[1] DAFF proposes a prohibition on the use of wire traces in this fishery from 2016 (RSA 2015)

reduce the risk of shark attack (Davies 1964), and were later introduced at other beaches. Fishing effort peaked in the 1990s (Dudley and Simpfendorfer 2006). The rationale of the programme is that localised depletion of shark numbers, particularly of bull sharks *Carcharhinus leucas*, would reduce the likelihood of shark–bather encounters (Dudley 1997). Other target species include white and tiger sharks *Galeocerdo cuvier*. Measures to reduce catches of sharks, batoids and other taxa, while still providing a protective function, were described by Cliff and Dudley (2011). These included an overall reduction in fishing effort but also the replacement of some nets with drumlines, which act as a more selective shark fishing device. Excluding animals released alive, the total annual landed catch of sharks and rays between 2010 and 2012 was 36 t, 44 t and 34 t, respectively (KZNSB unpublished data). The KZN bather protection programme caught a total of 22 chondrichthyan species between 2010 and 2012 (Appendix); however, a total of 30 species have been recorded in the past (Cliff and Dudley 2011). Several species, including snaggletooth *Hemipristis elongata*, lemon *Negaprion acutidens*, bignose *Carcharhinus altimus* and bigeye sixgill sharks *Hexanchus nakamurai* (Bass et al. 1975; KZNSB unpublished data), have not been caught in any other South African fishery.

The population status of 14 shark species caught in the KZN bather protection programme was assessed using catch data collected between 1978 and 2003 (Dudley and Simpfendorfer 2006). More recently, an extended time-series to 2011 revealed declines in catch rates of bull, dusky, sandbar *Carcharhinus plumbeus*, spotted ragged-tooth, shortfin mako, scalloped hammerhead *Sphyrna lewini* and great hammerhead sharks *Sphyrna mokarran* (KZNSB unpublished data). Given that fishing gear is deployed at fixed locations, site-specific decreases in catch rates may reflect localised rather than population-level effects (Dudley and Simpfendorfer 2006). Catch rates of tiger and smooth hammerhead sharks *Sphyrna zygaena* have increased (KZNSB unpublished data), with the increase in tiger sharks potentially reflecting an ability to exploit reduced competition (Dudley and Simpfendorfer 2006).

Linefishery

The linefishery operates along the entire 2 500 km coastline (excluding certain protected areas). This fishery is divided into commercial, recreational and subsistence sectors. Handline fishing can be traced back 5 000 years and, together with various trap fisheries, constitutes one of the oldest fisheries in South Africa (Parkington 2006). The current commercial (or traditional) linefishery is defined by the use of a simple hook-and-line fishing system (excluding the use of longlines and drumlines), with a limit of 10 hooks per line (DAFF 2014c). The fishery is entirely boat-based, is a multi-species fishery, and targets both teleosts and chondrichthyans. There are 455 vessels operating in this fishery, making it the largest fishing fleet in South Africa.

The fishery was open-access until 1985, when effort was capped at approximately 3 200 vessels (DAFF 2014c). Focused research on linefish species in the ensuing decade identified that many of the target teleost species were overfished (Griffiths 2000). In 2000, effort was reduced to 450 vessels (maximum crew of 3 450) to prevent further stock declines. Sharks, batoids and chimaeras are targeted, although to a lesser extent than teleosts, in the linefishery. There are few landing restrictions in the fishery, with the exception of chondrichthyans on the prohibited species list and four decommercialised species (leopard catshark *Poroderma pantherinum*, striped catshark *P. africanum*, spotted gully shark *Triakis megalopterus*, and spotted ragged-tooth shark) (RSA 2005).

Chondrichthyans continue to be a major source of income in fishing villages in the Western Cape province (da Silva 2007). Target species include smoothhound, soupfin, bronze whaler and broadnose sevengill shark *Notorynchus cepedianus*, as well as the four decommercialised species, albeit that trade in the latter is no longer legal. Historically, shark landings in the commercial linefishery have fluctuated dramatically in response to the availability of higher-value teleost species and to market forces. Between 1991 and 2003, however, there was a steady increase in landed catches, mirroring declines in more valuable linefish species (Sauer et al. 2003). Annual landings of chondrichthyans were reported as 277 t, 175 t and 165 t between 2010 and 2012, comprising 14 reported species and 37 expected species (Appendix). Vessels are monitored by VMS, and permit conditions require that fish be reported per trip. Logbook data are not verified and are considered to represent a significant underestimate of the total landed catch of sharks. Compounding this is the lack of species-level reporting for most landings.

The recreational linefishery includes shore- and boat-based participants who are active in both the marine and estuarine environments. Although most participants use rod and line, the sector also includes spearfishers, a limited number of whom target sharks, usually for illicit sale (SJL pers. obs.). An estimated 500 000 people participate in the South African recreational fishery (Griffiths and Lamberth 2002).

Shore-based angling is the biggest recreational pursuit in South Africa and sharks are an increasingly important component of this fishery, for both trophy and sport purposes (Griffiths and Lamberth 2002). The recreational linefishery seldom targets chondrichthyans, except for limited trophy-fishing for jaws or during fishing competitions. Bronze whaler, smoothhound, dusky and spotted ragged-tooth sharks are targeted commonly but at least 39 shark species are caught regularly in this fishery (Appendix). Recreational anglers are permitted to retain one individual of each shark species per day – with the exception of prohibited species including white, basking *Cetorhinus maximus* and whale sharks *Rhincodon typus*, as well as sawfishes (Pristidae) (RSA 2005) – with a limit of 10 individuals in total. Recreationally caught fish (teleosts and chondrichthyans) may not be sold and all fishers must be in possession of a recreational angling license. A few commercially valuable species are retained by anglers for illicit sale and a number of smaller species such as shysharks *Haploblepharus* spp. are sometimes killed as they are regarded as a nuisance (SJL pers. obs.).

Although sharks are increasingly tagged and released by recreational fishers, post-release lethal and sublethal fishing effects are unknown. There is no national monitoring of the recreational linefishery and hence total chondrichthyan mortality cannot be determined with any certainty. Local shore-based observer programmes, with the data captured on DAFF's National Marine Linefish System (NMLS), and competition records are becoming more common. Determination of landed catch trends may, therefore, be possible in future.

Currently, subsistence fishers are predominantly shore-based and, until South Africa's small-scale fishery policy (RSA 2012) is implemented,[2] governed by catch limitations similar to recreational fishers. Consequently, a small number of chondrichthyans are caught in this fishery.

Beach-seine and gillnet fisheries

The beach-seine fishery was introduced to South Africa with the arrival of European settlers in 1652, and is distributed primarily from False Bay to Port Nolloth on the West Coast (Lamberth 2006) (Figure 1). A few beach-seine permit holders in KZN target 'mixed shoaling fish' during the annual winter migration of sardine *Sardinops sagax* (Fréon et al. 2010). Dasyatid rays are caught as bycatch in KZN but are usually released alive.

In 2001, revision of the TAE, coupled with the reallocation of rights, saw a reduction in fishing effort from around 200 to 28 beach-seine operations. Nets range from 120 m to 275 m in length, with net depths that vary according to fishing area but that may not exceed 10 m (DAFF 2014d). The wings of the net have a minimum stretched-mesh size of 48 mm whereas that of the codend is 44 mm. In Cape waters, this fishery primarily targets southern mullet *Liza richardsonii* but considerable quantities of shark (primarily smaller demersal sharks) are also harvested (Lamberth 2006). Approximately 30 chondrichthyan species are caught in this fishery, with the St Joseph, smoothhound shark, lesser sandshark *Acroteriobatus annulatus,* blue stingray *Dasyatis chrysonota* and eagle ray *Myliobatis aquila* accounting for 98% of the chondrichthyan bycatch (Appendix). On the West Coast, the majority of the chondrichthyan bycatch is released in accordance with permit conditions that prohibit the retention of these species, with the exception of St Joseph. Beach-seine fishers in False Bay are subject to the same catch limitations that are imposed on the commercial linefishery.

The gillnet fishery was established by Portuguese fishers in the late 1890s and initially was aimed at intercepting migrating linefish species. Rapid declines in catches within the first 10 years of the fishery saw targeting switch to southern mullet, which has remained the target species for the last 100 years (Hutchings and Lamberth 2002a). St Joseph are targeted in this fishery (Hutchings and Lamberth 2002b).

The fishery is managed on a TAE basis, with 162 rights-holders operating from Yzerfontein to Port Nolloth on the West Coast. Surface-set mullet gillnets are restricted in size to 75 m × 5 m, with a minimum stretched-mesh size of 48 mm. Bottom-set gillnets for St Joseph are restricted to 75 m × 2.5 m, with a stretched mesh of 176–180 mm. Use of bottom-set gillnets is confined to St Helena Bay. Other shark species captured in bottom-set gillnets include broadnose sevengill shark, smoothhound shark and lesser sandshark (Lamberth et al. 1994; Hutchings and Lamberth 2002a, 2002b). An estimated total catch of 40 t, 76 t and 45 t in the beach-seine and gillnet fishery was reported in 2010, 2011 and 2012, respectively, comprising 13 reported chondrichthyan species and 18 expected species (Appendix). Mullet and St Joseph may be caught in both surface-set and bottom-set gillnets. Bycatch is restricted to 'baitfish' such as sardine *Sardinops sagax*. All other fish, including sharks and batoids, must be released alive. However, the False Bay seine-net operation may retain the same species as those caught by the traditional line fishery.

[2] Implementation plan anticipated in 2016

Bycatch fisheries

Demersal trawl fisheries

The demersal trawl fisheries consist of two separate components: an inshore trawl fishery targeting either shallow-water hake *Merluccius capensis* or East Coast sole *Austroglossus pectoralis*, and an offshore trawl fishery targeting deep-water hake *M. paradoxus*. The inshore fishery utilises vessels <30 m in length operating from the harbours at Mossel Bay and Port Elizabeth, with 24 vessels operating between Cape Agulhas on the South Coast and the Kei River on the East Coast (Figure 1). The offshore fishery operates from the Namibian border on the West Coast to 27° E on the South Coast (Figure 1). On the South Coast, offshore vessels are not permitted to fish in waters <100 m deep or within 20 nautical miles of the coast to prevent conflict with the inshore trawl sector. Although depth restrictions are not applied on the West Coast, the vessels do not fish in waters <200 m. The fishery is managed on a total allowable catch (TAC) basis with no bycatch restrictions for chondrichthyans, although 'move-on' rules to avoid areas of high teleost and chondrichthyan bycatch apply (DAFF 2014e). There is a ban on squalene production (DAFF 2014e). All vessels are monitored by VMS, and there is limited sea-based monitoring by the scientific observer programme. Discharge monitoring at landing sites is applied to all inshore trawl vessels, and there is limited random inspection and monitoring of offshore vessels. Chondrichthyan landings are reported in generic categories, but the majority of the chondrichthyan catch is discarded at sea. Both fisheries (inshore and offshore) land over 1 500 t of sharks, batoids and chimaeras with dogfish (Squalidae), soupfin and white-spotted smoothhound sharks, St Joseph and skates comprising the majority of the landed cartilaginous bycatch (DAFF unpublished data).

A detailed analysis of the geographic and bathymetric distribution of demersal chondrichthyans caught during hake biomass surveys off the West Coast was presented by Compagno et al. (1991). In 1990, annual bycatch of chondrichthyans in the offshore commercial trawl fishery was estimated at 606 t (Crawford et al. 1993) and a recent preliminary assessment of bycatch in the inshore trawl fishery indicated that chondrichthyans constitute approximately 15% (1 515.3 t) of the average annual landed catch of hake of 10 081 t (Attwood et al. 2011). The inshore trawl fishery takes a considerable bycatch of soupfin and smoothhound shark, as well as teleosts (Walmsley et al. 2007a). A high proportion of sharks observed at shark-processing factories are harvested by this fishery (da Silva and Bürgener 2007). The incentives for the trawl fisheries to retain chondrichthyan bycatch have increased recently due to the increased export market value of some species e.g. smoothhound shark (da Silva and Bürgener

2007). However, because the majority of the chondrichthyan species caught are still discarded at sea, few data exist on the incidental catch of chondrichthyans by the trawl fisheries. Estimates of discards per species are available for observed trawls (DAFF unpublished data), but observer coverage is limited and species misidentification within the fishery as a whole makes it difficult to quantify the total incidental catch of chondrichthyans in the trawl fisheries (Walmsley et al. 2007b). According to the national observer database, approximately 52 chondrichthyan species are caught in these fisheries, with another 18 species expected (Appendix). Annual chondrichthyan landed bycatch has been recorded at 1 727 t, 1 625 t and 1 576 t for 2010, 2011 and 2012, respectively. These fisheries potentially pose the greatest threat to several species of deep-water demersal chondrichthyans in South Africa (Sauer et al. 2003).

Small-pelagic and midwater trawl fisheries

The small-pelagic fishery targets anchovy *Engraulis encrasicolus*, sardine and redeye *Etrumeus whiteheadi*, using purse-seine gear. The fishery operates in four areas off the south and west coasts of South Africa, including two fishing grounds off Mossel Bay, one south of Cape Agulhas and one off the West Coast (Figure 1). Fishing grounds generally range in depth from 100 to 400 m. The chondrichthyan bycatch in the small-pelagic fishery is discarded once the main catch has been sorted, with 100% mortality of all chondrichthyans (DAFF unpublished data).

The midwater trawl fishery targets Cape horse mackerel *Trachurus capensis* and is restricted to the South Coast offshore of the 100 m isobath, with a single vessel taking the bulk of the catch. The midwater trawl fishery has been grouped with the small-pelagic fishery due to the similarity of species caught. No bycatch restrictions for sharks exist in this fishery (DAFF 2014f). However, a scientific observer is required to be present on all trips.

The midwater trawl fishery occasionally catches pelagic chondrichthyans such as bronze whaler, blue and shortfin mako sharks, as well as species such as mobulid rays (*Manta* and *Mobula* spp.), silky and oceanic whitetip sharks, several of which are of conservation concern. Since many of these species aggregate seasonally, they are occasionally caught in large numbers. When the total catch is small, most of the chondrichthyan catch is released alive. In larger catches, only chondrichthyans in the first section of the net are released alive (RWL pers. obs.). Excluder devices to prevent the capture of marine mammals and pelagic sharks are being evaluated, but, to date, none have been completely effective, due to the large size of the net and high trawling speeds (Leslie 2012). Very little of the chondrichthyan catch is landed, and usually is not recorded in the commercial catch statistics. Observers do, however, record numbers caught per species and release/discard status. Seventeen chondrichthyan species have been recorded by national observer programmes, with one additional species expected in this fishery (Appendix).

Hake longline fishery

The hake longline fishery comprises both inshore and offshore components, with a total of 64 active vessels operating from all major fishing ports in the Eastern Cape and Western Cape. The inshore component is restricted to 5 000 hooks per line, whereas the offshore component may set up to 20 000 hooks per line and may operate only in water >100 m deep. The fishery is managed on a TAC basis.

Chondrichthyan bycatch in this fishery is difficult to quantify as both the fishery and observers report only two grouped categories: 'sharks' and 'rays and skates'. However, given the areas and depths fished, bycatch species are thought to overlap with those of the demersal shark longline and trawl fisheries. Between 2010 and 2012, 6 t, 3 t and 4 t, respectively, of unidentified sharks, batoids and chimaeras were reported from this fishery. A total of 58 chondrichthyan species are expected to be caught by this fishery (Appendix).

Prawn trawl fishery

The prawn trawl fishery comprises shallow-water (10–40 m) and deep-water components (100–600 m) (Turpie and Lamberth 2010). The shallow-water fishery operates on the Thukela Banks, while the deep-water fishery operates along the shelf edge between Cape Vidal and Amanzimtoti (Figure 1). Species targeted in the shallow-water fishery include white prawns *Fenneropenaeus indicus*, brown prawns *Metapenaeus monoceros* and tiger prawns *Penaeus monodon*. The deep-water fishery targets pink prawns *Haliporoides triarthrus*, red prawns *Aristaemorpha foliacea* and langoustines *Metanephrops mozambicus* and *Nephropsis stewarti* (Turpie and Lamberth 2010). The fishery is managed on a TAE basis, with seasonal area-restrictions designed to mitigate catches of juvenile linefish (Fennessy 1994a). A total of 22 chondrichthyan species have been recorded as bycatch (Fennessy 1994b). An additional four species are expected to be caught by this fishery (Appendix). Although reported landings of chondrichthyans between 2010 and 2012 were low, at 0 t, 2 t and 1 t, respectively, fishing activity is concentrated in a region recognised as a shark biodiversity hotspot (Compagno 1999). Therefore, bycatch of regionally endemic demersal shark species is of concern.

Chondrichthyan fisheries management

DAFF, and specifically the fisheries management branch thereof, is the governmental agency responsible for the management of South African fisheries under the Marine Living Resources Act (MLRA) (Act No. 18 of 1998; RSA 1998). The MLRA provides the legal framework for the regulation of all fisheries in South Africa, including those aspects related to the processing, sale and import/export of most renewable marine resources. In terms of the MLRA, chondrichthyans may not be landed, transported, transshipped or disposed of with their fins removed without a permit (RSA 1998).

South Africa follows guidelines set up by the Food and Agriculture Organization (FAO) Code of Conduct for Responsible Fisheries (FAO 1995) and the International Plan of Action for the Conservation and Management of Sharks (IPOA-Sharks) (FAO 1999). The IPOA-Sharks requests member states of the FAO to develop a voluntary National Plan of Action for the Conservation and Management of Sharks (NPOA-Sharks) (FAO 2012). As chondrichthyans form only a minor part of the landed catch of many different South African fisheries, there is little cohesion between DAFF's fishery-specific Scientific Working Groups (SWGs) regarding chondrichthyan management. Therefore, despite earlier attempts to develop a draft document, the South African NPOA-Sharks was not published until November 2013 (DAFF 2013).

Availability of information on chondrichthyan fisheries

The minimum requirement for a basic resource assessment is a time-series of landed catches with associated effort data. Such data exist for commonly caught chondrichthyans in South African target fisheries (pelagic longline and demersal shark longline). For blue and shortfin mako sharks, catch and effort data are available since 1992 and length-frequency data of reasonable quality for the period 2002–2011 (DAFF unpublished data). Similarly, there are catch and effort data for smoothhound and soupfin sharks since 1992, but only those data from 2000 onwards are suitable due to: (i) low catch rates of demersal sharks during the years that the shark longline fishery targeted both demersal and pelagic sharks, and (ii) misidentification of sharks of the family Triakidae. Owing to the lack of an observer programme in the demersal shark longline fishery, length-frequency data are available only from 2007 onwards (DAFF unpublished data). Although some additional dataseries are available for certain species in other fisheries (Appendix), these either (i) contain too few species-specific records (e.g. trawl fisheries datasets), (ii) are deemed to contain too many errors to be useful (e.g. under-reporting and misidentification or grouping of species in trawl fisheries and commercial linefish datasets), or (iii) are restricted to localised areas of operation and therefore may not be representative of the population (e.g. KZN bather protection programme).

Although historical shark fisheries information from the early 1900s is available, it is largely anecdotal or includes ambiguous accounts of rare occasions when shark catches were large enough to be retained in collective memory (von Bonde 1934; SAEON 2013). Existing assessments are dating rapidly and attempts to conduct assessments are complicated by the multi-species nature of shark-directed and bycatch fisheries, and uncertainties regarding species identification. Furthermore, fluctuations in catch per unit effort (CPUE) of chondrichthyans may not be related directly to abundance. Fluctuations in CPUE may be related to market influences and the availability of higher-value species. These factors that inhibit the development of reliable stock assessments are not restricted to South Africa (Cochrane 1999).

Fishery-dependent data exist for 22 species of chondrichthyans; however, for reasons similar to those outlined above, these data are unsuitable for use in stock assessments (DAFF unpublished data). Several sources of fishery-independent data exist for 67 species. However, comprehensive data suitable for stock assessments potentially exist for <10% of the 99 chondrichthyan species that occur in southern Africa and are targeted regularly or taken as bycatch.

Analyses of population trends from single fisheries and multiple fisheries within a small geographical region show mixed results, with trends varying according to species (Dudley and Simpfendorfer 2006; Attwood et al. 2011; Best et al. 2013). There is evidence for a decline of certain families (such as the Pristidae) (Everett et al. 2015) and of species such as the scalloped and great hammerhead sharks (Dudley and Simpfendorfer 2006).

Basic population dynamics models have been applied to several species, including: per-recruit analysis of soupfin (McCord 2005) and smoothhound sharks (da Silva 2007), demographic modelling based on life-history parameters of the spotted gully shark (Booth et al. 2010), mark-recapture models for the spotted ragged-tooth shark (Dicken et al. 2008), and photo-identification of the white shark (Towner et al. 2013). Analyses of catch and effort data, albeit limited, have been undertaken for soupfin (McCord 2005), and smoothhound sharks (da Silva 2007). Despite the general inability to standardise landed-catch rate, there are observable trends for certain species. McCord (2005) showed that the soupfin shark is fully exploited and da Silva (2007) revealed that the smoothhound shark is marginally overexploited. Standardised CPUE analyses for blue and mako sharks revealed stable landed-catch trends for the blue shark (Jolly 2011) and declining landed-catch trends for shortfin mako sharks, at least for the South-West Indian Ocean (Foulis 2012).

Anecdotal evidence from the demersal shark longline industry suggests a shift in target species due to declining catch rates, with a move from the soupfin shark to the smoothhound shark and members of the Carcharhinidae. Although the spotted gully shark cannot legally be harvested commercially – because it is a legislated recreational species – it is often misidentified as the smoothhound shark and is therefore landed in target and bycatch fisheries. Abundance trends for the spotted ragged-tooth shark have remained relatively stable (Dicken et al. 2008), although the localised trend in the KZN bather protection programme is declining (KZNSB unpublished data). White shark catch rates declined between 1966 and 1993 in the KZN bather protection programme (Cliff et al. 1996), although showed no trend for the overlapping period 1978–2003 (Dudley and Simpfendorfer 2006). A population estimate by Towner et al. (2013) suggested that, despite the white shark being listed as protected in South Africa since 1991, no population growth had occurred since a previous estimate by Cliff et al. (1996). Trends for blue shark have remained stable despite heavy fishing pressure (Jolly 2011).

Certain shark species exhibit predictable spatio-temporal patterns of sex and size segregation, as well as site fidelity (Klimley 1987; Sims et al. 2001; Rodriguez-Cabello et al. 2007; Barnett et al. 2010). Such behaviour patterns are known to render such species particularly vulnerable to fisheries. For example, in South Africa, the St Joseph segregates by sex in offshore waters and migrates inshore to breed (Freer and Griffiths 1993b). Consequently, the potential exists for large numbers of St Joseph of a given sex to be caught in a single trawl offshore, or for breeding males and females to be caught in the gillnet fishery inshore (Freer and Griffiths 1993b). The gillnet fishery has been shown to target the larger females of the species (Freer and Griffiths 1993b).

Implementation of species-specific management plans is hampered by a number of constraints. Notably, most commercially valuable chondrichthyans are caught as bycatch, sometimes in large quantities by fisheries such as the inshore and offshore trawl fisheries that are relatively non-selective. Hence, it would be difficult to justify the implementation of chondrichthyan-specific catch restrictions on certain small, targeted fisheries if the same species are taken as bycatch in considerably greater quantities in industrial fisheries. In 2010, for example, 40 t of St Joseph was landed in the directed fishery, whereas the inshore and offshore trawl fisheries caught 900 t as bycatch. However, where species are known to be particularly vulnerable to smaller-scale fisheries, additional catch restrictions should be introduced. For example, the scyliorhinid catsharks are vulnerable to the commercial linefishery and the gillnet fishery (SJL pers. obs.).

Economic considerations

Data on the economics of South Africa's fisheries, including those for chondrichthyans, are both limited and dated, with the last assessment by Sauer et al. (2003). Demand for South African shark products (fresh, frozen or finned) has grown considerably during the past two decades (da Silva and Bürgener 2007). Chondrichthyan products can be divided into four components: (1) demersal shark carcasses that are processed into trunks and filleted; (2) pelagic shark carcasses that are processed into steaks; (3) fins of all sharks that are dried (da Silva and Bürgener 2007); and (4) low-value dried product distributed locally and to the Democratic Republic of the Congo (DAFF unpublished data). Within each of the first two components, sharks are further categorised in terms of market value. Pelagic sharks (e.g. shortfin mako) are considered valuable in both the fin and the fillet trades, irrespective of size. Most other shark species are considered low-value due to lack of muscle firmness and strongly flavoured meat that affects fillet and steak quality. These species, including blue and broadnose sevengill sharks, are targeted primarily for the sale of their fins or livers (Vannuccini 1999; da Silva and Bürgener 2007). Until recently, a number of cage-diving operations in the Western Cape used liver from broadnose sevengill sharks as chum to attract white sharks, thereby creating a new local market. This practice is now prohibited due to public opposition (DEA 2014).

In the trade for demersal shark fillets, the value of fillets is determined not only by species but also according to the handling and cleaning processes, as well as the mercury content of the flesh. In general, whole sharks weighing between 1.5 and 12 kg are considered ideal, as mercury and cadmium levels in animals over 12 kg often exceed permissible limits of 0.01 mg kg^{-1} and 0.03 mg kg^{-1}, respectively (da Silva and Bürgener 2007; DAFF 2012). Although heavy metal concentrations vary both by species and capture area, smaller sharks (2–7 kg) are generally of highest value. Larger demersal sharks tend to be caught exclusively for fins and liver.

Between 2000 and 2010, 498 t of fins (at R 134 kg^{-1}) (South African rands; US\$1 = R 12.01 on 8 April 2015), 45 t of fresh trunks (at R 108 kg^{-1}) and 10 225 t of frozen trunks (at R 25 kg^{-1}) were exported (M Bürgener, TRAFFIC South Africa, unpublished data). Fresh shark product is exported to Australia (72%), Philippines (20%) and Italy (6%) (M Bürgener unpublished data). Italy, Uruguay and Australia account for more than 80% of all exported frozen shark product (M Bürgener unpublished data). Although shark fins from South Africa are exported to 10 countries, Hong Kong, Democratic Republic of Congo, Japan and Australia account for 98% of fin exports. Fins are from both pelagic and demersal sharks landed in various fisheries. The global increase in fin price (Clarke et al. 2006a, 2006b) provides a significant incentive for the targeting of large sharks regardless of fillet value. Frozen shark product and fins are also imported into South Africa from Japan, Korea and Taiwan. Fresh shark product is imported from Spain (M Bürgener unpublished data).

Evidence indicates large quantities of shark fin are exported illegally with the involvement of Chinese triad gangs (Gastrow 2001). Discrepancies between fin export data from South Africa and import data to Hong Kong further demonstrate illegal finning activity (M Bürgener unpublished data). Trade data are therefore a poor indicator of shark landed catches in South Africa.

South African chondrichthyans are also threatened by oceanic gillnet fleets of North-West Indian Ocean countries, which have grown enormously over the past two decades (IOTC 2013). Rapid depletion of shark populations in those waters has seen a dispersal of effort southward as fishers attempt to maintain catch rates. It is suspected that some of these vessels now fish illegally in South African waters, as evidenced by recent vessel traffic and by the impounding of nets by management authorities (NSRI 2011). IUU (illegal, unregulated and unreported) fishing in this country – although likely not as high as in many other African countries – poses a significant threat to the sustainable utilisation of chondrichthyans in South Africa. Illegal fishing includes contraventions of permit conditions such as use of illegal fishing gear, fishing in prohibited areas (e.g. marine protected areas), or illegal fishing practices (e.g. finning).

Conclusions

South Africa has undergone considerable political, social and economic change since Kroese and Sauer's (1998) review on elasmobranch exploitation, particularly with respect to the reallocation of marine resources to include individuals that were historically disadvantaged under the previous apartheid government (Kleinschmidt et al. 2003). Since 1994 there have also been considerable changes to government agencies responsible for the management of South Africa's fisheries, as well as their areas of jurisdiction. This has included the shift of fisheries management responsibilities from the Department of Environmental Affairs and Tourism (DEAT) to DAFF in 2009.

South Africa has well-developed fisheries with a high degree of industrialisation and largely functional management structures. Management is most successful with respect to those resources that are of greatest value and that are harvested by few fishing sectors that are themselves internally organised. It is in these sectors that long-term catch and effort data are available, together with biological information, for the development of resource assessment models. Chondrichthyans, however, tend to be caught across multiple sectors, to the detriment of their monitoring, assessment and management.

A positive step has been the recent recognition of shark-directed fisheries in their own right, as well as recognition that a substantial bycatch is taken across a number of fisheries. However, non-governmental research remains focused on large and charismatic species that are particularly appealing both to aspiring scientists and funders alike (Ebert and van Hees 2015). Insufficient committed funding from government limits the number of studies focused on commercially exploited chondrichthyans. This phenomenon is apparent globally, with a small number of high-profile species (e.g. white and whale sharks, and mobulid rays) attracting disproportionate attention from researchers and funders (McClenachan et al. 2012; Huveneers et al. 2015).

This study identifies and summarises available fisheries-related data for chondrichthyans in South Africa. To advance the state of knowledge of chondrichthyans in local fisheries, and thereby improve conservation and management, research should be focused on the collection of fundamental life-history and ecological data as well as species-specific catch and effort data required for future resource assessments.

Requirements to improve the management of chondrichthyans caught in South African fisheries can be summarised as follows: (i) improved collection of catch and effort data, (ii) centralised management of chondrichthyans caught in South African fisheries, and (iii) resource assessment. The quality of catch and effort data could be improved by the inclusion of chondrichthyan identification guides with the logbooks that are distributed to fishery sectors. Additionally, an increase in observer effort with a focus on the collection of chondrichthyan data would improve data quality considerably.

Responsibility for chondrichthyan recommendations and management is currently fragmented across DAFF's scientific and fishery management working groups focused on individual fisheries. The introduction of a working group and management framework that encompasses all fisheries documented to catch chondrichthyans would ensure the coordination of management initiatives across fishing sectors. Lastly, an emphasis on adequate research funding and the initiation of assessments of commonly caught species are prerequisites for appropriate management.

Acknowledgements — We thank the following for providing catch data: Rob Cooper and Tracey Fairweather (DAFF) – trawl fisheries, hake longline fishery and observer databases; Sabine Wintner (KZNSB) – KZN bather protection programme; Stuart Dunlop – Oceanographic Research Institute's Cooperative Fish Tagging Project; and Christopher Wilke (DAFF) – commercial linefishery. We thank Larvika Singh, Carl van der Lingen, Craig Smith and Chris Wilke (all DAFF) for comments on the fishery sectors, and Dave Ebert (Pacific Shark Research Center) for comments on taxonomy and distribution. We would also like to thank various members of the former Chondrichthyan Working Group of the then Department of Environmental Affairs and Tourism who contributed to the original draft NPOA-Sharks living document, released in 2002, including Geremy Cliff (KZNSB), Leonard Compagno (formerly of the Iziko Museums of Cape Town) and Malcolm Smale (Bayworld). Lastly we would like to thank the anonymous reviewers for their valuable comments that improved previous drafts of this manuscript.

References

Anderson ED. 1990. Fishery models as applied to elasmobranch fisheries. In: Pratt HL, Gruber SH, Taniuchi T (eds), *Elasmobranchs as living resources: advances in the biology, ecology, systematics, and the status of fisheries*. *NOAA Technical Report NMFS* 90: 473–484.

Attwood CG, Peterson SL, Kerwath SE. 2011. Bycatch in South Africa's inshore trawl fishery as determined from observer records. *ICES Journal of Marine Science* 68: 2163–2174.

Barnett A, Stevens JD, Frusher SD, Semmens JM. 2010. Seasonal occurrence and population structure of the broadnose sevengill shark *Notorynchus cepedianus* in coastal habitats of Southeast Tasmania. *Journal of Fish Biology* 77: 1688–1701.

Barnett LAK, Ebert DA, Cailliet GM. 2012. Evidence of stability in a chondrichthyan population: case study of the spotted ratfish *Hydrolagus colliei* (Chondrichthyes: Chimaeridae). *Journal of Fish Biology* 80: 1765–1788.

Bass AJ, D'Aubrey JD, Kistnasamy N. 1975. Sharks of the east coast of southern Africa. V. The families Hexanchidae, Chlamydoselachidae, Heterodontidae, Pristiophoridae and Squatinidae. *Investigational Report* No. 43. Durban: Oceanographic Research Institute.

Baum JK, Meyers RA, Kehler DG, Worm B, Harley SJ, Doherty PA. 2003. Collapse and conservation of shark populations in the Northwest Atlantic. *Science* 299: 389–392.

Benavides MT, Horn RL, Feldheim KA, Shivji MS, Clarke SC, Wintner S et al. 2011. Global phylogeography of the dusky shark *Carcharhinus obscurus*: implications for fisheries management and monitoring the shark fin trade. *Endangered Species Research* 14: 13–22.

Best LN, Attwood CG, da Silva C, Lamberth SJ. 2013. Chondrichthyan occurrence and abundance trends in False Bay, South Africa, spanning a century of catch and survey records. *African Zoology* 48: 201–227.

Bonfil R. 1994. *Overview of world elasmobranch fisheries*. FAO Fisheries Technical Paper No. 341. Rome: Food and Agriculture Organization.

Booth AJ, Foulis AJ, Smale MJ. 2010. Age validation, growth, mortality, and demographic modeling of spotted gully shark (*Triakis megalopterus*) from the southeast coast of South Africa. *Fishery Bulletin* 109: 101–112.

Clarke SC, Magnussen JE, Abercrombie DL, McAllister MK, Shivji MS. 2006a. Identification of shark species composition and proportion in the Hong Kong shark fin market based on molecular genetics and trade records. *Conservation Biology* 20: 201–211.

Clarke SC, McAllister MK, Milner-Gulland EJ, Kirkwood GP, Michielsens CGJ, Agnew DJ et al. 2006b. Global estimates of shark catches using trade records from commercial markets. *Ecology Letters* 9: 1115–1126.

Cliff G, Dudley SFJ. 2011. Reducing the environmental impact of shark-control programmes: a case study from KwaZulu-Natal, South Africa. *Marine and Freshwater Research* 62: 700–709.

Cliff G, Dudley SFJ, Jury MR. 1996. Catches of white sharks in KwaZulu-Natal, South Africa and environmental influences. In: Klimley KA, Ainley DG (eds), *Great white sharks: the biology of* Carcharodon carcharias. San Diego, California: Academic Press. pp 351–362.

Cochrane KL. 1999. Complexity in fisheries and limitations in the increasing complexity of fisheries management. *ICES Journal of Marine Science* 56: 917–926.

Compagno LJV. 1999. An overview of chondrichthyan systematics and biodiversity in Southern Africa. *Transactions of the Royal Society of South Africa* 54: 75–120.

Compagno LJV, Ebert DA, Cowley PD. 1991. Distribution of offshore demersal cartilaginous fish (Class Chondrichthyes) off the west

coast of southern Africa, with notes on their systematics. *South African Journal of Marine Science* 11: 43–139.
Cortés E. 2007. Chondrichthyan demographic modelling: an essay on its use, abuse and future. *Marine and Freshwater Research* 58: 4–6.
Crawford RJM, Wilkinson IS, David JHM, Leslie RW, Stander GH, Oosthuizen WH, Schulein FH. 1993. Progress towards the development of an integrated management approach to fisheries for sharks and other chondrichthyans in South African waters. Unpublished task group report. Sea Fisheries Research Institute [now Branch: Fisheries Management, Department of Agriculture, Forestry and Fisheries], Cape Town.
DAFF. 2012. *Status of South African marine fishery resources 2012*. Cape Town: Department of Agriculture, Forestry and Fisheries. Available at www.nda.agric.za/doaDev/sideMenu/fisheries/03_areasofwork/Resources%20Research/STATUS%20REPORT%202012%20FINALB.pdf [accessed April 2015].
DAFF. 2013. *National plan of action for the conservation and management of sharks (NPOA-Sharks).* Rogge Bay [Cape Town]: Department of Agriculture, Forestry and Fisheries.
DAFF. 2014a. Section C. Sector specific permit conditions: demersal shark longline. Fishing season: 2014. Department of Agriculture, Forestry and Fisheries, Cape Town.
DAFF. 2014b. Section C. Sector specific permit conditions: tuna longline. Fishing season: 2014. Department of Agriculture, Forestry and Fisheries, Cape Town.
DAFF. 2014c. Section C. Sector specific conditions: commercial linefishery. Fishing season: 2014. Department of Agriculture, Forestry and Fisheries, Cape Town.
DAFF. 2014d. Section C. Sector specific conditions: beach seine and gillnet fishery. Fishing season: 2014. Department of Agriculture, Forestry and Fisheries, Cape Town.
DAFF. 2014e. Section C. Sector specific permit conditions: hake and inshore trawl. Fishing season: 2014. Department of Agriculture, Forestry and Fisheries, Cape Town.
DAFF. 2014f. Section C. Sector specific permit conditions: midwater trawl. Fishing season: 2014. Department of Agriculture, Forestry and Fisheries, Cape Town.
da Silva C. 2007. The status and prognosis of the smoothhound shark (*Mustelus mustelus*) fishery in the southeastern and southwestern Cape Coasts, MSc thesis, Rhodes University, South Africa. Available at http://contentpro.seals.ac.za/iii/cpro/DigitalItemViewPage.external?sp=1003287 [accessed 6 February 2015].
da Silva C, Bürgener M. 2007. South Africa's demersal shark meat harvest. *TRAFFIC Bulletin* 21: 55–56.
Davies DH. 1964. *About sharks and shark attack*. Pietermaritzburg: Shuter and Shooter.
DEA. 2014. Permit to undertake white shark cage diving. Department of Environmental Affairs, Cape Town.
Dicken ML, Booth AJ, Smale MJ. 2008. Estimates of juvenile and adult raggedtooth shark (*Carcharias taurus*) abundance along the east coast of South Africa. *Canadian Journal of Fisheries and Aquatic Sciences* 65: 621–632.
Dudley SFJ. 1997. A comparison of the shark control programmes of New South Wales and Queensland (Australia) and KwaZulu-Natal (South Africa). *Ocean and Coastal Management* 34: 1–27.
Dudley SFJ, Simpfendorfer CA. 2006. Population status of 14 shark species caught in the beach protection programme of KwaZulu-Natal, South Africa, 1978–2003. *Marine and Freshwater Research* 57: 225–240.
Dulvy NK, Baum JK, Clarke S, Compagno LJV, Cortés E, Domingo A et al. 2008. You can swim but you can't hide: the global status and conservation of oceanic pelagic sharks and rays. *Aquatic Conservation: Marine and Freshwater Ecosystems* 18: 459–482.
Dulvy NK, Fowler SL, Musick JA, Cavanagh RD, Kyne PM, Harrison LR et al. 2014. Extinction risk and conservation of the world's sharks and rays. *eLife* 3: e00590.
Ebert DA, Compagno LJV, Cowley PD. 2008. Aspects of the reproductive biology of skates (Chondrichthyes: Rajiformes: Rajoidei) from southern Africa. *ICES Journal of Marine Science* 65: 81–102.
Ebert DA, van Hees KE. 2015. Beyond *Jaws*: rediscovering the 'lost sharks' of southern Africa. In: Ebert DA, Huveneers C, Dudley SFJ (eds), *Advances in shark research*. *African Journal of Marine Science* 37: 141–156.
Everett BI, Cliff G, Dudley SFJ, Wintner SP, van der Elst RP. 2015. Do sawfish *Pristis* spp. represent South Africa's first local extirpation of a marine elasmobranch in the modern era? In: Ebert DA, Huveneers C, Dudley SFJ (eds), *Advances in shark research*. *African Journal of Marine Science* 37: 275–284.
FAO. 1995. *Code of conduct for responsible fisheries*. Rome: Food and Agriculture Organization.
FAO. 1999. *The international plan of action for the conservation and management of sharks*. Rome: Food and Agriculture Organization.
FAO. 2005. *Review of the state of world marine fishery resources.* FAO Fisheries Technical Paper No. 457. Rome: Food and Agriculture Organization.
FAO. 2011. *Review of the state of world marine fishery resources*. FAO Fisheries Technical Paper No. 569. Rome: Food and Agriculture Organization.
FAO. 2012. *Review of the implementation of the international plan of action for the conservation and management of sharks*. FAO Fisheries Circular No. 1076. Rome: Food and Agriculture Organization.
FAO. 2014. *The state of world fisheries and aquaculture: opportunities and challenges.* Rome: Food and Agriculture Organization.
Fennessy ST. 1994a. Incidental capture of elasmobranchs by commercial prawn trawlers on the Tugela bank, Natal, South Africa. *South African Journal of Marine Science* 14: 287–296.
Fennessy ST. 1994b. The impact of commercial trawlers on linefish off the north coast of Natal, South Africa. *South African Journal of Marine Science* 14: 263–279.
Field IC, Meekan MG, Buckworth RC, Bradshaw CJA. 2009. Susceptibility of sharks, rays and chimaeras to global extinction. *Advances in Marine Biology* 56: 275–363.
Foulis A. 2012. A retrospective analysis of shark catches made by pelagic longliners off the east coast of South Africa and biology and life history of shortfin mako shark, *Isurus oxyrinchus*. MSc thesis, University of KwaZulu-Natal, Durban, South Africa.
Freer DWL, Griffiths CL. 1993a. Estimation of age and growth in the St Joseph *Callorhinchus capensis* (Dumeril) off the south-western Cape, South Africa. *South African Journal of Marine Science* 13: 75–81.
Freer DWL, Griffiths CL. 1993b. The fishery for, and general biology of, the St Joseph *Callorhinchus capensis* (Dumeril), South Africa. *South African Journal of Marine Science* 13: 63–74.
Fréon P, Coetzee JC, van der Lingen CD, Connell AD, O'Donoghue SH, Roberts MJ et al. 2010. A review and tests of hypotheses about causes of the KwaZulu-Natal sardine run. *African Journal of Marine Science* 32: 449–479.
Gastrow P. 2001. *Triad societies and Chinese organised crime in South Africa*. Occasional Paper 48. South Africa: Institute for Security Studies.
Griffiths MH. 2000. Long-term trends in catch and effort of commercial linefish off South Africa's Cape Province: snapshots of the 20th century. *South African Journal of Marine Science* 22: 81–110.
Griffiths MH, Lamberth SJ. 2002. Evaluating a marine recreational fishery in South Africa. In: Pitcher TJ, Hollingworth CE (eds), *Recreational fisheries: ecological, economic and social evaluation.* Oxford: Blackwell Science. pp 227–251.
Hillborn R, Walters CJ. 1992. *Quantitative fisheries stock assessment: choice, dynamics and uncertainty.* New York: Chapman and Hall.
Hutchings K, Lamberth SJ. 2002a. Bycatch in the gillnet and

beach-seine fisheries in the Western Cape, South Africa, with implications for management. *South African Journal of Marine Science* 24: 227–241.

Hutchings K, Lamberth SJ. 2002b. Catch-and-effort estimates for the gillnet and beach-seine fisheries in the Western Cape. *South African Journal of Marine Science* 24: 205–225.

Huveneers C, Ebert DA, Dudley SFJ. 2015. The evolution of chondrichthyan research through a metadata analysis of dedicated international conferences between 1991 and 2014 (editorial overview). In: Ebert DA, Huveneers C, Dudley SFJ (eds), *Advances in shark research*. *African Journal of Marine Science* 37: 129–139.

IOTC. 2013. *Outcomes of the report on the estimation of fishing capacity by tuna fishing fleets in the Indian Ocean*. IOTC Secretariat Report IOTC/2013/SC16/19 [E]. Victoria, Seychelles: Indian Ocean Tuna Commission.

Jolly KA. 2011. Aspects of the biology and fishery of the blue shark (*Prionace glauca*) in South African waters. MSc thesis, University of Cape Town, South Africa.

Jolly KA, da Silva C, Attwood CG. 2013. Age, growth and reproductive biology of the blue shark (*Prionace glauca*) in South African waters. *African Journal of Marine Science* 35: 99–109.

Kleinschmidt H, Sauer WHH, Britz P. 2003. Commercial fishing rights allocation in post-apartheid South Africa: reconciling equity and stability. *African Journal of Marine Science* 25: 25–35.

Klimley AP. 1987. The determinants of sexual segregation in the scalloped hammerhead shark, *Sphyrna lewini*. *Environmental Biology of Fishes* 18: 27–40.

Kroese M, Sauer WH. 1998. Elasmobranch exploitation in Africa. *Marine and Freshwater Research* 49: 573–577.

Kroese M, Sauer WH, Penney AJ. 1996. An overview of shark catches and by-catches in South African fisheries. *Collective Volume of Scientific Papers ICCAT* 45: 318–328.

Lack M, Sant G. 2009. *Trends in global shark catch and recent developments in management*. Cambridge: TRAFFIC International.

Lamberth SJ. 2006. White sharks and other chondrichthyan interactions with the beach-seine (treknet) fishery in False Bay, South Africa. *African Journal of Marine Science* 28: 723–727.

Lamberth SJ, Bennett BA, Clarke BM. 1994. Catch composition of the commercial beach-seine fishery in False Bay, South Africa. *South African Journal of Marine Science* 14: 69–78.

Leslie RW. 2012. Testing of selector grids on the FV *Desert Diamond*. Report No. FISHERIES/2012/MAY/SW-DEM/05. Department of Agriculture, Forestry and Fisheries, Cape Town.

Lutjeharms JRE, Catzel R, Valentine HR. 1989. Eddies and other boundary phenomena of the Agulhas Current. *Continental Shelf Research* 9: 597–616.

McClenachan L, Cooper AB, Carpenter KE, Dulvy NK. 2012. Extinction risk and bottlenecks in the conservation of charismatic marine species. *Conservation Letters* 5: 73–80.

McCord ME. 2005. Aspects of the ecology and management of the soupfin shark (*Galeorhinus galeus*) in South Africa. MSc thesis, Rhodes University, South Africa. Available at http://contentpro.seals.ac.za/iii/cpro/DigitalItemViewPage.external?lang=eng&sp=1005066&sp=T&sp=Pall%2CRu1000001%40%2CQsoupfin+shark+diet&suite=def [accessed 5 February 2015].

NSRI (National Sea Rescue Institute). 2011. National Sea Rescue Institute Report. Available at www.nsri.org.za/2011/11/search-for-4-people-on-a-life-raft-adrift-at-sea/ [accessed 2 December 2013].

Parkington JP. 2006. *Shorelines, strandlopers and shell middens.* Cape Town: Krakadouw Trust.

Pauly D, Christensen V, Dalsgaard J, Froese R, Torres F. 1998. Fishing down marine food webs. *Science* 279: 860–863.

Prince JD. 2005. Gauntlet fisheries for elasmobranchs – the secret of sustainable shark fisheries. *Journal of Northwest Atlantic Fishery Science* 35: 407–416.

Rodriguez-Cabello C, Sanchez F, Olaso I. 2007. Distribution patterns and sexual segregations of *Scyliorhinus canicula* [L.] in the Cantabrian Sea. *Journal of Fish Biology* 70: 1568–1586.

RSA (Republic of South Africa). 1998. Marine Living Resources Act (Act No. 18 of 1998). *Government Gazette, South Africa* 395 (18930).

RSA (Republic of South Africa). 2005. Recreational catch restriction. *Government Gazette, South Africa* 478 (27453).

RSA (Republic of South Africa). 2012. Government Notice 474. Policy for the small scale fisheries sector in South Africa. *Government Gazette, South Africa* 564 (35445).

RSA (Republic of South Africa). 2015. Government Notice 495. Draft policies on the allocation and management of fishing rights in the large pelagic (tuna and swordfish longline) fishery: 2015. *Government Gazette, South Africa* 600 (38871).

Ryklief R, Pistorius PA, Johnson R. 2014. Spatial and seasonal patterns in sighting rate and life-history composition of the white shark *Carcharodon carcharias* at Mossel Bay, South Africa. *African Journal of Marine Science* 36: 449–453.

SAEON (South African Environmental Observation Network). 2013. Historical research survey database. Version 1. SAEON Egagasini Offshore Node, Cape Town. Available at http://data.saeon.ac.za/communities/community_egagasini/content/products/hmdb/database/ [accessed April 2015].

Sauer WHH, Hecht T, Britz PJ, Mather D. 2003. An economic and sectoral study of the South African fishing industry. Vol. 2. Fishery profiles. Report prepared for Marine and Coastal Management, Department of Environmental Affairs and Tourism [now Branch: Fisheries Management, Department of Agriculture, Forestry and Fisheries]. Rhodes University, Grahamstown.

Sims DW, Nash JP, Morrit D. 2001. Movement and activity of male and female dogfish in a tidal sea lough: alternative behavioural strategies and apparent sexual segregation. *Marine Biology* 139: 1165–1175.

Smale MJ. 2008. Pelagic shark fisheries in the Indian Ocean. In: Camhi MD, Pikitch EK, Babcock EA (eds), *Sharks of the open ocean: biology, fisheries and conservation.* Oxford: Blackwell. pp 247–259.

Smale MJ, Booth AJ, Farquhar MR, Meÿer MR, Rochat L. 2012. Migration and habitat use of formerly captive and wild raggedtooth sharks (*Carcharias taurus*) on the southeast Coast of South Africa. *Marine Biology Research* 8: 115–128.

Smith SE, Au DW, Show C. 1998. Intrinsic rebound potentials of 26 species of Pacific sharks. *Marine and Freshwater Research* 49: 663–678.

Stevens JD, Bonfil R, Dulvy NK, Walker PA. 2000. The effects of fishing on sharks, rays, and chimaeras (chondrichthyans), and the implications for marine ecosystems. *ICES Journal of Marine Science* 57: 476–494.

Towner AV, Wcisel MA, Reisinger RR, Edwards D, Jewell OJD. 2013. Gauging the threat: the first population estimate for white sharks in South Africa using photo identification and automated software. *PLoS ONE* 8: e66035.

Turpie JK, Lamberth SJ. 2010. Characteristics and value of the Thukela Banks crustacean and linefish fisheries, and the potential impacts of changes in river flow. *African Journal of Marine Science* 32: 613–624.

Vannuccini S. 1999. *Shark utilization, marketing and trade*. FAO Fisheries Technical Paper No. 389. Rome: Food and Agriculture Organization.

van Zyl K. 1993. *Marine products: die eerste 50 jaar*. Cape Town: Nationale Boekdrukkery.

von Bonde C. 1934. Shark fishing as an industry. *Fisheries and Marine Biology Division, Union of South Africa, Investigational Report* 2: 1–19.

Walker TI. 1998. Can shark resources be harvested sustainably? A question revisited with a review of shark fisheries. *Marine and Freshwater Research* 49: 553–572.

Walmsley SA, Leslie RW, Sauer WHH. 2007a. Managing South Africa's trawl bycatch. *ICES Journal of Marine Science* 64: 405–412.

Walmsley SA, Leslie RW, Sauer WHH. 2007b. Bycatch and discarding in the South African demersal trawl fishery. *Fisheries Research* 86: 15–30.

Watson G, Smale MJ. 1998. Reproductive biology of shortnose spiny dogfish, *Squalus megalops*, from the Agulhas Bank, South Africa. *Marine and Freshwater Research* 49: 695–703.

Weltz K, Kock AA, Winker H, Attwood CG, Sikweyiya M. 2013. The influence of environmental variables on the presence of white sharks, *Carcharodon carcharias* at two popular Cape Town bathing beaches: a generalized additive mixed model. *PLoS ONE* 8: e68554.

Wintner SP, Dudley SFJ, Kistnasamy N, Everett B. 2002. Age and growth estimates for the Zambezi shark, *Carcharhinus leucas*, from the east coast of South Africa. *Marine and Freshwater Research* 53: 557–566.

Worm B, Davis B, Kettemer L, Ward-Paige CA, Chapman D, Heithaus MR, Kessel ST, Gruber SH. 2013. Global catches, exploitation rates, and rebuilding options for sharks. *Marine Policy* 40: 194–204.

Manuscript received June 2014, revised January 2015, accepted April 2015

Appendix: Estimated average annual catches [t] of chondrichthyans caught by South African fisheries from 2010 to 2012. The total catch has been disaggregated by fishery as Δ =<1%, ⊘ = 1–10%, ○ = 11–25%, ● = 26–50%, □ = 51–75%, and ■ = 76–100%. ** indicates that a species is suspected to be caught by a particular fishery but not reported. The availability of fishery-dependent and fishery-independent survey data is indicated in the two last columns: < indicates limited species-specific data of uncertain quality, • indicates availability of species-specific data. Current scientific names follow Ebert and van Hees (2015)

Family	Scientific name	Estimated average annual catch 2010–2012 (t)	Demersal shark longline	Pelagic longline fishery	Bather protection programme	Recreational linefishery	Commercial linefishery	Beach-seine and gillnet fisheries	Offshore and inshore demersal trawl fishery	Small-pelagic and midwater trawl fisheries	Hake longline fishery	Prawn trawl fishery	Fishery-dependent data available	Fishery-independent data available
Alopiidae	*Alopias pelagicus*	<1		**	○		**		**	○				
	Alopias superciliosus	<1		**	○		**		**	○				
	Alopias vulpinus	1–10		●	○	Δ	●	○	○	○			<	<
Crurirajidae	*Cruriraja* spp.	11–100							■		**			<
Arhynchobatidae	*Bathyraja smithii*	11–100							■		**			<
Callorhinchidae	*Callorhinchus capensis*	801–900	Δ			Δ	**	⊘	■		**		•	•
Carcharhinidae	*Carcharhinus amboinensis*	<1		**	■	**						○		
	Carcharhinus brachyurus	101–200	○	○	Δ	Δ	●	Δ	Δ	Δ		**	•	•
	Carcharhinus brevipinna	1–10		**	■	**	**					Δ		
	Carcharhinus falciformis	1–10		**						⊘		Δ		<
	Carcharhinus leucas	1–10	**	**	○	**	**					**		
	Carcharhinus limbatus	1–10	**	**	⊘	⊘	●					**	<	
	Carcharhinus longimanus	<1		■						⊘			<	<
	Carcharhinus melanopterus	<1		**	○		**							
	Carcharhinus obscurus	11–100	○	○	□	Δ		○		⊘	**	Δ	<	•
	Carcharhinus plumbeus	1–10		**	■			**				Δ		
	Galeocerdo cuvier	1–10			■	**	**						<	
	Prionace glauca	301–600	Δ	□	Δ	Δ	⊘			Δ	**		•	•
	Rhizoprionodon acutus	<1				**	**					■		
Centrophoridae	*Centrophorus* spp.	<1							■		**			<
	Deania spp.	<1							■		**			<
Chimaeridae	*Hydrolagus or Chimaera* spp.	<1							**					<
Chlamydoselachidae	*Chlamydoselachus africana*	<1							**		**			
Dalatiidae	*Dalatias licha*	<1							■					
	Isistius brasiliensis	<1		**						**				
Dasyatidae	*Dasyatis brevicaudata*	<1	**			Δ	**	**	**					<
	Dasyatis chrysonota	<1				Δ	**	○	○	○	**	Δ		<
	Himantura gerrardi	<1					**		**		**	Δ		<
	Himantura uarnak	<1					**		**		**	Δ		
	Neotrygon kuhlii	<1					**		**			**		
	Pteroplatytrygon violacea	1–10		**					□	**	**			
	Taeniura lymma	<1					**		**		**	**		
Etmopteridae	*Centroscyllium fabricii*	<1							■		**			<
	Etmopterus spp.	1–10							■		**			<
Gymnuridae	*Gymnura natalensis*	1–10				Δ	**	○	○			Δ		<

Appendix: (cont.)

Family	Scientific name	Estimated average annual catch 2010–2012 (t)	Demersal shark longline	Pelagic longline fishery	Bather protection programme	Recreational linefishery	Commercial linefishery	Beach-seine and gillnet fisheries	Offshore and inshore demersal trawl fishery	Small-pelagic and midwater trawl fisheries	Hake longline fishery	Prawn trawl fishery	Fishery-dependent data available	Fishery-independent data available
Hexanchidae	*Heptranchias perlo*	<1									**			
	Hexanchus griseus	<1				**	**				**			
	Notorynchus cepedianus	1–10	○			Δ	■	**					•	•
Lamnidae	*Carcharodon carcharias*	<1			■			**						<
	Isurus oxyrinchus	301–700	Δ	■	Δ	Δ	Δ	**		Δ	**		•	•
	Lamna nasus	<1								□				
Mobulidae	*Manta* spp.	1–10			■					●				<
	Mobula spp.	<1			●					●				<
Myliobatidae	*Aetobatus narinari*	1–10					**		■		**	Δ		<
	Aetomylaeus bovina	1–10				**	**		□		**	Δ		<
	Myliobatis aquila	1–10				Δ	**	Δ	□		**	Δ		<
Narkidae	*Heteronarce garmani*	<1							■		**			<
	Narke capensis	1–10						Δ	■		**			<
Odontaspididae	*Carcharias taurus*	1–10			■	Δ	○	**						<
Pristiophoridae	*Pliotrema warreni*	<1							■		**	⊘		<
Pseudocarchariidae	*Pseudocarcharias kamoharai*	<1		**					**	Δ	**			<
Rajidae	*Dipturus pullopunctata*	11–100							■		**			<
	Dipturus springeri	11–100							■		**			<
	Leucoraja wallacei	11–100	**				**		■		**			<
	Malacoraja spinacidermis	1–10							■		**			<
	Raja miraletus	11–100	**			**	**	**	■		**	Δ		<
	Raja straeleni	201–300	**			**	**	**	■		**			<
	Raja spp.	11–100	Δ			Δ	Δ	**	■		**		•	<
	Rajella barnardi	1–10							■		**			<
	Rajella caudaspinosa	11–100							■		**			<
	Rajella leopardus	11–100							■		**			<
	Rajella ravidula	<1							**		**			<
	Rostroraja alba	11–100	**			Δ	**	**	□		**			<
Rhinobatidae	*Acroteriobatus annulatus*	11–100				⊘	**	⊘	■		**	Δ		<
	Acroteriobatus blochii	<1				Δ	**	□						
	Acroteriobatus leucospilus	<1					**		**		**	□		
	Acroteriobatus ocellatus	<1							**		**			
	Rhinobatos holcorhynchus	<1							**		**			
Rhinochimaeridae	*Harriotta raleighana*	<1							**		**			<
	Neoharriotta pinnata	<1							■					
	Rhinochimaera spp.	<1							**		**			<
Rhynchobatidae	*Rhynchobatus djiddensis*	<1				□			**			Δ		

Appendix: (cont.)

Family	Scientific name	Estimated average annual catch 2010–2012 (t)	Demersal shark longline	Pelagic longline fishery	Bather protection programme	Recreational linefishery	Commercial linefishery	Beach-seine and gillnet fisheries	Offshore and inshore demersal trawl fishery	Small-pelagic and midwater trawl fisheries	Hake longline fishery	Prawn trawl fishery	Fishery-dependent data available	Fishery-independent data available
Scyliorhinidae	*Apristurus* spp.	<1							■		**			
	Halaelurus lineatus	<1									**	■		
	Halaelurus natalensis	<1				**	**	**						<
	Haploblepharus edwardsii	1–10	**			**	**	**	●		**		<	<
	Haploblepharus fuscus	<1				**	**		■		**			
	Haploblepharus pictus	<1				**	**	**	■		**			
	Holohalaelurus favus	<1										■		
	Holohalaelurus regani	11–100					**		■		**			<
	Poroderma africanum	1–10	**			Δ	**	**	■				<	<
	Poroderma pantherinum	<1	**			⊘	**	**	■				<	<
	Scyliorhinus capensis	1–10	**				**		■		**			<
Somniosidae	*Centroscymnus* spp.	<1							■					<
Sphyrnidae	*Sphyrna lewini*	1–10	**	**	■		**		Δ	●	**	Δ		<
	Sphyrna mokarran	1–10		**	■	**	**							
	Sphyrna zygaena	1–10	●	○		⊘	●	**		⊘			<	<
Squalidae	*Cirrhigaleus asper*	<1										**		
	Squalus acanthias	<1	Δ				Δ	Δ	■				<	<
	Squalus acutipinna	11–100	**			**	**		■		**		<	<
	Squalus cf. *mitsukurii*	1–10							■		**			<
Squatinidae	*Squatina africana*	<1			■							Δ		<
Torpedinidae	*Tetronarce cowleyi*	1–10							■		**			<
	Torpedo fuscomaculata	1–10						**	■		**			<
	Torpedo sinuspersici	1–10							■		**	Δ		<
Triakidae	*Galeorhinus galeus*	101–400	●	Δ		Δ	●	Δ	●	Δ	**		•	•
	Mustelus mosis	1–10				**	**					■	<	<
	Mustelus mustelus	101–300	□			Δ	○	Δ	○	Δ	**		•	•
	Mustelus palumbes	1–100	⊘			**	**	⊘	■				<	•
	Triakis megalopterus	<1–10	**			●	●		Δ				<	<