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Accuracy of species identification by fisheries observers in a north Australian shark fishery

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ABSTRACT

Despite the importance of observers to collect data for effective fisheries management worldwide, their species-identification abilities are rarely assessed. Misidentifications could compromise observer data particularly in diverse, multi-species fisheries such as those in the tropics where visual identification is challenging. Here, we provide the first estimates of the ability of scientific observers to identify five species of morphologically similar carcharhinid sharks (*Carcharhinus leucas*, *C. amboinensis*, *C. tilstoni*, *C. sorrah* and *C. brevipinna*) in a fishery in northern Australia. We compared observer field identifications of sharks with genetic validation (814 bp mtDNA NADH dehydrogenase subunit 4) to quantify species identification errors. We used binomial generalised linear models to determine the influences of species, gender, total length, and the observer's experience on identification error. We found that identification error (~20%) depended predominately on the species in question (highest error for *C. tilstoni*). Male sharks were misidentified less frequently than females, and error decreased marginally with increasing total length. Surprisingly, we found no statistical evidence that observer experience influenced identification error. Our results provide the first benchmark of identification accuracy of observers for carcharhinid sharks in northern Australia and show that estimates of error in species identifications need to be incorporated into management strategies to ensure successful recovery of the many recently over-fished shark populations.

1. Introduction

Amid accelerating global declines of marine living resources over the past several decades (Dulvy et al., 2006; FAO, 2006; Hilborn et al., 2003; Hutchings, 2000; Jennings and Kaiser, 1998), there is growing pressure on fisheries to improve monitoring of catches (both harvests and discards) to determine whether current catches are sustainable. Correct species identification is fundamental to achieving these objectives. Without correct species identification, the likelihood of recognising ecosystem consequences, such as shifts in species abundances due to fishing, is greatly reduced or rendered impossible (Burgess et al., 2005a,b; Field et al., 2009b). Furthermore, the precision and accuracy of these data are crucial components for understanding the potential impact of current harvest rates on population viability (Dulvy et al., 2000; Field et al., 2009b; Nakano and Clarke, 2006).

One fish taxon in particular has experienced declines in many species globally: sharks and rays (chondrichthyans) (Burgess et al., 2005c; Dulvy et al., 2008; Field et al., 2009b; Robbins et al., 2006; Stevens et al., 2000; Walker, 1998). There has been much discussion regarding the causes of declines, with over-fishing identified as the greatest current threat (Coll et al., 2006; Field et al., 2009b; Jackson et al., 2001; Stevens et al., 2000; Ward and Myers, 2005; Worm et al., 2006). Historically, species-level identification of sharks in many fisheries has not been reported; rather, catch-records of similar-looking species were pooled. As such, determining whether current fishing pressures have already altered species abundances is often difficult to quantify (FAO, 2000). Changing current practices of record-keeping in commercial logbooks for species-level

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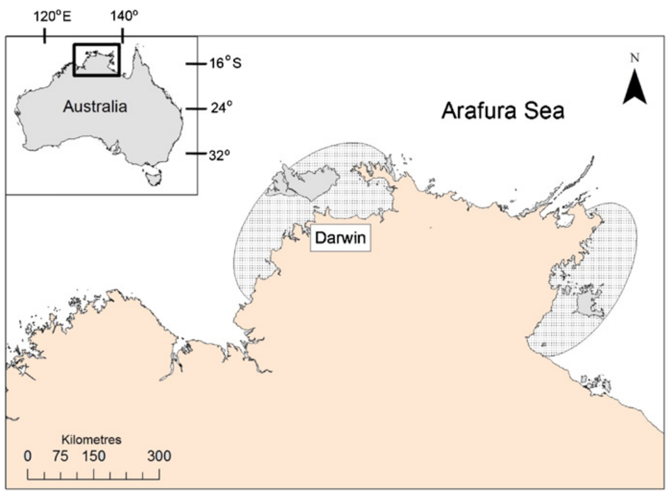

Fig. 1. Regions of northern Australian coastline sampled during Northern Territory Offshore Net and Line (NTONL) Fishery observer and shark tagging programmes. Total *n* (Observer species identification) = 632 (*Carcharhinus leucas*, *n* = 52; *C. tilstoni*, *n* = 201; *C. amboinensis*, *n* = 187; *C. brevipinna*, *n* = 40; *C. sorrah* *n* = 152).

reporting would improve regional estimates of species resilience, although correct species identification of many commercially valuable species such as the carcharhinids is confounded by their morphological similarity (Handley, 2010; Last and Stevens, 2009).

The Indo-Pacific region, including northern Australia, is widely recognised as an area of high carcharhinid biodiversity and endemism, and supports several target and mixed fisheries that catch elasmobranches, including the endangered *Glyphis* spp. sharks and Pristidae sawfishes (Last and Stevens, 2009). In northern Australia, sharks are landed in the Offshore Net and Line Fishery that operates predominately within 12 nm of the Northern Territory coastline, although fishing occurs within an area of 522,000 km^2 up to the boundary of the Australian Fishing Zone (Handley, 2010; Field et al., 2012). The predominant fishing methods employed include longlines (15 nm total length and no more than 1000 snoods) or pelagic nets (1000–2000 m total length with 160–185 mm mesh size and 50–100 mesh drop). This fishery targets the Australian (*Carcharhinus tilstoni*) and common black-tip (*C. limbatus*) and spot-tail (*Carcharhinus sorrah*) sharks (Field et al., 2012). In 2009, the reported fishery landed 371 tonnes of *C. tilstoni* and *C. limbatus* combined, and 86 tonnes of *C. sorrah* (Handley, 2010). The reported dominant by-catch species were hammerhead (*Sphyrna* spp; 118 tonnes), bull (*Carcharhinus leucas*; 73 tonnes), pig-eye (*Carcharhinus amboinensis*, 41 tonnes), lemon (*Negraprion actidens*; 36 tonnes) and tiger (*Galeocerdo curvier*; 34 tonnes) sharks (Handley, 2010).

Despite the small size relative to other locations of commercial fisheries (12 operational licenses) across northern Australia, current and historic (i.e., back to the Taiwanese fishery of the 1970s) fishing rates in the region are associated with illegal, unregulated and unreported catches (Field et al., 2009a) and flag the importance of accurate species-level monitoring (Field et al., 2009a; Handley, 2010; Stevens and Davenport, 1991). The presence of scientific observers on commercial fishing boats in north Australia has improved the reliability of catch records (Northern Territory Government Department of Regional Development, 2008; Zeroni, 2006), although their accuracy in species identifications has yet to be assessed empirically.

Genetic analysis offers a simple tool to confirm species identity, since diversity in the nucleotide sequence of selected regions of DNA is greater among than within species (Holmes et al., 2009; Ward et al., 2008; Wong et al., 2009). Gene regions in mitochondrial DNA have successfully discriminated species of coastal sharks (Morgan et al., 2011; Ovenden et al., 2010) and thus can be used to assess the accuracy of fishery-observer identifications. Here, we use analysis of mitochondrial DNA sequence to quantify the probability with which fishery observers correctly identify five common species of carcharhinid sharks caught in the Northern Territory Offshore Net and Line Fishery in northern Australia. We also test the relative influence of species, gender, individual total length and observer experience on error. We hypothesise that observer errors should be similar between genders of the same species of shark, but should differ among species. We also hypothesise errors to decrease with increasing total length because smaller sharks often have different markings from adults that might contribute to difficulties in species identification. Finally, we expect that errors will decrease with observer experience, because veterans should be more adept at identifying subtle differences among similar-looking species than novice observers.

2. Materials and methods

2.1. Genetic sample collection and observer identification

Observers participated in the Northern Territory Offshore Net and Line Fishery and shark tagging programmes around the Northern Territory coastline between September 2006 and December 2008 (Fig. 1). Fishery observers employed at commencement of the study ($n = 5$) were trained to identify five commonly caught morphologically similar carcharhinids (*C. tilstoni, C. sorrah, C. brevipinna, C. leucas and C. amboinensis*) using keys in Last and Stevens (1994), from specimen collections at Northern Territory Fisheries and the Northern Territory Museum, as well as on-board training. When this study was initiated, the frequency of *C. limbatus* to *C. tilstoni* on the Northern Territory coast was thought to be <1%, so observers were not trained to identify that species (Lavery and Shaklee, 1991). Ovenden et al. (2010) subsequently suggested that their frequency was much higher, approximately equal (~50:50). Consequently, we present overall misidentification errors with and without the two cryptic species of blacktip sharks (*C. tilstoni* and *C. limbatus*). We did not record sharks that were not identified by observers as any of the five target species. We categorised observers as ">50 days experience" ($n = 2$) or "<50 days experience" ($n = 3$) at sea to implement their training in field-based identification. Observers recorded the species, total length, and gender of each shark. A small skin clip from the dorsal fin was also collected from each measured shark and stored in 10% NaCl saturated dimethyl sulfoxide (DMSO) solution for genetic sequencing.

2.2. Genetic identification

Sharks were identified by comparing mitochondrial DNA sequences from each specimen with DNA sequences obtained from individuals in reference collections. These individuals included museum voucher specimens where possible, or had been identified by experienced taxonomists. Reference individuals were obtained from the Northern Territory Museum, Commonwealth Scientific and Industrial Research Organisation and research studies (Ovenden et al., 2009, 2010). Reference sequences obtained were for the five target species: Australian blacktip (*C. tilstoni*), spot-tail (*C. sorrah*), spinner (*C. brevipinna*), bull (*C. leucas*) and pig-eye (*C. amboinensis*) sharks, and regional congenerics sandbar (*C. plumbeus*), whitecheek (*C. dussumieri*), bignose (*C. altimus*), common black-tip (*C. limbatus*) and graceful (*C. amblyrhychoides*) sharks.