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# Post capture survival rate of bamboo sharks, *Chiloscyllium arabicum* and *Chiloscyllium griseum*, in Malvan, Maharashtra

**S. Kottillil[1]*, T. Gupta, M. Manoharakrishnan[2], C. Rao[2] and K. Shanker[2,3]**

[1]Department of Energy and Environment, TERI School of Advanced Studies, Vasant Kunj-110 070, New Delhi, India.
[2]Dakshin Foundation, CQAL Layout, Bangalore-560 092, Karnataka, India.
[3]Centre for Ecological Sciences, Indian Institute of Science, Bangalore-560 012, Karnataka, India.

*Correspondence e-mail: shruthi.kottillil@gmail.com

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Short Communication

## Abstract

Fishing gears have varying degrees of impact on the survival and mortality of targeted and non-targeted species, with extremely damaging consequences in some cases. This study carried out in Malvan, Maharashtra, attempted to understand the post-capture survival (PCS) rate of two species of bamboo sharks, classified in the 'Near Threatened' category by the IUCN. Primary data on physical/ response conditions of individuals were collected after capture. Individuals were identified to the species level and their biological parameters, including size, sex and maturity, in different fishing gears were recorded from landing centres. *Chiloscyllium arabicum* (Arabian bamboo shark) showed the highest PCS rate in gill nets (Kruskal Wallis Test Statistic, KW H = 8.23, $p < 0.05$) whereas *Chiloscyllium griseum* (grey bamboo shark) had a higher PCS rate in trawl nets (KW H = 6.68, $p < 0.05$). A comparison of the two species showed higher PCS for *C. arabicum* (overall KW H = 6.05, $p < 0.05$). Sex, maturity and size were found to have no impact on survival rates ($p > 0.1$). Thus, PCS was influenced by both species and fishing gear. This understanding can aid in devising conservation strategies for endangered elasmobranchs.

***Keywords***: *Elasmobranch, post-capture survival, mortality, maturity, conservation*

## Introduction

Fishing techniques have varying impacts on different species and individuals. While some are killed instantly, others may survive for a period after capture. However, they may, in the process, sustain physical injuries and/or experience psychological stress, which can vary with fishing gear and the sensitivity of the species (Jones *et al*., 2010). Fishing can alter size structure, population parameters and species abundance along with trophic interactions (Stevens *et al*., 2000). It can also impact growth rate, immune function, and reproductive processes that lead to exhaustion-induced mortality and post-release predation of elasmobranchs (Skomal and Mandelman, 2012; Gilman *et al*., 2013; Danylchuk *et al*., 2014). Thus, monitoring the survival can help understand physiological or biological processes most affected by the fishing techniques employed. This can be extrapolated further to understand the coping abilities of different species to not just fishing pressures but to environmental changes as well. These impacts can also vary between sexes, maturity stages and seasons (Moyes *et al*., 2006). Thus, the concept of 'survivorship' or the period of survival for an individual post-capture can help understand the impact of fisheries. Survivorship will help in understanding their coping behaviour and survival following release into the wild. A majority of fishes are dead by the time they are brought to shore for sales, while some survive, such as *Aplodactylus arctidens* and *Latridopsis forsteri* (Bell and Lyle, 2016) due to differences in their tolerance levels. Some species of sharks survive out of water for a relatively long period, such as the Arabian and grey bamboo sharks (*Chiloscyllium arabicum* and *Chiloscyllium griseum*) (Chapman and Renshaw, 2009).

Bamboo sharks show buccal-pump respiration (water drawn in by the movement of buccal cavity muscles), which enables them to breathe while stationary (Dapp *et al*., 2016). They are some of the most common shark species fished along the Konkan coast in western India. They are important sources of income and food in this region but are also threatened by overfishing (Lisney and Cavanagh, 2003). This study explores the potential for post-capture live release as a conservation strategy for these species. The objectives of the study were (1) to estimate the PCS rate for the two species of bamboo sharks, and (2) to identify factors that affect PCS rate in Malvan, Maharashtra.

# Material and methods

## *Study area*

The study site was Malvan (16.3492° N, 73.5594° E), which is the third largest fishing port in Maharashtra, on the west coast of India (Karnad *et al.*, 2020). Malvan hosts around 80-100 trawlers, 4-5 purse seines, at least 500 gill netters and several artisanal boats (shore seines, hook and lines and others; Gupta *et al.*, 2020). Multiday fishing operations are commonly seen for trawlers and gillnetters in Malvan, with fishing days ranging from one to three days for trawlers and a half to two days for gillnetters (Table 1).

Table 1. Fishery factors recorded

| Fishery factors | Details |
|---|---|
| Depth of operation | Gillnet: 1.8-30.7m<br>Hook and line: 1-27.4m<br>Trawler: 12.8-33.8m |
| Fishing days | Gillnet: ½-2 days<br>Hook and line: ½ day<br>Trawler: ½-3 days |
| Fishing location | Achra, Dandi, Malvan |
| Types of gear | Gillnet<br>Hook and line<br>Trawler |

## *Data collection*

Sampling was carried out from 15 January to 10 February 2020 at the fish auction site. One to two live individuals of *C. arabicum* and *C. griseum* were randomly selected at each sampling event, measured, sexed and maturity stages were assigned but were not weighed to avoid further stress. Information on location, depth of capture, number of days and time of fishing, and type of gear used were also recorded. The methodology was based on Manire *et al.* (2001) modified by Braccini *et al.* (2012), where individual responses were classified into high, moderate, low and nil (Table 2). The sampled individuals were purchased and placed in a dry box with minimal handling and released within 15 minutes. The release was carried out in the sea away from crowds and boats. During release, the response conditions for revival time and swimming capabilities were recorded (Table 2) for one minute. The values were multiplied to derive the final PCS rate, which ranged from 0 (least survival, dead) to 1 (highest survival). Ethics clearance was received from Animal Ethics Committee at Dakshin Foundation to handle live individuals.

Table 2. Indices used to estimate PCS rates for four arbitrary survival categories (Source: Braccini *et al.*, 2012 and Manire *et al.*, 2001)

| Index | Description | Survival category | | | |
|---|---|---|---|---|---|
| | | High | Moderate | Low | Nil |
| Observations made before release | | | | | |
| Activity and stimuli | Physical activity and response to stimuli | 1 (strong and lively, flopping around, shark can tightly clench jaws, no stiffness) | 0.66 (weaker movement, but still lively, response if stimulated or provoked, shark can clench jaw, no stiffness) | 0.33 (intermittent movement, physical activity limited to fin ripples or twitches, little response to stimuli, body appears limp but not in rigor mortis, some stiffness) | 0 (shark in rigor mortis or dead and limp, stiff and lifeless, no physical activity or response to stimuli, jaws hanging open) |
| Wounds and bleeding | Presence of wounds and bleeding | 1 (no cuts or bleeding observed) | 0.66 (1-3 small cuts or lacerations not deep only on skin, some bleeding but not flowing profusely, no exposed or damaged organs) | 0.33 (>3 small cuts or one severe cut or wound, some bleeding but not flowing profusely, little organ exposure and if exposed, organs are undamaged) | 0 (extensive small cuts or very severe wounds or missing body parts, excessive bleeding, blood flowing freely and continuously in large quantities, internal organs exposed and damaged, may be protruding) |
| Sea lice | Skin damage and sea lice | 1 (no penetration of body by sea lice, body is intact) | 0.66 (minor penetration of body by sea lice) | 0.33 (moderate body penetration, but sea lice mostly on the cloaca area) | 0 (extensive penetration of body via eyes, cloaca, gills and/or skin, sea lice ate tissue) |
| Skin damage and bruising | Skin damage and surface bruising by physical trauma | 1 (0% of skin body damage or bruises or redness) | 0.66 (<5% of skin body damage or bruises or redness) | 0.33 (5-40% of skin body damage or bruises or redness) | 0 (>40% of skin body damage or bruises or redness) |
| Observations made upon release | | | | | |
| Physical response | Physical response immediately upon release in water | 1 (no revival time required when shark was returned to the water; rapid swimming upon release, usually with a vigorous splash) | 0.66 (short revival time of up to 30 seconds required; once revived slow and sometimes atypical swimming upon release) | 0.33 (long revival time >30 seconds required; once revived limited or no swimming observed upon release but respiration functional) | 0 (dead upon release; unable to revive after a long submergence time) |

Values range from 0-1 for individual categories and final result.

 

## *Data analysis*

For each set of comparisons, we carried out non-parametric Kruskal Wallis and Dunn tests as the data did not meet the assumption of normal distribution. We also conducted correlations between sampled individual lengths and PCS rate. All analyses were conducted on R Studio (3.5.3). The packages used were Dunn.test (Dinno, 2017), dplyr (Wickham *et al.*, 2019), ggpubr (Kassambara, 2019) and ggplot2 (Wickham, 2016).

# Results

We sampled 41 (of 210) individuals of *C. arabicum* and 11 (of 55) individuals of *C. griseum*, which were encountered alive (Fig. 1). *C. arabicum* recorded an average PCS rate of 0.158 ± 0.13, while *C. griseum* had an average PCS rate of 0.114 ± 0.07 (Fig. 2). Males of *C. arabicum* (n = 21) recorded an average length of 53.7 ± 10.1 cm while females (n = 20) recorded 56.0 ± 9.0 cm. For *C. griseum*, males (n = 5) and females (n = 6), we recorded an average length of 52.3 ± 10.6 cm and 44.5 ± 9.2 cm respectively.

## *Effects of gear type*

For *C. arabicum,* those caught in gill nets had the highest PCS rates (Kruskal Wallis Test Statistic, KW H = 8.23, $p < 0.05$) while for *C. griseum,* those caught in trawl nets (KW H = 6.68, $p < 0.05$) had the highest PCS rate (Fig. 3). Comparing both, *C. arabicum* had a significantly higher PCS than *C. griseum* in gill nets (KW H = 6.05, $p < 0.05$). For both species pooled, PCS was found to be slightly higher in gillnets (0.18) compared to trawl nets (0.14).

## *Effects of gear type, size and maturity*

There was no relationship between PCS rates and individual length in different fishing gear (p values > 0.1). The average PCS values for males caught in gill nets, hook and line, and trawlers were 0.21, 0.12 and 0.17 compared to those of 0.17, 0.06 and 0.12 for females (Fig. 4). The differences in PCS rates across and in each fishing gear were not significant ($p > 0.1$). The differences in PCS rates for maturity stages across fishing gears and within each fishing gear across maturity stages were also not significant ($p > 0.1$).

Fig. 1. A bamboo shark (*Chiloscyllium griseum*) sampled for the study

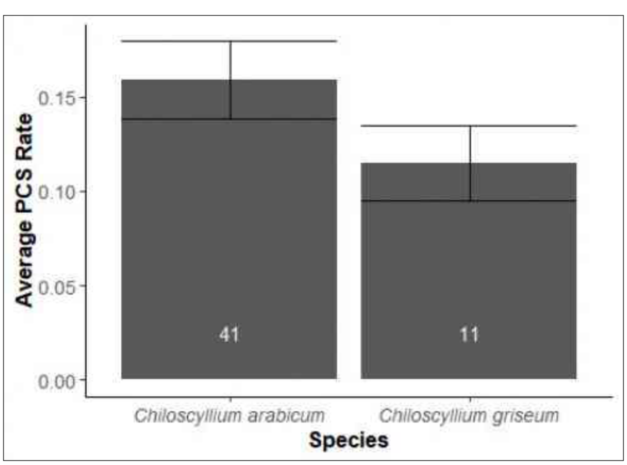


Fig. 2. Average PCS rate for each study species. The error bars represent the standard error of PCS rate for each species. Values at the base of the bars represent the sample sizes

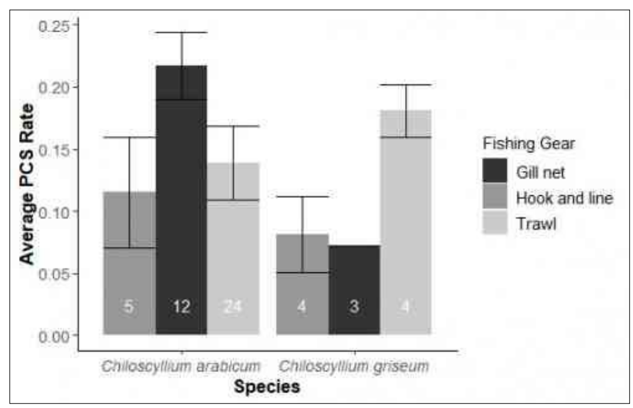


Fig. 3. Average PCS rate for each study species in each fishing gear. The error bars represent the standard error of PCS for each fishing gear. Values at the base of the bars represent the sample sizes.

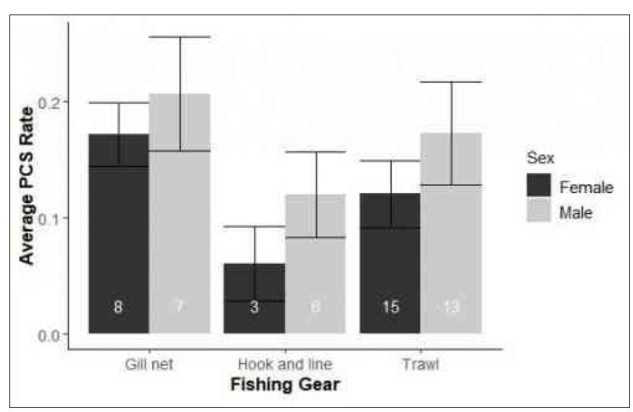


Fig. 4. Average PCS rate of each of the sexes in each fishing gear for both the species pooled. The error bars represent the standard error of PCS rate for each of the sexes. Values at the base of the bars represent the sample sizes

## Discussion

The physical condition of individuals is important to ensure their continued survival after release from fishing vessels. The present study found that PCS rates vary between species and fishing gear and are important indicators of survivorship. Modes of respiration, especially in elasmobranchs, differ between species. Sharks with buccal pump respiration (with spiracles) respire while stationary (Dapp *et al.*, 2016) while others, with obligate ram ventilation, have to keep swimming (reduced branchiostegal systems). Thus, when captured, those with stationary respiration survive better (Manire *et al.*, 2001). Exceptions exist as species such as *Carcharhinus leucas* (bull shark) and *Parascyllium ferrugineum* (rusty carpet shark) show buccal pump with absent/reduced spiracles while *Galeocerdo cuvier* (tiger shark) switches between the two modes (Heupel and Simpfendorfer, 2011).

The ability to survive hypoxic conditions also influences survival. Species such as brown-banded bamboo shark (*C. punctatum*) and epaulette shark (*Hemiscyllium ocellatum*) are hypoxia tolerant and can survive up to half a day and 3.5 hours out of water, respectively (Stensløkken *et al.*, 2004). This was also observed in the present study. Though no onboard fishing vessel surveys were possible, both species were found to survive at least 1-3 hours out of water. Carpet sharks (bamboo sharks) do so by increasing haematocrit, erythrocyte count and haemoglobin concentration while epaulette sharks reduce mean corpuscular haemoglobin concentration (Chapman and Renshaw, 2009). Their gills and heart can compensate for lack of oxygen and conserve energy while those that cannot show metabolic depression remain vulnerable to capture induced hypoxia (Renshaw, 2002). The *Chiloscyllium* sp. individuals in the present study are likely to be similarly hypoxia tolerant and hence can survive several hours outside water upon capture. This is because bamboo sharks (*Chiloscyllium* sp.) and epaulette sharks (*Hemiscyllium* sp.), belonging to the same family Hemiscylliidae, are closely related (Dudgeon *et al.*, 2020) and inhabit similar habitats such as intertidal and shallow coastal waters.

The slightly higher PCS (for both species combined) in gillnets could be due to the dominance of *C. arabicum* in the sample. The low survival rate of individuals in trawl nets as compared to gill nets for *C. arabicum* could be attributed to asphyxiation caused by compaction (weight) of catch (Dapp *et al.*, 2016). Whereas for *C. griseum*, the low PCS rate in gill nets could be due to frequent bouts of struggling during capture (Frick *et al.*, 2010). Within gill nets, *C. arabicum* had a higher survival ability than *C. griseum*. *C. griseum* is an inshore bottom dwelling species while *C. arabicum* is both an inshore and offshore species suggesting its hardy nature (Compagno, 2001). However, little is known about their biology and ecology and hence it is difficult to explain the differences in survival rate. No significant differences were observed for hook and line and between maturity stages, sexes and sizes. Young sharks are most vulnerable (Heupel and Simpfendorfer, 2011) suggesting that they may have lower survival rates but this requires further study.

Our study suggests that the PCS rates may vary between individuals and species and are influenced by the type of fishing gear employed. Thus, conservation efforts need to focus on preventing capture. However, for bamboo sharks (and related species), post-capture release may be a viable conservation strategy as capture avoidance may be difficult. Furthermore, our assessments were carried out at landing centres and survival would likely be higher if the animals are released immediately after capture onboard. Such studies will help understand the survival abilities of different species in different life stages and contribute toward informed conservation decisions. Our findings show that post-capture release for bamboo sharks, especially for juveniles, might be effective in reducing the impacts of fisheries on the population. Along with post-capture release, conservation efforts can also focus on increasing selectivity of fishing gears to prevent the capture of species and life stages most vulnerable to post-capture mortality. This can be coupled with controlled fishing efforts and quotas in commonly used aggregation grounds to reduce capture. Future research can focus on species level variation for *Chiloscyllium* species, as well as other threatened elasmobranchs that are commercially fished. Studies involving tagging of these species can provide more knowledge of their survival, which can aid conservation efforts.

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