arenaria possessing the life history statistics given above, 1 out of about 790,000 eggs produced during the lifetime of an individual must survive to ensure continuance of the population.

However, variable recruitment and high postlarval mortality tend to be the general rule among temperate and boreal marine invertebrates, especially the bivalves. At the Jones River in Gloucester, the tidal flat received a heavy set of young *Mya arenaria* in 1973 (Brousseau 1978a, b). Based on crude estimates of stock density, age-specific fecundity, and the density of the resultant spatfall, the settlement rate was 0.0498%, or about 34 times larger than the calculated $r_{s_{eq}}$. During the two subsequent years, on the other hand, this site received only a limited spatfall, which, coupled with high postlarval mortality, resulted in settlement rates of 0.0%. Under such fluctuating conditions, therefore, the settlement history of a population takes on added significance.

In addition to being of theoretical interest, determination of the equilibrium settlement rate for a commercially important species may be of value in its harvesting management as well. Although the impact of repeated exploitation is difficult to assess given the uncertainties of environmental conditions, continued harvesting on tidal flats receiving annual settlement rates below equilibrium may prove to be extremely harmful to the resident population.

Literature Cited

BROUSSEAU, D. J.

1978a. Spawning cycle, fecundity, and recruitment in a population of soft-shell clam, *Mya arenaria*, from Cape Ann, Massachusetts. Fish. Bull., U.S. 76:155-166.

1978b. Population dynamics of the soft-shell clam *Mya arenaria*. Mar. Biol. (Berl.) 50:63-71.

GLEDHILL, C.

1980. The influence of established infauna on recruitment of the soft-shell clam, *Mya arenaria* L. M.S. Thesis, Univ. Massachusetts, Amherst, 40 p.

LESLIE, P. H.

1945. On the use of matrices in certain population mathematics. Biometrika 33:183-212.

1948. Some further notes on the use of matrices in population mathematics. Biometrika 35:213-245.

MUUS, K.

1973. Settling, growth and mortality of young bivalves in the Oresund. Ophelia 12:79-116.

THORSON, G.

1950. Reproductive and larval ecology of marine bottom invertebrates. Biol. Rev. (Camb.) 25:1-45.

1966. Some factors influencing the recruitment and establishment of marine benthic communities. Neth. J. Sea Res. 3:267-293.

VAN WINKLE, W., D. L. DEANGELIS, AND S. R. BLUM.

1978. A density-dependent function for fishing mortality rate and a method of determining elements of a Leslie matrix with density-dependent parameters. Trans. Am. Fish. Soc. 107:395-401.

VAUGHAN, D. S., AND S. B. SAILA.

1976. A method for determining mortality rates using the Leslie matrix. Trans. Am. Fish. Soc. 105:380-383.

DIANE J. BROUSSEAU

Department of Biology
Fairfield University
Fairfield, CT 06430

JENNY A. BAGLIVO
GEORGE E. LANG, JR.

Department of Mathematics
Fairfield University
Fairfield, CT 06430

GROWTH OF JUVENILE RED SNAPPER *LUTJANUS CAMPECHANUS*, IN THE NORTHWESTERN GULF OF MEXICO[1]

The red snapper, *Lutjanus campechanus*, has received considerable attention in the past due to its importance as a commercial and sport fish in the Gulf of Mexico. Most published material deals with the fishery and is summarized in Carpenter (1965). Few major papers have dealt with the natural history of red snapper.

Moseley (1965) reported on growth, reproduction, and food habits of red snapper taken by trawl and handline off the Texas coast. He determined age and growth rate from scales by assuming that growth checks were produced during the spawning season. Bradley and Bryan (1975) also sampled red snapper along the middle Texas coast with trawl and hook and line. They were unable to distinguish age classes by length frequencies and attributed that to an extended spawning season. Futch and Bruger (1976) used otolith readings to determine age and growth of red snapper off the coast of Florida.

This paper presents new information on growth of young snapper and relates that information to their occurrence on an artificial reef.

[1]University of Texas Marine Science Contribution No. 519.

Study Area and Methods

The artificial reef, composed of three sunken World War II liberty ships, is located approximately 29 km offshore (lat. 27°35′N, long. 96°54′W) from Port Aransas, Tex., in 33 m of water. Red snapper were collected from the reef with fish traps in March, May, July, September, November, and December 1979. The rectangular traps (1.8m × 1.2m × 0.6m) were made of 1.25 cm reinforcing bar covered with 3.4 cm mesh plastic coated wire. The entrance cone had an initial opening of 60.9 × 45.7 cm terminating in a 90° downturn with a 25.4 cm diameter entrance port. During each sampling period, five traps were baited with fish scraps and set on the bottom around the reef for 24 h. All red snapper captured in traps were measured in standard and total lengths and placed in a flowing seawater live box onboard ship. Snapper which were in good condition after 1 h on board ship were tagged with numbered internal-anchor tags and released over the artificial reef.

Small red snappers (<160 mm) were collected from the south Texas outer continental shelf during 1975 through 1977 with a 10.7 m "flat trawl" with 4.45 cm stretch mesh in the body and 2.5 cm stretch mesh in the bag. From 1975 to June 1976 a 9.5 mm stretch mesh liner was used inside the bag. Trawl sampling depths ranged from 10 m to 132 m. Seventy-two trawl samples were taken in 1975, 222 in 1976, and 294 in 1977. All trawls were made at a speed of about 2 kn for 15 min. (For details of sampling sites and procedures see Flint 1981.)

Results

Growth

The smallest fish taken in the trawl samples were generally 20-29 mm (Table 1). Juveniles <40 mm were caught in August, September, and October, and eight individuals of this size were taken in June 1976. Two year classes can be identified in the length-frequency table (Table 1) and followed for 12-18 mo. The smallest fish taken in traps at the ship reef were 100-110 mm. Snapper <100 mm could escape through the mesh.

Length-frequency histograms for combined trawl and trap data are shown for each month (Fig. 1). Two cohorts, age group 0 and age group I, are apparent in the data and a third cohort, age group II, may be present in the March and July data.

Recruitment of small snapper (<40 mm) into the population occurred primarily in June and July as evidenced by the modal size of the age 0 year class in August, September, and October. Limited recruitment of small fish continued into October. Length-frequencies of snappers captured in June through December were distinctly bimodal. Modal size classes for age I fish were 110 mm in June and 130 mm in July. Modal size classes for age I+ fish were 150 mm in December

TABLE 1.—Length-frequency distribution of red snapper caught in trawl samples. The number of individuals of each size class in each month is shown. No samples were taken in months with an asterisk (*).

	1974	1975												1976												1977											
Length	D	J	F*	M*	A	M	J*	J*	A	S	O*	N*	D*	J*	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
10-19																			1																		
20-29									2	12									6																		
30-39									1	4									1			1	5														
40-49	1								7						1							3	12	6	1									2	3		
50-59	2								8	1						1						11	1	7	1	1								11	10		
60-69	5				1				3	1					11							1	3	3			1		1					24	11	1	
70-79	4				4				4	4					6							4	7							8				26	20	1	1
80-89	1	1			1	1			1	3					3				1			13	3	3				1		5				27	16	2	
90-99	2					2									6	2	2		2			9	4		1				2	4				5	2		
100-109	1															2			2			1					1			4				2	2	1	
110-119						1									2				2											5	2					1	1
120-129	1														1				1											3							
130-139	1														3				1																		
140-149																					1	2													1		
150-159																1						1												1			
160-169																				1	1						1										
170-179																				3		1					2	1							2		
180-189																												3									
190-199																						1						5									
200-209																					1							3									
210-219																												1									
220-229																												2									
230-239																												1									

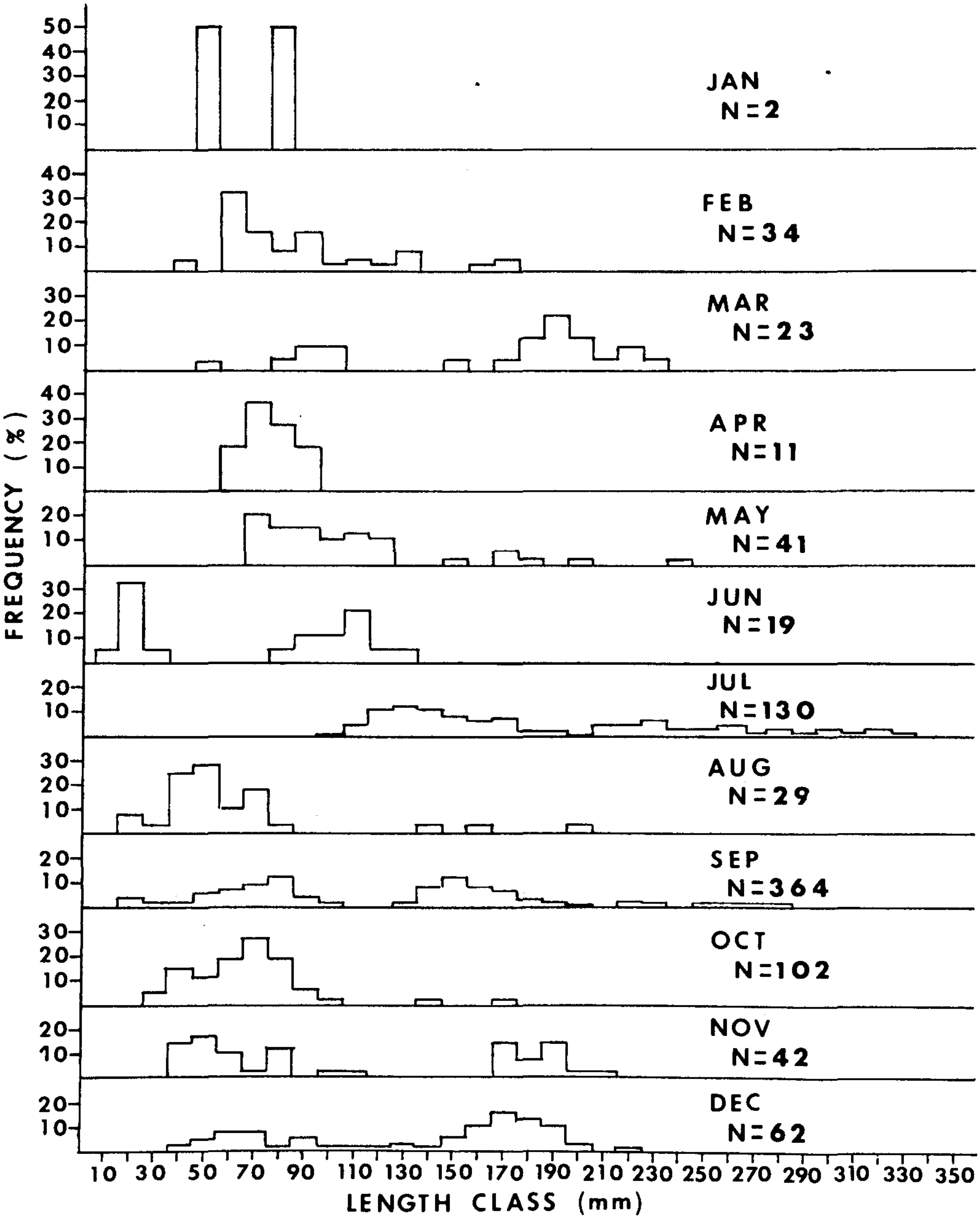

FIGURE 1.—Size distribution of young red snapper from pooled trawl and fish trap collections.

and 190 mm in March. It appears that age II snapper were 210-230 mm in July although few fish of that age class were caught.

Tagging

Numbered, internal-anchor tags were placed in 267 red snapper between 117 and 350 mm (mean = 192 mm) on the ship reef in July, September, and November 1979. Sportfishermen returned 28 tags and our fish trap sampling produced seven additional returns (13% total return rate). All fish were recaptured from the ship reef. The longest "free time" for any fish in our study was 92 d except for one fish which was tagged and recaptured twice over a 112-d period.

Sixty-three percent of the recaptures were within 30 d of release. No fish were recaptured after 11 December 1979 despite continued fishing effort on the ship reef during the winter and spring of 1980.

Measurements from the seven fish recaptured by our own sampling yielded growth rates of 0.12-0.55 mm/d (mean = 0.29 mm/d). Based on age determination from our length-frequency plots, these represent growth rates of age I+ snapper. Lengths of recaptured red snapper reported by sportfishermen were not considered accurate enough to use for growth determinations.

Discussion

Bimodal size distributions of red snapper caught in trawls and traps indicate that juvenile red snapper grow more slowly than previously thought. Moseley (1966) presented the first detailed account of growth rates for snapper using scale annuli for age determination. He assumed that growth checks were produced during the spawning period rather than during a midwinter slow growth period, an assumption confirmed by later workers (Futch and Bruger 1976). Moseley (1966) found that fish with one spawning check averaged 250 mm and determined a growth rate of about 90 mm between spawnings (about 0.25 mm/d). He proposed that red snapper grow 200-230 mm during their first year. Bradley and Bryan (1975) cited other unpublished data from Texas which indicated an initial growth check on scales at about 200 mm fork length and a mean growth rate of 60 mm/yr between formation of the first and the fifth rings. Futch and Bruger (1976) determined that maturity is probably reached after the second year (age II+) in Florida. Their data also indicated that the first growth check (on otoliths) generally occurred on snapper of about 200 mm.

A slower growth rate could be inferred from otolith, scale, and vertebrae aging by Bortone and Hollingsworth (1980) who found that snapper with one growth check averaged 163 mm and snapper with two growth checks averaged 197 mm. Small sample size (46) and one sampling date (17 October) may have influenced their results. That snapper mature at age II+ (Futch and Bruger 1976) and produce growth checks as a result of spawning activity suggest that fish with a single annulus are not age I+ as Moseley (1966) suggested but are age II+. Our data are consistent with this hypothesis. The distinct bimodality in length frequencies of snapper <220 mm during June through December (Fig. 1) indicates the presence of two year classes within this size range. We propose that red snapper grow to 110-130 mm during the first year and attain a size of 220-230 mm the second year. It is at this size (age II) that they apparently reach sexual maturity (Camber 1955; Futch and Bruger 1976). This growth rate is consistent with established postspawning growth rates of 60 (Bradley and Bryan 1975) to 90 mm/yr (Moseley 1966) between the first and fourth or fifth spawnings.

Red snapper >160 mm were uncommon in our trawl samples. Bradley and Bryan (1975) also collected few snapper between 150 mm and 220 mm in trawl or hook and line catches. Numerous fish of this size were trapped at the ship reef in July and September. Tagging data indicated that 130-250 mm (age I and early age II) snapper were abundant on the ship reef from July through September and some remained there through November or December. The absence of tag returns after December indicates that the fish present there all summer and fall either moved away, presumably to deeper water (Moseley 1966; Bradley and Bryan 1976) or had suffered substantial mortality. Fable (1980) found essentially no movement in 17 returns from 299 tagged red snapper in 60 m of water off the Texas coast.

Conclusions

1. We suggest that growth rates of juvenile red snapper during the first 2 yr are slower than previously reported. Our data indicate snapper attain a length of 110-130 mm the first year and 200-230 mm the second year.
2. Juvenile snapper <150 mm were common in trawl samples throughout most of the year.
3. Snapper 130-250 mm were common on the artificial reef from July through December. Tagging studies indicated the snapper remain around the artificial reef during the summer and fall but none were captured there or elsewhere after December.

Acknowledgments

We would like to thank the captain and crew of the RV *Longhorn* for their competence and assistance in doing the field work. Special thanks go to our colleagues Steve Rabalais and Rick Kalke for their invaluable assistance in the field. This manuscript benefited from the critical reviews by Dr. Checkley, J. Holt, and N. Rabalais and from reviews of an earlier draft by two reviewers. This work was supported by the Bureau of Land Management Contract AA550-GTG-17 and the Texas Coastal and Marine Council, Contract IAC (78-79)-2183 and IAC (80-81)-0044 to the University of Texas.

Literature Cited

BORTONE, S. A., AND C. L. HOLLINGSWORTH.
1980. Aging red snapper, *Lutjanus campechanus*, with otoliths, scales, and vertebrae. Northeast Gulf Sci. 4:60-63.

BRADLEY, E., AND C. E. BRYAN.
1975. Life history and fishery of the red snapper (*Lutjanus campechanus*) in the northwestern Gulf of Mexico: 1970-1974. Proc. Gulf Caribb. Fish. Inst. 27:77-106.

CAMBER, C. I.
1955. A survey of the red snapper fishery of the Gulf of Mexico, with special reference to the Campeche Banks. Fla. State Board Conserv. Tech. Ser. 12, 64 p.

CARPENTER, J. S.
1965. A review of the Gulf of Mexico snapper fishery. U.S. Fish Wildl. Serv., Circ. 208, 35 p.

FABLE, W. A., JR.
1980. Tagging studies of red snapper (*Lutjanus campechanus*) and vermilion snapper (*Rhomboplites aurorubens*) off the south Texas coast. Contrib. Mar. Sci. 23:115-121.

FLINT, R. W.
1981. Introduction. *In* R. W. Flint and N. N. Rabalais (editors), Environmental studies of a marine ecosystem, south Texas outer continental shelf, p. 3-14. Univ. Texas Press, Austin.

FUTCH, R. B., AND G. E. BRUGER.
1976. Age, growth, and reproduction of red snapper in Florida waters. *In* H. R. Bullis and A. C. Jones (editors), Proceedings: Colloquium on snapper-grouper fishery resources of the Western Central Atlantic Ocean, p. 165-184. Fla. Sea Grant Program Rep. 17.

MOSELEY, F. N.
1966. Biology of the red snapper, *Lutjanus aya* Bloch, of the northwestern Gulf of Mexico. Publ. Inst. Mar. Sci. Univ. Tex. 11:90-101.

SCOTT A. HOLT
CONNIE R. ARNOLD

The University of Texas
Marine Science Institute
Port Aransas Marine Laboratory
Port Aransas, TX 78373

AN ASSOCIATION BETWEEN A PELAGIC OCTOPOD, *ARGONAUTA* SP. LINNAEUS 1758, AND AGGREGATE SALPS

Biologists working in the epipelagic zone of the ocean have reported that representatives of numerous planktonic taxa seem to be closely associated with gelatinous zooplankton, including hyperiid amphipods (Madin and Harbison 1977; Harbison et al. 1977; Laval 1980), gammarid amphipods (Vader 1972), isopods (Barham and Pickwell 1969), decapods (Shojima 1963; Thomas 1963; Trott 1972; Bruce 1972; Herrnkind et al. 1976), cyclopoid copepods (Heron 1973), mysids (Băcescu 1973), cirripedes (Fernando and Ramamoorthi 1974), and fish (Mansueti 1963; Janssen and Harbison in press).

Some symbionts in these groups are morphologically adapted to feed principally on the host and/or on the food material which the host collects, while others seem to associate more intermittently with gelatinous zooplankton, dependent on their nutritional state and that of the gelatinous hosts. Accordingly, symbioses may range from specific, structural associations to temporary or casual associations.

In this note we report a previously undescribed association between a cephalopod and a planktonic gelatinous herbivore. While conducting research scuba studies of gelatinous zooplankton in the western Gulf of Mexico, we collected juvenile pelagic octopods of the genus *Argonauta* sp. Linnaeus 1758, in association with aggregate generation salps (*Pegea socia* (Bosc 1802)).

The salp chains were composed of 40-60 individuals, each approximately 10 cm in apical/basal length. Individuals within the aggregate generation of *Pegea socia* (Bosc 1802) are uniformly covered with fine reticulated gold pigmentation and contain orange nucleii. The individuals each have four noticeable body muscles forming two x-shaped groups. Within each group, the pair of muscles are not fused dorsally. Endostyle bands of each individual are slightly arched.

Two juvenile octopods, a male and female with mantle lengths 8.4 mm and 6.7 mm, respectively, were collected from separate chains at a depth of 5-10 m at lat. 26°21′N, long. 95°45′W, on 26 February 1981. The males and females of *Argonauta* sp. have eight circumoral appendages, none of which are filiform. The body is not flattened, has no fins and no aquiferous pores on the head. The dorsal arms of the female are not