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Investigating Black Skimmer Chick Diets Using Citizen Science and Digital Photography

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Abstract - *Rynchops niger* (Black Skimmer) is a colonial seabird that forages on small planktivorous fish that are caught while gliding just above the surface. Previous studies have found that baitfish abundance can affect skimmer productivity, so the purpose of this research was to determine the species and size of fish fed to chicks in Southwest Florida. During the 2015 and 2016 nesting seasons, we posted requests for photographs of Black Skimmer adults feeding chicks to several Facebook sites where photographers were posting images taken in Southwest Florida. We invited volunteers who were knowledgeable about fish to identify prey species. We received 256 photographs of which 211 could be included in our study. Black Skimmers fed chicks 22 different species of fish, including 9 that had not been previously recorded. The fish species did not differ by year, age of chick, or location; however, smaller chicks were fed significantly more small fish. Our research demonstrated that citizen science conducted through using photographs and social media is an accurate and efficient method of obtaining data about seabird diets.

Introduction

Rynchops niger L. (Black Skimmer) is a colonial seabird that nests on open, sandy, or gravel beaches along the Baja peninsula and the Atlantic and Gulf coasts of the US and Mexico (Gochfeld and Burger 1994). They forage on small planktivorous fish that are caught while gliding just above the surface of the water when the bill is open and the mandible submerged (Black and Harris 1983). Black Skimmers are sexually dimorphic; the males weigh more than females, and have a longer tarsus, culmen, and wing chord (Quinn 1990). Females are more involved in feeding the young, but the males are more likely to feed older chicks and often feed them larger prey (Quinn 1990).

Black Skimmers primarily feed at night when light levels are low, but also forage during the daylight, particularly when feeding their young (Erwin 1977, Yancey and Forys 2010). Erwin (1977) found that very young chicks (<6 days old) were fed once every 2 hours during the day and even the oldest chicks (>12 days old) were fed at least once during the day. Chick survival is dependent on the ability of adults to locate and catch suitably sized fish that are relatively nearby the nest site. Gordon et al. (2000) found an association between reproductive success and baitfish abundance. In addition, determining the species and size of fish fed to chicks is important for Black Skimmer conservation because surface-foraging seabirds are some of the species most sensitive to changes in fisheries stocks (Cury et al. 2011).

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Relatively few studies have been conducted on the fish fed to Black Skimmer chicks. Most have involved invasive techniques such as placing ligatures around the chick's neck, causing them to regurgitate food (King 1989, Loftin 1982) or attempting to visually identify the species and size of prey in the field (Arthur 1921, Erwin 1977). Larson and Craig (2006) found that photo vouchers decreased observer bias in studies of *Sterna caspia* Pallas (Caspian Tern). Similarly, Gaglio et al. (2016) found that use of digital photography to quantify prey species and size of fish fed to *Thalasseus bergii* (Lichtenstein) (Greater Crested Tern) was equally accurate as regurgitation, collected over twice the amount of data in the same time period, and was much less invasive. Compared to pure observation, the digital photography decreased observer bias and increased overall accuracy of species and size of prey.

Our study was motivated by seeing a large number of photographs of Black Skimmers feeding chicks that had been posted on social media sites such as Facebook and Flickr. Many of these images came from amateur photographers who were spending long periods of time at the colonies, investing in expensive camera equipment, and spending time processing and posting these images. In some cases, we would observe these photographers disturbing the nesting Black Skimmers by getting too close to the birds. Thus, the primary objective of our research was to use these photographs to determine which species were being fed to Black Skimmer chicks, but we additionally hoped to educate the photographers about skimmer conservation and engage them in actively protecting the species.

Field-site Description

We focused our research on Black Skimmer colonies on the open beaches of southwestern Florida (Fig. 1). Southwestern Florida beaches span from Collier County to the south to southern Pasco County to the north and is bounded to the west by the Gulf of Mexico. This region supports 42% (14/33) of the State of Florida's Black Skimmer colonies (FWC 2016a).

Methods

During the 2015 and 2016 nesting seasons, we posted requests for photographs of Black Skimmer adults feeding chicks to several Facebook sites where photographers were posting images taken in Southwest Florida. We also reached out to individual photographers who had posted photographs on Flickr. The vast majority of birds were photographed at colonies on crowded, highly accessible, public beaches. When requesting images, we also explained that Black Skimmers are an imperiled species whose reproductive success can be lowered by disturbance and that we only wanted photographs from outside of the symbolic fencing around the colonies. We created a closed Facebook group where photographers could post images with the assurance that the images would not be used for other purposes. We asked photographers to include in their posts the date and time the photograph was taken, the location, and any other observations. In addition to photographs taken

during these 2 seasons, we encouraged photographers to submit additional images from recent years.

To identify the prey species, we invited volunteers who were knowledgeable about fish, including 2 people who worked professionally in the field. A fisheries biologist at the Florida Fish and Wildlife Research Institute (St. Petersburg, FL), volunteered his time to review all species identifications.

We reviewed the images when they were uploaded onto Facebook to make sure they contained the relevant information and contacted the photographers if

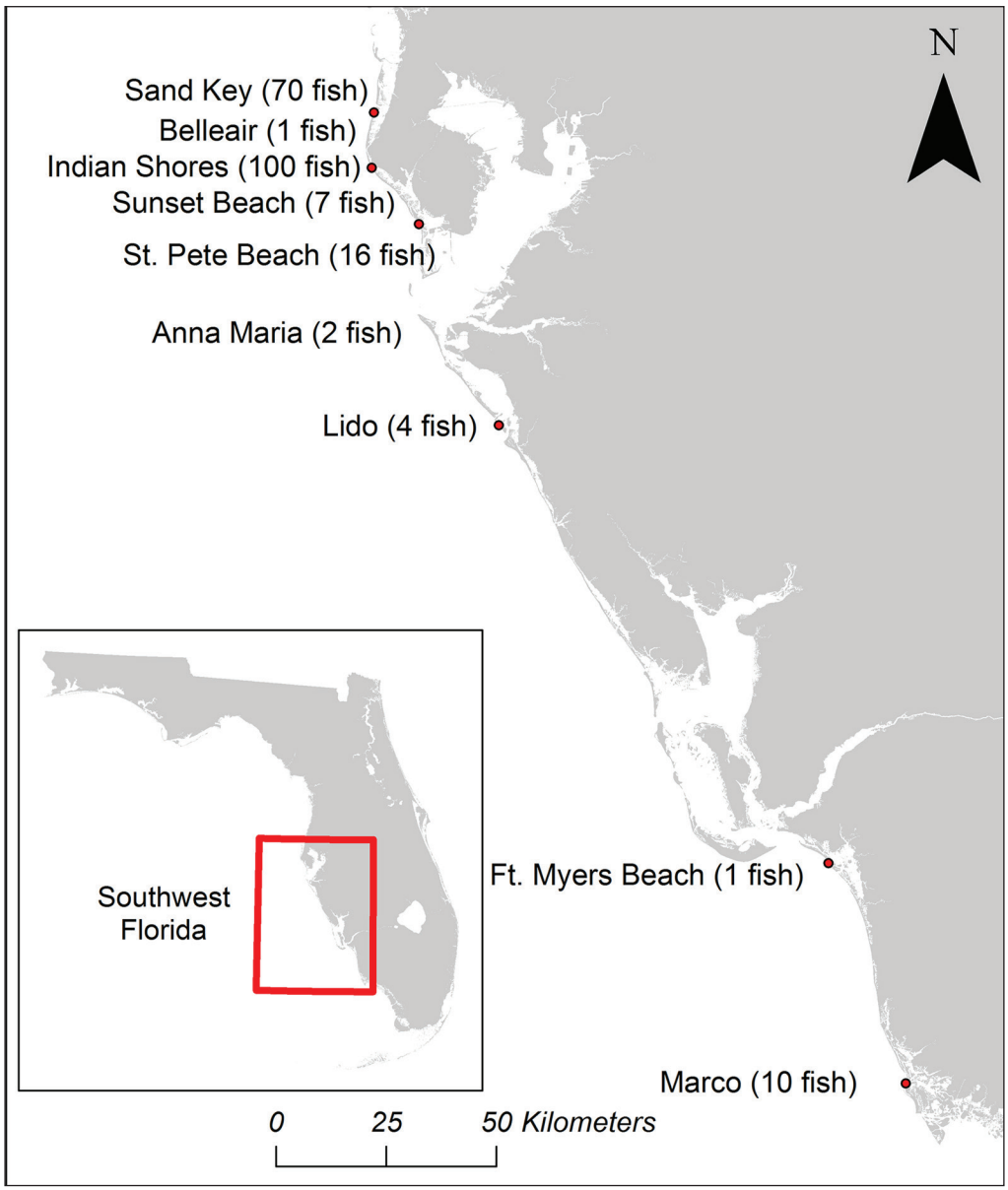

Figure 1. Map of the Black Skimmer colonies in Southwestern Florida and number of usable photos submitted to the Facebook page by citizen scientists.

more details were needed. Based on our knowledge of the field sites and apparent age of the chicks, we were also able to verify the location and rough date of the photograph.

We included in our analysis only images in which it was clear that an adult had fed a chick and where the prey was readily identifiable. For each entry, we recorded the date, location, photographer, volunteer who identified the fish, and the size of the fish relative to the culmen (dorsal ridge of the upper mandible). We classified fish into 4 categories based on the photographs (1 = fish length <51% of the adult's culmen length, 2 = fish length 51–100% of the adult's culmen length, 3 = fish length 101–150% of the adult's culmen length, and 4 = fish length >150% of the adult's culmen length), similar to groupings used by Erwin (1977). We were not able to accurately determine the gender of the skimmers feeding the chicks from many of the photographs, but the difference in the size of the culmens would likely not impact these broad categories of fish size. Based on an average culmen size of 6.7 cm (Mariano-Jelicich et al. 2007), fish length was <3.3 cm in category 1, 3.3–6.7 cm in category 2, 6.7–10 cm in category 3, and 10 cm in category 4. We classified the chicks as being downy, partially feathered, or fledged based on their plumage.

We used all the acceptable images from any location or year to create a list of species fed to skimmer chicks. To further analyze the influence of year, location, and age of chick on which species they consumed, we only used data from sites that had at least 10 photographs from each of our main study years (2015 and 2016) and we only included fish that appeared in 5 photographs. We used a chi-square test to determine if the portion of each species of fish differed. We also tested to see if the size category of the fish consumed by the chick differed by the 3 age stages.

Information about the colonies came from the Florida Shorebird Database (FWC 2016a). To compile the database, Black Skimmer colonies were monitored at least every 3 weeks using an established protocol, and the data underwent a rigorous QA/QC process (FWC 2016b).

Results

During 2015 and 2016, 256 photographs were uploaded to the Facebook group. We were able to get all the necessary data from 211 photographs. Images were submitted by 17 people, approximately half of whom (47%) had never volunteered for a bird organization. Only a few individuals commented on Facebook to identify most of the fish shown in the photographs; and only in 1 case did the professional fish biologist differ from the other volunteers in his interpretation of the species shown in the photograph.

Photographers obtained images at 9 colonies in southwestern Florida during the 2011–2016 period (Fig. 1). The majority of the images were taken at 2 well established colonies in Pinellas County (Indians Shores and Sand Key) that are ~16 km apart. Both skimmer colonies had ~250 pairs during each year and both had modest productivity varing from 0.5 to 0.9 fledges/pair.

Black Skimmers fed 22 species of fish to their chicks (Table 1), and all prey items were fish. Thirteen of the species had been recorded in adult and/or chick

diets by previous studies (Arther 1921, Erwin 1977, Gochfeld and Burger 1994, Gordon et al. 2000, King 1989, Mariano-Jelicich et al. 2007, Naves and Voorhen 2006, Tomkins 1933, White et al. 1984), and the 9 others were new. About half of the fish fed were from 3 species (or genera), the most common fish was *Menticirrhus* sp. (either *Menticirrhus americanus* (L.) [Southern Kingfish] or *Menticirrhus littoralis* (Holbrook) [Gulf Kingfish]), frequently used as marine baitfish.

The second-most common was *Lepomis macrochirus* (Bluegill), a species found exclusively in freshwater. The third-most common was *Strongylura marina* (Atlantic Needlefish), a marine baitfish. Needlefish and *Sardinella aurita* (Spanish Sardine) were seen being fed to chicks at the most colonies (7), followed by *Harengula jaguana* (Scaled Sardine) (5). Although the majority of fish were marine, 19.1% of the items fed are only found in freshwater, indicating that skimmers at 4 colonies (Indian Shores, Marco Island, Sand Key, and St. Pete Beach) were foraging in freshwater ponds.

We conducted all further analyses on fish photographed in 2015 and 2016 at the Sand Key and Indian Shores colonies and on fish species for which we had 5 or more photographs. The range in the dates that images were taken and the number of unique days when photographs were taken were similar, indicating survey effort was equivalent at the 2 sites during the 2 years of the study (Table 2).

Table 1. Fish species fed to Black Skimmer chicks from 9 colonies in Southwestern Florida (2011–2016). *indicates species of prey not previously known to be consumed by Black Skimmers. Habitat: M = marine, F = Freshwater, and B = brackish. # = number of sites.

Scientific name	Local Common Name	Habitat	Count	Percent	#
Menticirrhus sp.	Kingfish/whiting	M	43	19.5	4
Lepomis macrochirus Rafinesque	Bluegill	F	33	15.0	4
Strongylura marina (Walbaum)	Atlantic Needlefish	M	26	11.8	8
Poecilia latipinna (Lesueur)	Sailfin Molly	M, F, B,	17	7.7	4
Sardinella aurita Valenciennes	Spanish Sardine*	M	17	7.7	7
Harengula jaguana Poey	Scaled Sardine*	M	16	7.3	5
Hemiramphus brasiliensis (L.)	Ballyhoo*	M	9	4.1	3
Fundulus grandis Baird & Girard	Gulf Killifish	M	8	3.6	4
Cyprinodon variegatus Lacépède	Sheepshead Minnow	M	8	3.6	3
Anchoa mitchilli (L.)	Bay Anchovy	M	9	4.1	4
Brevoortia patronus Goode	Gulf Menhaden	M	7	3.2	2
Micropterus salmoides (Lacépède)	Largemouth Bass	M	6	2.7	2
Mugil sp.	Mullet	M	4	1.8	2
Trachinotus carolinus (L.)	Florida Pompano	M	4	1.8	3
Notemigonus crysoleucas (Mitchill)	Golden Shiner*	F	3	1.4	1
Lagodon rhomboids (L.)	Pinfish	M	3	1.4	2
Eucinostomus gula (Quoy & Gaimard)	Jenny Mojarra*	M, F, B	2	0.9	1
Rachycentron canadum (L.)	Cobia*	M	1	0.5	1
Nicholsina usta (Valenciennes)	Emerald Parrotfish	M	1	0.5	1
Elops saurus L.	Ladyfish	M, B	1	0.5	1
Opisthonema oglinum (Lesueur)	Atlantic Thread Herring	M	1	0.5	1
Oreochromis aureus (Steindachner)	Blue Tilapia*	F, B	1	0.5	1

The proportion of each species did not differ significantly between the 2 colonies ($\chi^2 = 13.11$, df = 9, $P = 0.12$). It also did not differ between the 2 years ($\chi^2 = 6.932$, df = 9, $P = 0.64$). The proportion of each species fed to downy, partially feathered and fledged chicks did not differ significantly ($\chi^2 = 30.653$, df = 18, $P = 0.23$); however, the size class of the fish was significantly different ($\chi^2 = 30.653$, df = 6, $P < 0.001$; Fig. 2). Downy chicks were fed nearly exclusively category 1 and 2 fish, and feathered chicks were fed primarily category 2 and 3 fish. The downy chicks were fed mostly very small fish, but several relatively large category 4 fish were successfully fed to downy chicks, although the photographer noted that the adult broke the bones in the fish before feeding it to the chick.

Discussion

With relatively little funding and time, researchers were able to document the fish fed to different sized Black Skimmer chicks from 9 colonies over 6 years

Table 2. The dates and total number of days that photographers took usable photos at the 2 main colonies in 2015 and 2016.

Colony	Year	Dates	Total number of days
Indian Shores	2015	6/12–8/11	13
Sand Key	2015	6/17–8/28	17
Indian Shores	2016	6/15–8/6	18
Sand Key	2016	6/15–8/20	21

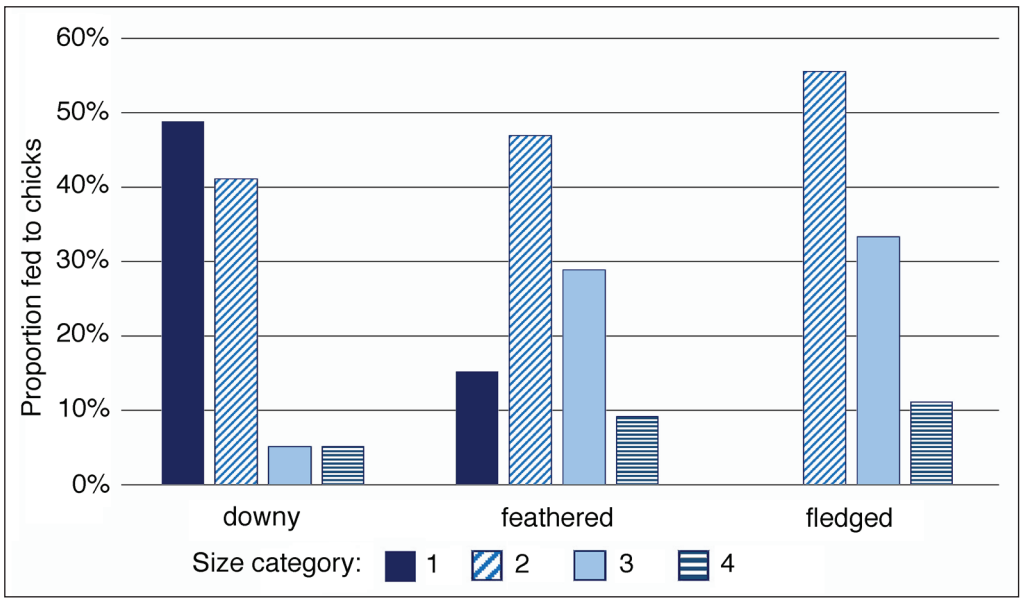

Figure 2. Proportion of fish in each size category fed to downy, feathered, and fledged Black Skimmer chicks. Size categories were defined as: 1 = fish length <51% of the adult's culmen length, 2 = fish length 51–100% of the adult's culmen length, 3 = fish length 101–150% of the adult's culmen length, and 4 = fish length >150% of the adult's culmen length.

during 93 separate visits. This study expanded the knowledge about which species skimmers feed their chicks and developed a baseline of which species were most important to Black Skimmers in Southwestern Florida.

Skimmers in Southwest Florida exclusively fed their chicks fish, which is similar to what has been reported in most studies (Arthur 1921, Erwin 1977, Loftin 1982) although King (1989) found a few *Penaeus* sp. (shrimp) that were ingested by chicks in Galveston Bay, TX, and Tomkins (1933) found shrimp dropped near chicks in Georgia.

The species and numbers of fish fed to chicks was similar between years (2015, 2016) and locations (Indian Shores, Sand Key). It should be noted that the colonies used for this analysis were relatively close together (within 16 km) and, therefore, foraging areas are likely to overlap. The most common type of fish fed to chicks at both main sites was kingfish, which was not found in any of the published Black Skimmer diet studies in the US, but was one of the most common fish eaten by adults in southern Brazil (Naves and Vooren 2006). Bluegill was the second most common species and was previously seen by King (1989). Bluegill are only found in freshwater, indicating that skimmers were foraging at least 2.9 km from the Indian Shores colonies and 3.8 km from the Sand Key colonies. It is likely that skimmers forage in freshwater when it is windy at the beaches and bays (Gochfeld and Burger 1994); this result suggests that the presence of freshwater ponds near a colony may increase productivity.

Ours is the first study to statistically compare the size of fish and the age of the chicks fed, however our results that smaller chicks are fed smaller fish is supported by broader observations from Erwin (1977) and Gochfeld and Burger (1994). Availability of smaller baitfish in relatively calm waters is likely another factor in Black Skimmer productivity.

Finally, this study demonstrated the potential of social media to generate high-quality diet data from photographers. The data was collected using photographs with the species identification listed below each post; thus, it was easily verified by researchers, which increased its accuracy over unverified data collected by citizen scientists (Gardiner et al. 2012). While we did not explicitly measure the impact of the photographer's involvement in the project on their knowledge and attitudes about the skimmers, we did note that 100% of the photographers interacted and commented on photographs other than their own, indicating engagement with the project. None of the participating photographers were seen intruding into the skimmer colonies while taking photographs during the 2015 and 2016 field season (colony stewards noted at least 2 photographers in the colony at Indian Shores, but neither was known from the Facebook page). In the future, we plan to develop a long-term database of fish fed to chicks and investigate the role of participation on photographer behavior. Ideally, we will standardize the number days photographs were taken at each colony and expand the geographic range of our study so that we can establish a broader baseline of what species are fed to chicks. We could survey photographers before and after participating in our project to see if their knowledge of Black Skimmers increased and if this increase translated into fewer photographer-caused disturbances and more protection.

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