

# JUVENILE SNOOK SPECIES IN PUERTO RICO ESTUARIES : DISTRIBUTION, ABUNDANCE AND HABITAT DESCRIPTION

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## ABSTRACT

Early stages of juvenile *Centropomus* spp., a group of economically important species, were surveyed in Puerto Rico estuarine areas. Sampling was conducted from April '92 to December '93. Habitat included shallow fresh water areas (<3m), such as river banks and tributaries (marsh, water hyacinths), and in brackish to salt water areas, such as lagoons and backwaters (red and black mangrove).

Five species of snook were collected : *Centropomus undecimalis*, *C. ensiferus*, *C. parallelus*, *C. mexicanus* and *C. pectinatus*. The distribution of the 5 species varied among habitat sampled. Early juvenile snook (SL<50mm) in river systems were largely dominated by *C. parallelus* (75%); and in lagoon systems, by *C. undecimalis* (60%) and *C. ensiferus* (35%). Colonization peaks of the 3 dominant species show broad overlapping : from June to November for *C. undecimalis*, from April to December for *C. parallelus* and from June to August and December to January for *C. ensiferus*.

Preferred nursery habitats are very turbid and calm waters, in the vicinity of shelter (mangrove roots, grass, or water hyacinths). The physical parameter range of juvenile snook habitat is relatively broad : salinity from 0 to 30, temperature from 24° to 35°C, anoxic to high oxygenated water. Condition factors of fish < 100mm SL showed no significant difference (non parametric test of Kruskal-Wallis) between river and lagoon systems. Although their food habits were similar during early stages (SL<100mm), food does not seem to be a limiting factor among the different systems.

## INTRODUCTION

The genus *Centropomus*, commonly known as snook or robalo, consists of 12 species confined in the tropics and subtropics of the American Continent. A systematic review of the genus was provided by Rivas (1986), who described 6 species in the Pacific and 6 in the Atlantic waters, none occurring in both oceans. Among the Atlantic species, one has a very limited distribution in Mexico (*C. poeyi*). The other 5, *C. undecimalis*, *C. ensiferus*, *C. parallelus*, *C. pectinatus* and

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*C. mexicanus*, are distributed from about 30°N to 30°S of latitude range. *C. undecimalis* has the largest range, from north Florida (USA) to Brazil. Their distribution can be partially explained by the fact that *Centropomus* species are stenothermic and do not survive at temperatures below 15°C (Shafland and Foote, 1983). They are euryhaline, diadromous and estuarine-dependent, and are not found in islands deprived of permanent streams (Rivas, 1986). They are also closely related to mangrove (Rivas, 1986) and seagrass beds (Gilmore et al., 1983). Snook are known to spawn offshore close to estuaries. After hatching, larvae drift with the currents inshore and colonize shallow and protected estuarine areas (Gilmore et al, 1983; Lasserre et Toffart, 1977; Mc Michael e et al., 1989).

Four snook species are reported in Puerto Rico (Erdman, 1967), the most southern island of the Greater Antilles. For the fifth species, *C. mexicanus*, no publication nor report mentioned it in the island, except in Rivas (1986) and yet the statement was not clear. *C. mexicanus* was plotted on the map of Puerto Rico but no reference could be found in the text. From all the species *C. undecimalis* is the largest (Table 1) and most interesting for recreational fishery. All of them are actively exploited by commercial fishermen throughout the year, and are considered as highly valued fishery resource. Yet none of these species had been studied on the island until recently. Moreover, most of the literature found on snook concerns *C. undecimalis* biology or fishery management in Florida (USA). Very little information is available on any other species of snook.

The present study has the purpose of studying simultaneously 5 of these species under insular tropical environment. Its objectives are: 1) to describe juvenile snook relative abundance in space and time, and 2) to define their nursery habitat preference and suitability.

### **METHODS AND MATERIALS**

Puerto Rico is the easternmost and smallest of the Greater Antilles and lies between 18° 31' N and 17° 55' N latitude and 65° 37' W and 67° 17' W longitude.

Air temperature is almost constant throughout the year (25°C ±3), whereas precipitation accounts for a marked but non regular seasonality. The period of greater rainfall prevails from May through November (wet season), while the driest period extends from December to April (dry season). These seasonal changes reflect in profound habitat modifications : whole systems (river or lagoon) can be temporary close to sea, substantial morphologic changes occur with flooding conditions, and vegetation can be exuberant or flushed out with drainage water (e.g., water hyacinths in freshwater systems).

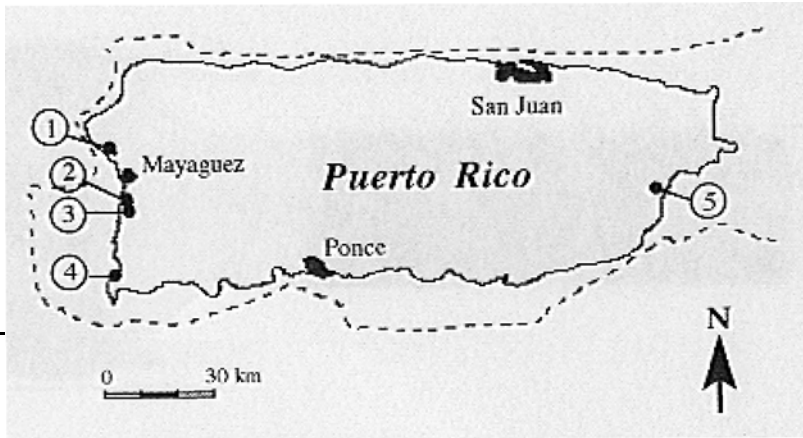


Figure 1 : Puerto Rico island with areas of sampling : 1) Añasco river, 2) Corazones lagoon, 3) Guanajibo river, 4) Boquerón lagoon, and 5) Humacao lagoon.

As juvenile snook are known to be estuarine-dependent, various coastal habitat types were sampled (Figure 1).

Site 1: Añasco river (ANA) is a larger river (6m wide, 3.5 m deep) receiving several irrigation canals.

Site 2: Corazones lagoon (COR) is a 5 ha saltwater lagoon surrounded by 83 ha of black and red mangrove.

Site 3: Guanajibo river (GUA) is characterized by a narrow (3m) and deep (4.5m) section.

Site 4 : Boquerón system (BOQ) is composed of different wetland systems : the lagoon itself (75 ha and 0.75 m of average depth) is open to the sea by a deep canal. It receives, through its drainage channel, a continuous freshwater input coming from adjacent fields or occasionally from an impoundment when gates overflow. The impounded area used as bird refuge (170 ha) is filled with freshwater. The backwater area (about 70

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ha), is characterized by very shallow waters (0.5 m deep) and salinity comprised from fresh to hyper saline depending on season.

Site 5 : Humacao Wildlife Refuge (HUM) is located on the east coast of Puerto Rico. It is composed of 5 brackish lagoons, with an average depth of 1.5m (maximum depth = 2m), and connected to the sea by a narrow river. The surrounding vegetation is mainly composed of marsh and floating vegetation, which produces a rich bottom of decomposing organic matter.

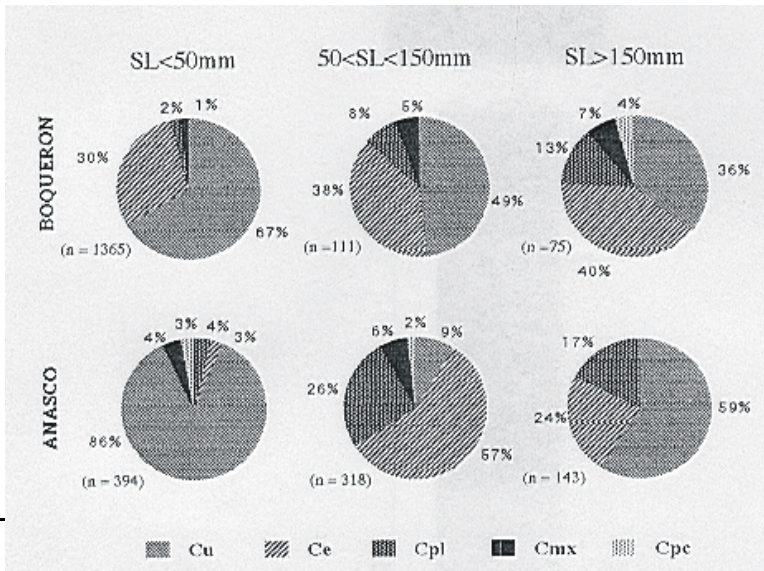


Figure 2 : Snook species distribution (by frequencies), separated in 3 size classes, observed in 2 systems (Boquerón lagoon and Añasco river).

**Sampling Techniques**

From April 1992 to December 1993, collections of fish were made monthly in the various systems of the West coast, bimonthly on the East coast. Sampling involved several techniques depending of the habitat : a small bag seine

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(L=8m, H=1.3m, 1.5mm square mesh) was used for beaches, small pools, creeks and mud flats, in depth ranging from 50 to 150cm; trap nets were set blocking small creeks or canals (aisle : 7m long, 3mm square mesh; bag : 3m long, 3 hoops built with funnels); gill nets were also deployed (12, 25 50mm square mesh), in short panels (3 to 6m long) to block creeks and channels, or in long panels (30m long experimental gill nets of 3 panels of the above mesh) in the middle of lagoons. In few occasions fish were also collected by rotenone poisoning in mangrove roots, and in canals (dose of 2 g of 5% powdered rotenone for 1 m<sup>3</sup> of water); or from cast netting (radius = 1.5, 2.1 or 2.4m) in the open water.

### Environmental Descriptors

Habitat descriptors, such as water depth, water clarity (Secchi), temperature, pH, dissolved oxygen, salinity and vegetation cover, were collected to aid in the characterization of essential habitats for juvenile snook.

### Lab Work

Collected fish were either released in the field (about 40%) or put immediately in ice and kept frozen before processing. Released fish were measured in standard (SL) and total length (TL) to the nearest mm. Fish processed at the laboratory had also the two lengths measured to the nearest mm, and the weight, to the nearest 0.01g. Length given in this article will be standard unless noted otherwise.

Snook species, for individuals bigger than 100mm were identified according to the systematic review of Rivas (1986). For early juvenile snook, this key is no longer applicable, and a new key, based on meristic ratios and pigmentation, was built.

Condition factor was calculated using the formula :  $CF = W/L^b$  where W = weight in g and SL in mm and b is the parameter calculated from the weight-length relationship. Only fish measured at the laboratory were included in this analysis.

Stomach contents were processed at the same time as fish. They were observed through binocular and occurrence of prey category noted : fish, shrimp, crab, insect, plankton, or detritus.

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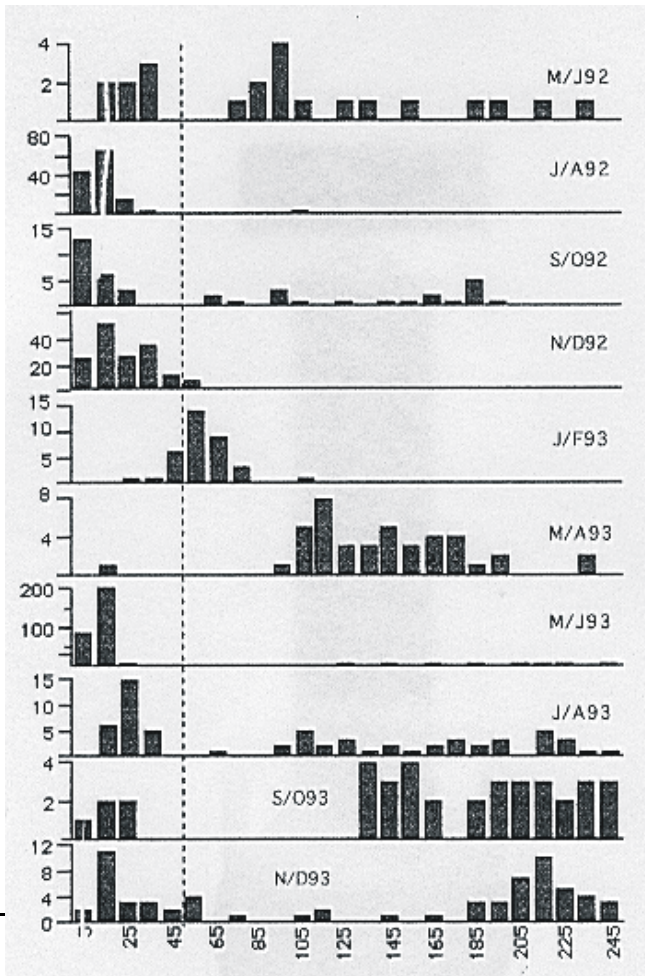


Figure 3 :  
Pooled  
bi-monthly size frequencies of *C. undecimalis*, observed from May 1992 to December 1993, from west Puerto Rico.

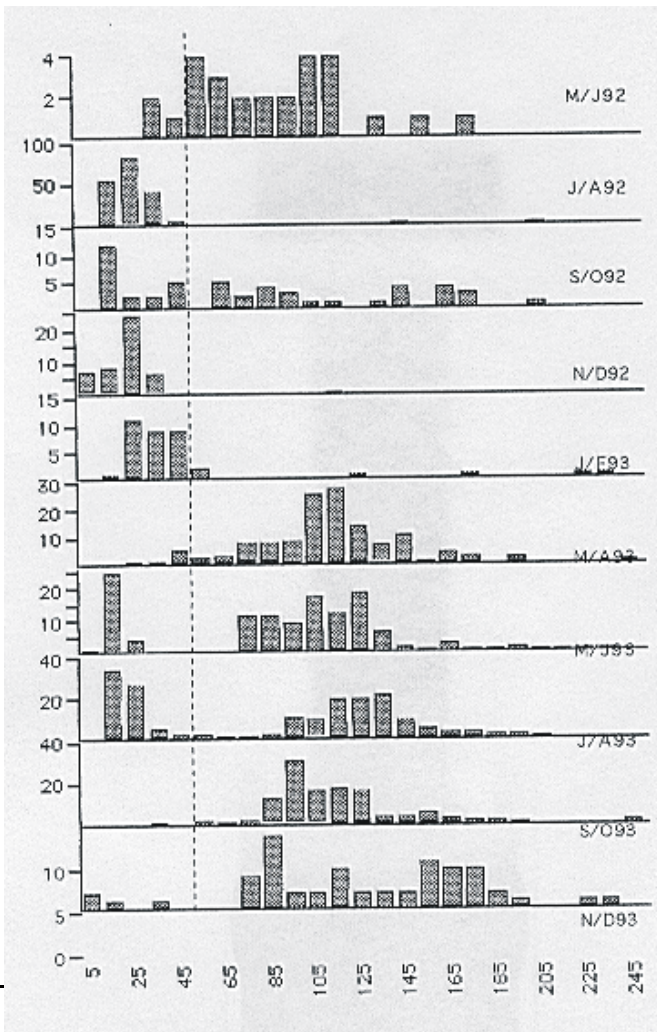


Figure 4 :

Pooled bi-monthly size frequencies of *C. ensiferus* observed from May 1992 to December 1993, from west Puerto Rico.

RESULTS

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### Snook Species Distribution In The Diverse Areas

During 1992-93 sampling about 3000 snook juveniles were collected: 40% were *C. undecimalis*, 35% *C. ensiferus*, 22% *C. parallelus*, and less than 3% were the 2 other species (2% *C. mexicanus* and <1% *C. pectinatus*). *C. mexicanus* was positively confirmed as different species than *C. parallelus* using genetic analyses (Tringali, unpublished data).

Data observed in 2 lagoons : Boquerón, Corazones, and 2 rivers : Guanajibo and Añasco were utilized and relative abundance of the snook species, compared. The relative densities are shown in table 2. Distribution among the areas shows a significant difference (Chi square test,  $P < 0.0001$ ,  $n = 3040$ ,  $\chi^2 = 1406$ ).

Data observed in only 2 of these systems (Boquerón and Añasco) are summarized per size class (Figure 2). For size class <50mm, Boquerón is dominated by *C. undecimalis*, while Añasco is largely dominated by *C. parallelus*. Between 50 to 150mm, the dominance ranks remain in Boquerón but already change in Añasco (*C. ensiferus* dominant). For SL>150, a more equal share is observed between snook species in Boquerón but the same dominance is still observed, where once again Añasco shows another change in favor of *C. undecimalis*.

### Temporal Distribution Of Young-of-year Snook

Bi-monthly frequencies of *C. undecimalis*, *C. ensiferus* and *C. parallelus* are presented in Figure 3, 4 and 5, respectively. Data from river and lagoon were combined and months pooled by pair for clarity of the graphs.

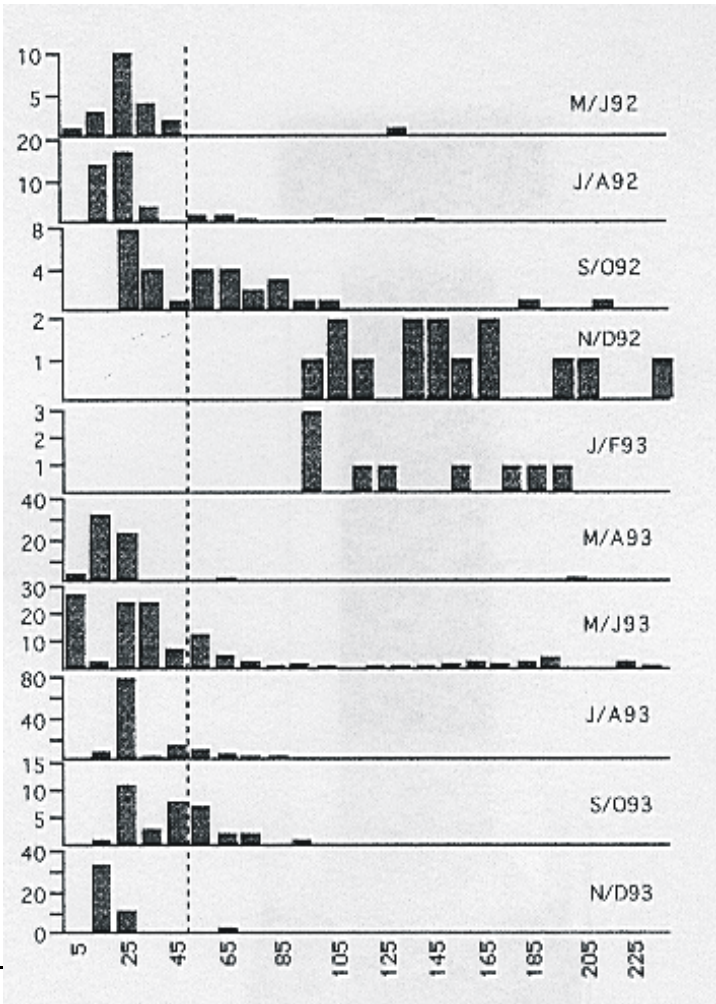
Snook (any species) arrive at the nursery ground as small as 7 mm SL. Period of higher colonization was from June to Dec in both years for *C. undecimalis*, from June to January and in June-July for *C. ensiferus*, and from May to October '92 and May to November 93 for *C. parallelus*.

### Habitat Description

In rivers, juvenile snook were found at the mouth and closed-by irrigation canals, usually close to floating or over-hanging vegetation (water hyacinth, bamboo, dead trees...). The 5 species were found at the mouth level, whereas only *C. parallelus* was found up river, after the limit of saltwater wedge. In lagoon, juvenile snook were found in shallow waters, among mangrove roots, in drainage channels or in backwater areas. They seem to migrate to the most remote place from mouth of the lagoon.



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Figure

5 : Pooled bi-monthly size frequencies of *C. parallelus*, observed from May 1992 to December 1993, from west Puerto Rico.

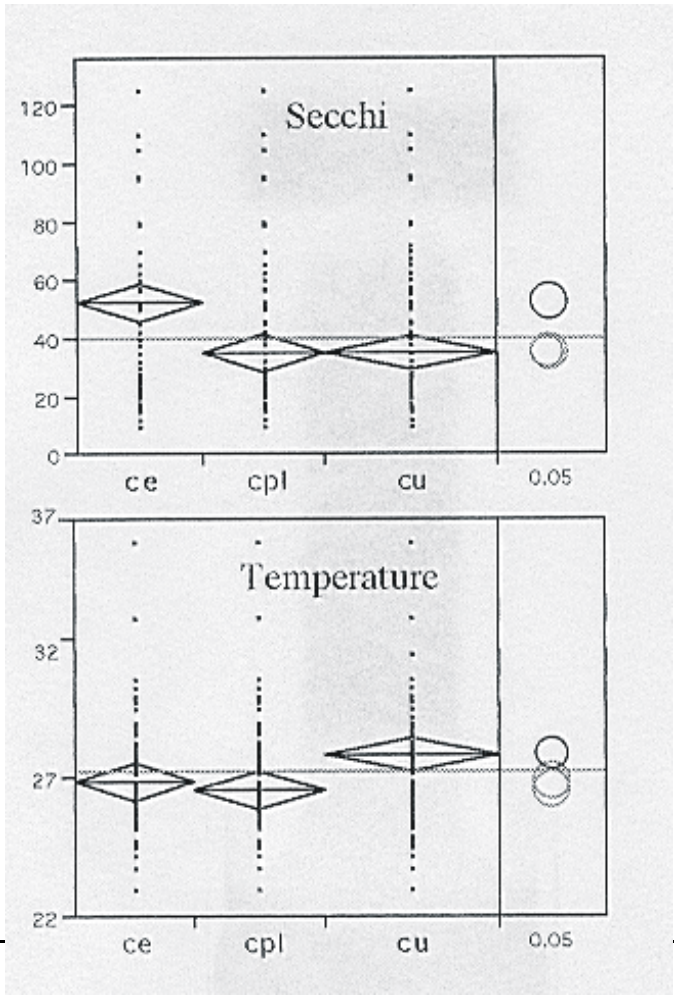


Figure 6 :

Preferred habitat features of snook species : distribution, mean (horizontal bar) and 95% confidence interval (diamond) of Secchi and Temperature, observed for ce= *C. ensiferus*, cpl=*C. parallelus* and cu=*C. undecimalis*. Student t test is significant if circles are separate.

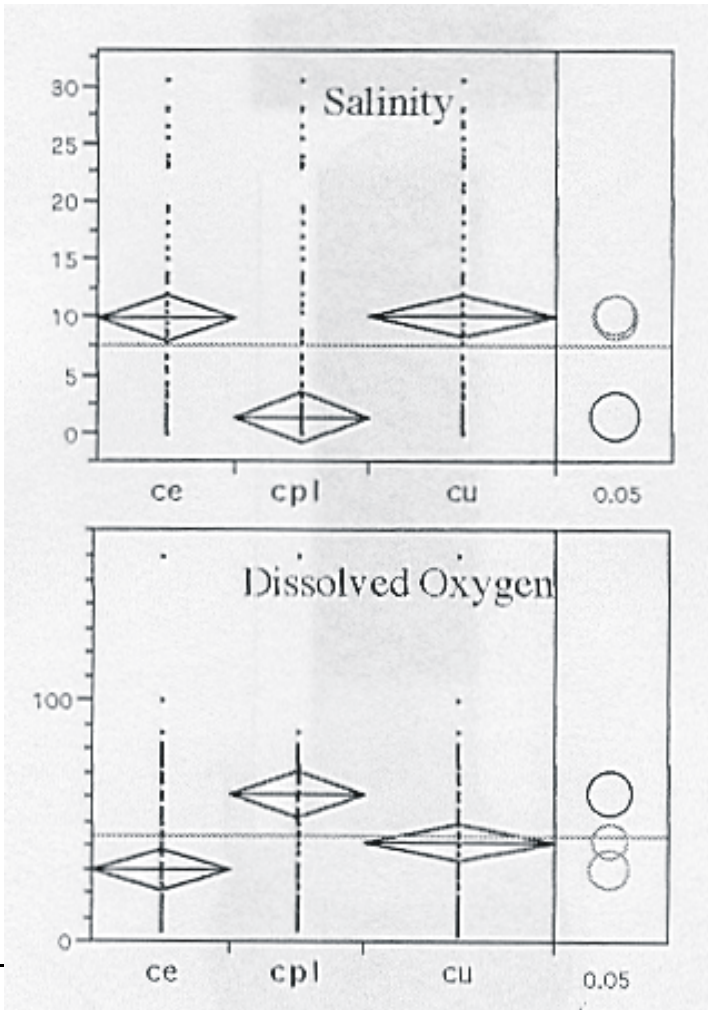


Figure 7

: Preferred habitat features of snook species : distribution, mean (horizontal bar) and 95% confidence interval (diamond) of Salinity and Dissolved Oxygen, observed for cu=*C. undecimalis*, ce=*C. ensiferus*, and cpl= *C. parallelus* . Student t test is significant if circles are separate.

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Physical parameters that characterize juvenile snook habitat were studied. Measurements of depth, Secchi, temperature, salinity and dissolved oxygen where early juveniles were caught (550 *C. undecimalis*, 400 *C. ensiferus*, and 325 *C. parallelus*) are summarized in the Table 3. All 3 species had parameter ranges rather broad and similar : salinity from 0 to 28-30; dissolved oxygen from anoxic to high oxygenated habitat and temperature ranges from 24 to 35°C. These data show a wide tolerance of snook early juveniles for habitat water quality.

To define the preferred habitat, parameter means were compared, using a Student t test (Figures 6 and 7). *C. parallelus* is characterized by low salinity and high dissolved oxygen (mean significantly different than 2 other species,  $P < 0.05$ ). This result was expected since they are found primarily in rivers. *C. ensiferus* is found in water with a Secchi significantly higher than for the 2 other species ( $P < 0.05$ ) and with dissolved oxygen especially low, even though not significantly different than for *C. undecimalis*. For *C. undecimalis*, only the temperature is higher than for the 2 others ( $P < 0.05$ ), this species does not show any other preferences.

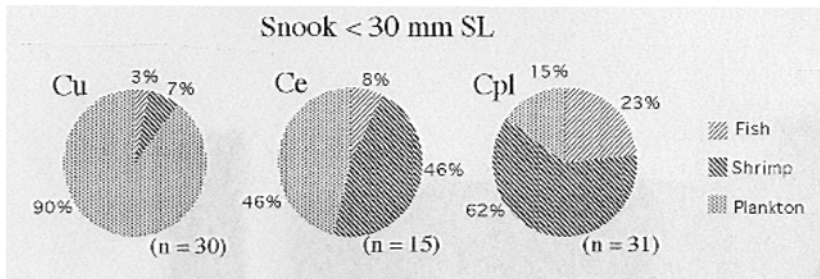


Figure 8 : Food habits (prey occurrence) of cu=*C. undecimalis*, ce=*C. ensiferus*, and cpl= *C. parallelus* for individuals smaller than 30 mm.

### Habitat Use and Benefits

Condition factors (CF) were calculated for fish < 100mm and 100mm < fish < 300mm, and compared between river and lagoon systems. A summary of the results is given on Table 4. CF of early juveniles show not significant difference among the 2 systems (Student t test,  $P > 0.05$ ). CF of late juvenile *C. ensiferus* show a significant difference with river CF higher than lagoon CF (Student t test,  $P <$

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0.01), where *C. undecimalis* and *C. parallelus* CF show no significant difference.

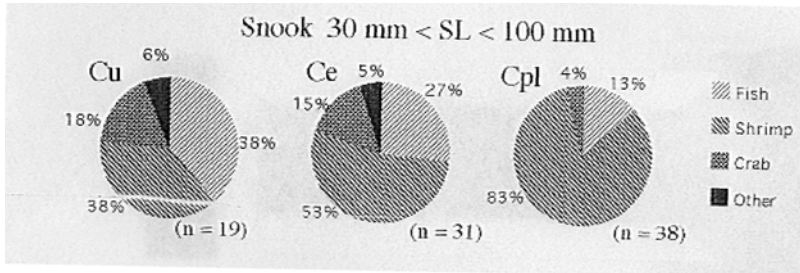


Figure 9 : Food habits (prey occurrence) of cu =*C. undecimalis*, ce=*C. ensiferus*, and cpl= *C. parallelus* for individuals comprised between 30 and 100 mm SL.

Food habits were studied for snook juveniles (SL<100mm). Empty stomachs represented 32% for *C. undecimalis* (n=73), 23% for *C. ensiferus* (n=60) and 29% for *C. parallelus* (n=97). When juvenile is less than 30 mm (Figure 8), snook species do not show same food habits (Chi2, P < 0.001); *C. parallelus* eat mainly fish and shrimps (n = 31), while *C. undecimalis* feed primarily on plankton (n = 30). Their limit size for being planktivorous was found to be 30 mm for *C. undecimalis*, 25 mm for *C. ensiferus*, and 20 mm for *C. parallelus*. Later they all switch to fish and shrimp, sometimes crabs, mollusk or insects.

For snook 30 < SL < 100 mm (Figure 9), the difference in food habits decreases but is still significantly different (Chi2, P < 0.05; *C. undecimalis* = 19, *C. ensiferus* = 31, and *C. parallelus* = 38). *C. parallelus* have then shrimps as a preferred food.

As food habit may be a function of habitat resource, stomach contents were compared among snook species (at size ranging from 30 to 300 mm) collected in river (*C. undecimalis* = 16, *C. ensiferus* = 23 *C. parallelus* = 46) and in lagoon (*C. undecimalis* = 53, *C. ensiferus* = 115, not enough data for *C. parallelus*). Results are summarized in Figure 10. The dominant prey item found in lagoon is fish for *C. undecimalis* and *C. ensiferus* (Chi2 = 5.8, not significant), and shrimp in the river (Chi2 = 4.7, not significant).

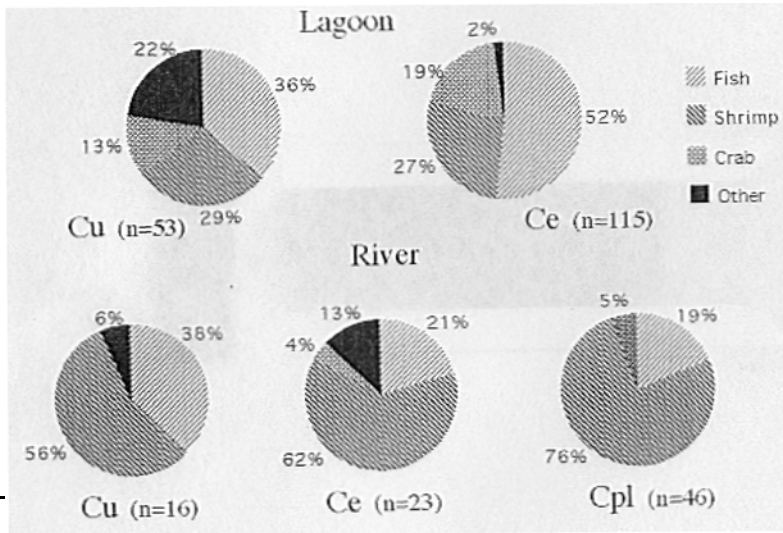


Figure 10 : Food habits (prey occurrence) of cu = *C. undecimalis*, ce = *C. ensiferus*, and cpl = *C. parallelus* collected in river and lagoon systems.

#### DISCUSSION

Four species of snook were reported in Puerto Rico (Erdman, 1967; Martin and Patus, 1984). During this study a fifth species *C. mexicanus* was positively confirmed.

Among the 5 species, 3 are clearly dominant (*C. undecimalis*, *C. ensiferus* and *C. parallelus*). This situation is not usual and has rarely been subject to study. In Florida 4 snook species are reported but one is largely dominant (*C. undecimalis*), probably due to the fact that Florida is the northern limit of the 3 other species. In Mexico 4 species co-exist : *C. undecimalis*, *C. parallelus*, *C. pectinatus*, and *C. poeyi* (Chavez, 1963). *C. mexicanus* probably occurs too but was mis-identified (Rivas, 1986). But according to literature from Mexico, only *C. undecimalis* and *C. poeyi* seem dominant (Chavez, 1963; Carvajal, 1975; Fuentes, 1973). In Brazil, same snook species as Puerto Rico are listed but only *C. undecimalis* and *C. parallelus* were studied and are believed to be dominant

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(Vasconcelos Filho and Broga Galiza, 1980). In Cuba, another Caribbean island, *C. undecimalis*, *C. parallelus* are reported, with data only for *C. undecimalis* (Alvarez-Lajonchere et al., 1982). Here 3 species are simultaneously studied with reference to their preferred habitat.

In opposition to other studies, *C. undecimalis* in Puerto Rico is not largely dominant in Puerto Rico. Moreover the abundance of the swordspine snook (*C. ensiferus*) with 35% of the catch of juveniles is most surprising. This species has barely been reported in ichthyological check lists (Puyo, 1949; Regan, 1907; Castro-Aguirre 1978; Boeseman, 1956; Cervigon, 1966), and never really studied.

### **Snook Distribution Among Systems**

*C. parallelus* shows a clear preference for freshwater habitat when early juveniles (SL < 50mm), compared to *C. undecimalis* or *C. ensiferus*, which are rather found in saltwater lagoon systems. This pattern is then deeply modified when fish get larger and *C. undecimalis* can be found in any system when it reaches 250mm. *C. parallelus* was already reported as a more freshwater inclined species than any other snook species (Rivas, 1986).

### **Temporal Distribution Of Young-of-year Snook**

Colonization of the 3 most dominant species of snook in Puerto Rico overlaps largely, with a common peak occurring from May to August. Period of no colonization is limited to few months (January to April for *C. undecimalis* and *C. ensiferus*, November to February for *C. parallelus*) and occurs during dry season. The broad range of colonization for *C. undecimalis* is as described in other works : from August to October in Mexico for a minimum catch size of 45mm SL (Chavez, 1963); on the east coast of Florida 15-20 mm SL juvenile snook recruit into freshwater and brackish habitats between April and January (Gilmore et al., 1983; Tucker and Campbell, 1988); on the west coast of Florida, colonization of < 30 mm SL snook juveniles is observed from July to December (McMichael et al., 1989). Colonization for *C. parallelus* juveniles in Mexican coasts is reported from June to November (Chavez, 1963), which is very similar to the present study findings. Unfortunately no reference on *C. ensiferus* colonization could be found. From the 3 species of snook, *C. ensiferus* seems to present a more inter-annual variability in its colonization pattern. Spawning activity is maybe more subject to environment changes for this species.

Considering that snook species share same habitat and at the same time, competition phenomenon has to be further investigated.

### **Habitat Description**

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Snook species have proved to be tolerant to wide ranges of environmental parameters. It is the case for *C. undecimalis* (Chavez, 1963; Gilmore et al., 1983; Fore and Schmidt, 1973), for *C. parallelus* (Della Patrona, 1984) and for *C. ensiferus* (Austin, 1971). Nevertheless a preferred habitat can be described for *C. parallelus* as a well-oxygenated, fresh water, for *C. ensiferus* as low-oxygen and turbid water, and for *C. undecimalis* no real preference, but with rather higher temperature than the two other species.

### **Habitat Use and Benefits**

The preliminary results found on stomach contents analyses, show that prey composition is different among species at various stages of their lives. *C. parallelus* were found to be the earliest species (as small as 15mm) to switch from plankton to fish and shrimp. In that regard, these results disagree with Della Patrona (1984), who described *C. parallelus* as non piscivorous until 120 mm SL. The differences among snook species decrease with size. All 3 species feed upon fishes, shrimps, crabs or insects. A comparison test among species found still a significant difference, with *C. parallelus*' diet composed mainly of shrimps. However, this difference disappears when river and lagoon samples are been studied separately. In river the main item is shrimp, while in the lagoon, it is fish. At a given habitat, snook food habits are similar, but they seem to be enough opportunistic to switch prey and to find sufficient food. As a consequence they do not seem to suffer of competition between themselves and present same condition factor wherever they are.

### **CONCLUSION**

In nursery grounds of Puerto Rico, 3 species of snook share dominance : *C. undecimalis*, *C. ensiferus*, and *C. parallelus*. *C. ensiferus* has an unusual high abundance compared to the rest of the tropical and sub-tropical American continent. The dominance varies among estuarine systems : *C. undecimalis* and *C. ensiferus* nurseries are primarily located in lagoons, while *C. parallelus* juveniles are rather found in rivers.

Nevertheless, an important overlapping in space and time is observed in the habitat use of young-of-year snook species. Common peak of colonization (fish under 50 mm SL) was observed from May to August.

Food habit analysis shows that snook species switch prey items while dealing with a different habitat. They are opportunistic feeders and did not present different condition factors even though they were not collected from their preferred habitat.



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Table 1 : Snook species characteristics from literature. Cu = *Centropomus undecimalis*; Cpl = *C. parallelus*; Cpc = *C. pectinatus*; Cmx = *C. mexicanus*; and Ce = *C. ensiferus*. F = female, M = Male

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		Cu	CPL	Cpc	Cmx	Ce	Reference
Max Length	SL(cm)	101	58	39.7	34.5	27	Rivas, 1986
Venezuela F	TL(cm)	44.1	27				Carvajal Rojas, 1972
M	TL(cm)	36.0	28				
Mexico F	SL(cm)	38.8	15	29.7			Chavez, 1963
M		34.3	15.4	26.1			
Florida (USA) F	FL(cm)	40					Marshall, 1958
M		40					
Brazil F	SL(cm)		16				Radasewsky, 1976
M			24				
Brazil F	SL(cm)		30				Della Patrona, 1984
M			23				

Table 2 : Snook species relative frequencies in 2 lagoons (Boquerón and Corazones) and 2 rivers (Añasco and Guanajibo) of Puerto Rico. Cu = *Centropomus undecimalis*; Cpl = *C. parallelus*; Cpc = *C. pectinatus*; Cmx = *C. mexicanus*; and Ce = *C. ensiferus*.

	Cu # %	Ce # %	Cpl # %	Cmx # %	Cpc # %
Boquerón	992 63%	479 31%	49 3%	23 2%	8 1%
Corazones	181 35%	306 60%	13 3%	5 1%	1 0%
Guanajibo	20 28%	1 1%	48 68%	2 3%	0 0%

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Añasco	116 14%	219 26%	443 54%	37 4%	15 2%
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Table 3 : Habitat description for snook juveniles smaller than 50 mm SL. Temp. = temperature, St.dev. = standard deviation. Cu = *Centropomus undecimalis*; Cpl = *C. parallelus* and Ce = *C. ensiferus*.

	Species	n	Mean	S.D.	Range
Depth (cm)	Cu	500	76	142	17-175
	Ce	380	91	106	25-175
	Cpl	350	93	87	17-125
Scchi (cm)	Cu	500	34.5	70	10-125
	Ce	380	53	76.6	10-125
	Cpl	350	34.5	69.5	10-96
Temp °C	Cu	500	28	11	23-35.5
	Ce	380	27	4.8	23-35.5
	Cpl	350	26.5	4.8	24-33
Salinity	Cu	500	10	30.6	0-34.2
	Ce	380	10	19	0-28.2
	Cpl	350	1.2	15.6	0-34.2
D.O. (% sat.)	Cu	500	41	156	3-160
	Ce	380	28.5	57	5-160
	Cpl	350	62	62	5.5-87

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Table 4 : Condition factor (CF) comparison among systems, for *C. undecimalis*, *C. ensiferus* and *C. parallelus* separated in 2 size classes (SL<100mm, and 100mm<SL<300mm).

SL < 100mm	<i>C. undecimalis</i>		<i>C. ensiferus</i>		<i>C. parallelus</i>	
System	River	Lagoon	River	Lagoon	River	Lagoon
Mean CF	96.3	100.3	100.6	98.9	100.6	99.1
n	38	42	89	116	50	40
Student t	Not Significant		Not Significant		Not Significant	
100<SL< 300mm	<i>C. undecimalis</i>		<i>C. ensiferus</i>		<i>C. parallelus</i>	
System	River	Lagoon	River	Lagoon	River	Lagoon
Mean CF	100	100.3	100.7	99.5	99.9	99.9
n	75	89	108	139	35	25
Student t	Not Significant		Signif: P<0.01		Not Significant	