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BIRD'S-EYE VIEW OF THE PELAGIC FISH COMMUNITY OF SURFACE WATERS OFF EXTREME SOUTH FLORIDA

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SUMMARY

Dietary information from sooty terns nesting in the Dry Tortugas is being used to examine the small pelagic fish community in nearby surface waters of the Dry Tortugas National Park, the Florida Keys National Marine Sanctuary, and adjacent Florida Current waters. Information on the full component of the catch is providing context for formulating and evaluating an abundance index of bluefin tuna based on the catch of small juveniles by the birds. Analyses of three years of data, acquired without sacrificing birds, indicates that the birds' catch is mainly composed of roughly a dozen fish families and squid. Three fish families--Scombridae, Carangidae, and Clupeidae--are particularly well represented, but vary in relative proportion from year to year. Representation of species within these three families appears more consistent. Each year, *Sardinella aurita* was the main clupeid caught, *Decapturas punctatus* was the main carangid, and *Auxis* sp. was the main scombrid. Although previous studies show that bluefin tuna made up a substantial proportion of the scombrid catch of the birds in the late 196Os and, to a lesser extent, the mid 1970s, they were a very small component of the scombrid catch in all three years of this study. Results of efforts to collect bluefin tuna larvae with plankton tows in the Florida Current in 1995, compared to similar effort in the 197Os, show the same change. This year's bird-based indices were lower than those reported for last year.

RESUMÉ

L'information trophique sur les hirondelles de mer des Dry Tortugas est utilisée ici pour examiner la communauté de petits pélagiques dans les eaux de surface à proximité du Dry Tortugas National Park, du Florida Keys National Marine Sanctuary et des eaux avoisinantes du Courant de Floride. L'information sur la composition totale de la prise fournit le contexte pour formuler et évaluer un indice d'abondance du thon rouge basé sur la capture de petits juvéniles par les oiseaux. L'analyse de trois années de données, acquises sans sacrifier d'oiseaux, montre que la capture de ces derniers se compose surtout d'une douzaine environ de familles de poissons et de calmars. Trois familles de poissons, les Scombridés, les Carangidés et les Clupéïdés, sont particulièrement bien représentées, mais leur proportion relative varient d'une année sur l'autre. La représentation des espèces au sein de ces trois familles semble plus régulière. Chaque année, la *Sardinella aurita* est le principal clupéïdé capturé, le *Decapturus punctatus* le principal carangidé, et les *Auxis spp.* les principaux scombridés. Bien que des études antérieures aient montré que le thon rouge constituait à la fin des années 60, et dans une moindre mesure au milieu des années 70, une partie substantielle de la prise de scombridés par les oiseaux, il s'agissait d'une partie très réduite de la prise de scombridés pendant les trois années sous étude. Les résultats des efforts de collecte de larves de thon rouge au moyen de filets à plancton dans le Courante de Floride en 1995, comparés à des efforts similaires pendant les années 70, montrent les mêmes changements. Cette année, les indices basés sur les oiseaux étaient plus faibles que ceux qui avaient été signalés l'an dernier.

RESUMEN

Se está empleando información sobre la dieta de la golondrina de mar (*Sterna fuscata*), que anida en Dry Tortugas para examinar la pequeña comunidad de peces pelágicos en los alrededores de las aguas superficiales del Dry Tortugas National Park, Florida Keys National Marine Sanctuary y aguas adyacentes a la Corriente de Florida. La información sobre el componente global de la captura está facilitando el medio para formular y evaluar un índice de abundancia de atún rojo, basado en la captura de pequeños juveniles por los pájaros. Los análisis de tres años de datos, obtenidos sin sacrificar a los pájaros, indican que la captura obtenida por éstos se compone principalmente de aproximadamente una docena de familias piscícolas y calamar. Tres familias piscícolas - Scombridae, Carangidae, y Clupeidae - se encuentran particularmente bien representadas, pero varían en proporción relativa de año a año. La representación de especies dentro de estas tres familias parece más coherente. Cada año, *Sardinella aurita* ha sido el principal clupéido capturado, *Decapturas punctatus* el principal carángido, y *Auxis* sp., el principal escómbrido. Aunque estudios preliminares indican que el atún rojo componía una proporción sustancial de la captura de escómbridos por los pájaros a finales de los años 60, y en menor término, a mediado de los 70, eran un componente muy pequeño de la captura de escómbridos en el conjunto de los tres años de este estudio. Los resultados de los esfuerzos para recolectar larvas de atún rojo con plancton en la Corriente de Florida en 1995, en comparación con un esfuerzo similar desarrollado en los años 70, muestra el mismo cambio. Este año, los índices basados en pájaros fueron inferiores a los que se comunicaron para el año pasado.

INTRODUCTION

Seabirds in the Dry Tortugas are being studied to learn more about the ecology of marine surface waters in the vicinity of the Dry Tortugas, Florida, and to obtain an index of abundance of bluefin tuna, which spawn in the eastern Gulf of Mexico. Pelagic seabirds feed on small pelagic fish in marine surface waters in an apparently indiscriminant manner and, therefore, their diet may reflect the species composition of the small pelagic fish communities in their feeding areas. Seabirds and their diets have been studied in several parts of the world, and the information has been shown to be related to prey density and abundance (Safina et al. 1988, Monoghan et al. 1989). The fish community sampled by small pelagic seabirds includes not only small species but also the smaller life stages of large oceanic fish. Because seabirds can catch fast moving species that are often able to avoid sampling gear, their diets may provide a more representative view of the community of small pelagic fish in their feeding area than could be obtained from resource cruises.

In this report, we provide a summary of dietary information collected from three visits one year apart to the Sooty Tern colony in the Dry Tortugas, Florida. In addition, we update previously reported (Miller et al. 1995) provisional indicators of abundance of bluefin tuna that are based on the occurrence of young juvenile bluefin in samples of dietary items from Sooty Terns.

Sooty Terns form the main component of a complex of pelagic seabirds nesting in the Dry Tortugas, a small archipelago of seven islands 65 miles west of Key West, Florida (latitude 24°40'N, 82°52'W) (Robertson 1964). The diet of the Dry Tortugas Sooty Tern colony has been described qualitatively several times over the past 70 years. The availability of the birds and their regurgitated food items can be ascribed to an ongoing longterm population study of the colony (Robertson 1964, Robertson 1969, Robertson 1978, Robertson and Robertson In press).

An exploratory study of the Dry Tortugas Sooty Tern 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 of commercial and recreational importance, particularly bluefin tuna. The colony was visited again in late spring of 1994 and 1995. Information from the 1994 samples can now be compared with that of previous years. Analysis of 1995 samples is still in its early stages. An understanding of the taxonomic composition of the diet is important to developing an index of tuna abundances from the bird samples. This paper reports on taxonomic composition at the family level.

BACKGROUND

The Dry Tortugas, now a national park, is located on the northern edge of the Florida Straits. The islands are formed of sand on a shallow, submerged limestone platform. Bush Key has been the site of Sooty and Noddy tern nesting since 1933 (Robertson 1964). It is a narrow, elongated island of roughly 9.2 hectares (when last measured, 1946) (Robertson 1964). Terns nest on Bush Key in areas of low, scrubby coastal strand vegetation that cover the island immediately inland from the beach. Sooty Terns lay their eggs on the ground on bare patches of sand or under the canopy of higher shrubs. Brown Noddies build nests in shrubs in the same areas. Magnificent Frigate Birds nest in nearby mangrove trees. The Sooty Tern is the most abundant species nesting on Bush Key. The last population census, made in the 1980s, indicated from 60,000 to 100,000 adult Sooty Terns and about 3000 adult Brown Noddies migrated annually to the Dry Tortugas.

Bluefin tuna spawn in the Gulf of Mexico (Richards 1976, 1977, McGowan and Richards 1989), and the Loop Current carries the young into the Florida Straits. The annual spawning period is roughly centered around mid May (Richards, pers. comm.). Scombrids were reported in the Sooty Tern diet as early as the 1920s.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 (1995) reported bluefin in the diet of Dry Tortugas Sooty Terns in the 1960s and 1970s.

Sooty Tern nesting on Bush Key starts about the third week in February and extends to about mid July, a period of about 5 months (Robertson and Robertson in press). Not all birds nest at the same time, so nesting activity is in different stages at different sites (Robertson and Robertson In Press). Radio

tracking by Robertson and Stoneburner (1979) suggested that the Sooties in the Dry Tortugas forage mainly within 80 km of Bush Key. The nearby Florida Straits are a probable feeding site.

METHODS

Trips were scheduled to coincide with the time of the year of previous sampling and the time of the year when scombrids were found in the samples (Miller et al. 1995). Collections were made during the following periods: 3-6 June, 1992; 2-11 June, 1993; 31 May-8 June, 1994; 30 May-10 June, 1995. One day of sampliing was skipped in 1995 (June 4) because of the passage of Tropical Storm Allison.

Collecting, recording, and processing were roughly the same each year, except for refinements added after 1992. Samples were collected in the evening between 6:00 pm and 8:00 pm. Mist nets were stretched parallel to the nesting areas, between the most heavily populated areas and the beach. Beginning in 1993, a handnet was used in addition to the mist net. Data recorded included date, time, location on the island, every bird caught (after 1992), species (Sooty Tern or Brown Noddy), age (adult or juvenile), band (if present), capture method (mist net or hand net), and whether or not the bird regurgitated. Each regurgitant sample was assigned a number and placed in a plastic bag on ice in the field. Each sample was preserved in ethanol upon return to our quarters each night.

Morning collecting (between 8:00 am and 10:00 am) was also performed on one or more days of each trip, this report includes only the results of evening sampling. Morning sampling was relatively unproductive, suggesting that the birds may do most of their foraging in the evening. For example, in 1995, only one of 60 birds caught in the morning regurgitated. Hensley and Hensley (in press) found that the taxonomic composition of morning samples differed from that of evening samples, and this is being reported by them in greater detail (Hensley et al. in prep).

In an initial screening process, specimens were identified to family on the basis of body shape and other external characteristics using Robins et al. (1986). Most of the distinguishing characteristics of the families are present in the juvenile stage. Identification of our specimens was made more difficult by the fact that they were in various stages of decomposition due to the time they spent in the digestive tracts of terns. The heads of many specimens were missing. Identifications were confirmed after grouping the specimens by family and subjecting them to greater scrutiny. The nomenclature of Eschmeyer (1990) is used in referring to families throughout this paper.

Initially, scombrids, carangids, holocentrids, and gemphylids were separated from the other samples on the basis of their 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) in cleared and stained specimens 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 from scombrids (Johnson 1978, Robins et al. 1986, Woods and Sonada 1973, Miller and Jorgenson 1973). Gemphylids also could be readily distinguished from scombrids on the bases of vertebral analyses, once the specimens were cleared and stained.

Various characteristics allowed us to separate the families having relatively wide caudal peduncles. Exocoetids were easily identified by their elongated caudal fin lobe or the single dorsal fin near the rear of the body. Clupeids could be readily distinguished from engraulids and atherinids by their belly scutes, if these were still entact. Otherwise, upturned mouths (if heads were present) and lack of a dark stripe along the lateral line (in most clupeids) distinguished them from engraulids and atherinids. Lack of two dorsal fins and lack of a dark stripe along the lateral line distinguished them from atherinids. Other families, such as tetraodontids, stromateids, monocanthids, syngnathids, could be identified by body shape.

Scombrids were identified to species on the basis of vertebral column analysis (counts and other features) and gill raker counts (Potthoff and Richards 1970). All the specimens that initial examination suggested could be scombrids were cleared and stained for this analysis, as in Potthoff and Richards (1970). Final identification of scombrids was made by W. Richards.

A separate process was used for identifying carangids. In the 1992 and 1993 specimens, carangids were cleared and stained and identified to species using a meristic list of characters from Fischer (1978) and Aprieto (1973). But, beginning in 1994, specimens that were clearly not scombrids were not cleared and stained. Clearing and staining of carangids was eliminated because the dominant carangids were more easily identified by their external characteristics than by vertebral column analysis. Carangid specimens initially identified as *Selar crumenophthalmus* were later changed to *Decapturus punctatus*. Both species are characterized by the curve of the lateral line and the presence of scutes on the rear section of the lateral line (Johnson 1978). *Caranx crysos* and *Caranx hippos* were identified using the description of Johnson (1978) and the FAO guide to meristic characters of the family Carangidae (Fischer 1978).

Clupeids were identified to species using the descriptions of Robins et al. (1986) and Johnson (1978). Meristic data were compared with Whitehead (1973), and differences were noted. The dominant species was *Sardinella aurita*. Originally, these specimens were identified as *Sardinella brasiliensis*, but Wilson and Alberdi (1991) raise doubt about the separation of *S. aurita* and *S. brasiliensis*, and we have therefore taken the more conservative route. Identification of Holocentridae to species was performed using the meristic characters in Woods and Sonada (1973).

Weight and displacement volume were determined for all specimens, and length measurements were made on all intact fish. Field and laboratory data pertaining to the samples were entered into data files using spreadsheet software for analysis.

RESULTS

The number of field days was roughly the same number of days in the field in 1994 and 1995, but total captures differed tremendously, amounting to 699 in 1994 and 2,569 in 1995 (Table 1). Birds captured that did not regurgitate were not recorded in 1992. Since 1993, all adults captured were counted, but captured juveniles that did not regurgitate were not counted until 1994; therefore we cannot compare captures in 1993 to those in 1994 and 1995, except for adults. Captured adults totaled 721 in 1993 and 552 in 1994.

Roughly the same proportion of the specimens could be identified at least to family each year: 79% in 1992, 75% in 1993, and 76% in 1994 (Table 2). Seventeen fish families were identified in the samples over the three years. A few families dominated the samples. Carangids and scombrids made up more than 5% of total specimens in all three years. Carangids, clupeids, engraulids, monocanthids, and scombrids each made up more than 5% of total specimens in at least one year. The catch of clupeids and carangids varied enormously from one year to the next. For instance, clupeids varied from 4.5% in 1992 to 42% in 1993 and carangids varied from 10% in 1993 to 51% in 1992. On the other hand, scombrids made up a relatively consistent part of the specimens each year: 8.2% in 1992, 10.1% in 1993, and 6.9% in 1994. Processing of 1995 samples has not yet been completed, but over 100 specimens have been tentatively identified as scombrids in the first 125 samples. Squid made up from 2.5% to 4.1% of specimens from 1992 through 1994.

Six scombrid taxa were observed in the Sooty Tern diet in the years 1992 through 1994: *Thunnus albacares* (yellowfin tuna), (*T. atlanticus* (blackfin tuna), *T. thynnus* (bluefin tuna), *Euthynnus alletteratus* (little tunny), *Katsuwonus pelamis* (skipjack tuna), and the genus *Auxis* (bullet or frigate tuna) (Table 3).

No bluefin were found in 1992, and two specimens were identified as bluefin were found in 1993. One possible bluefin was found in 1994. Identification on the basis of vertebral column analysis was uncertain, however the possibility that this specimen was *T. atlanticus* could be discounted. *T. atlanticus* is the species with which *T. thynnus* is most likely to be confused in vertebral column analysis. Since we did not obtain a positive identification of the one specimen, the two 1994 indices, '*T. thynnus*/scombrid' and '*T. thynnus*/bird', are either both zero or 0.0154 and 0.0074 respectively (Table 3). If we assume that our sample was a bluefin, the scombrid-based index is very similar to the 1993 value, however the bird-based index is an order of magnitude smaller than the 1993 value (Fig. 1).

In Table 3, the term "identifiable specimens", used in Miller et al. (1995), was replaced by the term "distinct specimens". We believe the latter term is more accurate since not all distinct specimens are necessarily identifiable.

DISCUSSION

Hensley and Hensley (in press) list 31 families in the catch of Sooty Terns from historic studies, including their own collections from 1974 through 1976. Specimens representing 17 families were found in 1992-1994 evening collections. The Hensley and Hensley report (in press) covered three periods, before 1941, 1960-64, and 1974-76. The three studies observed 23, 21, and 15 families respectively. Therefore our results are consistent with previous work. Our work adds two new families to the catch of Dry Tortugas Sooty Terns: Cliniidae and Sygnathidae.

Our results suggest that the birds depend on a few families for most of their support. The principal families in the years 1992-1994 were Carangidae, Scombridae, and Clupeidae. Next in importance were Monocanthidae and Engraulidae, followed by Exocoetidae. Since the exocoetids in the birds' diets tended to be the largest fish found, they may contribute more to the energy supply of Dry Tortugas Sooty Terns than suggested by their numerical representation in the diet.

The presence of clupeids as a major item in the diet of the Dry Tortugas Sooty Terns suggests that the terns feed not only in oceanic environments but also in the shallow, coastal environment of the Dry Tortugas archipelago. *Sardinella aurita*, the principal clupeid identified in food items sampled from the Sooty Terns, was the same species identified in food items of Brown Noddies obtained from the Bush Key colony. Brown Noddy Terns, in small aggregations, forage heavily inside the Dry Tortugas area. We have seen an occasional Sooty Tern in these noddy aggregations, although we have not observed them feeding.

While the proportions of other families in the birds' diets varied enormously from year to year, the proportion of scombrids was relatively constant. This lends credence to the use of the ratio of bluefin to scombrids as an index of bluefin abundance. Unfortunately, there is uncertainty in the data point added to the short time series of tern-based bluefin abundance indices. One specimen probably is a bluefin, but could not be identified with certainty that it is a bluefin based on the vertebral column analysis alone. The scombrid specimens are undergoing genetic analysis at the Charleston Laboratory of the National Marine Fisheries Service, and identification to species using DNA analysis may may allow us to obtain a firmer 1994 index. However, one can infer from either result that bluefin abundances were no higher in 1994 than in 1993, when, by all indices measured, they were very low.

Processing of our 1995 samples is still in progress. We have, however, already found many scombrids in these samples. It will be interesting to know whether bluefin are among them.

Plankton collecting effort in the Florida Current off Miami in 1995 suggested that bluefin tuna larvae were scarce this year, whereas the larvae of other oceanic pelagic species were more common. Results of extensive surface plankton tows in the Florida Current off Miami between May 10 and about June 9, 1995, by W. Richards yielded no larval bluefin, whereas they had been plentiful in the same area when the same collecting methods were used at about the same time of year 15 yrs previously (Brothers et al. 1982). A total of 369 small juvenile bluefin were collected in three trips in late May, 1979, and one trip in early June, 1980 (Brothers et al. 1982). Substantial numbers of *Thunnus atlanticus*, *Istiophorus platypterus*, and *Makaira nigricans* larvae were caught, as in previous years. Only the bluefin were conspicuously absent.

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Table 1. Statistics on Sooty Terns and collections for each sampling year

Statistic	1992	1993	1994	1995
Number of birds captured	NC	789	699	2569
Number of birds regurgitating			139	345
Number of birds with more than liquid or fragments	54	218	136	
Number of distinct specimens	248	1289	939	
Number identified to family	200	1041	735	

Table 2. Number and proportion of food items, by taxa, for each sampling year

	Number			Proportion		
Taxa	1992	1993	1994	1992	1993	1994
Squid	7	54	23	0.0288	0.0411	0.0245
Fish, by family:						
Unidentified	43	272	204	0.1770	0.2072	0.2173
Carangidae	123	108	314	0.5062	0.1013	0.3344
Cliniidae	1	0	0	0.0041	0.0000	0.0000
Clupeidae	11	553	211	0.0453	0.4212	0.2247
Coryphaenidae	0	3	2	0.0000	0.0023	0.0021
Dactylopteridae	0	0	1	0.0000	0.0000	0.0011
Echeneidae	0	1	0	0.0000	0.0008	0.0000
Engraulidae	24	69	0	0.0988	0.0526	0.0000
Exocoetidae	3	62	13	0.0123	0.0472	0.0138
Gempylidae	2	13	16	0.0082	0.0099	0.0170
Gobiidae	0	1	1	0.0000	0.0008	0.0011
Holocentridae	8	16	4	0.0329	0.0122	0.0043
Monocanthidae	1	23	72	0.0041	0.0175	0.0767
Scombridae	20	132	65	0.0823	0.1005	0.0692
Serranidae	0	0	3	0.0000	0.0000	0.0032
Stromateidae	0	2	5	0.0000	0.0015	0.0053
Syngnathidae	0	1	0	0.0000	0.0008	0.0000
Tetraodontidae	0	3	5	0.0000	0.0023	0.0053
Total identified fish	193	987	712	0.7942	0.7540	0.7583
Total fish	236	1,259	916	0.9712	0.9589	0.9755
Total fish and squid	243	1,313	939	1.0000	1.0000	1.0000

Table 3. Data summary of 1992, 1993, and 1994 PM Sooty Tern samples and their scombrids, shown with the same information from earlier studies (1960-67 and 1976)

Number	1960-67	1976	1992	1993	1994
Birds captured	NC	NC	NC	846[a]	699
Birds that regurgitated			68	325	139
Birds with distinct specimens [b]		156	54	218	136
Distinct specimens[b]		745	248	1289	939
Identified specimens			200	1041	735
All scombrids	207	95	20	132	65
Scombrids ID'ed to genus	207	95	20	123	
Thunnus albacares		na	1	0	1
Thunnus atlanticus	48	na	0	6	6
Thunnus thynnus	40	21	0	2	1?
Unid. Thunnus sp.		na	0	2	5
Euthynnus alletteratus	47	na	5	14	20
Katsuwonus pelamis	23	na	0	5	8
Auxis sp.	37	na	11	73	24
Unidentified scombrids	12	na	3	30	0
Scombrids/total distinct specimens		na	0.0806	0.1024	0.0692
Scombrids/total identified specimens			0.1000	0.1268	0.0884
Scombrids/bird with distinct specimens		0.1275	0.3704	0.6055	0.4779
T. thynnus/identified scombrids	0.1932	0.2211	0	0.0163	0.0154?
Distinct specimens/bird with distinct specimens		4.6296	4.5926	5.9128	6.904
T. thynnus/bird with distinct specimens		0.1346	0.0000	0.0092	0.0074?

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.
[a] Does not include juveniles captured that did not regurgitate.
[b] In this report, distinct specimens are anything more than liquid or fragments of tissue or bone).

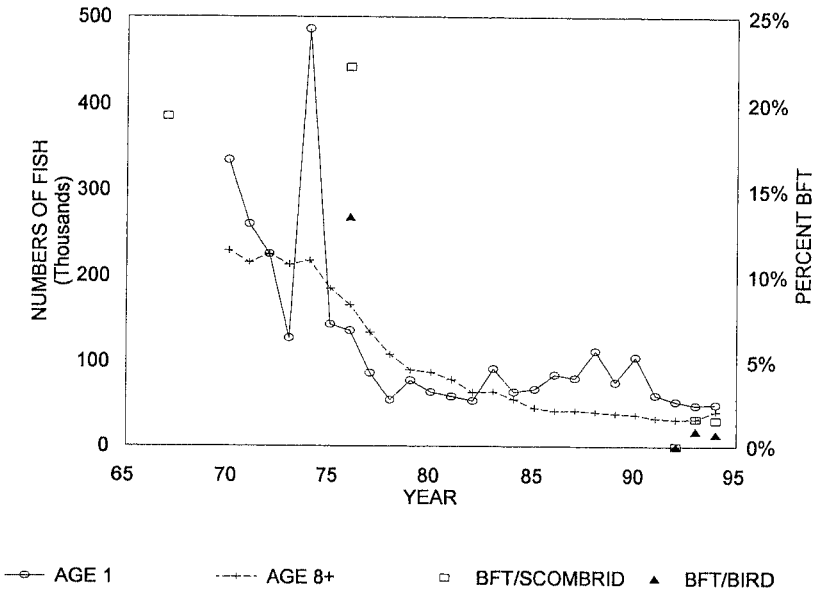

Figure 1. Tern-based indices of young bluefin tuna abundance, shown in comparison with VPA-based population estimates for age 1 and age 8+ bluefin.