UPDATED US CONVENTIONAL TAGGING DATA BASE FOR ATLANTIC BLUE MARLIN (1955-2008), WITH COMMENTS ON POTENTIAL STOCK STRUCTURE

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SUMMARY

The U.S. conventional tagging data base for Atlantic blue marlin, Makaira nigricans*, consists of data from the NOAA Southeast Fishery Science Center's Cooperative Tagging Center (CTC 1955-2008), The Billfish Foundation (TBF 1990-2008), and the South Carolina Department of Natural Resources (SCDNR 1987-2008) tagging programs. We examined the patterns of blue marlin tag release and recapture results in the Atlantic Ocean from the aforementioned programs using a composite analysis. In addition, we discuss tagging results and other data that might provide insight into Atlantic blue marlin stock structure and species distribution.*

RÉSUMÉ

*La base de données de marquage conventionnel des Etats-unis en ce qui concerne le makaire bleu de l'Atlantique (*Makaira nigricans*) est composée de données provenant du Cooperative Tagging Center (CTC 1955-2008,) du Southeast Fishery Science Center de la NOAA et du Billfish Foundation (TBF 1990-2008) et des programmes de marquage du South Carolina Department of Natural Resources (SCDNR 1987-2008). Nous avons examiné les modes des résultats d'apposition des marques sur les makaires bleus et de leur récupération dans l'océan Atlantique, obtenus des programmes susmentionnés à l'aide d'une analyse composite. En outre, nous discutons des résultats de marquage et d'autres données susceptibles de nous éclairer sur la structure du stock et la distribution spécifique du makaire bleu de l'Atlantique.*

RESUMEN

La base de datos de marcado convencional estadounidense para la aguja azul del Atlántico, Makaira nigricans*, consiste en datos del Centro de marcado cooperativo (CTC, 1955-2008) del Centro de ciencias pesqueras del Sudoeste de la NOAA, de The Billfish Foundation (TBF, 1990-2008) y de los programas de marcado del Departamento de recursos naturales de Carolina del Sur (SCDNR, 1987-2008). Se han examinado los patrones de los resultados de marcado y recaptura de aguja azul en el Atlántico de los programas mencionados utilizando un análisis compuesto. Además, se discuten los resultados de marcado y otros datos que podrían proporcionar información sobre la estructura y la distribución de especies del stock de aguja azul del Atlántico.*

KEYWORDS

Blue marlin, tagging, size composition, geographical distribution
stock assessment, fishery management

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1. Introduction

For over a century, mark-recapture studies have been used as an effective low cost method to document fish movements (Arnold and Dewar 2001). Mark-recapture studies are particularly useful with rare event species, such as billfish, which are difficult to monitor. The Cooperative Tagging Center (CTC) has been continuously supplying recreational and commercial fisherman with tagging kits since its development by Frank J. Mather III of Woods Hole Oceanographic Institution (WHOI) in 1954 (Scott et al. 1990). The program was initially known as the Cooperative Game Fish Tagging Program (CGFTP) and primarily targeted bluefin tuna *Thunnus thynnus*. The CGFTP quickly expanded to include other pelagic species such as blue marlin *Makaira nigricans*, white marlin *Tetrapturus albidus*, sailfish *Istiophorus platypterus*, Swordfish *Xiphias gladius*, yellowfin tuna, *T. albacares*, albacore tuna *T. alalunga*, bigeye tuna *T. obesus* and blackfin tuna *T. atlanticus*. In 1978, the tagging program was transferred to the Southeast Fisheries Science Center (SEFSC) in Miami, FL and has since been known as the Cooperative Tagging Center (CTC). In 1986, The Billfish Foundation (TBF) was founded with the intent of conserving and enhancing worldwide billfish populations. To help accomplish these goals TBF started their own constituent-based tagging program in 1990 which promoted the tag and release of istiophorid billfishes and swordfish. Through a memorandum of understanding (1990), the CTC and TBF agreed to use similar tagging protocols to expedite future analyses. While the CTC and TBF account for the overwhelming majority of blue marlin tag releases, other programs that do not specifically target blue marlin, such as the South Carolina Department of Natural Resources (SCDNR) marine game fish tagging program, have constituents who opportunistically tag billfish (Davy 1994). The objectives of this document are to provide a summary and update of the tag and release records available for Atlantic blue marlin, as well as comment on movements and distribution throughout the Atlantic which might provide insights into stock structure of this species in the Atlantic Ocean.

2. Materials and methods

Early tag designs used by the CTC consisted of streamer tags affixed to stainless steel anchors. In a collaborative effort, the CTC and TBF developed a medical grade nylon anchor which proved to have a better retention rate than the previous anchor types (Prince et al., 2002). The nylon anchor, which has been used by TBF since 1990, was adopted by the CTC in 1995. The SCDNR continues to use a streamer with a stainless steel anchor, similar to early tag design used by the CTC.

Overall, constituents of the CTC, TBF, and SCDNR programs have been tagging blue marlin since 1955, 1990, and 1987, respectively. Tag and release of fish were conducted by scientific, recreational, and commercial fisherman on an opportunistic basis. Data from all programs were merged for the purpose of providing the summary statistics presented here. The release and recapture location data were plotted on a worldwide map using ArcGIS (ESRI) to allow for removal of non-Atlantic interactions, and graphically present recapture data. ArcGIS Spatial Analyst was used to create relative density profiles of the blue marlin tag release effort.

3. Results

Between 1955 and 2008 the CTC, TBF, and SCDR tagging programs documented 57,287 blue marlin tagged and released in the Atlantic (**Table 1**). Subsequently, 809 (1.41%) of these were recaptured, which is less than the recapture rates observed for Atlantic sailfish (2.05%) and white marlin (1.95%). Although tags have been deployed throughout the Atlantic, the majority of releases have occurred in the western North Atlantic (**Figure 1**). Most recaptures occurred within two years of tagging, but several fish have been recaptured in excess of 12 years (**Figure 2**).

3.1 Historical tag release and tag recaptures by agency

The historical tag release and recapture effort data for Atlantic blue marlin are illustrated in **Figure 3**. Since 1955 the CTC has listed blue marlin as one of its target species. Combined tagging effort rose gradually till it reached a maximum in 1990, after which the number of deployments fell steadily over the next decade (**Figure 3a**). With the formation of TBF in 1990, the majority of tag and release effort shifted to this program. TBF tagging effort reached its pinnacle in 1996, and like the CTC, tagging effort for TBF has steadily declined albeit less precipitously. Historical Atlantic blue marlin recapture rates for the CTC and TBF are 1.08% and 1.71%, respectively (**Table 1**), which is the lowest recapture rate of the istiophorids (Orbesen et al., 2010). Recapture

trends for the CTC and TBF closely follow that of the release effort with maximums occurring in 1999 for both programs (**Figure 3b**).

Unlike the CTC and TBF, the SCDNR tagging program does not directly target istiophorid billfish. Though an ancillary species, the SCDNR constituents have combined to tag and release 1,162 blue marlin during the period 1987-2008, with the peak tagging effort occurring in 1999. Despite a lower number of deployments, SCDNR blue marlin recapture rates were similar to the CTC and TBF programs (**Table 1**) and had a peak in recaptures in 1999.

3.2 Long distance movements

Despite having the lowest recapture rate for Atlantic billfishes, these recaptures indicate that blue marlin have the broadest range of any Atlantic billfish species (Orbesen et al. 2008), with 20 incidents recorded for trans-Atlantic (i.e., crossing the mid-Atlantic ridge) and six incidents showing trans-equatorial movements (**Figure 4**). Blue marlin are also the only species documented for inter-oceanic movement, in this case a single individual moving from the Atlantic into the Indian Ocean.

3.3 Seasonality of tag release activities

For the purpose of this analysis we have divided the Atlantic into quadrants using the equator to define the North/South boundary, and a line representing the midpoint of the Atlantic to define the East/West boundary (50˚N 40˚W, 5˚N 40˚W, 5˚N 30˚W, 0˚ 30˚W, 0˚ 20˚W, 50˚S 20˚W) (**Figure 5**). Tag and release effort in the NW and NE Atlantic had similar distributions with the peak months being May through September. The majority of tag and release effort in the SW and SE Atlantic occurred between November and March.

4. Discussion

Tag release and recapture efforts for blue marlin have sharply declined since previous ICCAT tagging reports from the mid-1990's through 2000 (Bayley and Prince, 1994; Jones and Prince, 1998; Prince et al., 2001). Despite this decline, the current recapture rate was similar to previous reports (1.41%). Conventional tag releases showed a spatial distribution for Atlantic blue marlin ranging from 48˚N to 25˚S. Although no blue marlin were tagged below 25˚S, the blue marlin which crossed into the Indian Ocean was required to pass below 35˚S to round the tip of South Africa. The 2000 ICCAT billfish stock assessment (Anon. 2001), reported 6 trans-Atlantic and 2 trans-equatorial movements for blue marlin from the conventional tagging programs. A decade later, these totals have increased three fold to 20 trans-Atlantic and 6 trans-equatorial movements (**Table 1**), which is consistent with a total Atlantic hypothesis.

Tag and release data are dictated by fishing effort, and although conventional tagging data has illustrated blue marlin have the ability to make both trans-equatorial and trans-Atlantic movements, low fishing effort along migration paths and non-reporting could mask the frequency of long distance movements. Pop-up satellite archival tags (PSATs) deployed by the National Marine Fisheries Service (NMFS) SEFSC revealed trans-equatorial and trans-Atlantic movements occurring in a relatively short time period (<90 d). The fishery independent method of data collection afforded by PSAT's allows for continuous monitoring of fish in areas where conventional tagging effort is minimal (**Figure 4**). While long distance movements have been observed with both conventional and electronic tagging studies, future research with PSAT's could provide a better understanding of possible seasonal migration patterns.

Atlantic blue marlin were originally recognized by ICCAT as two separate stocks (Anon. 1994) with the boundary occurring at 5˚N. The high mobility of Atlantic blue marlin observed in mark recapture studies coupled with a detailed Atlantic-wide genetic analyses of mitochondrial DNA which found no significant heterogeneity between north and south Atlantic samples (Graves and McDowell, 2001, Graves and McDowell 2003), resulted in the ICCAT Standing Committee for Research and Statistics to consider a single Atlantic-wide stock for the 1996 assessment (Anon. 1998). Recent tagging results from both conventional and electronic tagging studies continue to be consistent with a total Atlantic stock hypothesis for this species.

5. References

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Table 1. Conventional tag release and recoveries for blue marlin from the Cooperative Tagging Center (CTC, 1955-2008), The Billfish Foundation (TBF, 1990-2008), and the South Carolina Department of Natural Resources (SCDNR, 1987-2008) tagging programs. The number of trans-Atlantic and trans-equatorial recaptures and the associated percentages (in parentheses) are calculated based on the percentage of recaptures which observed each movement type.

AGENCY	*Released*	*Recaptured*	*% Recaptured*	*Transatlantic*	*Trans-equatorial*
CTC	26,192	283	1.08%	12 (4.24%)	1 (0.35%)
TBF	29,933	512	1.71%	7 (1.37%)	4 (0.78%)
SCDNR	1,162	14	1.20%	1 (7.14%)	1 (7.14%)
Total	57,287	809	1.41%	20 (2.47%)	6 (0.74%)

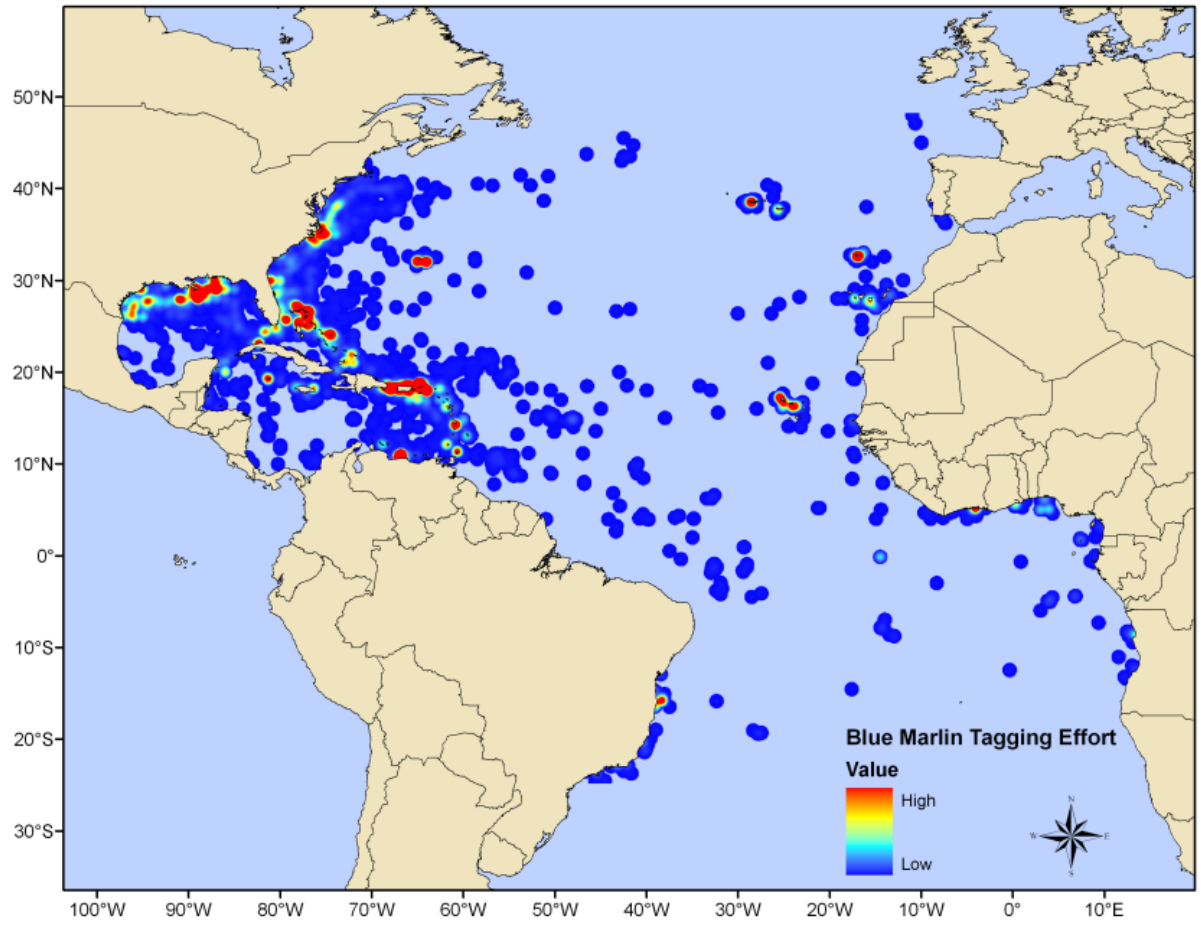


Figure 1. Spatial distribution and relative density tag and release deployment effort for Atlantic blue marlin by constituents of the Cooperative tagging Center (CTC, 1955-2008), The Billfish Foundation (TBF, 1990-2008), and the South Carolina Department of Natural Resources (SCDNR 1987-2008) constituent tagging programs.

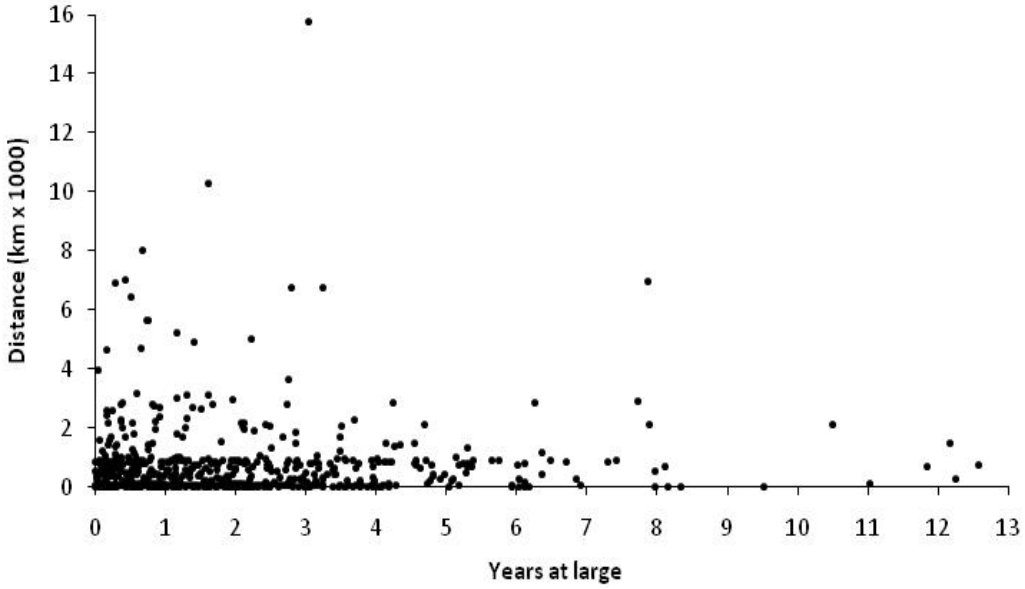
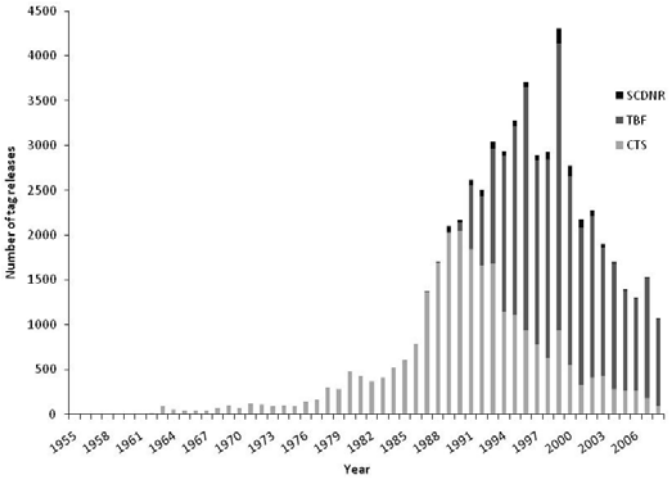


Figure 2. Distance traveled, in relation to days at large for tag recaptured Atlantic blue marlin. Distances were calculated as great-circle arc vectors between release and recapture locations.

a)



b)

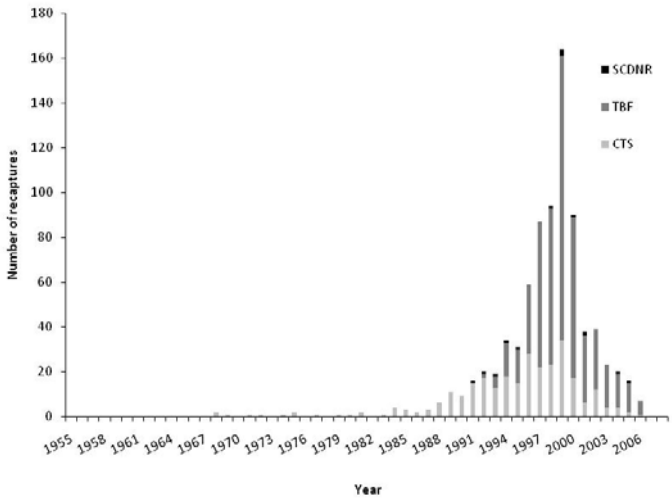


Figure 3. Number of tag releases (a.) and recaptures (b.) for Atlantic blue marlin from the Cooperative Tagging Center (CTC, 1955-2008, shown in light gray), The Billfish Foundation (TBF, 1990-2008, shown in gray), and the South Carolina Department of Natural Resources (SCDNR, 1987-2008, shown in black) tagging programs

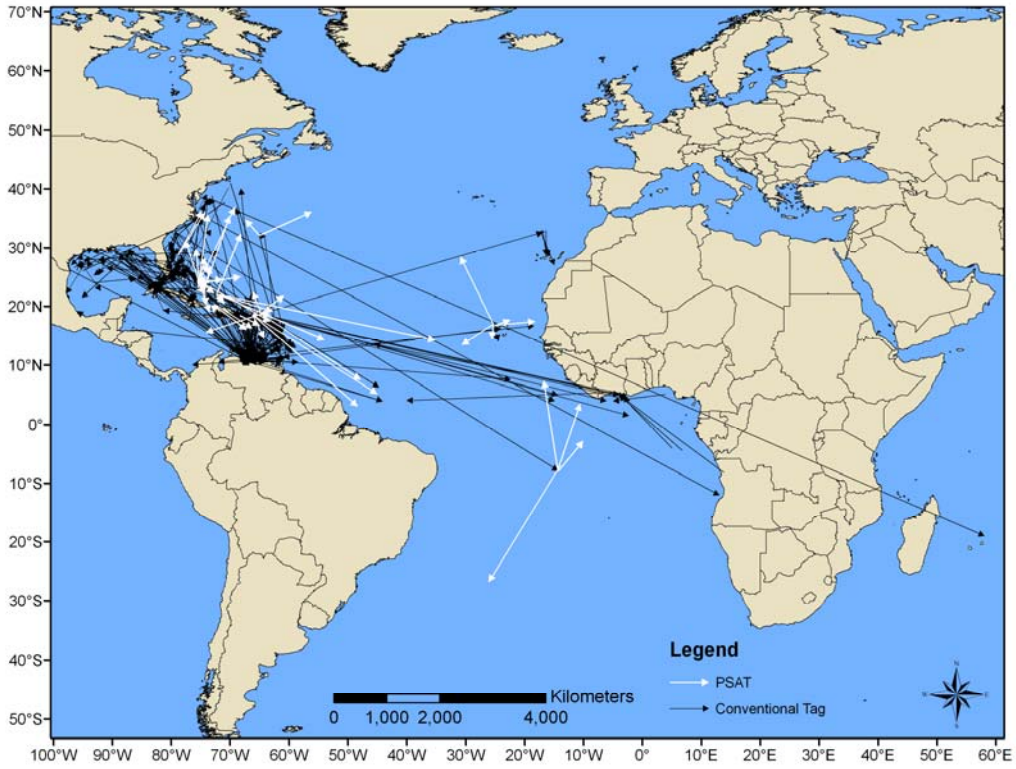


Figure 4. Atlantic blue marlin tag displacements. Black lines represent conventional tag release-recapture displacement vectors from the composite CTC (1955-2008), TBF (1990-2008), and SCDNR (1987-2008) tagging data bases. White lines represent release and pop-up locations derived from the Southeast Fisheries Science Center's popup satellite archival tag (PSAT) database (2002-2006).

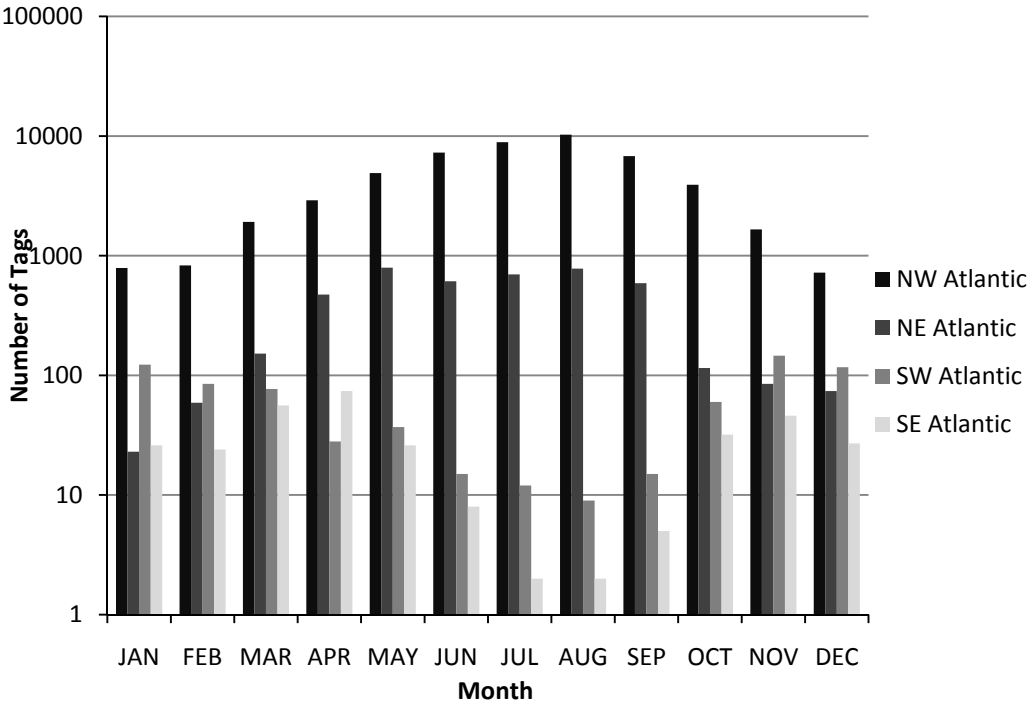


Figure 5. Monthly tag release effort by the CTC, TBF, and SCDNR tagging constituents. Data was divided into quadrants using the equator to define North and South, and a line representing the midpoint of the Atlantic to define the East/West boundary (50˚N 40˚W, 5˚N 40˚W, 5˚N 30˚W, 0˚ 30˚W, 0˚ 20˚W, 50˚S 20˚W). The NW Atlantic is in black, the NE Atlantic is in dark gray, the SW Atlantic is in gray, and the SE Atlantic is in light gray.