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AN UPDATE OF THE TAG RELEASE AND RECAPTURE FILES FOR ATLANTIC WHITE MARLIN

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SUMMARY

An update of the historical tag release and recapture files from western Atlantic tagging programs for Atlantic white marlin (Tetrapturus albidus) *are presented. The primary sources of data are the Southeast Fisheries Science Center's Cooperative Tagging Center (CTC) and The Billfish Foundation (TBF). Limited information was also obtained from the South Carolina Division of Marine Resources (SCDMR), the National Marine Fisheries Service's (NMFS) shark tagging program, and the BOAT U.S. tagging program. Data for white marlin are available from 1954 to 2001 for the CTC, from 1990 to 2001 for TBF, from 1974 to 2001 for SCDMR, from 1962 to 2001 for the NMFS shark tagging program, and from 2000-2001 for BOAT U.S. The tag release and recapture data are presented by agency, species, gear type, and season for the primary programs. We also examine the database as a possible source for information on white marlin growth and for information on white marlin mortality rates. This information is compromised by the fact that an empirically-based growth curve for this species has yet to be developed and due to lack of knowledge about the confounding effects of tag loss or other factors for tagged white marlin.*

RÉSUMÉ

Le présent document fournit une actualisation des données historiques de marquage et de récupération de marques de programmes de marquage menés dans l'Atlantique ouest pour le makaire blanc de l'Atlantique (Tetrapturus albidus)*. Les principales sources de données sont le Cooperative Tagging Center (CTC) du Southeast Fisheries Science Center et The Billfish Foundation (TBF). Une information limitée a également été obtenue de la South Carolina Division of Marine Resources (SCDMR), du programme de marquage de requins du National Marine Fisheries Service (NMFS), et du programme de marquage du BOAT U.S.. Les données relatives au makaire blanc sont disponibles de 1954 à 2001 pour le CTC, de 1990 à 2001 pour le TBF, de 1974 à 2001 pour le SCDMR, de 1962 à 2001 pour le programme de marquage de requins du NMFS, et de 2000-2001 pour BOAT U.S.. Les données de marquage et de récupération de marques sont présentées par agence, espèce, type d'engin, et saison pour les programmes principaux. Nous examinons aussi la base de données comme source éventuelle d'information sur la croissance du makaire blanc et sur les taux de mortalité du makaire blanc. Cette information est compromise par le fait qu'il faut encore mettre au point une courbe de croissance empirique pour cette espèce et que l'on ne connaît pas bien les effets confondants de la perte des marques ou autres facteurs relatifs au makaire blanc porteur de marques.*

RESUMEN

Se presenta una actualización de los archivos históricos de liberación y recaptura de marcas de los programas de marcado del Atlántico occidental para la aguja blanca del Atlántico (Tetrapturus albidus)*. Las fuentes principales de datos son el Centro del Marcado Cooperativo (CTC) del Centro de Ciencia Pesquera del Sudeste y la Fundación de Marlines (TBF). También se*

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obtuvo información limitada de la División de Recursos Marinos de Carolina del Sur (SCDMR), del programa de marcado de tiburones del Servicio Nacional de Pesquerías Marinas (NMFS) y del programa de marcado estadounidense BOAT. Se dispone de datos para la aguja blanca desde 1954 hasta 2001 provenientes del CTC, desde 1990 hasta 2001 del TBF; de 1974 a 2001 de la SCDMR; desde 1962 a 2001 del programa de marcado de tiburones del NMFS y de 2000-2001 del BOAT estadounidense. Los datos de colocación y recuperación de marcas se presentan por agencia, especie, tipo de arte y temporada para los programas principales. También examinamos la base de datos como una posible fuente de información sobre el crecimiento de la aguja blanca y para información sobre tasas de mortalidad de la misma. Esta información se ve comprometida por el hecho de que no se ha desarrollado todavía una curva de crecimiento empírica para esta especie y debido a la falta de conocimiento sobre los efectos de la pérdida de marcas que conducen a confusión o de otros factores derivados del marcado de la aguja blanca.

1. INTRODUCTION

The Cooperative Tagging Center (CTC), formerly known as the Cooperative Game Fish Tagging Program, has been the longest operating tagging program of its type in the world that targets highly migratory species, including Istiophoridae (Scott *et al.*,1990, Ortiz *et al.*, In press). Frank Mather III initiated the CTC in 1954 at the Woods Hole Laboratory and the program was transferred to the Southeast Fisheries Science Center in 1978. Marlin and sailfish have always been among the primary target species of the CTC. In addition to the CTC, The Billfish Foundation (TBF) tagging program also targets istiophorids in the Atlantic Ocean, as well as other water bodies (Peel *et al.*, 1990, Ortiz *et al.*, In press). Other US Atlantic constituent-based tagging programs that opportunistically tag billfish include the South Carolina Marine Resources Department tagging program (Davy 1994), and the National Marine Fisheries Service's (NMFS) shark tagging program (Kohler *et al.*, 1998). Tagging through the auspices of the ICCAT Enhanced Research Program for Billfish has also resulted in an increase in international tagging of istiophorids and other species. The objective of this document is to provide a summary and update of the tag release and recapture records available from the primary Atlantic tagging programs targeting white marlin (*Tetrapturus albidus*). That is to say that the summary is based on the predominant, but not the total data sources for white marlin release and recapture in the Atlantic. In addition, efforts were made to assemble all ancillary Atlantic white marlin tagging data from secondary sources.

2. METHODS

Descriptions of the CTC and TBF tagging programs are given in Scott *et al.*, (1990), Peel *et al.*, (1996), and most recently in Ortiz *et al.* (In press). The tags used by the CTC have changed over the years. Initially, a stainless steel dart tag (1954-1995) was used in the CTC. A medical grade double barb nylon dart tag, developed jointly by NMFS and TBF, was introduced by TBF in 1990 and adopted by the CTC in 1995. Since that time, TBF and CTC have been using the same tagging equipment. The South Carolina Division of Marine Resources (SCDMR) has used the stainless steel dart tag since the program began in 1974 (Davy 1994). The NMFS shark tagging program, operated from the Narragansett laboratory, has also used a stainless steel dart tag since its inception (1962), but this tag was modified using a legend on the capsule that contained the tag number and return address of the agency (Kohler *et al.*, 1998). The SCDMR and NMFS's shark tagging programs (STP) only tag billfishes on an opportunistic basis, whereas the CTC and the TBF tagging programs specifically target billfishes.

Analyses were made of data from the primary and available secondary tagging agencies sources in order to summarize the release and recovery files for white marlin by agency, year and gear. In addition, data are also presented that summarize release information by month to assess the seasonality of tagging activities. Finally, growth was examined by subtracting release length (lower jaw fork length, LJFL) from recapture length and then plotting these values by time at-large. Other measures of length were converted to LJFL using the regressions presented by Prager *et al.*, 1995). The possible effect of refraction on these values was also explored.

The total loss rate of tags (Z) was estimated for four time periods (1961-1969, 1970-1979, 1980-1989, 1990-2001) from the time at large of recovered tags (822 tag recoveries between 1960 and 2000) using the method of Porch (1999). Two models were examined. The first model assumed the recovery rate of recaptured tags has not changed relative to the 1960's, whereas the second model estimated the relative recovery rates (*?*).

3. RESULTS

The release and recovery records for white marlin from the primary (CTC and TBF tagging programs) and secondary (SCDMR, STP) tagging programs are summarized in **Table 1**. From these data a total of 42,681 white marlin have been documented as tagged and 854 have been recaptured in the Atlantic Ocean by the CTC and TBF tagging programs since 1954. The combined recapture percentage for white marlin is 2.03% (both agencies). The TBF recapture percentage for white marlin (2.55 %) is considerably higher than the CTC recapture rate for this species (1.87%) **(Table 1)**. Billfishes tagged incidentally in the SCDMR and STP programs represent much smaller tagging efforts for all billfish species compared to the CTC and TBF tagging programs. There were a total of 994 white marlin tag releases from the three secondary programs from which we obtained data and 17 of these have been documented as recaptured. Overall, the data show 43,673 white marlin have been tagged and released and 871 have been recorded recaptured by these Atlantic tagging agencies. This corresponds to an overall recapture percentage of 1.99%.

The total number of releases and recaptures for the primary agencies increased during the most recent years **(Figure 1)**. However, TBF program has gradually increased release and recapture activities, while the CTC activity has decreased during this same period. The historical trends for release and recaptures by gear type are illustrated in **Figure 2**. Clearly, rod and reel gear dominates tag release activities for both agencies although, since 1978, the CTC has conducted some modest longline release activities. The trends in recapture gear were quite stable for about the first 40 years of the program, with rod and reel and longline gear being the most dominant. In the mid-1990's longline and gillnet recaptures increased, primarily from the fisheries in Venezuela. This increased recapture activity was due, in part, to increased outreach activities through the ICCAT Enhanced Research Program for Billfish in South America. In terms of seasonality, release and recapture activities **(Figure 3)** by the two primary agencies were highest in the warmer summer months of June through October, although white marlin were tagged and recaptured during every month of the year. White marlin releases by gear for the CTC and TBF programs were dominated by rod and reel (91 and 99 %, respectively), although the CTC program did have some significant longline release activity (9%, **Figure 3**). Conversely, recapture gears **(Figure 4)** for the two primary programs showed an increased reliance on longline (40 and 44%, respectively) and gillnet gears (4 and 22%, respectively) and a decrease in the dominance of rod and reel gear (49% and 16% respectively) compared to releases. The Billfish Foundation database did have relatively large numbers of recaptured billfish where gear type was not specified (18%).

Those recaptured white marlin (for which release and recapture locations are available) that noticeably moved from the original site of release are illustrated in **Figure 5**. Displacement vectors, with arrows showing direction of movement, demonstrate that most movements were restricted to the northwest Atlantic, but more ocean-wide movements to the east Atlantic and near the equator also occurred.

The combined white marlin release-recapture database was examined for information on growth. Of the 854 individuals recaptured, the requisite information to calculate change in size (measured in cm) was available for 539 (63%) individuals **(Figure 7)**. Of this group, 227 (42%) (apparently) decreased in recorded length from time of release to time of recapture, 65 (12%) did not change in recorded size and 247 (46%) increased in recorded length **(Figure 7)**. Refraction causes objects observed underwater to appear about one third larger than their true size. This may have been a factor when size was estimated at release during in-water tagging, and thus, may have affected the above estimates of size change. To account for this possibility, we divided size at release by 1.3345 (Austin and Halikis 1976) for records where the length was estimated and re-calculated size changes accordingly **(Figure 7)**. This refractive index correction had the effect of elevating the number of fish that apparently grew while at-large (285, 53%) and decreasing the numbers of fish that appeared to decrease in size (201, 37%) or not grow at all (53, 10%). Both refraction-uncorrected and corrected size changes were then plotted against time at-large **(Figure 8)**. While there was a slight tendency for size to increase over time (at 3.5-3.7 cm yr^{-1}), this relationship was very weak and not statistically significant.

The tagging loss rate analyses resulted in estimates from both models which suggest that the total loss of tagged white marlin has been fairly stable over time at levels of about 0.5 yr^{-1} **(Table 2)**. The estimates of relative reporting rate, on the other hand, increased four-fold. However Akaike's information criterion (AIC) suggests that the reporting rate parameters do not significantly contribute to the model's ability to fit the time at large data (i.e., the estimates of *?* are not statistically different from 1).

4. DISCUSSION

Increases in tag release and recapture activities identified in the last update of the billfish tagging data base (Prince *et al.*, 2001) continued for white marlin through 2002. These improvements have taken place despite a reduction in the available tagging equipment distributed through the CTC in most recent years due to budget constraints. The TBF program has compensated for these shortages, thus allowing the Atlantic-wide program to continue to progress. An overview of all constituent-based billfish tagging programs by Ortiz *et al.* (In press) indicates that the five major programs operating worldwide (including the two primary programs identified here) have also demonstrated increased release and recapture activities, particularly over the last decade. Jones and Prince (1998) also confirmed statistically significant increases in istiophorid tag release and tag recapture activities in the southeast Caribbean Sea after implementation of the ICCAT Billfish Tagging Program (IBTP) in this area. Implementation of the IBTP consisted mostly of establishing outreach activities to publicize the program in known billfishing areas.

Historically, tag recapture percentages for istiophorids have been below 2% from all major tagging agencies operating in the world oceans (Scott *et al.*, 1990; Pepperell 1990; Miyake 1990; Murray 1990; Van Der Elst 1990; Oritz *et al.*, In press). However, some improvements in tag recapture/reporting percentages for Istiophoridae are evident by examining the evolution of the CTC. For example, Scott *et al.*, (1990) reported that the tag recapture percentage for white marlin in the CTC through 1989 was 1.7%. Some years later, Jones and Prince (1998) reported tag recapture/reporting percentages for these species had increased to 1.8% for white marlin by 1996. Further evidence demonstrating improvements in CTC tag recapture percentage are presented in this paper (1.84%). Its interesting to note that the initial TBF recapture/reporting percentages observed for white marlin by Peel *et al.*. (1998) after six years of TBF program operation (1.12%), currently improved to 2.46% for this species **(Table 1)**. The TBF recapture percentage of 2.46% for white marlin represents a milestone in the sense that this is the first tag recapture percentage for an Istiophorid reported by an Ocean-wide program that has exceeded 2%. In addition, the fact that a small artisanal gillnet fishery in Venezuela could account for up to 80% of Atlantic-wide tag recaptures for blue marlin in 1997 (Peel *et al.*, 1998), is another example that demonstrates the effectiveness and potential of implementing proper outreach activities for improving tag recapture/reporting percentages.

The continued improvement of Istiophorid tag recapture/reporting percentages are likely due to numerous factors including: proper identification of critical billfish fisheries; implementation of outreach procedures in these areas (Jones and Prince 1998); and improved tagging equipment which could reduce tag shedding rates (Ortiz *et al.*, In press). Atlantic-wide implementation of outreach procedures have also been aided by the development of the ICCAT Tag Recovery Network (ITRN) first established in 1998 (Prince and Cort 1997). Although the ITRN was established primarily to assist bluefin tuna archival tag recoveries, conventional tag recoveries, including those for billfish, have also benefited from this program. Improved reporting of marlin tag recaptures from longline gear, particularly from the Spanish longline fleet in recent years, is one example of the benefits of the ITRN.

The subject of gaining information on growth from the tagging data has been an issue at previous billfish workshops. In this paper, we attempted to characterize the type of data on growth that might be extracted from the white marlin tagging database. About 37% of the white marlin recaptures were invalid (i.e., no unknown length data for either the release or the recapture records). Of the remaining 539 recaptures, 42% had a smaller size at recapture than release. This apparent negative growth clearly demonstrates the problem of estimating size at release and this problem has been recognized in constituent-based tagging program in the past (Scott *et al.*, 1990; Ortiz *et al.*, In press).

Our attempt to compensate, at least in part, for the apparent over-estimation of size at release using the refractive index correction did increase the number of fish that apparently grew (53%). However, this preliminary analysis cannot be expected to reduce all sources of size estimation error. The problems inherent with a tagging procedure which relies mainly on estimating size at release creates difficulties in extracting growth data. This problem would likely affect any type of billfish tagging program because the large size of billfish makes it difficult to measure length under field conditions. In the future, estimates of fish age should be incorporated into growth analyses of this kind since the magnitude of size change will depend on life stage. A size-at-age curve based on hardpart analysis has not be developed for this species and this stresses the importance of conducting empirical work on white marlin ageing.

The relatively flat trend in total mortality rates is somewhat surprising given that the fishery is believed to have been relatively new during the 1960's. Part of the explanation may have to do with the fact that the total loss rate estimates include factors other than fishing that could affect the expected time until recapture, such as natural mortality, tag shedding and emigration. It is obvious from **Figure 6**, that the predominance of returns are from the western north Atlantic fisheries, while little or no information is available from the balance of the Atlantic fisheries affecting white marlin. It may be that some of these factors have changed over time, counterbalancing the increase in fishing mortality. Tag-shedding in particular is a likely candidate for reducing the total loss rate (apparent Z) with time owing to greater education about how and where to place the tags and the shift to double barb nylon dart tags in the 1990's.

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Table 1. Total white marlin releases and recaptures by Agency, recapture gear, and release gear. Primary tagging agencies include the NMFS Cooperative Tagging Center (MIA) and The Billfish Foundation (TBF). Secondary tagging agencies include South Carolina Department of Marine Resources (SCDMR) and the NMFS Atlantic shark tagging program (STP).

PRIMARY PROGRAMS

RELEASE RECAPTURE DATA

	Initial Release	1st Recapture	1st Re-release	2nd Recapture	Recapture Percentage
MIA	31796	586	49	0	1.84
TBF	10883	268	15	0	2.46
TOTALS	**42681**	**854**	**64**	**0**	**2.00**

RECAPTURES BY GEAR

	Rod & Reel	Longline	Gillnet	Other	Total
MIA	284	237	26	39	586
TBF	43	117	59	49	268
TOTALS	**327**	**354**	**85**	**88**	**854**

RELEASES BY GEAR

	Rod & Reel	Longline	Other	Total
MIA	28952	2780	64	31796
TBF	10745	138		10883
TOTALS	**39699**	**2918**	**64**	**42681**

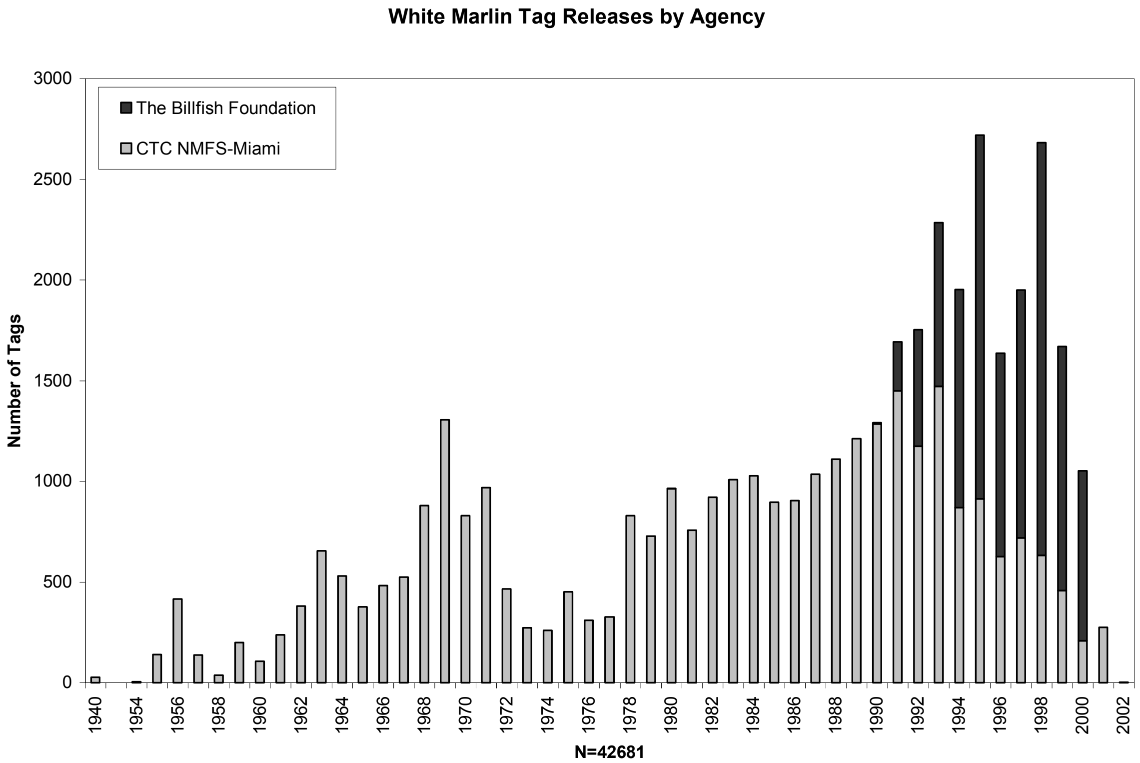
SECONDARY PROGRAMS

RELEASE RECAPTURE DATA

	Initial Release	1st Recapture	Recapture Percentage
SCDMR	409	6	1.47
AST	583	11	1.89
TOTALS	**992**	**17**	**1.71**
GRAND TOTALS	**43,673**	**871**	**1.99**

Table 2. Estimates of total loss rate from the time at large of recovered tags.

Model	Parameter	Time period	Estimate	Std. error	CV
		1961-1969	0.511	0.060	12
		1970-1979	0.523	0.047	9
		1980-1989	0.489	0.038	8
1	Z	1990-2000	0.450	0.031	7
		1961-1969	0.553	0.110	20
		1970-1979	0.571	0.057	10
		1980-1989	0.572	0.057	10
	Z	1990-2000	0.445	0.031	7
		1961-1969	1.000		
		1970-1979	1.219	0.577	47
		1980-1989	2.262	1.420	63
2	λ	1990-2000	4.657	3.290	71



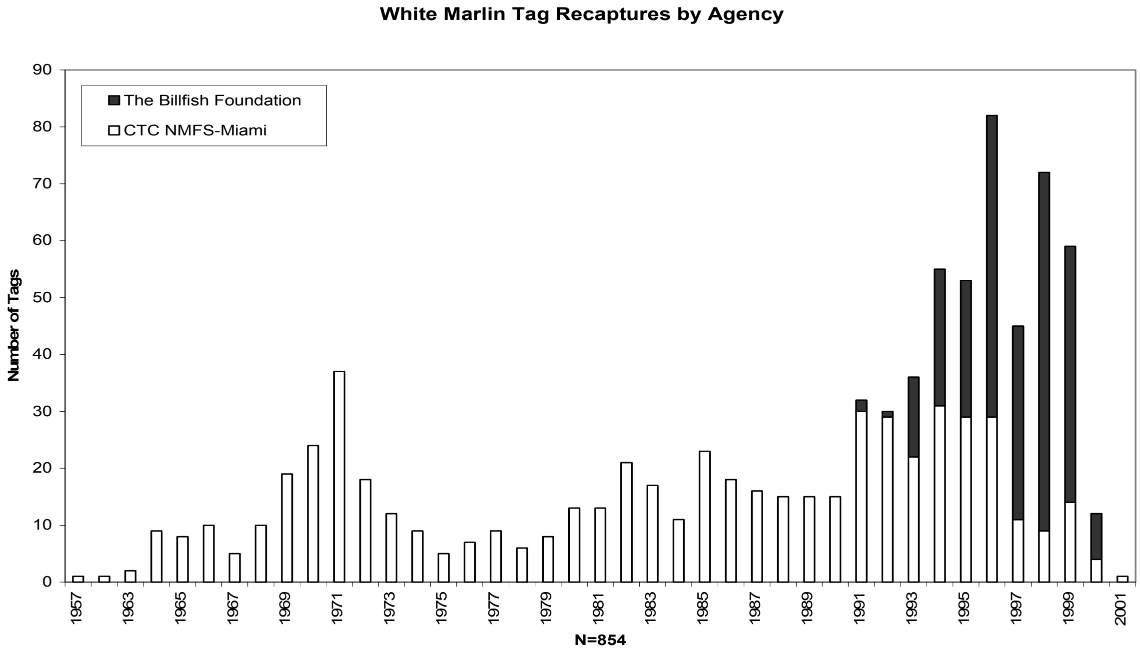
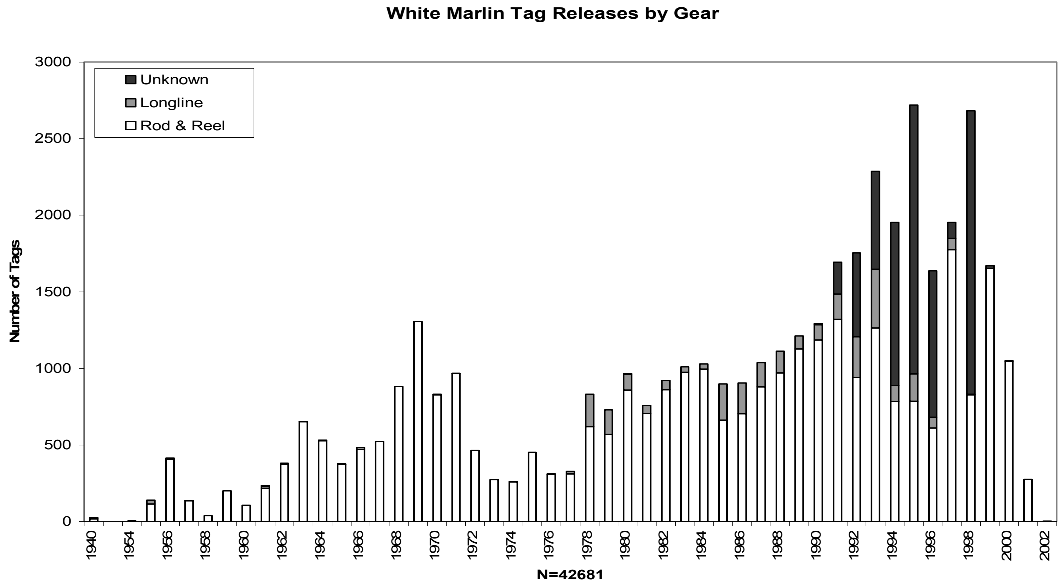


Figure 1. White marlin tag releases (top) and tag recaptures (bottom) by primary tagging agency—NMFS Cooperative Tagging Center and The Billfish Foundation.



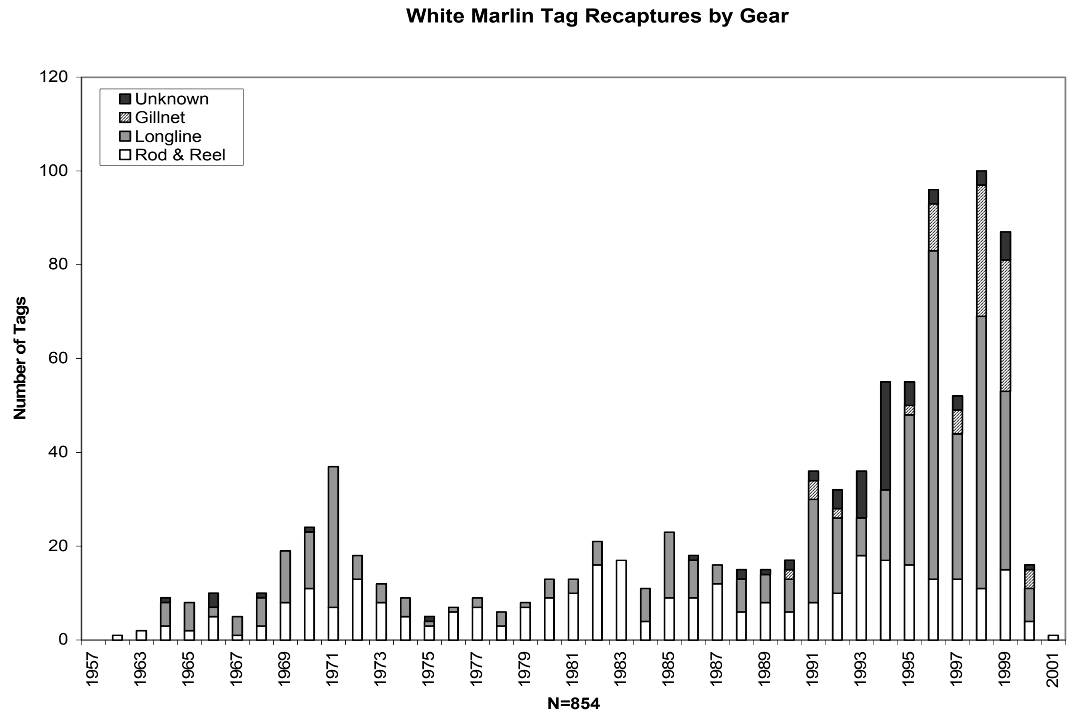
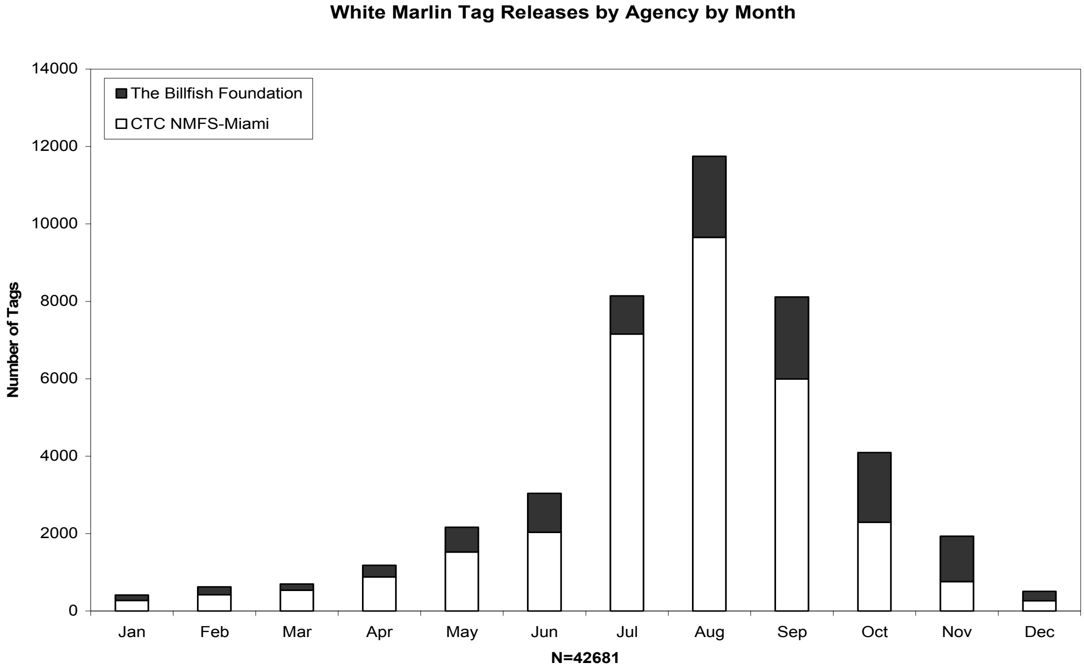


Figure 2. White marlin tag releases (top) and recaptures (bottom) by gear type for the NMFS Cooperative Tagging Center and The Billfish Foundation tagging programs.



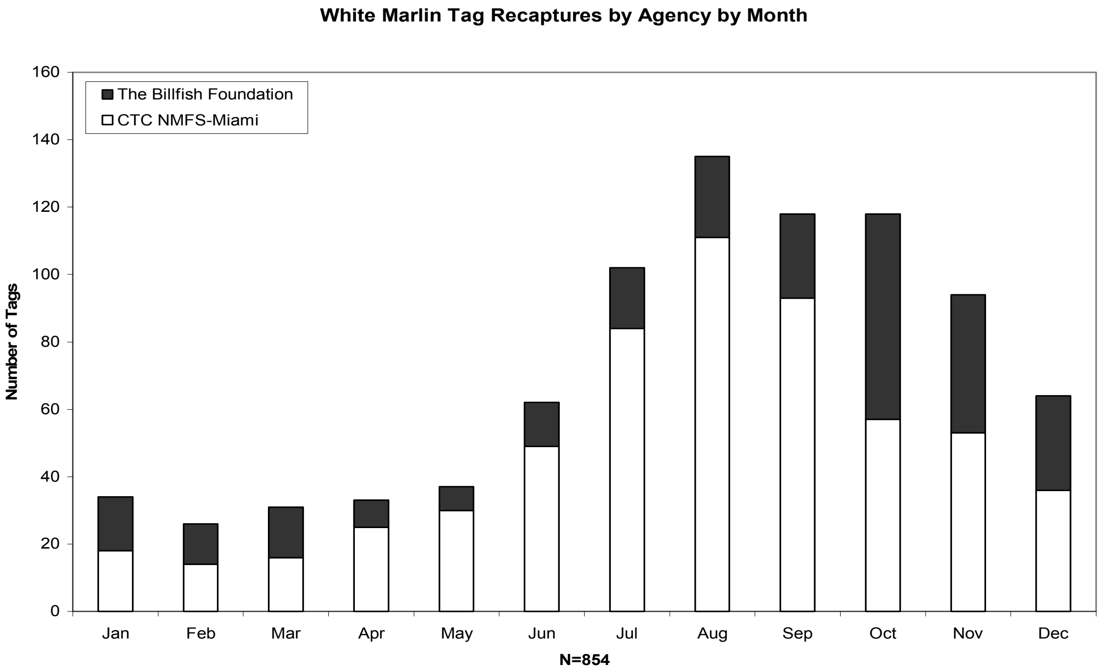
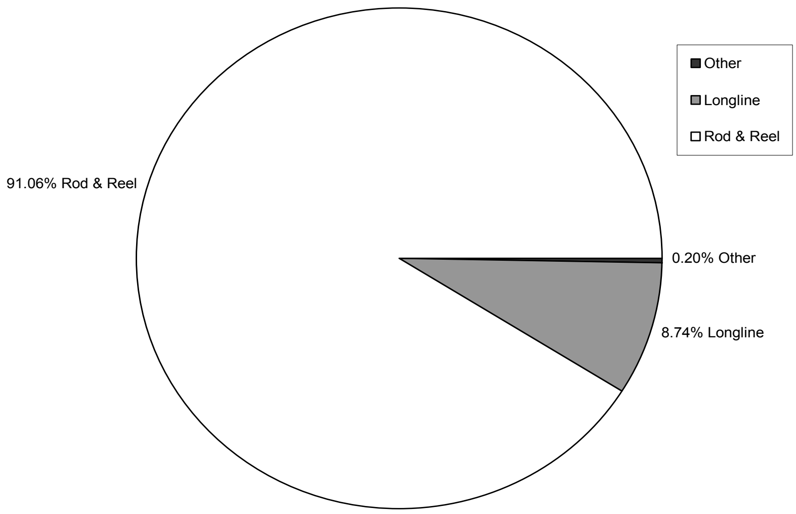


Figure 3. White marlin tag releases (top) and recaptures (bottom) for primary tagging Agencies (NMFS Cooperative Tagging Center and The Billfish Foundation) by month.

CTC NMFS-Miami White Marlin Release Distribution by Gear Type



The Billfish Foundation White Marlin Release Distribution by Gear Type

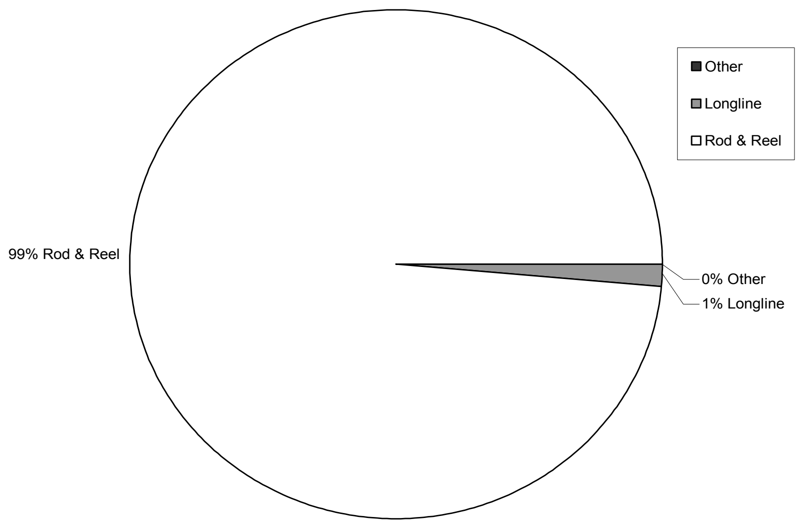
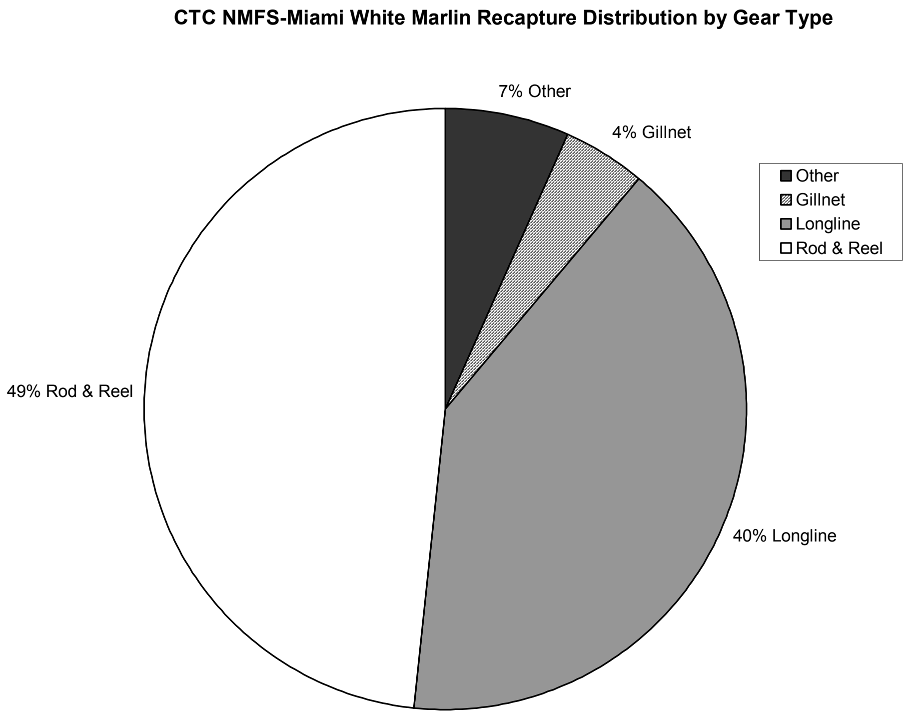


Figure 4. Proportion of tag releases from the NMFS Cooperative Tagging Center (top) and the Billfish Foundation (bottom) by gear type.



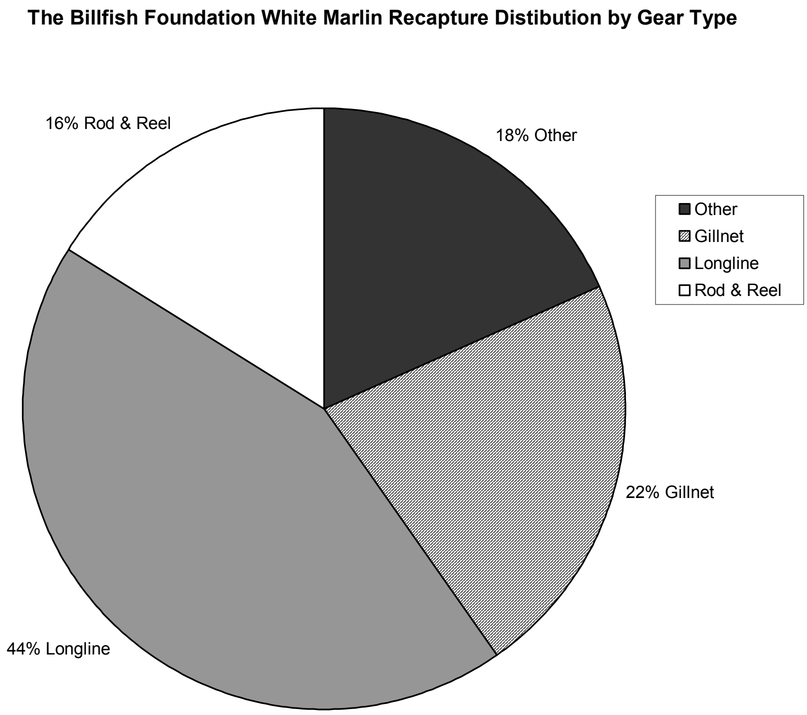


Figure 5. Proportion of recaptures from the NMFS Cooperative Tagging Center (top) and the Billfish Foundation (bottom) by gear type.

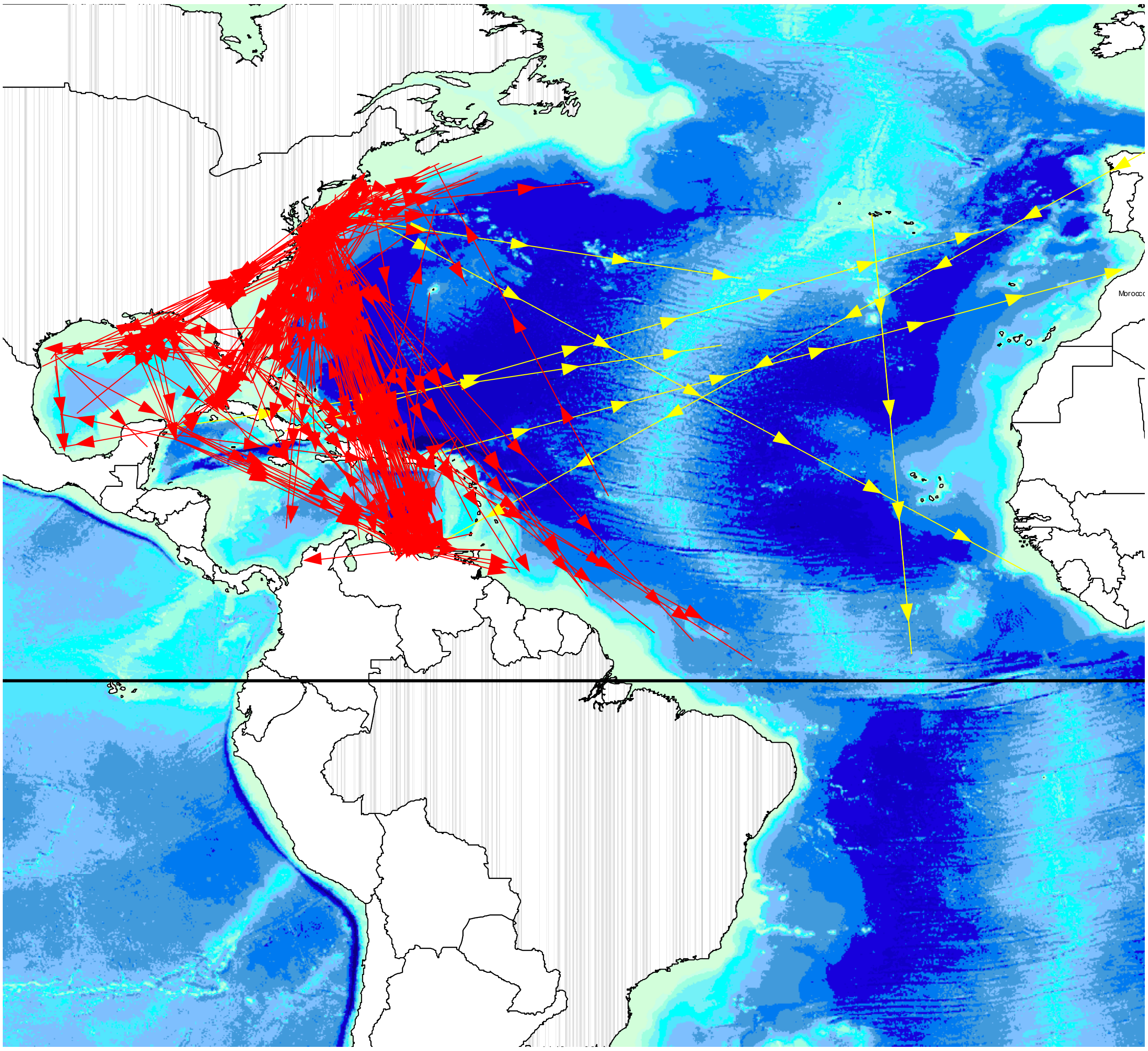


Figure 6. Summary of white marlin recaptures from the two primary tagging agencies-- NMFS Cooperative Tagging Center and The Billfish Foundation. Displacement vectors restricted to the western Atlantic are given in red and displacement vectors with more ocean-wide movement patterns are given in yellow.

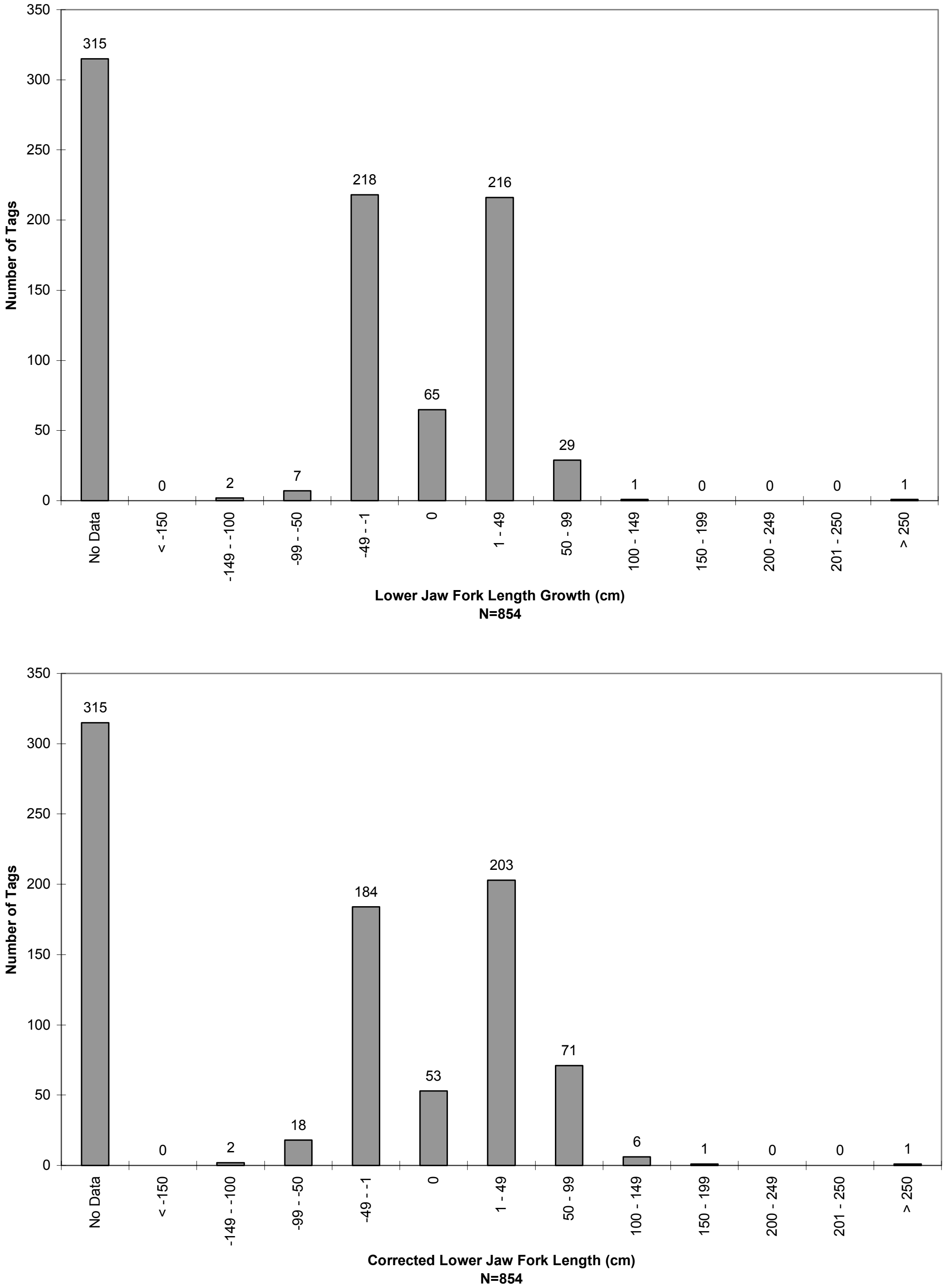


Figure 7. Frequency distribution of change in size data calculated from white marlin recaptures. Size change values were determined by subtracting size at release (LJFL, cm) from size at recapture (top panel). Bottom panel shows refractive index corrected size change distribution.

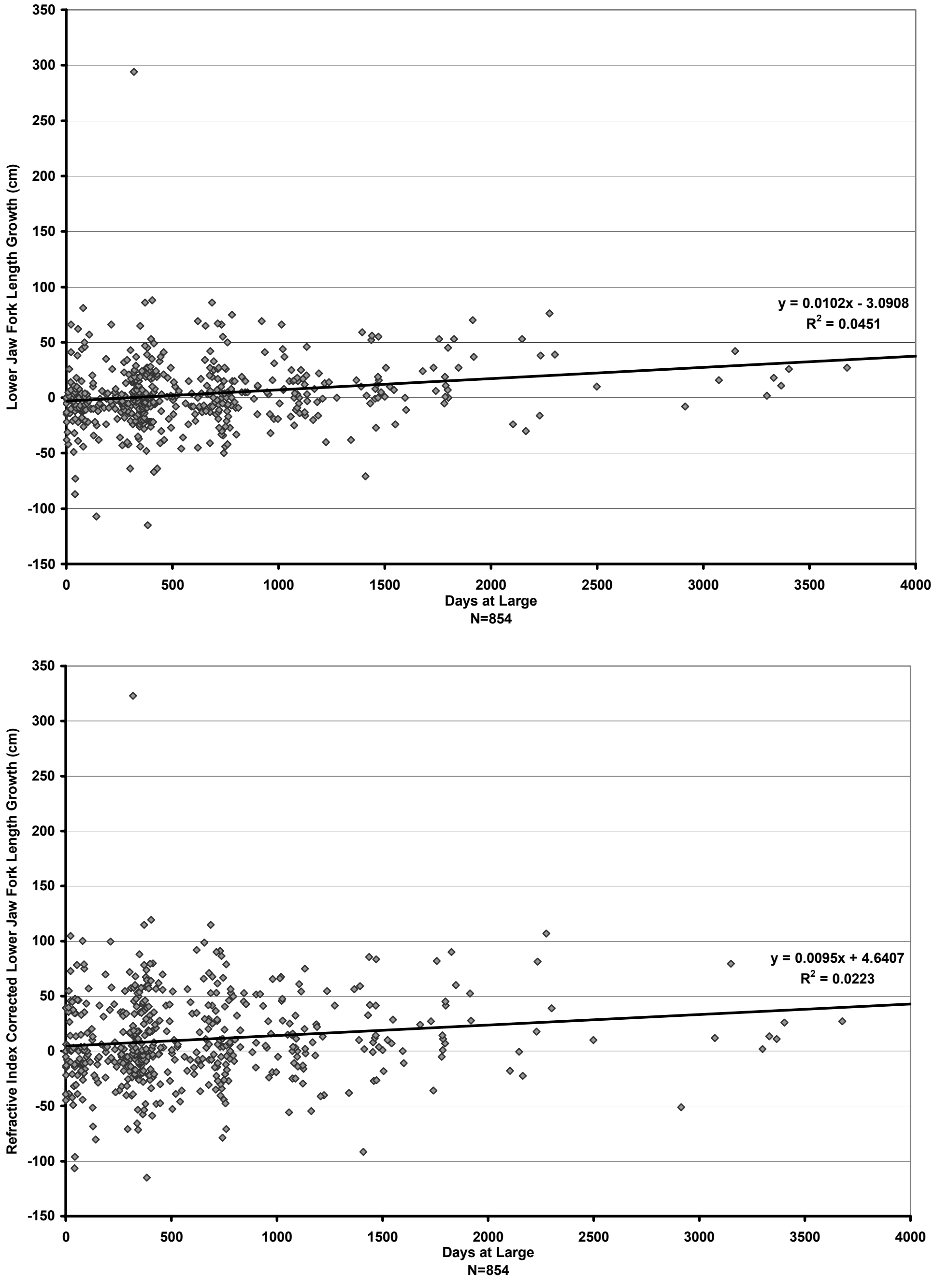


Figure 8. Regression of uncorrected (top) and refractive index corrected (bottom) size change (lower jaw fork length, LJFL, cm) versus days at-large for 539 recaptured white marlin from both primary tagging agencies. Regression equation and r^2 are given for both cases.