

## Short Communication

**First documented southern transatlantic migration of a blue shark *Prionace glauca* tagged off South Africa**C da Silva<sup>1\*</sup>, SE Kerwath<sup>1,2</sup>, C Wilke<sup>1</sup>, M Mejer<sup>3</sup> and SJ Lamberth<sup>1,4</sup><sup>1</sup> Branch Fisheries, Department of Agriculture, Forestry and Fisheries, Private Bag X2, Rogge Bay 8012, South Africa<sup>2</sup> Department of Zoology, University of Cape Town, Private Bag X3, Rondebosch 7701, South Africa<sup>3</sup> Oceans and Coasts, Department of Environmental Affairs, Private Bag X2, Rogge Bay 8012, South Africa<sup>4</sup> South African Institute for Aquatic Biodiversity, Private Bag 1015, Grahamstown 6140, South Africa

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The first documented recapture of a South African-tagged juvenile blue shark *Prionace glauca* off Uruguay lends weight to the hypothesis of a single blue shark population in the South Atlantic. The presence of neonate blue sharks with umbilical scars and females with post-parturition scars, as well as the high frequency of small juveniles in research longline catches, confirm the existence of a parturition and nursery area off South Africa. The final positions of three tagged sharks suggest that large-scale movement patterns in the South Atlantic are a mirror image of movements in the North Atlantic, with sharks using the north-westerly Benguela Drift to migrate into the tropics and ultimately across into South American waters. The confirmed existence of a parturition and nursery area off the south coast of South Africa and the movement of sharks into both adjacent ocean basins suggest the possibility that the southern African blue sharks are part of a single stock that straddles the South Atlantic and Indian oceans and possibly the entire Southern Hemisphere.

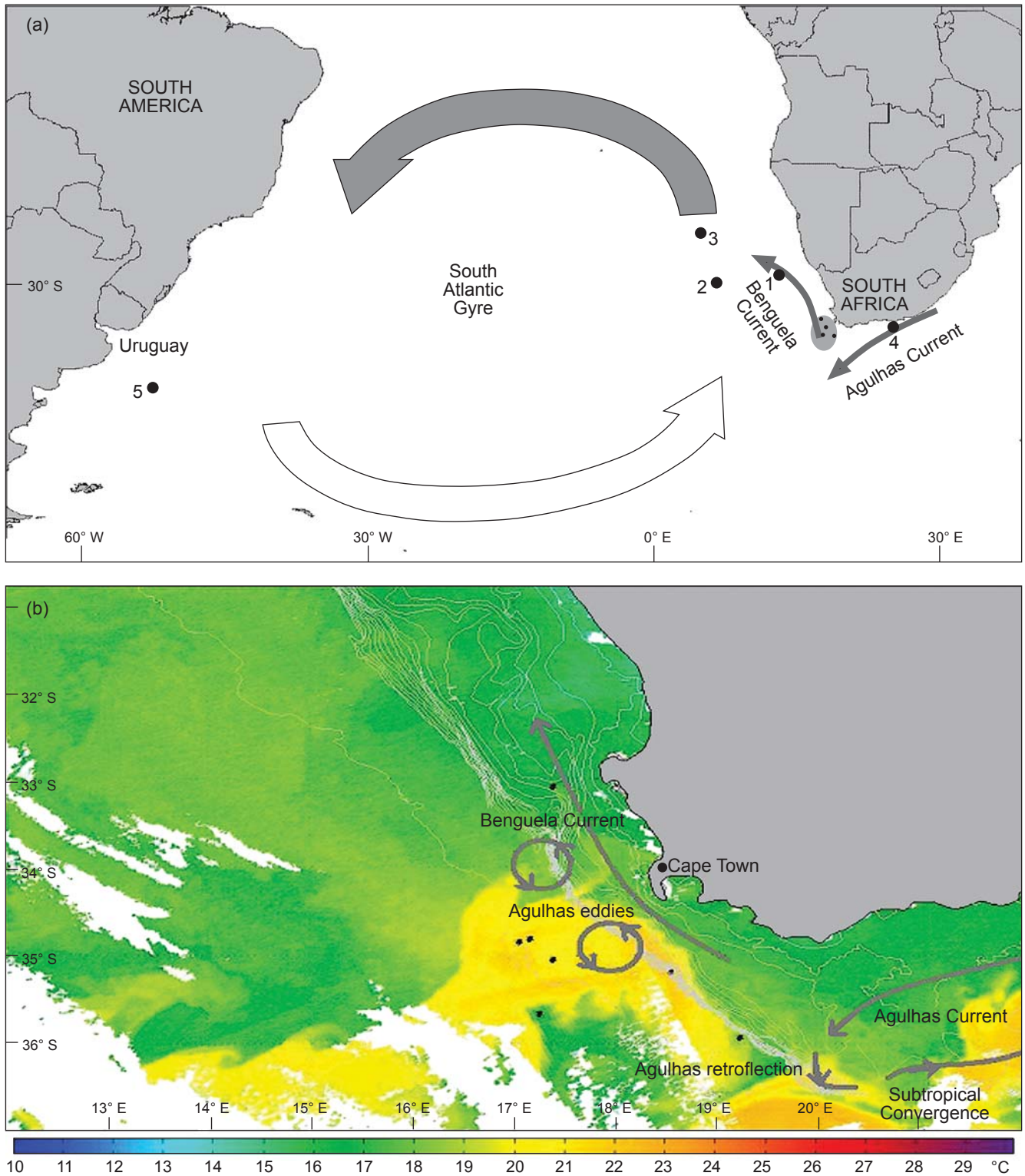
**Keywords:** blue shark, length frequency, migration, nursery area, *Prionace glauca*, South Atlantic**Introduction**

The blue shark *Prionace glauca* is a wide-ranging, circum-global species (Compagno 1984) in tropical, subtropical and temperate seas (Bigelow and Schroeder 1948) and has the widest geographic distribution among all sharks (Lessa et al. 2004, Stevens et al. 2010). This highly mobile shark is oceanic-epipelagic and fringe-littoral (Compagno 1984) and undergoes seasonally different horizontal (Sciarrotta and Nelson 1977, Stevens 1990) and daily vertical migrations (Stevens et al. 2010), which is heavily influenced by migration of their prey (Carey et al. 1990), water temperature (Nakano 1994) and reproductive state (Stevens 1976, Hazin et al. 1994). Tag and recapture telemetry and satellite tracking data on blue sharks suggest complex, long-distance migrations related to size and sex, which include movements across major oceans (Casey 1985, Kohler et al. 1998). Crossings of ocean basins have been reported for the blue sharks in the southern Indian Ocean in a westward direction, the southern Pacific in an eastward direction, the northern Pacific in a westward direction (Cox and Francis 1997, West et al. 2004), and the northern Atlantic in both westward and eastward directions (Casey 1985,

Kohler et al. 1998). Here, we provide the first documentation of a trans-ocean migration in the South Atlantic of a blue shark, tagged off South Africa and recaptured off Uruguay.

**Methods**

A total of 441 blue sharks was caught and tagged off South Africa during three separate pelagic longline research surveys: in June 2008, October 2008 and June 2009. All sharks were captured from the RS *Ellen Khuzwayo*, using drifting pelagic longline fishing gear similar to American commercial operations of a monofilament main line set with a Lindgren Pitman spool off the stern of the ship. Sharks in visibly good condition were tagged with conventional dart tags (Hallprint Pty Ltd), and were measured and sexed before release. Selected sharks were tagged with MK10 pop-up archival tags (PAT, Wildlife Computers Inc., Redmond, Washington). All mortalities were dissected for biological analyses. Features such as umbilical and parturition scars were noted.



**Figure 1:** (a) Map of the South Atlantic showing the major currents. The ellipse denotes the tagging area, recapture or final pop-up tag positions individually shown for the five sharks; (b) map of the ocean off south-western South Africa showing bathymetry and common oceanographic features. Black dots denote research longline fishing positions in 2008 and 2009. Sea surface temperature from early June 2009 is superimposed. The warm water south-east of Cape Town indicates the formation of an Agulhas ring, a mass of warm Indian Ocean water that enters the Atlantic Ocean in form of an anticyclonic eddy

Length frequencies of blue sharks caught commercially and reported by the South African Pelagic Longline National Observer Programme were separated into two regions, South-West Indian Ocean and the South-East Atlantic Ocean. Length frequencies from catches in October 2008 and 2009 and June 2008 and 2009 were compared to length frequencies of the sharks caught during the research surveys in those respective months.

## Results and discussion

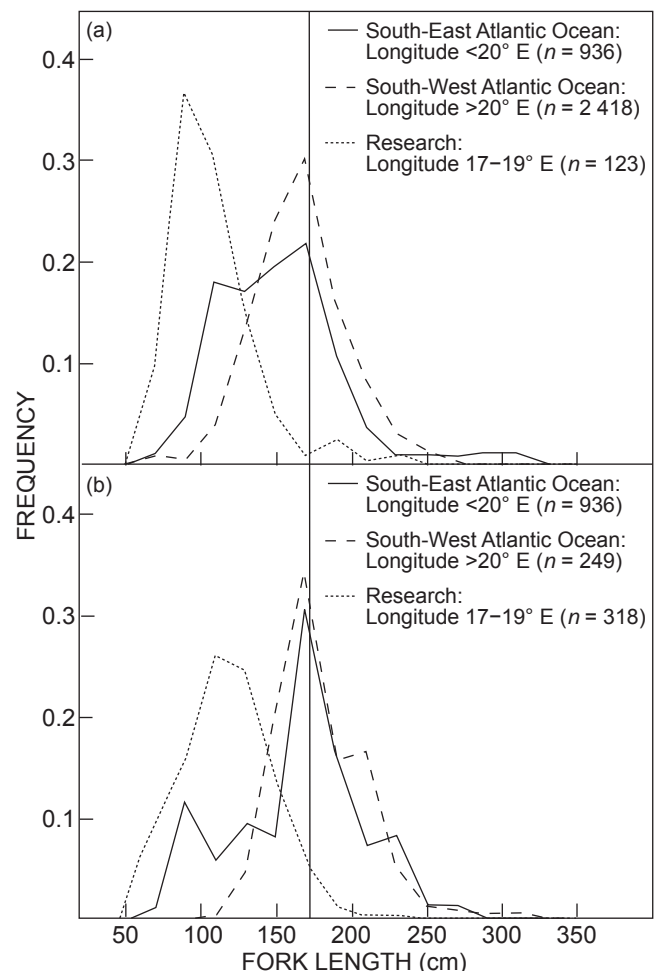
The recapture of a small juvenile (923 mm FL) male blue shark off Uruguay (41°19'00" S, 52°28'00" W; Figure 1a), which was dart-tagged off the Cape of Good Hope (35°42'31" S, 17°53'22" E) on 27 October 2008, represents the first confirmed crossing of the South Atlantic by this species. This finding supports the hypothesis of a single blue shark stock in the South Atlantic Ocean (Hazin 2000, Montealegre-Quijano and Vooren 2010). Northern transatlantic movements of blue sharks are common leading to the assumption of a single North Atlantic stock, and is managed as such (Casey 1985, Kohler et al. 2000). Hazin et al. (2000) suggested that the parturition area for the South Atlantic stock is situated in the South-East Atlantic, within the Benguela upwelling region and bounded by the subtropical convergence.

Small juveniles with open umbilical scars were observed during the surveys in 2008 and 2009, at positions 34°02'24" S, 17°41'12" E and 34°50'15" S, 18°05'27" E) respectively. During the latter survey, a single large female with uterine post-parturition scars was caught. These findings, coupled with the high frequency of small juveniles caught on longline gear during the surveys, which were of similar length frequencies than those from South-West Indian and South-East Atlantic commercial longline catches within the same time period, confirms the existence of a parturition area off South Africa (Figure 2). Parturition and nursery areas have been reported from the North-East Atlantic (Pratt 1979), the North Pacific (Nakano 1994), and the South-West Atlantic (Montealegre-Quijano and Vooren 2010), and they seem to be associated with oceanic fronts with large horizontal temperature gradients and high productivity, such as at subtropical and polar convergences. The parturition area off South Africa is no exception, with all juveniles being caught within the Benguela/Agulhas Current transition filaments (Figure 1b). The temperature at depth of capture, measured with Vemco minilog (Amirix Systems Inc.) temperature pressure sensors, varied between 16 and 20 °C, within the preferred temperature range of 16–18 °C for small juvenile blue sharks (Montealegre-Quijano and Vooren 2010).

Although large-scale longitudinal movements are common in blue sharks, there seems to be limited exchange across the Equator (Mejuto et al. 2005). The comprehensive North Atlantic tagging datasets suggest a clockwise circular migration associated with oceanic gyres, as well as smaller oceanographic features such as Gulf Stream eddies (Carey et al. 1990). The final positions of three sharks tagged with conventional and MK10 PAT tags off

the Cape of Good Hope (Table 1, Figure 1a) suggest that a similar pattern, mirroring those in the North Atlantic, might exist in the South Atlantic with sharks using the Benguela Drift in a north-westerly direction to migrate into the tropical South Atlantic and ultimately across into South American waters. Blue sharks appear to rely on ocean currents to accomplish extensive migrations (Stevens 1976). In this regard, it is noteworthy that countercurrent migrations were never observed during a tracking study of these sharks in the North-East Atlantic (Carey et al. 1990).

One PAT-tagged adult male blue shark moved eastwards and its final position was recorded on the inside edge of the Agulhas Current, in the Indian Ocean (34°39'13" S, 25°08'22" E; Figure 1a). This suggests possible intermixing of Indian Ocean and South Atlantic Ocean blue shark stocks, which has implications for stock management. The South African EEZ straddles the jurisdiction boundary (20° E) of the two regional management forums (i.e. the



**Figure 2:** Length-frequency distribution of *Prionace glauca* longline catches from South African-based vessels in the South-East Atlantic, the South-West Indian Ocean and those from two research longline surveys in the Atlantic–Indian confluence zone (17–19° E) in (a) winter (June 2008 and 2009) and (b) summer (October 2008 and 2009). The vertical line illustrates approximate size at maturity

**Table 1:** Size, sex and maturity of recaptured blue sharks showing days at liberty and total linear distance travelled between capture and recapture positions

Shark #	Fork length (mm)	Sex	Days at liberty	Distance travelled (km)	Tagging date	Recapture position
1	1 992	M	158	552	26 October 2008	34°39'22" S, 25°08'39" E
2	2 125	M	100	752	6 July 2009	29°26'28" S, 13°12'11" E
3	2 047	F	27	1 215	8 July 2009	30°16'48" S, 06°35'56" E
4	1 079	M	81	1 583	23 June 2008	25°00'00" S, 05°00'00" E
5	923	M	512	5 991	27 October 2008	41°19'00" S, 52°28'00" W

International Commission for the Conservation of Atlantic Tuna and the Indian Ocean Tuna Commission) and South African blue shark catches for assessment purposes are divided accordingly when reported to the respective Regional Fisheries Management forums. The possibility of a parturition and nursery area off the Cape and the movement of sharks into both adjacent ocean basins suggest that this division might not be appropriate for stock assessment purposes. Based on our observations and other tag-recapture information in the western South Pacific (West et al. 2004), we suggest that the South African blue sharks are part of a single stock that straddles the South Atlantic and the Indian Ocean, and possibly the entire Southern Hemisphere.

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