

**Behavioral Observations of Lilliputian Piscivores:  
Young-of-year *Sphyraena barracuda* at Offshore Sub-tropical  
Reefs (NW Atlantic Ocean)**

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**Abstract** - Direct observations were made in June 2009 and 2010 of newly recruited young-of-year (YOY) *Sphyraena barracuda* (Great Barracuda; 50–80 mm total length) occurring on “live bottom” sub-tropical reefs off the southeast US at depths of 18–25 m. Counts of YOY fish from roving diver surveys along multiple reefs with under-cut ledges ranged from 0–122 individuals, indicating patchy distributions at the scale of individual reefs. Individual fish occurred in groups of 2–20+, primarily along the undercut side of ledges, where dense schools of *Haemulon aurolineatum* (Tomtate), *Decapterus punctatus* (Round Scad), *Decapterus macarellus* (Mackeral Scad), *Stenotomus chrysops* (Scup), and Atherinid sp. (silverside) were concentrated. Groups of YOY Great Barracuda attacked, captured and consumed YOY Tomtate and Silverside that occurred in schools in the water column adjacent to (just above the sediment-water interface) and directly above the undercut edge of the reefs. Prey reacted during attacks by reducing nearest neighbor distances and retreating to the reef edge, where they were subsequently attacked by the demersal piscivores *Centropristis striata* (Black Sea Bass), *Centropristis ocyurus* (Bank Sea Bass), and *Mycteroperca phenax* (Scamp Grouper). That groups of YOY piscivores, at sizes close to settlement, can assume such a functional role in regards to driving such species interactions suggests greater attention should be given to the roles played by the wider diversity of YOY piscivores recruiting to reef communities.

Considerable effort has been directed at understanding the distribution and role that nearshore nursery habitats play in mediating the population dynamics of reef fishes (e.g., Almany and Webster 2006, Jones 1991, Laegdsgaard and Johnson 2001). Questions about cues for settlement, variation in survivorship and growth across habitats, ontogenetic shifts in habitat use, and impacts on prey have been central to such studies. Answers to similar questions at offshore sites have focused on relatively fewer and more sedentary species in part due to the problems related to sampling at increased depths, especially in areas of rough topography. Given the role that piscivory plays in structuring reef fish communities (Heinlein et al. 2010, Hixon and Carr 1997), understanding recruitment and immigration of piscivores to reef ecosystems can lead to greater understanding of the dynamics of reef-fish recruitment and population dynamics. Here we report limited but rare direct underwater observations of newly recruited young-of-year *Sphyraena barracuda* (Edwards) (Great Barracuda) within a sub-tropical reef system, and describe their post-settlement habitats and their group behavior as it relates to their ecological role. Great Barracuda are common reef piscivores, so increased knowledge of their early demersal phase life histories could aid in developing more refined questions about recruitment processes, trophic interactions, and better target sampling strategies.

A modified roving-diver transect (sensu Schmitt and Sullivan 1996) was employed at undercut medium- and high-relief sandstone ledge “live-bottom” reefs off the coast of Georgia (see Kendall et al. [2005, 2007] for a description of reef types) during June 2009 and 2010 as part of a larger study of the behavioral interactions of piscivores and their prey (Fig. 1a, b). During survey dives, one diver collected data on species

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composition (total counts of all species observed during each dive to calculate relative abundance indices), while the other diver focused on details of the interactions between piscivores and prey (species, number, and behavioral relationships related to capture of prey). The roving-diver technique was used because of our a priori decision to focus on the undercut ledge habitats of offshore reefs and the highly variable direction and length of ledges over the seafloor (Fig. 1c). Further, in an earlier 2008 study (Auster et al. 2009; P.J. Auster, unpubl. data) we found that encounter rates of predation events were higher by swimming along ledges compared to making observations from stationary positions. Divers collected data on fish observed along the tops of ledges as well as those found in the undercut crevices. After it was clear that we were observing young-of-year (YOY)

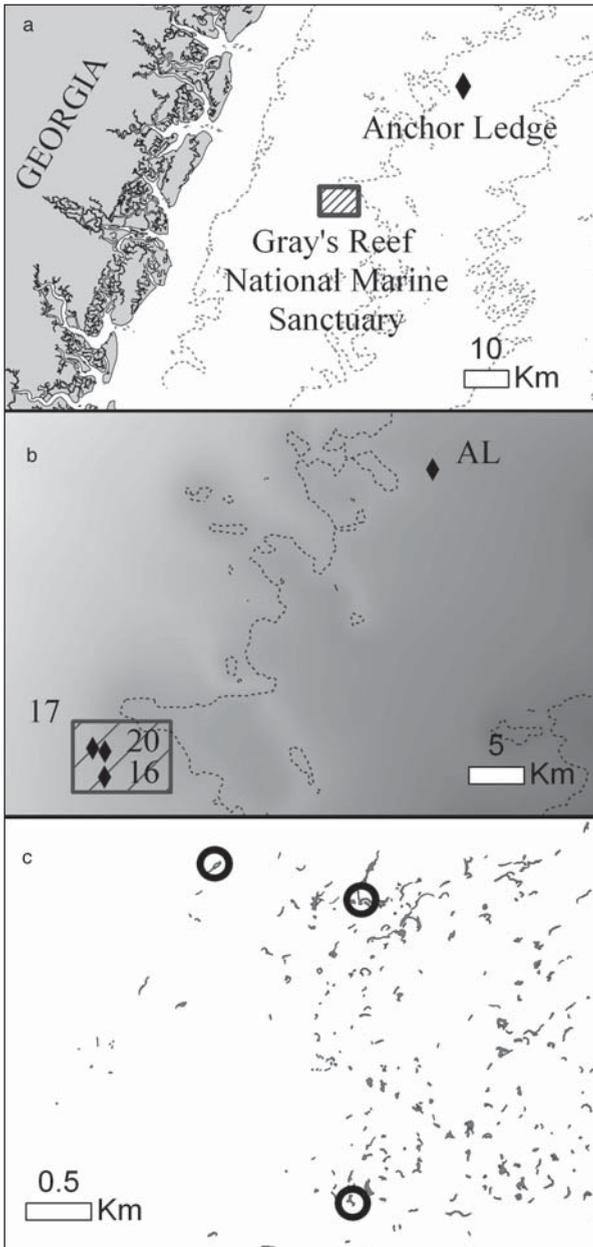


Figure 1. a. Location of survey sites off the coast of Georgia. b. Detailed distribution of sites offshore. c. Location of study sites within Gray's Reef National Marine Sanctuary on map of medium and high relief sandstone ledge "reefs" based on Kendall et al. (2005). Note the non-linear form and variable length of individual reefs.

Great Barracuda, we began parsing YOY from older juveniles and adults in our counts and observations. This report focuses only on YOY Great Barracuda, as their small size and information characterizing their interactions with co-occurring species is unique. We defined YOY individuals as those at sizes from settlement to over the first weeks of demersal existence, as described in the literature (i.e., 25–100 mm TL), rather than lumping all small fish as juveniles, which are generally determined as <333 mm TL (based on deSylva [1963] and Schmidt [1989]).

A total of 45.1 hrs of bottom time was expended while conducting fish surveys and quantifying species interactions at depths ranging from 18–25 m. Additional dives (41.4 hrs) were conducted to identify study sites, make general observations, and document behaviors and habitats. Fish sizes, as well as distances between fish and habitat features, were based on visual length and distance estimates by divers and gauged against objects of known length (e.g., scale on dive slate, objects measured with slate post encounter).

We observed 648 YOY Great Barracuda, approximately 50–80 mm TL, aggregated along multiple reefs with undercut crevices during quantitative surveys, with an additional 100 individuals observed during non-survey dives (Fig. 2a). Encounters with YOY fish at the scale of individual reefs were highly patchy in space and time, with a mean of 23.1 individuals/survey (S.D. = 25.5) over the course of 28 surveys (Table 1). There was little consistency in numbers of recruits encountered even at the same reef on the same day. It is worth noting that the number of older juvenile and adult fish was also variable across reefs and that these older fish represented only 14.8% of all Great Barracuda observed. We were not able to quantify the abundance of recruits in every coherent group within reefs due to multiple tasks on each dive, but group sizes ranged from two to approximately 20-plus individuals based on photographs and noting the size of larger groups.

During both years, spatially extensive (i.e., meters to tens of meters) and dense aggregations and schools of juvenile and adult *Decapterus punctatus* (Cuvier) (Round Scad) and *Decapterus macarellus* (Cuvier) (Mackerel Scad) as well as YOY *Haemulon aurolineatum* Cuvier (Tomtate), YOY *Stenotomus chrysops* (L.) (Scup), and silverside (family Atherinidae) occurred in the water column adjacent to (just above the sediment-water interface) and up to approximately 2 m outwards and 2 m above the undercut edge of the reefs. These are the principal prey species of both mid-water and demersal piscivores at these reefs (see Kendall et al. [2007] and Auster et al. [2009] for details of piscivore species, habitat associations, and predation behavior).

Aggregations of YOY Great Barracuda were observed in 2009 and 2010 following (i.e., based on directed movements) YOY Scup and Tomtate, of the same approximate size as the YOY Great Barracuda. While no direct predation was observed, schools of prey did react to rapid approaches by predators by altering swimming direction and forming vacuoles within schools. During two dives on 3–4 June 2010 at Site 16 (20 m depth), we observed aggregations of YOY Great Barracuda mounting sequential attacks (e.g., in one case, approximately 20 attacks within approximately 3 minutes) on schools of YOY Tomtate and silverside (Fig. 2b). When attacked, schools of prey retreated towards the reef where they were attacked by *Centropristis striata* (L.) (Black Sea Bass), *Centropristis ocyurus* (Jordan and Evermann) (Bank Sea Bass), and *Mycteroperca phenax* Jordan and Swain (Scamp Grouper) (Fig. 2c). In this context, prey taxa reduced nearest neighbor distances from 0.75–2 body lengths to less than 0.25 body length during attacks (i.e., from approximately 160 mm when undisturbed to less than 10 mm shortest distance between individuals during attacks), producing ephemeral high density prey patches for demersal piscivores. Prey were not fully consumed by YOY Great Barracuda at first capture (Great Barracuda severed the caudal fin region to mid-body), and the primary attacker as well as co-occurring piscivores ate fish remains.

Great Barracuda are known to function as piscivores from settlement based on stomach contents data (de Sylva 1963, Randall 1967, Schmidt 1989). Here, albeit from a very limited set of direct underwater observations, we showed that YOY Great Barracuda exhibited patchy distributions at the scale of individual reefs, occurred in coherent groups within reefs, and were not simply operating as individual predators but cooperated via group stalking and attack behaviors. As far as we know, these observations of fine-scale distribution and attacks by YOY Great Barracuda on prey of nearly equal size are unique. That YOY Great Barracuda co-occurred in topographically complex habitats with prey of near equal size and high abundance makes recognition of this species during visual surveys difficult unless they are specially targeted. That the standard deviation of abundance per survey exceeded mean abundance is indicative of highly patchy distributions and illustrates the potential difficulties in regards to sample size and spatial coverage.

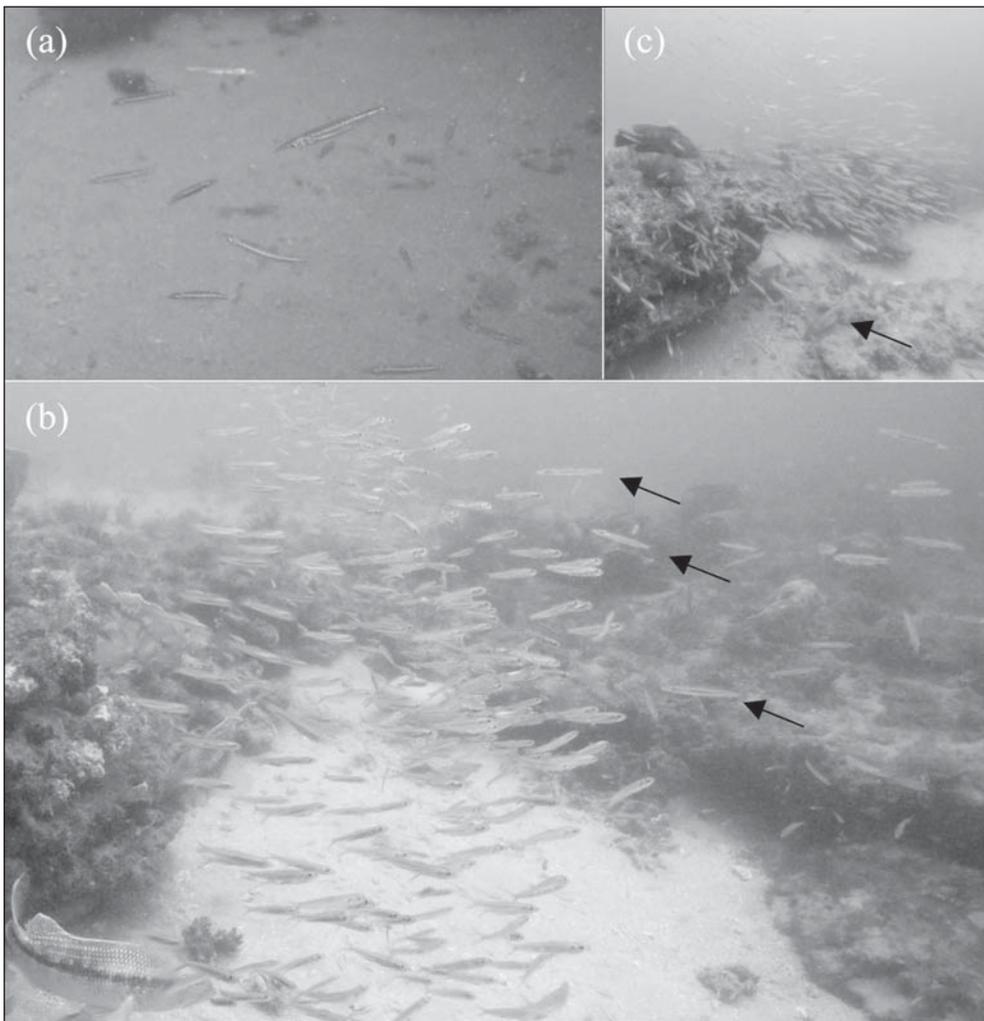


Figure 2. a. Aggregation of approximately 13 young-of-year Great Barracuda. b. YOY Great Barracuda (arrows) prior to attacking a school of silversides. Note Bank Sea Bass on reef edge (left) oriented towards school and other YOY Great Barracuda not presently oriented towards the prey (far right). c. School of silverside in burst pattern after sequential attack by Great Barracuda and then by Bank Sea Bass (arrow).

Previous work documented prey species reacting during attacks of single and mixed species groups of adult and late juvenile sizes of mid-water piscivores by reducing nearest neighbor distances and retreating to reefs, facilitating opportunities for predation by the guild of demersal piscivores (Auster et al. 2009; P. J. Auster, pers. observ.). That the predatory behaviors of YOY Great Barracuda can induce similar synergistic effects with other reef predators is an important finding if such facilitative interactions are widespread. That is, if YOY Great Barracuda increase the rate of such interactions and have indirect but positive effects on consumption rates of co-occurring piscivores.

Variation and persistence of YOY Great Barracuda in groups across space and time is an open but important question, as well as whether patch formation and group behavior emerge during pre- or post-settlement periods. If small scale distribution patterns at settlement are set in part by oceanographic processes during the pre-settlement stage, then formation of aggregations in the plankton (e.g., in eddies or along frontal boundaries) could be tightly linked to spatial variation in patterns of predation by this species at the early juvenile stage (Sponaugle et al. 2005). If post-settlement processes are the primary drivers for aggregation, then the spatial arrangement of reef habitats within the seafloor

Table 1. Summary by date and location of proportion of recruits to total number of Great Barracuda (recruits + larger juveniles and adults) observed along roving-diver transects at each reef with undercut ledges. Bottom temperatures are given in degrees centigrade.

Site	Date	Temperature	Proportion new recruits
Site 16	10-Jun-09	25.0	0 of 1
		25.0	0 of 0
		25.0	10 of 21
	11-Jun-09	24.4	25 of 25
	14-Jun-09	23.8	21 of 21
Site 20	11-Jun-09	23.8	11 of 16
		25.0	0 of 0
	12-Jun-09	23.8	22 of 40
	14-Jun-09	23.8	0 of 20
	15-Jun-09	23.8	34 of 52
Anchor Ledge	13-Jun-09	23.8	20 of 20
		23.8	13 of 13
	18-Jun-09	23.8	61 of 61
		23.8	57 of 58
		23.8	122 of 125
Site 16	2-Jun-10	25.5	21 of 25
		25.5	41 of 44
	4-Jun-10	26.1	25 of 25
		26.6	34 of 34
Site 20	3-Jun-10	25.5	0 of 7
Anchor Ledge	5-Jun-10	25.0	15 of 16
		25.0	29 of 32
	6-Jun-10	25.5	32 of 36
Site 17	2-Jun-10	25.5	0 of 0
		26.6	0 of 1
	7-Jun-10	26.6	15 of 15

landscape as well as patterns of prey abundance and behavior could explain spatial variation in group size and abundance (Grober-Dunsmore et al. 2007, Kracker et al. 2008). The observations we report here could aid in designing sampling strategies to tease apart the processes that result in local patterns of abundance and the resultant functional role of this piscivore.

We suggest that greater attention be given to early demersal phases of piscivores in studies of behavioral interactions of reef fishes. Understanding the behaviors of predators and prey can provide insight into the conditions that mediate the dynamics of abundance in reef fish species (Baskett et al. 2007, Grober-Dunsmore et al. 2008) and are important when considering conservation and management strategies for fish and fisheries. Further, if Lilliputian piscivores are widespread and as rapacious as individuals observed in this study, we could be underestimating the number and strength of trophic links in food web studies of reef fishes based on assumptions that new recruits serve only as prey (e.g., Walters and Kitchell 2001).

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