BIOLOGICAL ASSESSMENT OF TUNAS AND OTHER PREY OF SOOTY TERNS NESTING IN THE DRY TORTUGAS, FLORIDA

SCRS/1994/070

Col.Vol.Sci.Pap. ICCAT, 44 (1) : 155-158 (1995)

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SUMMARY

A project was initiated to determine whether Sooty Tern dietary information could be used to index abundance of large pelagic fish of commercial and recreational importance, particularly bluefin tuna. The bluefin spawning season in the Gulf of Mexico is centered around mid-May. Sooty Terns at the Dry Try Tortugas start nesting in late winter, and the colony is active until at least mid-summer. The birds feed primarily on pelagic fishes and squid and are known to eat very young juvenile bluefin tuna. The colony has been visited by scientists intermittently since the late 1930s to conduct large-scale banding. Prey studies are based on analysis of regurgitated gut contents. Previous analyses have been conducted, including one quantitative analysis in 1976. In the present study, the Dry Tortugas Sooty Tern colony was sampled during the late May-early June of the nesting seasons of 1992, 1993, and 1994. Results of the 1992 and 1993 analyses are presented in relation to information from previous years and in the context of previously prepared western bluefin VPAs.

RESUME

Un projet a été mis en route pour déterminer si l'information sur l'alimentation de la sterne fuligineuse pourrait servir à indexer l'abondance des grands pélagiques d'importance commerciale et sportive, en particulier le thon rouge. La saison de ponte du thon rouge dans le golfe du Mexique se situe autour de la mi-mai. Les sternes fuligineuses des Dry Tortugas commencent à faire leur nid à la fin de l'hiver, et la colonie est active au moins jusqu'au milieu de l'été. Les oiseaux s'alimentent principalement de poissons pélagiques et de calmars, et on sait qu'ils consomment du thon rouge juvénile de très petite taille. Des scientifiques ont visité cette colonie de façon intermittente depuis la fin des années trente pour baguer des oiseaux sur une grande échelle. Les études sur les proies se fondent sur l'analyse du contenu stomacal régurgité. Des analyses ont été menées antérieurement, dont une analyse quantitative en 1976. Dans la présente étude, la colonie de sternes fuligineuses des Dry Tortugas a été échantillonnée pendant la partie fin-mai-début juin de l'époque des nids de 1992, 1993 et 1994. Les résultats des analyses de 1992 et de 1993 sont présentés dans l'optique de l'information d'années passées et dans le contexte des VPA préparées antérieurement sur le thon rouge de l'ouest.

RESUMEN

Se inició un proyecto para determinar si era posible utilizar información sobre la dieta del "sooty tern" (*Sterna fuscata*) para confeccionar un índice de abundancia de grandes peces pelágicos de importancia comercial y deportiva, particularmente de atún rojo. La temporada de desove del atún rojo en el Golfo de México se centra a mediados de mayo. En Dry Tortugas el "sooty tern" empieza a anidar a finales de invierno, y la colonia se mantiene activa hasta por lo menos mediados de verano. Los pájaros se alimentan principalmente de peces pelágicos y calamares, y se sabe que comen juveniles de muy corta edad de atún rojo. La colonia ha sido visitada intermitentemente por científicos desde finales de los años 30 para anillar a gran escala. Los estudios sobre las presas se basan en análisis de contenido estomacal regurgitado. Se llevaron a cabo análisis anteriores, incluyendo un análisis cuantitativo en 1976. En el presente estudio, la colonia de "sooty tern" en Dry Tortugas se muestreó desde finales de mayo a comienzos de junio en las temporadas de nidificación de 1992, 1993 y 1994. Se presentan los resultados de los análisis de 1992 y 1993 en relación con la información de años anteriores y en el contexto de VPA de atún rojo del oeste previamente preparados.

INTRODUCTION

An exploratory study of the Dry Tortugas Sooty Tern (Sterna fuscata) colony was conducted in the late spring of 1992 and 1993 to determine whether quantitative Sooty Tern dietary information might be useful as an index of abundance of large pelagic fish, such as bluefin tuna (Thunnus thynnus). Indices of abundance which could be related to the fishable biomass of the early juvenile stages of these species would be a valuable contribution to stock assessments.

Because pelagic seabirds are thought to feed on small pelagic fish in an indiscriminate manner, their diets may tend of reflect the abundance of their forage species within the bird's foraging range. Seabird numbers and breeding success have previously been used as indicators of changes in marine fish populations (Monaghan et al. 1989). The fish community sampled by small pelagic seabirds includes not only small forage fish but the smaller stages of large oceanic fish such as the tunas.

Sooty Terns are the main component of a complex of pelagic seabirds nesting in the Dry Tortugas, an archipelago of seven small islands 105 km west of Key West, Florida (latitude 24•40'N, 82•52'W) (Robertson 1964). Their abundance and ease of capture in mist nets, coupled with their habit of readily regurgitating food when caught, make Sooty Terns particularly suitable for dietary studies. The fact that the diet of the Tortugas Sooty Tern colony has been at least cursorily described several times over the past 70 years (Hensley and Hensley in press) makes it a useful colony for making comparisons of food habits among years and conducting more in-depth studies. The availability of the birds and their regurgitated food items can be ascribed to an ongoing long-term population study of the colony (Robertson 1964, 1978, Robertson and Robertson in press). Intensive banding of nestlings at the Dry Tortugas colony was carried out for many years, beginning in 1959 (Robertson 1969). Less intensive banding was conducted into the 1980s. The return of banded birds to the colony is still being followed (Robertson and Robertson in press).

BACKGROUND

The Gulf of Mexico is the major spawning ground for bluefin tuna in the Western Hemisphere (Richards 1976, 1977, McGowan and Richards 1989). The annual spawning period is roughly centered around mid-May (Richards pers. comm.). Catch records from the Japanese longline fishery suggest that bluefin aggregate near the Loop Current (Maul and Roffer 1984). The Loop Current may carry young tuna spawned in the Gulf of Mexico into the Florida Straits, which lie immediately south of the Dry Tortugas. Potthoff and Richards (1970) reported that scombrid fishes, including bluefin tuna were a component of the diet of the Dry Tortugas Sooty Terns in the 1960s. Hensley and Hensley (in press) reported the presence of scombrids, including bluefin and other tuna, in the diet of Dry Tortugas Sooty Terns in 1976. Hensley and Hensley (in press) reviewed early descriptions of the diet of the terns, which indicated that scombrids were a part of the diet as early as the 1920s. V. Hensley and D. Hensley (University of Puerto Rico at Mayaguez, pers. comm.) have raw data concerning the collections made in the 1960s and 1970s that may provide additional quantitative information concerning tuna in Sooty Tern diets.

The Dry Tortugas are located on the northern edge of the Florida Straits. The largest of the seven existing islands are Garden and Loggerhead Keys. Ft. Jefferson is located on Garden Key. The Dry Tortugas are a national park, and park headquarters is located on Garden Key inside the fort. A description of the islands and a history of tern nesting is given by Robertson (1964). The islands are composed of calcareous and coral rubble on a shallowly, submerged limestone platform. Due to the forces of wind and currents, the islands change their shape over time and are sometimes converted to submerged shoals. For instance, Bird Key, where Sooty Terns and other seabirds had nested since at least 1832, washed away in the early 1930s (Robertson 1964).

Across the channel and immediately to the east of Garden Key is Bush Key, the principal site of Sooty Tern and Brown Noddy (Anous stolidus) nesting since 1933 (Robertson 1964). Bush Key is a narrow, elongated island of roughly 9.2 hectare (when last measured, 1946) (Robertson 1964). Parts of Bush Key where the birds once nested are no longer present and other nesting sites are new land formed within the past 30 years. The recent cycle of erosion and re-deposition dates from hurricane Alma in 1966. Robertson (1964) chronicled the changes that have occurred on Bush Key due to island-shaping forces since the Tortugas were first charted.

Terns nest on Bush Key in areas of low, scrubby coastal strand vegetation that covers the island immediately inland from the beach. They lay their eggs on the ground on bare patches of sand or under the canopy of higher shrubs. Brown Noddies nest in the same areas, but build nests in the shrubs rather than laying eggs on the ground. Sooty Tern nesting sites are found over most of the upland part of Bush Key. Sooty Terns are by far the most abundant species on Bush Key. The last detailed population estimate, made in the 1980s, indicated that 60,000 to 100,000 adult Sooty Terns and about 5,000 adult Brown Noddies nested annually at Dry Tortugas. Magnificent Frigate birds (Fregata magnificens) nest on adjacent Long Key, selecting mangrove trees as their nesting sites.

In recent years nesting by Sooty Terns on Bush Key commenced in the third week in February, and the colony is active until mid July (Robertson and Robertson in press). Some members of the colony start nesting as much as a month after the start of the nesting period. The time of nest initiation has gradually become earlier over the past 30 years (Robertson and Robertson in press).

Observations of radio-tagged individuals suggest that nesting Sooty Terns of the Dry Tortugas colony feed mainly within 80 km of Bush Key (Robertson and Stoneburner, 1979). The Florida Straits and nearby shelf waters are possible feeding sites for terns from the Tortugas colony. The Tortugas gyre, when present, might hold small fish in the area. In 1993 en route to the Dry Tortugas from Key West we observed Sooty Terns in a feeding aggregation roughly 7.3 km north, northwest from the Marquesas Keys, roughly 75 km from the Dry Tortugas. Sooty Terns in the Tortugas thus generally make shorter foraging trips than those observed in other colonies (i.e., Ascension Island, Christmas Island, Seychelles Island) (Dinsmore 1972), possibly because food is more abundant near the Tortugas colony. Sooty Tern chicks at the Dry Tortugas colony, unlike those in many other colonies, have not been known to experience mortality as a result of food shortages (Robertson 1964).

METHODS

Our annual visits to the Dry Tortugas were scheduled to coincide with the time of year of the previous sampling and time of the year when scombrids had been found in the earlier samples. Referring to samples collected on trips made in April-May and June-July from 1960 through 1967, Potthoff and Richards (1970) noted that scombrids were missing from April samples. The number of scombrids in the Potthoff and Richards (1970) samples increased from May through July. According to Robertson (pers. comm.), almost all the young in the colony have fledged by July, and captured birds tend to regurgitate less food after the young have fledged. We scheduled our sampling to start near the end of May in order to maximize the collection of scrombrids. The 1992 sampling was conducted from June 3 to June 6. The 1993 sampling was from June 2 to June 11.

During the many years of mist-netting for tagging, trips had been made in the early morning and in the early evening, from about dawn to 10 am and from about 5 pm to dark. We began sampling during the same time intervals and used the same methods as previous studies. We found that a much lower percentage of captured birds regurgitated food in the morning. Furthermore, we observed taxonomic composition of regurgitated material collected in the morning differed from that in the evening, and fewer scombrids were caught in the morning. Therefore, we concentrated most of our sampling activity in the evening. In 1992, we made 2 morning trips and 4 evening trips. In 1993, we made 2 morning trips and 10 evening trips.

Mist nets were stretched parallel to the nesting areas, between the most heavily populated areas and

the beach. In 1993 and 1994 birds were also captured with a handnet on a long pole (capture method was recorded). In 1992, only the birds from which samples were collected were noted. In 1993, we began recording all birds caught in the nets, even those that did not produce a sample (this allowed us to compare the proportion of birds caught that regurgitated).

Because Brown Noddies were also occasionally caught in the mist nets, bird species was noted. Maturity (immature or mature) also was noted. Specimens collected from each bird were stored separately in labeled ziplock plastic bags to which a small amount of seawater and baking soda (to retard decomposition by stomach acids) had been added. Packaged specimens were stored on ice and returned to the base at Garden Key, where they were rinsed and transferred into 95% ethyl alcohol. The alcohol was changed the following day. Time of day of each collection was noted. Birds with bands were recorded.

Specimens were identified to family on the basis of external characteristics. Initially, scombrids, carangids, and holocentrids were separated from the other samples on the basis of the narrow caudal peduncle. Characteristics particularly useful in distinguishing carangids from scombrids were the large eye, the lack of detached dorsal and anal finlets, the curve of the lateral line, and the scutes present on the rear section of the lateral line. In questionable cases, the presence of 14-16 caudal vertebrae (Fischer 1978) distinguished carangids from scombrids. Their diamond shaped scales, the presence of large preopercular spines, finray and spine counts, or, for incomplete samples, gill raker counts, were used to distinguish holocentrids. The remaining families were identified using Robins' (1986) descriptions and will be the topic of another report. Many of the distinguishing characteristics of the families were present in the juvenile stage. Scombrids were identified to species on the basis of vertebral column analysis (counts and other features) and gill raker counts (Potthoff and Richards 1970).

Identifications were made more difficult by the condition of some of the specimens. Although many of the specimens were intact, some had undergone considerable disintegration. As reported by Imber (1973) and by Harrison et al. (1983), the terns swallow their fish head first, so the posterior part of the body is more likely to be intact than the head.

Several indicators of bluefin tuna relative abundance were considered, and may, in the long run be used, but for this paper we selected (1) the ratio of bluefin to total scombrids in the samples and (2) average number of bluefin captured per bird. The first was selected as an index because this information was readily available for three decades: 1960s, 1970s, and 1990s. The second was selected as an index because it is not affected by changes in relative abundance of species other than bluefin. The latter index is not available at this time for the 1960-1967 period.

RESULTS

Results of our 1992 and 1993 visits to the Tortugas are summarized in Table 1. In 1992, potentially identifiable regur-gitated food samples were obtained from 54 Sooty Terns. In 1993, 862 Sooty Terns were caught in mist nets or with a hand net. Only 2 of the 73 Sooties captured in the morning regurgitated food whereas, 218 of the 789 Sooty Terns captured in the evening regurgitated potentially identifiable food. Our reported results are based on the evening sampling.

Scombrids formed a substantial portion of our specimens, being the third most numerous family in the samples both years. In 1992, scombrids ranked below only carangids and engraulids in number. In 1993, scombrids ranked below only clupeids and carangids in number.

No bluefin tuna were identified in the 1992 sample and only 2 bluefin tuna were identified in the 1993 sample. Table 1 lists the number of Sooty Terns captured in 1993, the number of birds with identifiable specimens in 1992 and 1993, and the number of scombrids caught, by species, in 1992 and 1993 in our collections from the terns. Also shown on this table for comparison are the number of scombrids in samples collected by D. Hensley (pers. comm.) in 1976 and by Potthoff and Richards (1970). We collected 248 potentially identifiable specimens in 1992 and 1289 in 1993. Of these, 20 and 112 were identified as scombrids in 1992 and 1993, respectively. The number of scombrids in our collections, as percent of the total specimens, was similar both years: 8.1% in 1992 and 8.5% in 1993. In Figure 1 our two indices, (1) ratio of bluefin to total scombrids and (2) average number of bluefin per bird, are shown in comparison to estimates of bluefin tuna abundance based on age zero and adult fish from the 1993 ICCAT-SCRS virtual population analysis (VPA). Values for 1960-67 are from Potthoff and Richards (1970), and values for 1976 are from V. Hensley and D. Hensley (pers. comm.).

DISCUSSION

The SCRS VPA in Figure 1 suggests that bluefin tuna were much more abundant prior to the late 1970's than at present. Both tern indices shown in Figure 1 exhibit higher values in the early part of the time series are higher than in the most recent period. Higher index values correspond to the period when adult (age 8+) bluefin abundance was estimated as much larger than current adult abundance. The proportion of bluefin in the Sooty Tern catch of scombrids does not appear to link as tightly with the estimated recruitment patterns as with estimated adult abundance, but too few observations are available to allow firm conclusions to be drawn concerning relationships.

In the Potthoff and Richards (1970) specimens, bluefin was one of the principal scombrid species taken by the birds. Other principal scombrids in the Potthoff and Richards specimens were blackfin tuna (Thunnus atlanticus), little tunny (Euthynnus alletteratus, and Auxis spp. (frigate tuna). In our samples, on the other hand, Auxis spp. was the main taxon. Bluefin tuna were only minimally present. This was true to some extent of the other scombrid species as well. Thus there appears to have been a major change in scombrid species composition of Sooty Tern diets over the time period, and the reduction of bluefin in the diet is the strongest example of that. It would be useful to know the total number of specimens in the 1960-1967 sample so that we could determine whether the proportion that were scombrids has changed substantially over the years. Even more valuable would be a knowledge of the number of birds from which samples were collected, which would enable a determination of the average number of bluefin per bird.

Our work thus far suggests that quantitative dietary information from Sooty Terns in the Tortugas might provide a useful perspective for bluefin tuna stock assessments. The change in proportion of bluefin in the scombrids caught by Sooty Terns is correlated with the estimated change of adult (age 8+) abundance over a similar time period. The change in bluefin caught per bird follows a similar pattern during the time for which it can be calculated. Planned future work entails obtaining Tortugas samples in future years, acquiring additional existing data from previous years, and using all the collected data to develop a quantitative characterization of the taxonomic composition of the Sooty Tern diet and its variation.

ACKNOWLEDGMENTS

We wish to thank Valentine and Danny Hensley of the University of Puerto Rico, Mayaguez, for sharing some of their data with us, as well as providing useful suggestions on sampling methodology, and for giving us a prepublication copy of their paper.

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Table 1. Data summary of 1992 and 1993 PM Sooty Tern samples and their scombrids.

Number	1960-67	1976	1992	1993
Birds captured	NC	NC	NC	789
Birds with identifiable specimens		156	54	218
Identifiable specimens		745	248	1289
All scombrids	207	95	20	112
Thunnus albacares		na	1	0
Thunnus atlanticus	48	na	0	6
Thunnus thynnus	40	21	0	2
Unid. Thunnus sp.		na	0	2
Euthynnus alletteratus	47	na	5	14
Katsuwonus pelamis	23	na	0	5
Auxis	37	na	11	63
Unidentified scombrids	12	na	3	20
Scombrids/total		na	0.0806	0.0869
T. thynnus/scombrid	0.1932	0.2211	0	0.0179
Specimens/bird with identifiable specimens		4.6296	4.5926	5.9128
T. thynnus/bird with identifiable specimens		0.1346	0.0000	0.0092

1960-67: Potthoff and Richards (1970)
1976: V. Hensley and D. Hensley (pers. comm.)
NC: Information not recorded.
na: Unavailable information that will later to be published.

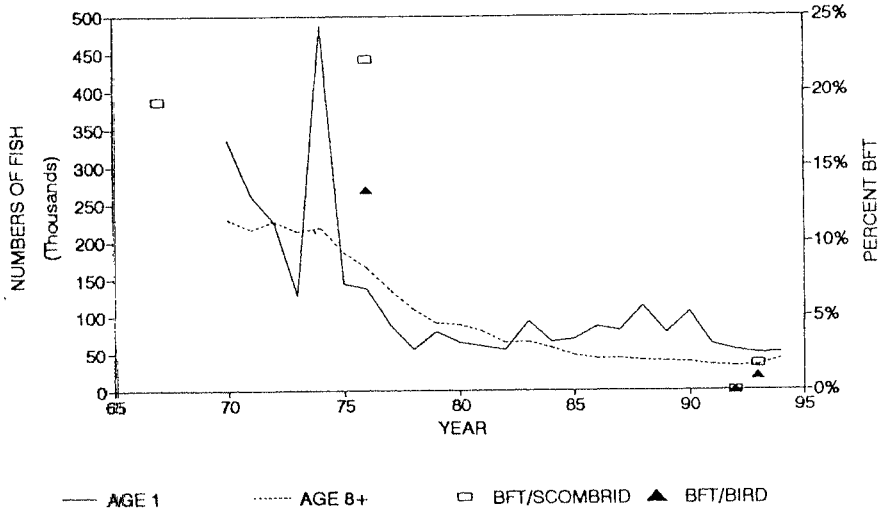

Figure 1: West Atlantic Bluefin tuna abundance from the 1994 SCRS VPA and the proportion of bluefin per scombrid caught and proportion of bluefin caught per bird.