Growth and morphology of larval and juvenile captive bred yellowtail snapper, *Ocyurus chrysurus**

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The snappers (Lutjanidae) are major components of the reef fish fishery in the Gulf of Mexico (Nakamura, 1976), and recent declines in their populations have prompted interest in a number of management practices including limited catches, size limits, area closures, and additions of artificial reef habitat to improve survival of wild stocks (Leis, 1987; Munro, 1987). Studies on the spawning, distribution, larval and juvenile ecology, and stock assessment of new recruits are crucial to the development of management strategies for reef species since little is known about their early life history (Grimes, 1987). During most developmental stages, snapper larvae are pelagic and widely dispersed, limiting the numbers of specimens to be found in taxonomic collections (Munro, 1987). The similarity in size and pigmentation of small larval lutjanids (<5 mm) and the paucity of species-specific details of size at age and morphological development has made identification of individuals in ichthyoplankton samples difficult (Leis, 1987). Of the fourteen species of snappers that are found in the Gulf of Mexico,[1] larval development has been fully described for only three species: red snapper, *Lutjanus campechanus*, from both laboratory spawned (Rabalais et al., 1980) and wild caught larvae (Collins et al., 1980); gray snapper, *L. griseus*, from wild eggs reared in the laboratory (Richards and Saksena, 1980); and vermilion snapper, *Rhomboplites aurorubens*, from wild preserved specimens (Laroche, 1977). A recent NOAA report by Richards et al.[2] summarizes the larval lutjanid descriptions listed above and introduces some newly available descriptive material for several additional species of snappers including some stages of yellowtail snapper, *Ocyurus chrysurus*. In their report, the yellowtail snapper is included in the genus *Lutjanus*, a change suggested as a result of two recent treatments by Loftus (1992) and Domeier and Clark (1992).

The commercial and recreational importance of snappers has also been recognized by the aquaculture industry, and efforts are underway to culture several of these species in captivity. In this paper we describe the development and growth of laboratory spawned and reared yellowtail snapper. This species is found from Massachusetts through the Caribbean and south to Brazil (Hoese and Moore, 1977). Laboratory culture allowed us to document growth and development of the critical larval and juvenile stages of yellowtail snapper that will aid identification and ageing of larval snappers collected in the field. We have also included information on the effects of a commonly used preservative (ethyl alcohol) on length measurements and pigmentation characteristics of laboratory-cultured larvae for purposes of comparative use with wild-collected larvae.

Materials and methods

Young adult *Ocyurus chrysurus* were collected by hook and line in July 1990 from the Florida Keys and were transported to the laboratory where they were matured and cycled for one year following the methods described by Arnold (1988). Adults began spawning in July 1991 and continued to March 1994.

Eggs were stocked at a density of 50/L in fiberglass tanks (300 and 600 L) with internal biofilters. Larvae were reared at 27–28°C with 12 hours light at salinities of 33–38 ppt on a diet of zooplankton (collected from the Corpus Christi Ship Channel), rotifers (*Branchionus plicatilis*) and brine shrimp nauplii (*Artemia salina*).

The description of larval development is based on larvae from multiple spawns of two different groups of broodstock (15 adults/tank). Larvae were measured live (SL=tip of snout to posterior tip of notochord) to the nearest 0.01 mm on a stereomicroscope equipped with a drawing tube and digitizing

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1 Lyczkowski-Shultz, J., and B. H. Comyns. 1992. Early life history of snappers in coastal and shelf waters of the northcentral Gulf of Mexico (late summer/fall months, 1983–1989). Final Rep. to MARFIN, NA90AA-H-MF730.

2 Richards, W. J., K. C. Lindeman, J. L. Shultz, J. M. Leis, A. Ropke, M. E. Clark, and B. H. Comyns. 1994. Preliminary guide to the identification of the early life history stages of lutjanid fishes of the western central Atlantic. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-SEFSC-345, 49 p.

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Fishery Bulletin 93:179–185 (1995).

pad. Drawings were made with a dissecting scope and camera lucida attachment of live, anesthetized larvae before they were preserved in 80% ethyl alcohol (ETOH). To determine laboratory shrinkage rates, the larvae were remeasured after at least one month in ETOH, and preserved lengths were compared to those of the previous, live measurements. Since larvae were drawn from living specimens, no staining or special preparations were required for observation of spines, rays, or other details of morphology.

Results

Pigmentation and overall development

Daily measurements and developmental milestones are presented in Table 1. The pelagic eggs were spherical, averaged 0.96 mm diameter, had a single oil globule, and hatched in 22–24 hours at 27°C. Eggs were essentially transparent, the only pigment observed was a series of small chromatophores on the dorsal surface of the embryo (Fig. 1A). After hatching and through the two day yolk-sac stage, larvae possessed a single unpigmented oil globule in the anterior end of the yolk-sac, an unpigmented finfold, and 24 myomeres. Within 12 hours after hatching (Fig. 1B), the dorsal chromatophores of the embryo had migrated to form a series along the ventral surface of the body and tail; a single stellate chromatophore was present on the gut anterior to the anus, and a light scattering of dark pigment was found on the yolk-sac and lateral surfaces of the head. Exogenous feeding coincided with development of eye pigmentation, functional jaws, and gas bladder inflation at 3.36 mm (age 3 days, Fig. 1C). Pigmentation at this stage included a large dark chromatophore on the ventral surface of the gut, four chromatophores over the dorsal surface of the gut and gas bladder, and a single, dark chromatophore on the ventral tip of the notochord. In live specimens at this stage, we first observed the development of a yellow chromatophore (indicated by arrow on Fig. 1C) located on the lateral surface of the body at about midgut. Larvae 3.67–3.82 mm (Fig. 2A) showed dramatic developmental changes. The development of numerous yellow chromatophores (indicated on illustrations by solid arrows) scattered on the lateral surfaces of the head, gut, and upper body near the base of the pectoral fin, as well as dark stellate chromatophores on the hindbrain and on the ventral edge of the cleithrum coincided with eruption of the pelvic fin buds and the appearance of preopercular spination. Larvae 4.10–4.53 mm (Fig. 2, B–D) were characterized by daily increases in the number of dorsal spines and by elongation of the pelvic fins, as well as by an increase in the density of yellow chromatophores on the lateral head region. Notochord flexion occurred when larvae reached 4.40 mm at 15–16 days posthatch (Fig. 3A) and was followed by full fin formation. Changes in pigmentation consisted primarily of increasingly dense concentrations of yellow pigment on the lateral upper body and head, dark web-like pigment in the membranes of developing fins, and diffuse internal pigment over the gut surface (Fig. 3B). The first indication of adult coloration was visible on early juveniles approximately 14.00 mm SL (Fig. 3C) where yellow chromatophores formed a horizontal line through the eye onto the snout and were also interspersed with the dark chromatophores lining the dorsal and ventral margins of the body at the fin bases. Yellow pigment was also present along the lateral midline of the tail. Near-adult pigmentation was present by 16.00 mm (age 62 days) at which time juveniles were fully scaled (Fig. 3D).

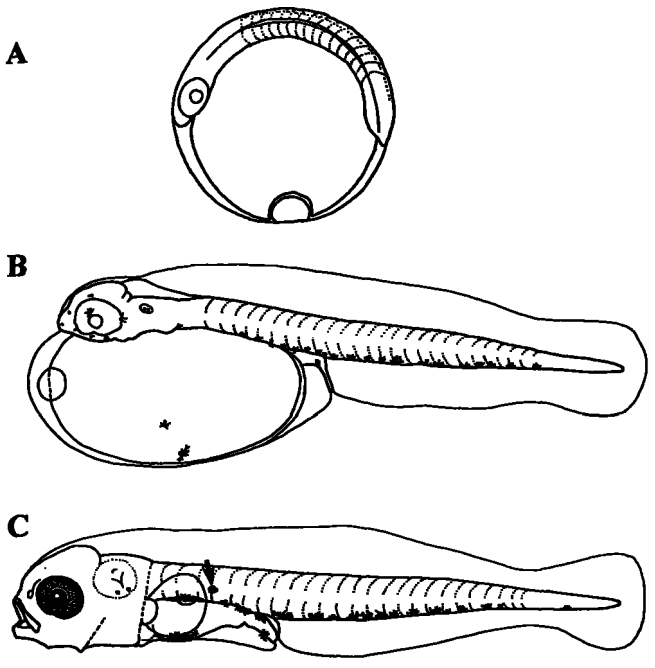

Figure 1

Early developmental stages of yellowtail snapper, *Ocyurus chrysurus*, illustrated from live specimens. (A) late embryo egg, 0.96 mm diameter; (B) 2.23 mm SL newly hatched larva; (C) 3.36 mm, 3 days posthatch. Dark arrows indicate location of yellow chromatophore.

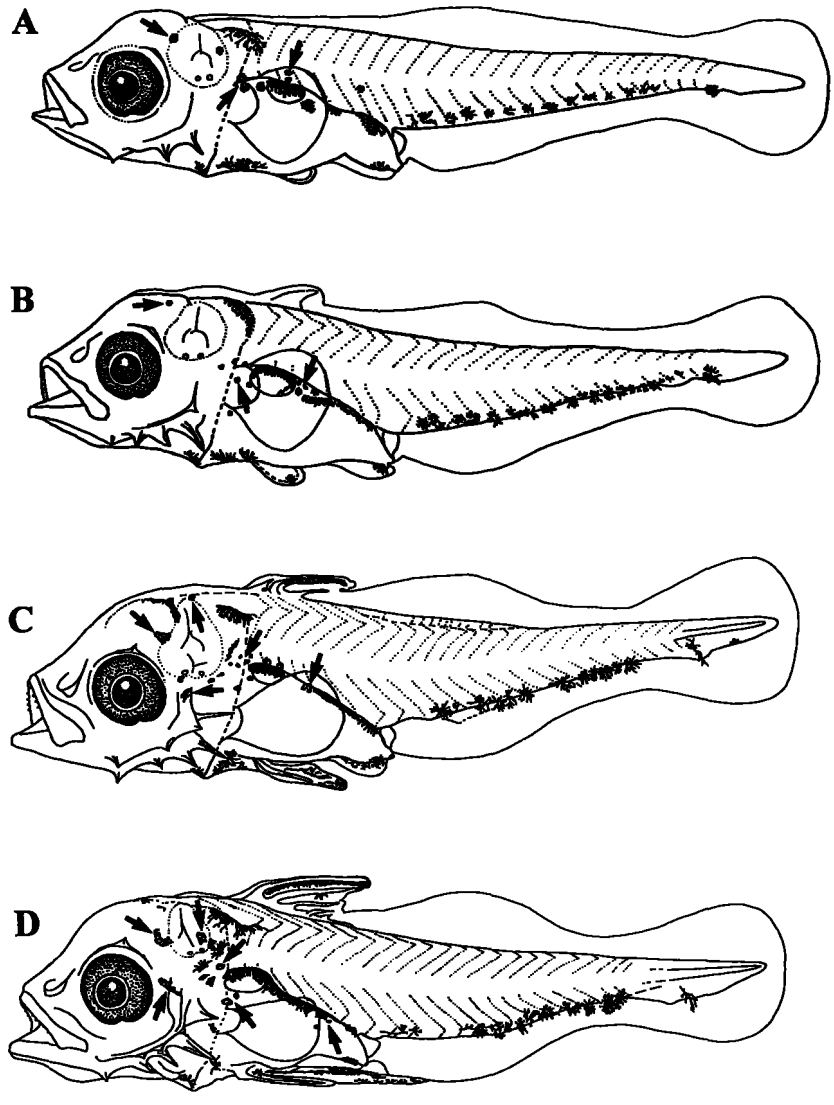

Figure 2

Developmental stages and mean live lengths of yellowtail snapper. Dark arrows indicate location of yellow chromatophores. (A) 3.67–3.82 mm SL, days 7-9 posthatch; (B) 4.10–4.53 mm SL, days 10-11 posthatch; (C) 4.51 mm SL, day 12 posthatch; (D) 4.11 mm SL, day 13 posthatch.

Head spination

One or two paired, smooth spines on the posterior edge of the preoperculum first occurred in larvae 3.67–3.82 mm (Fig. 2A). Preopercular spination increased to four and a supraocular ridge with one spine was present at 4.10 mm (Fig. 2B). At 4.50 mm (Fig. 2C), 5 or 6 elongated preopercular spines were present, the longest of which occurred at the preopercal angle. Larvae at 4.80 mm and 16 days of age (Fig. 3A) had a fully formed supraocular ridge with 4 short, smooth spines and 3 supracleithral spines. A reduction in the length of all head spines began at approximately 6.00 mm, but some short, opercular spines remained on the oldest juveniles.

Fin formation

The adult meristic complement of *O. chrysurus* is X+12–14 dorsal, 9 + 8 caudal, I + 5 pelvic, III + 8–9 anal, and 15 or 16 pectoral (Hoese and Moore, 1977). In laboratory-reared larvae, fin development oc-

curred in the following sequence: pelvic and dorsal spines, caudal, dorsal and anal soft rays, pectoral rays (Table 1). The spinous pelvic and dorsal fin formation occurred simultaneously at 4.10 mm. Dorsal and anal fin analage were first visible at 4.51 mm and ray bases were fully formed by 5.35 mm. Caudal flexion and caudal ray formation occurred in larvae between 4.40 and 4.75 mm and was followed by development of the soft rays of the dorsal and anal fins (Fig. 3A); additionally, the spines of the dorsal and pelvic fins were strongly serrated. By 6.23 mm SL, all juveniles had the full adult complement of fin spines and rays (Fig. 3B); however, serrated spines, characteristic of larvae, were still present on juveniles 14.66 mm.

Growth and shrinkage

Laboratory-reared yellowtail snapper showed large variation in size among larvae of the same age (Table 1), and key developmental events were tightly linked to larval size more than to age. Growth rates prior to flexion averaged 0.31 mm/day and decreased to only 0.18 mm/day during the process of transformation to juveniles (4.83–7.00 mm SL, ages 14–28 days). During the last month and a half of recorded development, juvenile growth averaged 0.25 mm/day.

Mean daily lengths of postpreservation larvae are listed on Table 1. Shrinkage after preservation was greatest in larvae prior to any fin development (<4.00 mm), averaging 10.36% through the first 13 days. Larvae with partial fin development (4.83–5.72 mm SL) shrank an average of 9.32%. Once larvae attained complete development of the dorsal and pelvic fins (>5.00 mm); shrinkage was reduced to an average of 7.24% throughout the remaining juvenile stages examined.

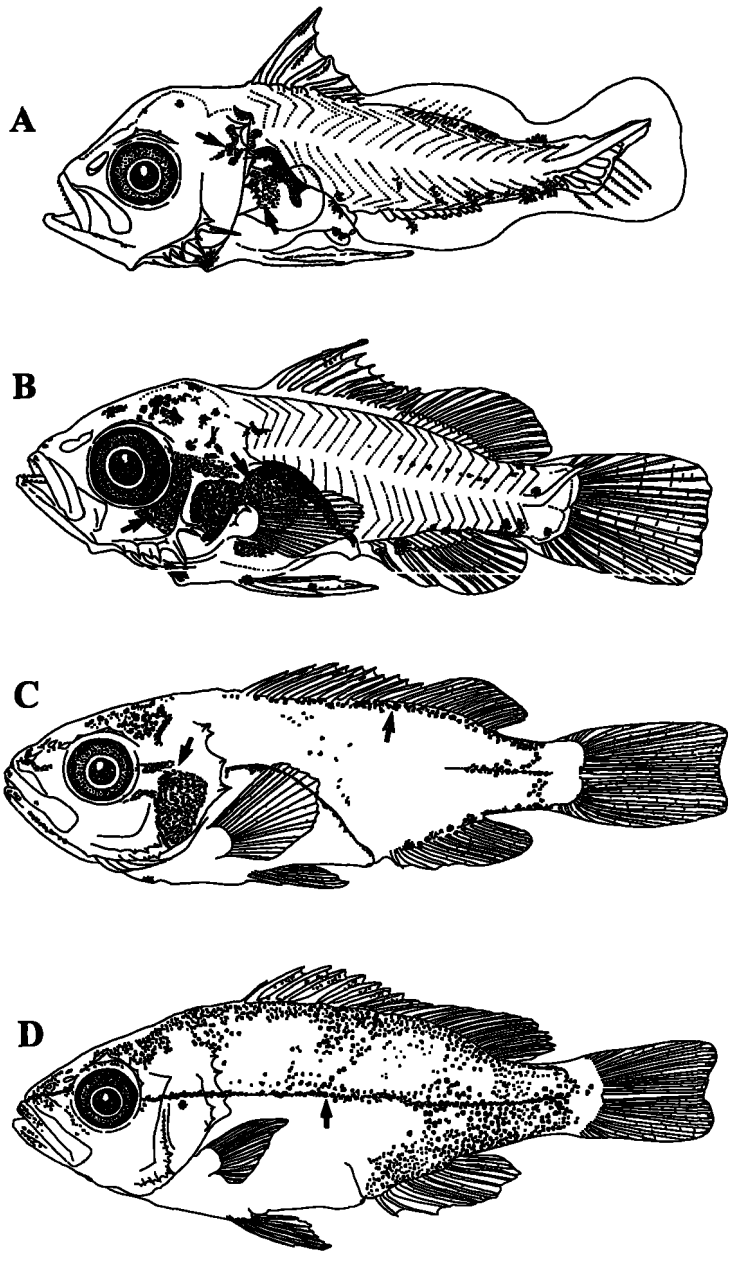

Figure 3

Late developmental stages and mean lengths of yellowtail snapper. Dark arrows indicate location of yellow chromatophores. (**A**) 4.64–4.80 mm SL, days 15–16; (**B**) 6.23–6.73 mm SL, days 18–28; (**C**) 14.66 mm SL, day 31, drawn from preserved specimen; (**D**) 16.05 mm SL, day 62, from preserved specimen.

Discussion

Ocyurus chrysurus have similar larval characteristics to the previously described snappers *Lutjanus campechanus* (Collins et al., 1980), *L. griseus* (Richards and Saksena, 1980), and *Rhomboplites aurorubens* (Laroche, 1977). Preflexion larvae of each of the four species have a series of chromatophores along the ventral midline and have pigment covering the dorsum of the gut and gas bladder. All have

Table 1

Sizes and meristic characteristics of laboratory-spawned and reared larval and juvenile yellowtail snapper, *Ocyurus chrysurus*. All ages listed are in days except for NH = newly hatched < 1 hr old, *n* = number of individuals examined, SD = standard deviation, Shrinkage = % decrease in mean SL after preservation.

	Live SL (mm)					Preserved SL (mm)		Dorsal fin		Pelvic fin		Anal fin		Caudal fin		Pectoral fin	
Age	*n*	Min	Max	Mean	SD	Mean	SD	Spines	Rays	Spines	Rays	Spines	Rays	Principal	Rays	Rays	Notocord flexure
EGG	30	0.92	0.99	0.96	0.02	0.94	0.02	0	0	0	0	0	0	0	0	0	—
NH	42	1.99	2.78	2.23	0.16	2.09	0.23	0	0	0	0	0	0	0	0	0	straight
1	56	2.47	3.60	3.14	0.25	2.85	0.16	0	0	0	0	0	0	0	0	0	straight
2	42	3.09	3.99	3.57	0.26	3.00	0.21	0	0	0	0	0	0	0	0	0	straight
3	39	2.76	3.72	3.36	0.23	3.07	0.20	0	0	0	0	0	0	0	0	0	straight
4	23	3.12	3.68	3.44	0.16	3.05	0.28	0	0	0	0	0	0	0	0	0	straight
5	20	3.24	3.76	3.49	0.18	3.08	0.36	0	0	0	0	0	0	0	0	0	straight
6	23	3.33	3.92	3.64	0.15	3.21	0.28	0	0	0	0	0	0	0	0	0	straight
7	34	3.18	4.22	3.67	0.27	3.35	0.22	0	0	0	0	0	0	0	0	0	straight
8	21	3.51	4.46	3.92	0.25	3.43	0.36	0	0	0	0	0	0	0	0	0	straight
9	13	3.44	4.38	3.82	0.23	3.66	0.46	1	0	1	0	0	0	0	0	0	straight
10	21	3.59	4.76	4.10	0.34	3.67	0.38	1	0	1	0	0	0	0	0	0	straight
11	12	3.88	5.13	4.53	0.37	4.03	0.36	2–3	0	1	0	0	0	0	0	0	straight
12	14	3.50	5.45	4.51	0.59	3.84	0.66	3–4	0	1	0	0	0	0	0	0	straight
13	24	3.77	5.40	4.11	0.35	3.77	0.41	3–4	0	1	0	0	0	0	0	0	straight
15	14	3.95	5.47	4.69	0.57	4.01	0.80	5	0	1	3	0	0	8	4	0	flexed
16	4	3.80	5.52	4.80	0.76	4.59	0.61	5	0	1	3	0	0	9	4	0	flexed
18	6	5.70	6.56	6.22	0.31	5.63	0.33	8	13	1	3	3	9	9	8	0	flexed
21	8	4.80	7.46	5.72	0.86	5.34	0.82	8–9	13	1	4	3	9	9	8	16	flexed
25	11	5.31	8.86	6.69	1.12	6.05	0.82	10	13	1	4	3	9	9	8	16	flexed
28	7	5.68	9.32	7.00	1.28	6.75	1.15	10	13	1	5	3	9	9	8	16	flexed
31	4	7.80	14.66	11.52	3.31	12.19	1.75	10	13	1	5	3	9	9	8	16	flexed
62[1]	5	14.48	17.71	—	—	16.05	1.32	10	13	1	5	3	9	9	8	16	flexed

[1] = Preserved lengths only

large solitary chromatophores on the cleithral symphysis, gut ventrum, anus, and on the notochord at the point of flexure, and all undergo flexion within a narrow size range of 4.2–5.2 mm SL.

There are, however, a few distinctive characteristics that can be used to separate the larvae of these species. Immediately following flexion at 4.40 mm, larvae of *O. chrysurus* and *R. aurorubens* (flexion at 4.7 mm, Laroche, 1977) possess large serrations on both the anterior and posterior margins of the dorsal spines, but these are not present on larvae of *L. campechanus* (Collins et al., 1980) or *L. griseus* (Richards and Saksena, 1980). Preopercular spination is also a useful character in that the longest spine (located at the preopercle angle in each described species) is serrated in *R. aurorubens* but not in *L. campechanus*, *L. griseus* (Laroche, 1977), or *O. chrysurus* (present study). Lyczkowski-Shultz and Comyns[1] compared small, preserved larval *R. aurorubens* and *L. campechanus*, and found that both species had two dorsal spines and 4 or 5 preopercular spines at 3.3 to 3.9 mm SL. Yellowtail snapper differ in having fewer or no dorsal spines and only three preopercular spines at the same preserved sizes (corresponding to days 7–11, Fig. 2, A and B). Lyczkowski-Shultz and Comyns[1] also examined pigmentation differences in <4.0 mm larvae and identified a characteristic pigment spot in *R. aurorubens* located on the branchial chamber and visible through the operculum; they also observed pigment on the anterior surface of the gut (at the level of the pectoral fin base) in *L. campechanus*. Larval *O. chrysurus* of the same size range were devoid of pigment in either of these locations. Larval *R. aurorubens* (Laroche, 1977) had numerous, dark chromatophores located on both the midbrain and hindbrain regions in all sizes of larvae examined, however, the two species of *Lutjanus* and *O. chrysurus* had head pigment only on the hindbrain area. The yellow chromatophores found on live or recently preserved specimens of *O. chrysurus* are definitive characteristics for identification of this species; unfortunately, this light-colored pigment was not visible after the 30-day preservation period in larvae <7.00 mm SL and would not likely be detected in ichthyoplankton samples preserved in ETOH. The yellow chromatophores were faintly visible on the snout, operculum, and lateral line of the larger preserved individuals. Larval *O. chrysurus* can be distinguished from the other described lutjanid species by utilizing combinations of the above characteristics including the presence of heavy serrations on both the anterior and posterior margins of the dorsal spines at the time of flexion, lack of serrations on the longest preopercle spine, reduced number of preopercle spines and dorsal spines at comparable sizes, and lack of internal pigment on the anterior surface of the gut or branchial chamber.

Newly hatched and early developmental stages of larval fishes are rarely collected or retained in net samples.[3] Those larvae that are collected show significant handling effects (Theilacker, 1980; Hay, 1981; McGurk, 1985), including distortion and size reduction that result in less than optimal depictions of size at critical stages of development. In contrast, laboratory-reared specimens provide more realistic size values and information on age and pigmentation not available to studies with field-caught larvae. The shrinkage rates at each age and phase of morphological development in *O. chrysurus* are conservative measures because field-collected larvae show additional shrinkage from net damage. In small unossified larvae, reduction in SL as a result of net collection alone increased shrinkage rates of laboratory-preserved northern anchovy by 19% (Theilacker, 1980) and in Pacific herring by about 8% (Hay, 1981). From these results it is clear that some additional allowance for net shrinkage should be applied to the laboratory-preserved lengths of *O. chrysurus* when compared to those of field-caught individuals; however, shrinkage rates may be variable between species; therefore the value to be used is unclear. Shrinkage rates have been shown to decrease with increasing age and size of larvae (Theilacker, 1980; McGurk, 1985) and to become equivalent to that of larvae exposed to laboratory handling only (e.g. no net damage) once larvae are completely ossified. Shrinkage rates of laboratory *O. chrysurus* also decreased in postflexion larvae, stabilizing at <10% in early juveniles. Therefore, to make predictions regarding the live size or age of field-collected larval snappers, an additional, though unknown, rate of shrinkage due to net damage should be taken into account in preflexion stages but not in postlarvae and juveniles.

The nomenclatural status of the yellowtail snapper has come under review recently. After describing the morphology of the natural hybrid between *O. chrysurus* and *Lutjanus synagris* (Loftus, 1992) and the laboratory-produced hybrids of *O. chrysurus* and *L. synagris* (Domeier and Clarke, 1992), the authors of these studies concluded that the morphological and meristic data indicated that *Ocyurus* is probably not a distinct genus from *Lutjanus*. The larval morphology described in this study of *O. chrysurus* also confirms the very similar size and developmental characteristics of this species with the previously described members of the genus *Lutjanus*.

[3] Lyczkowski-Shultz, J. Southeast Fish. Sci. Cent. NOAA, NMFS, Pascagoula, MS. Personal commun., Jan. 1994.

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Literature cited

Arnold, C. R.
1988. Controlled year-round spawning of red drum *Sciaenops ocellatus* in captivity. Contrib. Mar. Sci. (Suppl.) 30:65–70.

Collins, L. A., J. H. Finucane, and L. E. Barger.
1980. Description of larval and juvenile red snapper, *Lutjanus campechanus*. Fish. Bull. 77:965–974.

Domeier, M. L., and M. E. Clark.
1992. A laboratory produced hybrid between *Lutjanus synagris* and *Ocyurus chrysurus* and a probable hybrid between *L. griseus* and *O. chrysurus* (Perciformes: Lutjanidae). Bull. Mar. Sci. 50:501–507.

Grimes, C. B.
1987. Reproductive biology of the Lutjanidae: a review. *In* J. Polovina and S. Ralston (eds.), Tropical snappers and groupers: biology and fisheries management, p. 230–294. Westview Press, Boulder, Colorado.

Hay, D. E.
1981. Effects of capture and fixation on gut contents and body size of Pacific herring larvae. Rapp. P.-V. Reun. Cons. Int. Explor. Mer 178:395–400.

Hoese, H. D., and R. H. Moore.
1977. Fishes of the Gulf of Mexico, Texas, Louisiana, and adjacent waters. Texas A&M Univ. Press, College Station, 327 p.

Laroche, W. A.
1977. Description of larval and early juvenile vermilion snapper, *Rhomboplites aurorubens*. Fish. Bull. 75:547–554.

Leis, J. M.
1987. Review of the early life history of tropical groupers (Serranidae) and snappers (Lutjanidae). *In* J. Polovina and S. Ralston (eds.), Tropical snappers and groupers: biology and fisheries management, p. 189–237. Westview Press, Boulder, CO.

Loftus, W. F.
1992. *Lutjanus ambiguus* (Poey), a natural intergeneric hybrid of *Ocyurus chrysurus* (Bloch) and *Lutjanus synagris* (Linnaeus). Bull. Mar. Sci. 50:489–499.

McGurk, M. D.
1985. Effects of net capture on the postpreservation morphometry, dry weight, and condition factor of Pacific herring larvae. Trans. Am. Fish. Soc. 114:348–355.

Munro, J. L.
1987. Workshop synthesis and directions for future research. *In* J. Polovina and S. Ralston (eds.), Tropical snappers and groupers: biology and fisheries management, p. 639–659. Westview Press, Boulder, Colorado.

Nakamura, F. I.
1976. Recreational fisheries for snappers and groupers in the Gulf of Mexico. *In* H. R. Bullis Jr. and A. C. Jones (eds.), Proceedings of the colloquium on snapper-grouper fishery resources of the western central Atlantic Ocean, p. 77–85. Florida Sea Grant Program Rep. 17, Gainsville, FL.

Rabalais, N. N., S. C. Rabalais, and C. R. Arnold.
1980. Description of eggs and larvae of laboratory reared red snapper (*Lutjanus campechanus* Poey). Copeia 1980:704–708.

Richards, W. J., and V. P. Saksena.
1980. Description of larvae and early juveniles of laboratory-reared gray snapper, *Lutjanus griseus* (Linnaeus) (Pisces, Lutjanidae). Bull. Mar. Sci. 30:515–521.

Theilacker, G. H.
1980. Changes in body measurements of larval northern anchovy, *Engraulis mordax*, and other fishes due to handling and preservation. Fish. Bull. 78:685–692.