TOPIC AREA
INDIGENOUS SEPCIES DEVELOPMENT

DEVELOPMENT OF SNOOK (*CENTROPOMUS* SPP) SEED PRODUCTION TECHNOLOGY FOR APPLICATION IN AQUACULTURE AND RESTOCKING OF OVER-FISHED POPULATIONS

Indigenous Species Development/Experiment/ 07IND01UA

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INTRODUCTION

Most fisheries stocks in southeastern Mexico have been reduced or depleted due to an increase in the demand for fish products and in the number of fishermen, natural changes on stocks, and to anthropogenic alterations of aquatic habitats. Aquaculture is a viable

option to capture fisheries, proving alternatives for local employment and income generation. The development of aquaculture techniques for native species not only would help reduce fishing pressures on wild stocks, but it also would provide a source of fingerlings for the development and implementation of plans to restore depleted stocks. Snooks are the most valuable fishery species in southeastern Mexico. Common snook (*Centropomus undecimalis*) and fat snook (*C. parallelus*) support the regional snooks fisheries in the Mexican Atlantic coast. The natural range of common snook extends from North Carolina to Brazil (Muller et al., 2001), making the status of wild snook populations of international concern in the Americas due to local interest in each country for recreational, commercial fisheries and the possibility of fishes are migrating at different life stages in these habitats.

Knowledge of the reproductive biology of snooks is limited. Most information available concerns the common snook. Snooks are considered to be protandric hermaphrodites (Taylor et al., 2000). Spawning has been successfully induced by hormone treatment in wild-caught common snook broodstock (Neidig et al., 2000) and in captive fat snook broodstock (Alvarez-Lajonchere et al., 2002). Common snook broodstock has been difficult to maintain in captivity and thus the few available hatchery-spawning programs have mostly relied on wild-caught fish. Wild-caught broodstock are either immediately processed upon capture to obtain gametes for in vitro fertilization, or they are brought to the hatchery where they are promptly injected with hormones to induce spawning (Anonymous, 2001). Alvarez-Lajonchere and colleagues (2002) developed spawning techniques for fat snook that are based on chronic and acute hormone treatment methods. Although fat snook larvae have been successfully reared and weaned in other places (Alvarez-Lajonchere et al., 2002; Alves et al., 2006).

Snook larvae are small (approx.1.5 mm) and require small prey organisms for their survival and growth. The rearing of larval fish is the most critical stage in the production cycle for many species, and the primary obstacle is that of an adequate food supply (Léger et al., 1986; Abi-Ayad and Kestemont, 1994). A diet which is ready and available and of high nutritional quality, and that is accepted and digested by larval fish must be used (Kim et al.., 1996). Feeding protocols using microalgae, rotifers and Artemia nauplii are currently used for many species. At first feeding, adequate live food density and particle size are also essential for larval fish survival during this critical stage (García-Ortega and Lazo, 2004). Little information is currently available on the dietary requirements of captive common snook larvae. However, fat snook larvae have been successfully reared on a combination of rotifers and Artemia nauplii (Alvarez-Lajonchere et al., 2002), or solely on Artemia nauplii (Alves et al., 2006).

Seed production of fat snook at an experimental scale in Brazil and of the related species, Barramundi (Lates calcarifer) at a commercial scale has been successful achieved (Alvarez-Lajonchere et al., 2002). The laboratory of aquaculture at UJAT also has conducted pilot tests that demonstrate the feasibility of rearing common snook juveniles on artificial diets (Silvercup™ trout pellets; J.M. Vidal et al., unpublished data).

Spawning and larval rearing technologies and methods available for snooks need to be validated on site at the target locations to confirm their general applicability. Specific methods used elsewhere (or for other species) need to be tested on site to determine the precise conditions that result in larvae of good quality. Information regarding the timing, hormone type and dose and water quality conditions is particularly needed. There is the possibility of differences between species in their "manageability."

Implementation of aquaculture activities in Mexico and Central America strongly depends on the availability of fingerlings (seed); which until now has primarily focused on exotic tilapias. Recently, some fishermen in the region successfully raised snooks in freshwater earthen-ponds utilizing wild-caught seed. This practice was subsequently banned by the Secretariat of Natural Resources (SEMARNAT) and by state agencies because it was rapidly spreading, raising concerns about the potential impact on wild stocks recruitment. Despite its short life, this experience justified the development of snook seed production technologies because it showed (1) an interest in and a demand for snook seed for the purpose of aquaculture, (2) the feasibility of growing snook juveniles in freshwater ponds; and (3) a commitment by state and federal management agencies to manage the snook fisheries and aquaculture industry on the basis of ecologically sound principles.

Recent institutional efforts have been organized for snook information exchange between researchers, students, government and NGO´s technicians, farmers and, economical and recreational fishermen. In spring 2004, TTU and UJAT organized a successful international workshop on the biology and culture of snooks. Presenters included leading world experts on these topics. Since then, we have generated new information on the use of artificial diets for juvenile common snook (Vidal, 2009), status of common snook in Texas (Pope et al., in press), and freshwater habitat for juvenile common snook (Huber , 2007); and important information on the larval rearing of snooks has been developed by others (e.g., Alves et al., 2006). As part of this project we organized the Second International Workshop on Snook Biology and Culture for the purpose of collecting and widely disseminating the latest information on snooks.

METHODS AND MATERIALS

Objective 1: To develop techniques for the production of good quality snook eggs

General Experimental Procedure. All experiments were conducted in the recently built snook research facility in the coastal county of Centla, in the fishermen community of Jalapita, Tabasco. This rural facility was established by precedent collaboration projects (CRSP-UJAT-Cooperativa Pesquera San Ramón).

Common and fat snook wild broodstock were collected in coastal areas near to the facility during spawning season using 3 or 7 inch gill nets according with fish size. Collected fishes were transported to the facility and maintained in a 25 m^3 holding tank and fed with live food (local sardines, *Clupeidae*). Thirty six fishes were selected for each experiment (12 females and 24 males). All fat snook experiments were conducted using

recently caught wild broodstock and common snook were conducted with animals kept in captivity for 1-2 years in our facilities.

Before manipulation for gamete sampling, all fish were anesthetized using MS-222 (Finquel ™). Female maturity was confirmed using the gonad biopsy protocol suggested by Alvarez-Lajonchère & Hernandez Molejón (2001). Egg diameter and location of the oocyte´s germinal vesicle were determined; whereas male maturity was consider by abundant milt presence when abdominal pressure was applied. Ripe fish were transferred to holding tanks.

One female and two males were used in each experimental unit. Total length and weight were recorded from each fish. Treatments consisted of the application of either an injection or a pellet containing different concentrations (µg/female) of GnRHa (Argent Labs, USA). Pellet elaboration and application followed the methodology proposed by Alvarez-Lajonchère & Hernandez Molejón (2001) using a mixture of cholesterol/cellulose (95:5) and cocoa butter used for agglutination. After treatment, all fish were placed in 2,000 L tanks (for fat snook) or 9,000 L tanks (for common snook) connected to a recirculation system. Small tanks had a 20 L egg collector while large tanks had an 80 L egg collector. Egg collectors were equipped with a 400 um mesh bag for capturing the eggs. Sand-filtered sea water was supplied to the system and the water quality was maintained by daily 50% water exchange. Temperature, pH and dissolved Oxygen were measured daily (Hanna Instruments & YSI Corp). A second biopsy was performed to females post-spawning in order to determine the continuous action of GnRHa.

Treatment effectiveness was determined by presence or absence of spawnings and egg quality, subsequent implantation was performed and oocyte diameter was recorded. Eggs were collected and buoyant eggs selected for incubation in a 80 L cylindroconical tank. Number of eggs produced was estimated taking three 50 mL samples from the egg collector and eggs counted using a Petri dish to obtain total estimation. Fertilization was recorded after 30 minutes by blastomer observation of 100 eggs using a dissecting microscope (Álvarez-Lajonchere & Hernández-Molejón, 2001). Fertilized egg diameter was obtained from 100 viable embryos using an ocular micrometer attached to a dissecting microscope.

For hatching estimation, viable eggs were incubated in a 300 L tank using sea water similar to the one used in spawning tanks (similar temperature, oxygen level and salinity). After 48 h of incubation, three 50 mL samples were taken from each incubation tank for larval counting under the microscope. Larval survival was determined by the same counting method and total length was recorded under a dissecting microscope at first feeding time.

In all cases, the experimental designed used was a randomized complete block design using one blocking criteria. Due to a lack of enough ripe female availability a pseudo-replication (by date) was used to complete all treatments. Statistical analysis for treatments in the response variables: egg number, egg diameter and larvae total length

was performed using a one-factor ANCOVA. Replication trial (pseudo-replicates) was used as a blocked factor. Results from fertilization rates, hatching, and survival to first feeding were compared among treatments by Chi square test using contingency tables (CT). All statistical analyses were conducted using STATGRAPHICS™ 5.1 and graphical description by Sigma Plot V. 11.0™. We consider statistical differences when the probability level was less than 0.05.

Experiment 1a: Fat Snook spawning induction by GnRHa-saline injections. Except for hormone delivery, most procedures and analyses were conducted as described previously. GnRHa vials were dissolved in 0.9 % saline solution just before injections. A second gonadal biopsy was performed to females that did not spawned in order to determine GnRHa effects.
Treatments: Females were injected with saline solution (vehicle, no GnRHa), 75 µg GnRHa/kg, or 150 µg GnRHa/kg. All males were injected with 50 µg GnRHa/kg.
This experiment was conducted two times (1a-i).

Experiment 1b: Common snook spawning induction by GnRHa-saline injections. This experiment was not conducted due to a lack of broodstock. Despite several attempts, no wild fish (broodstock quality) were caught during 2009. Twenty-eight fish that were kept in captivity for three years died during the flooding episode of 2008, since electricity and communications were lost for two weeks. During this time, our emergency plant failed and the lack of power affected water quality.

Experiment 2a: Fat snook spawning induction by pelleted-GnRHa implantation. Females were implanted with pelleted vehicle (no GnRHa), 100 µg GnRHa, or 200 µg GnRHa/fish. All males were implanted with 100 µg GnRHa pellets.

Experiment 2b: Common snook spawning induction by pelleted-GnRHa implantation (Captive broodstock). Due to the size of the organisms, experimental tanks used for spawning induction were 4 m in diameter. Each tank had an 80 L egg collector. All other procedures and analyses were as described previously. When spawnings were not observed, a second gonadal biopsy was performed to females in order to determine the GnRHa effects.

Treatments: Females were implanted with pelleted vehicle (no GnRHa), 100 µg GnRHa pellet/fish, or 200 µg GnRHa/fish. All males were implanted with 100 µg GnRHa/male pellets.

Experiment 2b-i: Common snook spawning induction by pelleted-GnRHa implantation (Wild broodstock). Recently caught organisms were used according to availability. All procedures and analyses were as described previously.

Objective 2. To develop techniques for the production of snook seed
Experiment 3. Evaluation of Initial stocking rates for fat snook larvae. Because of the lack of spawnings with common snook and better results with fat snook in experiments 1 and 2, fat snook larvae were used for density trials at UJAT. Additional

efforts were conducted in collaboration with researchers from Universidad Nacional Autonoma de Mexico (Sisal, Yucatan-Unit) to obtain larvae from their common snook broodstock, resulting in two spawnings; but, in both cases, not enough larvae were obtained in order to run our density trials.

Two batches of fat snook larvae were obtained at our UJAT-CRSP-Cooperativa San Ramon- facility by GnRHa pellet induction (200 ug/fish dosage; experiment 2a). Embryos were transported to the Tropical Aquaculture Laboratory in Villahermosa, Tabasco and incubated for hatching. Incubation was performed in 100-L cylindroconical incubation tanks using sea water (at 24 ºC and 35 ppt of salinity). The number of yolk-sac larvae was estimated according to survival at hatching (87% fertilization & 80% hatching rate). Yolk-sac larvae were transferred from the incubator to fifteen culture tanks at desired treatment densities (densities were estimated by volumetric method). Initial stocking densities for snook larvae were 20, 40, 60, 80, and 100 larvae/L. Each treatment was conducted in triplicate. Each experimental unit was supplied with filtered sea water (35 ppt) and aeration and the room temperature was maintained at 24°C. Two trials were performed as follows:

Experiment 3a. Five liter culture tank. Desired densities were stocked in tanks containing a total volume of 5 L. The general feeding schedule was as follows: rotifers *Brachionus plicatilis* during days 2-14 post-hatch. Prior to presentation to larvae, rotifers were intensively fed with *Nannochloris* spp. and enriched with Selco (INVE) for 4 h. Random samples of approximately 10 larvae per tank (30 per density) were taken every five days. Fish were anaesthetized with MS-222 and fixed with 4% formaldehyde. Larvae were measured from a digitized image (Sigma Scan Pro V. 4.0) captured with an optical microscope Zeiss (8X). Due to the size of the larvae, weight was not recorded.

Experiment 3b. Ten liter culture tank. All procedures were similar to those described in the preceding experiment, only the tank volume used was different (10 L) in order to avoid excessive larval manipulation.

Growth data was compared using a nested ANOVA (treatment; tanks nested into treatments) followed by Tukey's HSD.

Objective 3. To conduct an international workshop on snook biology and culture. **T**he Second International Workshop on Snook Biology and Culture was organized at UJAT on the basis of our successful experience with the first (2004) workshop. The meeting consisted of four days of workshops and three days of conferences (International Snook Symposium). The meeting was widely advertised by using listservs, newsletters, and web site outlets that targeted both fisheries and aquaculture audiences as well as by personal contacts.

RESULTS

Objective 1: To develop techniques for the production of good quality snook eggs

Experiment 1a: Fat snook spawning induction by GnRHa-saline injections (wild broodstock). Initial statistical differences in oocyte diameter were observed among treatments (ANCOVA, $p<0.001$). The effect of treatment assignment was statistically significant ($p<0.001$). The blocked factor (date of pseudo-replication) had a significant effect in oocyte diameter ($p<0.001$), and the covariate (female weight) also had a significant effect ($p<0.001$). The random allocation of females resulted in differences in oocyte diameter, been larger in the 150 µg/kg treatment (359.82 ± 76.62 µm), while oocytes from the 75 µg treatment showed the lowest size (337.40 ± 76.31 µm; Fig 1); therefore, initial size of oocytes was included as covariate in the post-injection analysis. After injections, no spawning activity was observed in any of the treatments. Therefore, oocyte diameter was measured as response of the treatments. Post-injection ovarian biopsy from no-spawned females showed an increase in oocyte diameter when GnRHa was present (ANCOVA, $p<0.001$). The effect of hormone was statistically significant ($p<0.001$). The blocked factor (date of pseudo-replication) had a slight significant effect in oocyte diameter ($p=0.04$) and the covariates, initial oocyte diameter and female weight had no significant effects ($p= 0.48$ and 0.70, respectively). Oocyte diameter was larger in the 150 µg/kg dosage (392.87 ± 88.80 µm), while no changes were observed in control females (325.00 ± 68.73 µm; Fig. 2).

Experiment 1a-i: Fat snook spawning induction by GnRHa-saline injections (wild broodstock). All replicates were initiated at the same time; therefore, no pseudo-replication was needed. Initial statistical differences in oocyte diameter were observed among treatments (ANCOVA, $p<0.001$). The effect of treatment assignment was statistically significant ($p<0.001$). The covariate (female weight) also had a significant effect ($p<0.001$). The random allocation of females in treatments resulted in differences in oocyte diameter, sampled oocytes in the 75 µg GnRHa/kg treatment were the largest (402.12 ± 70.98 µm), while oocytes from control treatment showed the lowest size (380.12 ± 61.09 µm; Fig. 3). High mortality of adult fish was observed in all treatments.

Post-injection ovarian biopsy of no-spawned females, indicate an increase in oocyte diameter when GnRHa was present (ANCOVA, $p< 0.001$). Oocyte diameter was larger in the 150 µg/kg dosage (481.25 ± 120.03 µm), while no significant changes where observed in control females (399.37 ± 51.47 µ µm) when compared with initial oocyte diameter. The covariates, initial oocyte diameter and female weight had no significant effects ($p= 0.33$ and 0.09, respectively).

Experiment 2a: Fat snook spawning induction by pelleted-GnRHa implantation (wild broodstock). Initial statistical differences in oocyte diameter were observed among treatments (ANCOVA, $p<0.001$). The effect of treatment assignment was statistically significant ($p<0.001$). The blocked factor (date of pseudo-replication) had a significant effect in oocyte diameter ($p<0.001$), and the covariate (female weight) also had a significant effect ($p<0.001$). The random allocation of females resulted in differences in oocyte diameter. In all cases the nucleus position was the same, initial diameter (µm) was 371.25 (± 63.31) for the control group, 383.25 (± 68.41) for 100 µg GnRHa/fish, and 388.62 (± 57.09) for females in treatment with 200 µg GnRHa/fish. Results on the second

biopsy (post-spawning) indicated that new oocyte batches are ready for consecutive spawning events when GnRHa was used.

Spawning was observed around 30 hour post-implantation only in treatments when GnRHa was present, whereas no spawning activity was observed when in the control group. The number of females that spawned per treatment were: 0/4 for the control group, 3/4 for 100 µg GnRHa/fish and 4/4 for 200 µg GnRHa/fish.

Average total number of eggs by treatment was 28,919 eggs (± 3897.3) for the treatment with 100 µg and 40,370 eggs (± 4478.7) for the treatment with 200 µg. Fertilization rate was higher when the lower dosage was used (CT, $p<0.001$; Fig 4a). While the opposite was observed for hatching rate; resulting higher when 200 µg were used (CT, $p<0.001$; Fig 4a).

No statistical differences were observed in diameter of spawned eggs (ANCOVA, $p = 0.6$). Egg diameter in the treatment with 100 ug/fish was 607.17 (± 68.0 µm) and 605.98 (± 51.60) for the treatment with 200 ug/fish. Statistical differences were found for total length of first feeding larvae; larvae from the treatment with 100 ug were higher (1.80 ± 0.25 mm) than those from the treatment with 200 ug (1.60 ± 0.12 mm; KW, $p= 0.0$) (Fig. 5).

Similar water quality (temperature, dissolved oxygen and salinity) was observed in all treatments during the entire experiment (Table 1).

Experiment 2b: Common snook spawning induction by pelleted-GnRHa implantation (Captive broodstock). Due to a lack of mature females, only one female per treatment was used. Statistical differences were observed for the initial oocyte diameter among treatments (ANOVA, $p< 0.001$; Fig 6). The biggest oocytes obtained from the ovarian biopsy were observed for females implanted with the 200 µg GnRHa pellet (328.27 ± 71.86 µm), whereas small oocytes were obtained from females implanted with 100 µg GnRHa pellets (201.80 ± 94.12 µm).

One spawning event was observed from the 200 µg GnRHa/pellet treated female; however, no fertile eggs were obtained. Egg diameter obtained from this spawn was 696.42 ± 16.45 µm. Post-spawning ovarian biopsy showed no significant changes in oocyte diameter for this spawned female (369.89 ± 141.29 µm).

Experiment 2b-i: Common snook spawning induction by pelleted-GnRHa implantation (Wild broodstock). Because of no female availability from several catching efforts (1 female and 19 males), the only female captured was implanted with a 200 µg GnRHa/pellet.

Initial oocyte diameter was 376.86 ± 77.47 µm and no spawning activity was observed. Second ovarian biopsy indicated that oocyte growth achieved 412.13 (± 69.47 µm; Fig. 7).

Objective 2. To develop techniques for the production of snook seed

Experiment 3. Evaluation of Initial stocking rates for fat snook larvae.

Experiment 3a. Five liter culture tank. Initial average larval length was 1.66 ± 0.09 mm. No significant differences among treatments (caused by random allocation in tanks) were found the first day of experimentation ($p > 0.05$). Yolk sac was absorbed at day three post-hatching. After this time, all tanks received their feeding regimes (*Brachionus plicatilis)* three times a day. Sampling for growth evaluation was conducted as planned on day five, resulting in significant differences between treatments ($p < 0.001$). The largest larvae were found in the treatment with a density of 60 larvae/L (2.10 ± 0.10 mm). The smallest larvae were measured in the treatment with 100 larvae/L (1.9 ± 0.10 mm; Fig. 8). Larvae in all treatments died at day 8 post-hatching. After revision of stomachal content, no rotifers were found. Water quality was maintained in optimal conditions in all treatments (temperature = 22.7, DO = 6.2 and salinity = 33.0; Table 2).

Experiment 3b. Ten liter culture tank. Initial average larval length was 1.64 ± 0.10 mm. No significant differences among treatments (caused by random allocation in tanks) were found the first day of experimentation ($p > 0.05$). Yolk sac was absorbed at day three post-hatching. No significant differences between treatments ($p > 0.05$) were found after 5 days of experimentation. The largest larvae were found in the treatment with a density of 80 and 100 larvae/L (2.00 ± 0.01 mm). The smallest larvae were measured in the treatment with 40 larvae/L (1.85 ± 0.15 mm; Fig. 8). Larvae in all treatments died at day 8 post-hatching. After revision of stomachal content, no rotifers were found. Water quality was maintained in optimal conditions (temperature 23.1, DO 6.4 and salinity 32.9; Table 3).

Objective 3. To conduct an international workshop on snook biology and culture. The 7-day workshop was divided in two sections. The first section consisted of four days of workshops contained the following topics: Snook age determination, Recirculation in aquaculture, Larval Culture and grow-out of Fat snook juveniles and Histological determination of gonadal development on Teleost fish; with emphasis on common snook. The second section consisted of a symposium on snook biology and aquaculture that lasted three days; the symposium was divided in three main topics: Biology and ecology, captive breeding and snook culture. All activities were conducted at División Académica de Ciencias Biológicas, UJAT.

An abstract for each workshop is presented below:

Snook age determination, July 8 2009, Villahermosa, Tabasco. Dr. Allyse Ferrara (Nicholls State University). Thirty participants assisted. The workshop initiated with a presentation of the theory behind age determination in fish and the importance of determining the fish age based on otoliths development. The instructor explained about the use of some other bony structure, such as: radio, spines, etc. Several techniques for measuring age were described with emphasis on snook species. After the theory, a practical session was held using different fish species (cichlids, catfish and snook). In the

practical activity the participants performed otolith extraction, cleaning, mounting and ring counting for age determination.

Recirculation in aquaculture. July 9, 2009, Villahermosa, Tabasco. Dr. Quenton Fontenot (Nicholls State University). Thirty-one participants assisted. The workshop initiated with aspects related to the importance of the use of recirculation systems in aquaculture. In this workshop there was given a review on aspects of water re-use and exchange and its importance on fish growth. All these aspects included; tanks size as determining factor for fish volume production, as well as, the cautious selection of high quality inputs to achieve the best production without having negative impacts on the system. Physiological aspects were included in the workshop; fish classification according to osmoregulatory challenges in fresh water and marine water fish and the effect of salinity on plasma osmolarity. Other aspects of fish included were: exact and constant amount of feed and enough oxygen supply in order to achieve better growth rates, feed selection (based on protein percentage, lipid content and floatability). Another important point presented was feed fish intake, correct feed supply according to fish biomass and those aspects will vary with each species, culture system and environmental conditions. The final topic addressed the need of controlling physicochemical water quality parameters (ammonia, nitrates and nitrites) which may have a direct effect on production rates.

Larval Culture and grow-out of fat snook juveniles (*Centropomus parallelus*). July 10, 2009, Villahermosa, Tabasco. Dr. Vinicius Ronzani Cerqueira (Universidad Federal de Santa Catarina, Brazil). Thirty-five participants assisted. The present workshop was divided into 6 parts. 1. Brazilian Aquaculture, 2. Snook biology: distribution, habitat, reproduction and growth, 3. Reproduction in captivity: broodstock, spawning induction, eggs hatching, eggs development and embryo development, 4. Larvae culture: embryo development, culture systems, intensive systems, environment management, feeding, growth and survival, 5. Pre- grow-out; and 6. Grow-out. All aspects presented represent experiences on snook aquaculture in Brazil; particularly on fat snook which have high importance in commercial and scientific areas in addition with the achievements and experiences in Tabasco and Gulf of Mexico.

Histological determination of gonadal development on Teleost fish, with emphasis on common snook. July 10, 2009. Villahermosa, Tabasco. Dr. Harry Grier (University of South Florida). Thirty-two participants assisted 32 participants. This workshop was divided in two parts. The first part was directed to review and compare the different stages of development and snook oocytes maturation. A new proposal for reviewing the ovarian tissues was presented, providing more accuracy for determining the exact degree of development in snook eggs. In the second part Dr. Grier explained how to differentiate physiologically and anatomically males from females when the reproductive season is close, making emphasis to the shape of the belly, inflammation of the genital papilla, etc. He also explained how to perform ovary biopsies and be able to determine the maturation level of the oocytes.

Second International Symposium on the Biology and Culture of Snooks.

Villahermosa, Tabasco, Mexico. 13 – 15, July 2009. Fifty seven persons attended the symposium composed of twenty-seven talks. Fifteen talks were on biology and ecology of snooks, three on captive breeding and nine on snook aquaculture (program in appendix 1 and abstracts in appendix 2). Participant countries were: Mexico (five states), United States (three states), Brazil (one state) and Guatemala (one state). The audience was composed of 20 females and 37 males; fifteen were students, forty were researchers, one was an extension agent and one was a sport fisherman (list of participants in appendix 3). The entire afternoon of the last day of the symposium was dedicated to build the international network of snook researchers. Officials and delegates were named and objectives delineated.

DISCUSSION

In this experimental study we were able of obtaining larvae from the fat snook (*C. parallelus*) in Tabasco, Mexico, while no larvae of the common snook (*C. undecimalis*) were produced, despite achieving oocyte maturation. Implantation of GnRH-a at doses of 100 and 200 µg/fish were effective inducing both maturation and spawning, while injections of the same hormone only reached maturation with no spawning activity. Egg quality was considered good since 85-99% of fertilized eggs and 89-97% hatching were reached. Álvarez-Lajonchere et al. (2002) reported 90% fertilization rates for the same species in Brazil. Our results also indicate that implants significantly induced egg maturation, similar to results reported by Cerqueira y Canarín (2008). These authors also reached spawning of *C. parallelus* using 30 and 50 µg/kg of GnRH-a when wild broodstock was induced. Ferraz *et al.* (2002), obtained spawnings with the same species after 35-42 hours of induction using injections of 50 µg/kg of LHRH-a. However, this group found that females in the control group also released eggs. They concluded that injections and implants were effective inducing fat snooks to spawn finding no significant differences in the number of eggs produced, fertilization and hatching rates. In our study, we were able of identifying mature females from recently caught wild fish. Spawning was attained after a week of induction. Despite differences in egg diameter caused by the time of capture, the use of hormone successfully resulted in final maturation and release. The size of the eggs was also directly influenced by the size of the female, consisting in larger females producing larger eggs. This has been confirmed by several authors including Bagenal (1969). Duncan *et al*. (2003), concluded that LHRH-a induces final maturation in *Sphoeroides annulatus*, using both injections or implants; however, spawning was not reached by the majority of the females treated. The advantage of using implants consists in less manipulation of the fish, reducing stress considerably.

Maturity of the eggs in *C. parallelus*, measured as egg diameter was very significant in our study. All females induced responded to GnRH-a treatments and several released the eggs. In some cases not al lthe eggs were fertilized. With respect to this, Berlinsky *et al.* (1996), indicated that GnRH-a implants produce viable eggs in repeated spawnings of *Paralichtys lethostigma*. The fact that the implant slowly reduces the hormone is considered the main factor for spawning induction. Similar results were reported by Lee *et al*. (1986), reaching maturity in males and females of the milkfish *Chanos chanos.* Khay (1980), succesfully stimulated vitelogenesis in the goldfish *Carassius auratus* and the aruan *Ophiocephalus striatus* using hCG implants. In our study we obtained positive

results with the lowest dose used (100 µg/fish); however, no differences were found when the largest dose was used (200 µg/fish).

Regarding results obtained with injections, we were able of increasing the size of the eggs without been released, despite application of repeated injections. Other studies with *C. parallelus* have reported successful spawning using this technique with recently caught fish (Reis y Cerqueira, 2003). It is possible that the fish that they used from the wild were in an advanced stage of maturation and potentially close to ovulation or even during spawning time. It is important to mention that *C. parallelus* is a multiple-spawner species; therefore the fish could be caught even in between spawning events been at the maximum stage of maturity. Cerqueira *et al.* (2005) reported that injections of hCG in dosages of 1,100 IU were sufficient to get ovulated females. Álvarez-Lajonchere and Hernández-Molejón (2001) recommended that injections must be performed in partial dosages to allow the entire maturation of the oocyte. In our study, we used single dosages; therefore, it is possible that final maturation was not reached. It is possible that the injections we applied to the snooks were not at the right time. Fitzpatrick *et al.* (1987), determined that GnRH-a is efficient accelerating final maturation of oocytes in the coho salmon, *Oncorhynchus kisutch*, however, best results are obtained when enough fish are used so that females are selected at the most favorable time. Álvarez-Lajonchere and Hernández-Molejón (2001) recommended application of injection in snooks when oocyte diameter reached between 400 y 500 µ, unfortunately our fish where always significantly below that diameter. Sullivan *et al*. (2003) suggested induction at the time when the oocytes completed growth, since most fish initiate ovarian regression when placed in captivity.

Other researchers have mentioned that failure in fish induced spawning may be caused by ovarian atresia caused by captivity. Zohar and Mylonas (2001) emphasized this particularly at the end of egg maturation. On the other hand, males can also limit the success of an induction experiment, since they may not fertilize the eggs (Diana, 1951). Captivity may also alter hormonal cycles in males resulting in a lack of circulating LH Zohar and Mylonas (2001). Males of *Sparus aurata,* may present spawnings behavior, lacking mature spermatozoids (Zohar, 1989). Females may release the eggs, but never get fertilized.

All stressful conditions present during captivity can definitely alter final maturation of oocytes and affect spawning. Contreras-Sánchez et al., (1998) reported that reproduction patterns were significantly altered by stress present during farming conditions of adult rainbow trout (*Oncorhynchus mykiss*). The impact in reproduction was also related to the time at which stress was applied to the fish.

The quality of the eggs has been related to the nutritional condition of the broodstock. Tucker (1994), emphasized that even seasonal changes may affect female condition and the quality of the spawning events. This author pointed out that in *Epinephelus striatus* the size of the egg varies between fish maintained in captivity and fish from the wild. In our study, fish induced came from wild captures and we assume that nutrition was not a

factor affecting the results. More information is needed regarding comparisons between wild and captive broodstock in this species.

The size of the larvae obtained in our experiments was very similar to that reported by Álvarez-Lajonchere *et al*. (2002). Unfortunately, larvae obtained from fat snooks died on day eight of experimentation. Our explanation is that the size of the rotifers used was larger than the size of the mouth opening. Cerqueira and Tsuzuki (2009) also reported that the majority of the mortality presented in some experiments with *C. parallelus* is present during the first week of life, been higher around the third or fourth day after disappearance of the yolk sac. Cerqueira *et al*. (1995) suggested *Brachionus plicatilis* and *Bachionus rotundiformis* as food for *C. parallelus* starting on day three post-hatching, and posteriorly changing to artemia nauplii. We used *B. plicatilis*, but apparently the size of the rotifers was too large. Regarding to this, Verreth (1994) pointed out the need for optimal conditions Turing larval rearing as well as appropriate size of the food; particularly for marine species with a very small larval size. Planas and Planas y Cunha (1999) highly recommended the use of *Brachionus plicatilis* and *B. rotundiformes*) when feeding marine fish; these species were very efficient when feeding larvae of *Sparus aurata* (Polo *et al*., 1992). Tucker (1998) suggested *B. plicatilis*, with emphasis in rotifers between 100 and 240 μm in size. Our results could be affected if the rotifers used where adults surpassing the size needed for the larvae obtained.

More research is needed in order to obtain a good protocol for first feeding of snook. One option could be the use of mesocosms systems when feeding the larvae, making sure that feeds with different sizes are available for the fish (Prieto *et al*., 2006; Hunter, 1981). Addition of essential fatty acids (HUFA) may also be needed for improving these feeds (Koven et al., 1992). Silva (1999) mentioned that other microalgae such as *Isochrysis galbana*, can significantly improve larval rearing

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Table 1. Water quality measured as average temperature, Dissolved Oxygen and Salinity during experiment 2a.

Treatment (μg GnRHa/fish)	**Temperature (°C)**	**DO (mg/L)**	**Salinity (S)**
0	26.0 ± 0.68	6.5 ± 0.16	32.2 ± 0.43
100	26.5 ± 0.25	6.5 ± 0.10	35.0 ± 0.0
200	26.8 ± 0.59	6.5 ± 0.27	35.2 ± 0.43

Table 2. Water quality measured as average temperature, Dissolved Oxygen and Salinity during experiment 3a.

Treatment (Larvae/L)	**Temperature (°C)**	**DO (mg/L)**	**Salinity (S)**
20	22.69 ± 6.13	6.13 ±1.65	33.67 ± 1.25
40	22.60 ± 0.38	6.22 ± 1.79	33.50 ± 1.24
60	22.67 ± 0.46	6.11 ±1.54	33.14 ± 1.24
80	22.62 ± 0.60	6.21 ± 1.71	33.62 ± 1.09
100	22.70 ± 0.42	6.21 ± 1.76	31.29 ± 4.23

Table 3. Water quality measured as average temperature, Dissolved Oxygen and Salinity during experiment 3b.

Treatment (Larvae/L)	**Temperature (°C)**	**DO (mg/L)**	**Salinity (S)**
20	22. 93 ± 0.33	6.42 ±1.89	32.76 ± 0.62
40	22.95 ± 0.42	6.53 ± 1.90	32.52 ± 0.87
60	23.65 ± 2.66	6.62 ±1.63	33.10 ± 0.94
80	22.88 ± 0.28	6.41 ± 1.80	32.90 ± 0.89
100	22.88 ± 0.49	6.13 ± 1.60	33.00 ± 1.10

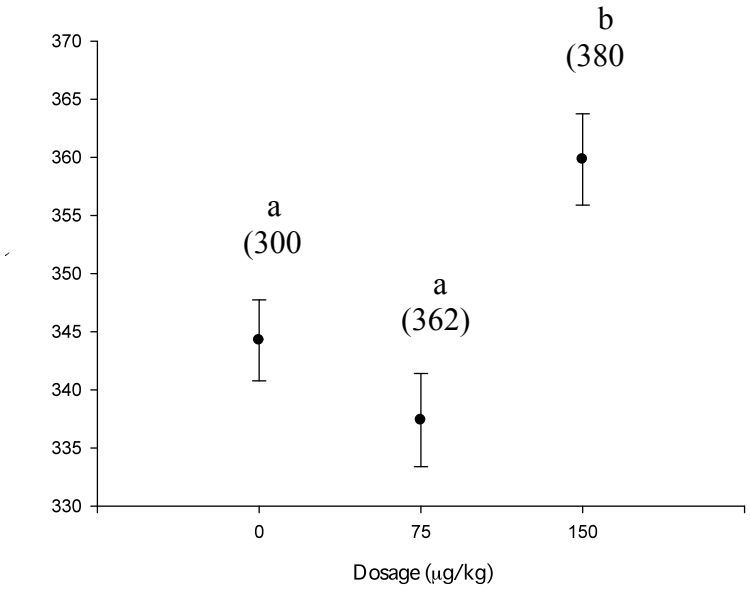

Figure 1. Oocyte diameter of *C. parallelus* before GnRH-a injection. Numbers in parenthesis indicate the number of oocytes measured. Different letters indicate significant statistical differences.

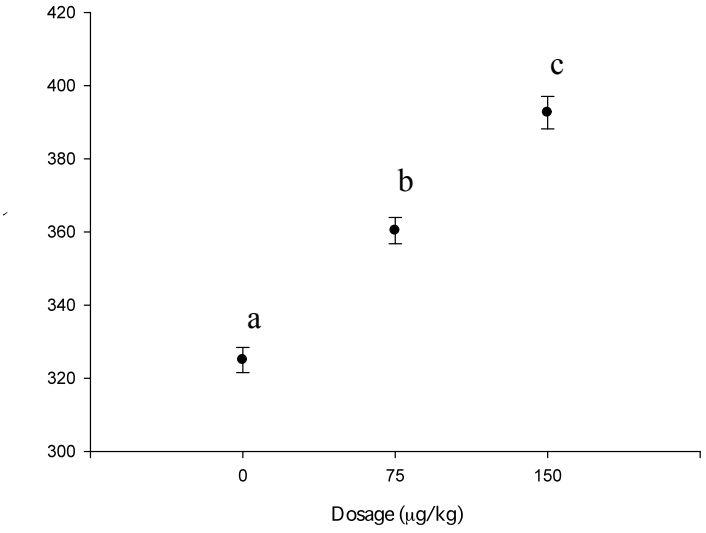

Figure 2. Oocyte diameter of *C. parallelus* after GnRH-a injection. In all treatments n = 400 eggs. Different letters indicate significant statistical differences.

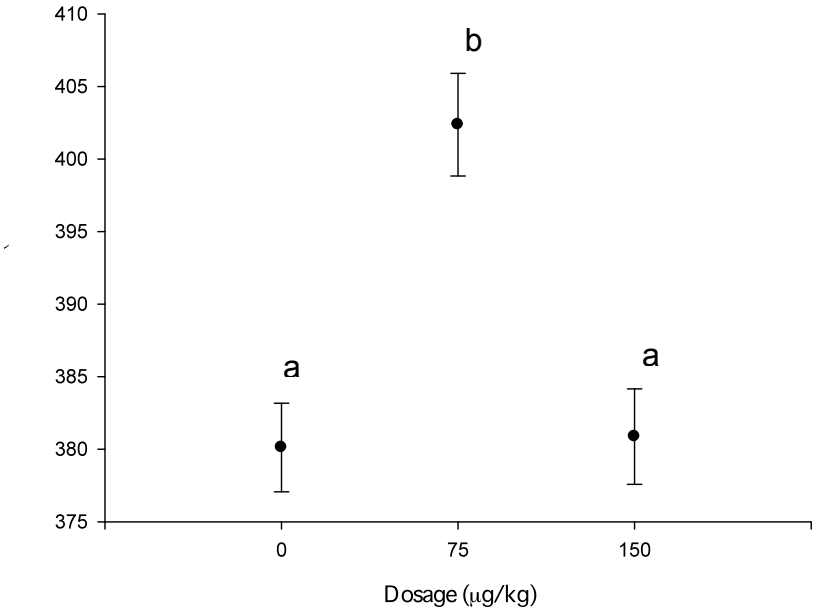

Figure 3. Oocyte diameter of *C. parallelus* before GnRH-a injections application. In all treatments n= 400. Different letters indicate significant statistical differences.

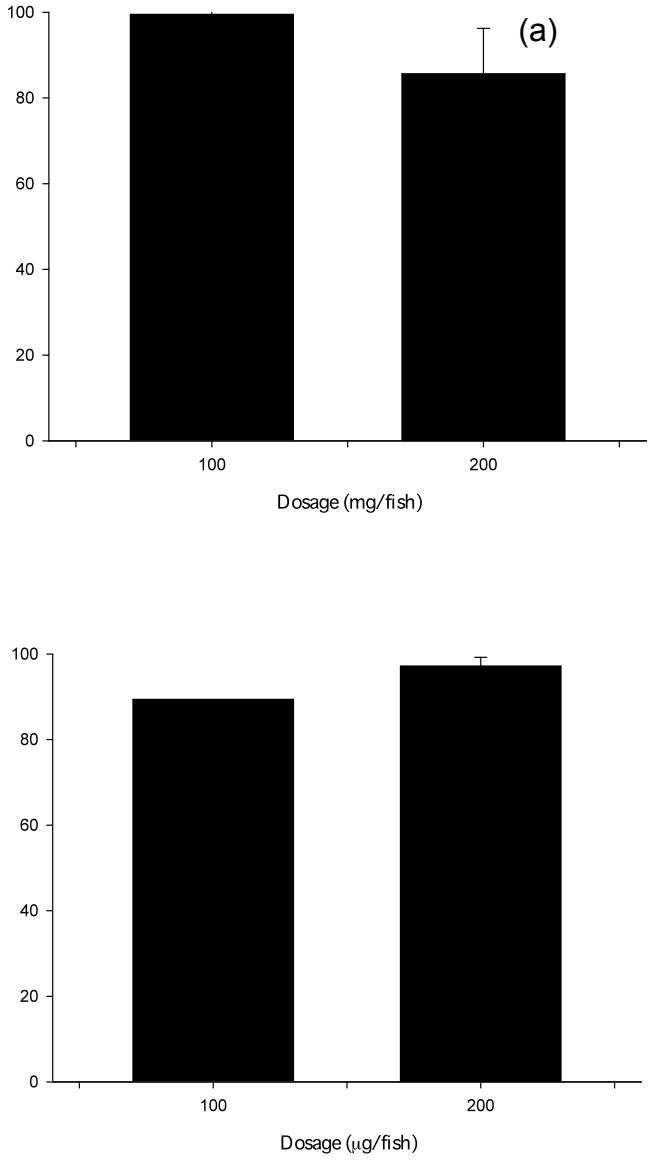

Figure 4. Fertilization (a) and Hatching (b) rates for *C. parallelus* viable eggs obtained from females induced by implantation of pelleted GnRHa. Asterisks indicate statistically significant differences.

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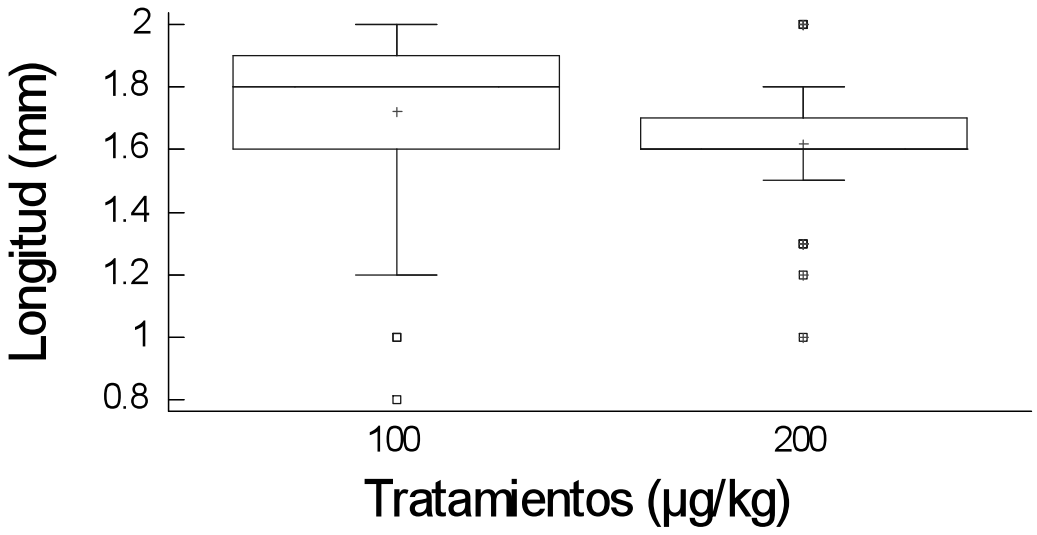

Figure 5. Initial size for larvae of *C. parallelus* obtained from females induced by implantation of pelleted GnRHa.

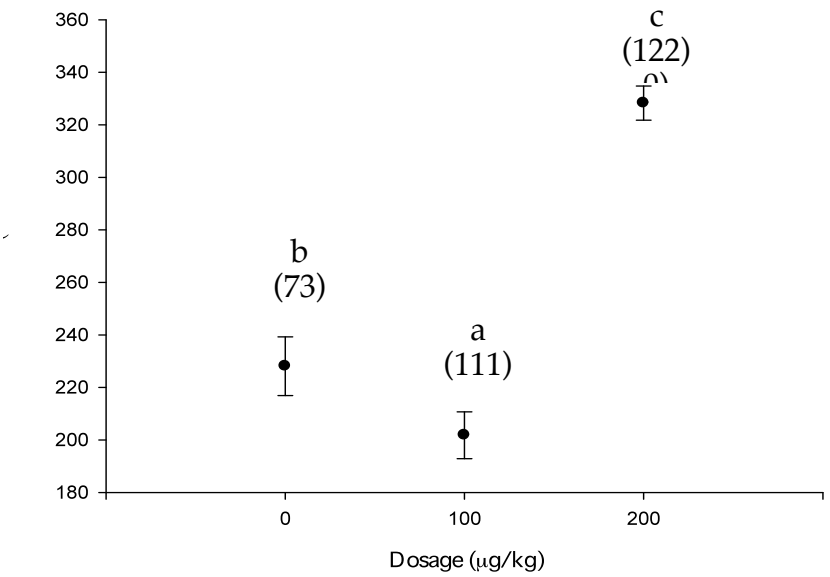

Figure 6. Oocyte diameter of *C. undecimalis* before GnRH-a implant application. Numbers in parenthesis indicate the number oocytes reviewed. Different letters indicate significant statistical differences.

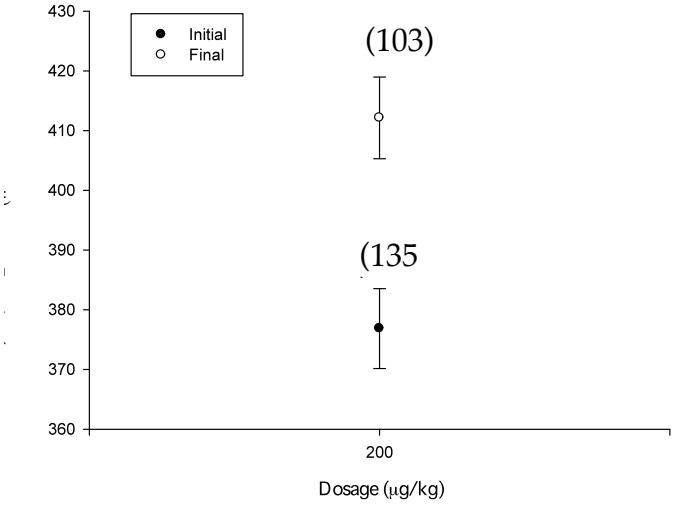

Figure 7. Oocyte diameter of *C. undecimalis* before and after GnRH-a implants application. Number in parenthesis correspond to the number oocytes reviewed. Both values are from the only female sampled at different times (before and after treatment).

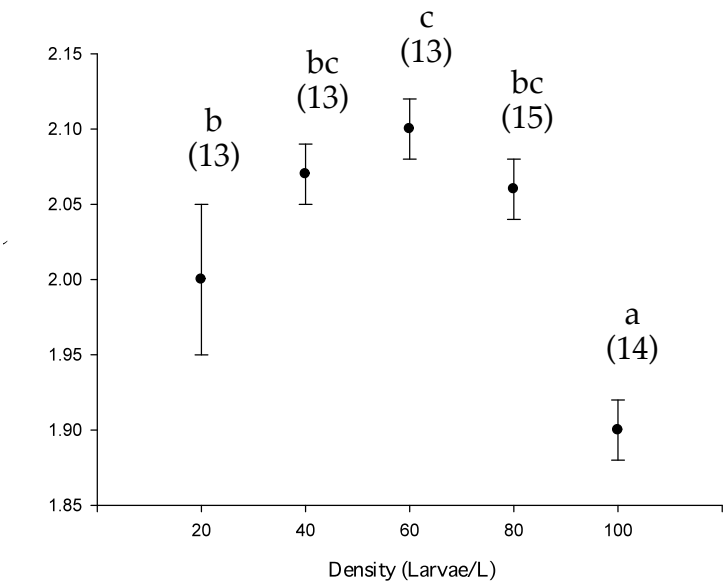

Figure 8. Average larval length of *C. parallelus* after five days of experimentation in experiment 3a. Numbers in parenthesis indicate the number larvae reviewed. Different letterS indicate statistical significant differences.

APPENDIX
1


UNIVERSIDAD JUÁREZ AUTÓNOMA DE TABASCO
División Académica de Ciencias Biológicas
Laboratorio de Acuicultura Tropical
Segundo simposio Internacional sobre Biología y Cultivo de Robalos
Villahermosa, Tabasco, México del 13 al 15 de Julio del 2009
Resúmenes/Abstracts

Second International Symposium on the Biology and Culture of Snooks
Villahermosa, Tabasco, Mexico
13 – 15, July 2009
Villahermosa, Tabasco, México

División Académica de Ciencias Biológicas
Universidad Juárez Autónoma de Tabasco

Room: Alexandr I. Oparin

PROGRAM

ORGANIZING COMITEE

UJAT
Wilfrido Miguel Contreras Sánchez
Ulises Hernández Vidal
Arlette Hernández Franyutti
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Lenin Arias Rodríguez
Salomón Paramo Delgadillo
Gabriel Márquez Couturier
Alejandro Macdonal Vera

TTU
Reynaldo Patiño

CONFERENCES
July 13

Registration 8-9 AM

Inauguration Ceremony 9:00-9:30

Biology and Ecology

Time	Authors	Title
10:00-10:40	Carole McIvor, Adam Brame, and Justin Krebs.	**Habitat ecology of young of the year Common Snook (*Centropomus undecimalis*) in two Gulf of Mexico estuaries, Florida, USA.**
10:40-11:20	Philip W. Stevens, David A. Blewett, and Gregg R. Poulakis	**A conceptual model of juvenile Snook habitat use and application to a variety of estuarine systems**.
11:20-12:00	Caleb G. Huber, Kevin L. Pope, and Reynaldo Patiño	**Habitat preferences of juvenile Common Snook in the Lower Rio Grande/Bravo del Norte**.
12:00-12:30	**BREAK**	
12:30-13:10	Martha A. Perera-García, Manuel Mendoza-Carranza, Wilfrido Contreras-Sánchez, Eunice Pérez-Sánchez, Allyse Ferrara, Maricela Huerta-Ortiz, and Salomón Páramo-Delgadillo	**Comparison of age and growth of Common Snook (*Centropomus undecimalis*) in two different tropical systems (coast and river), in Tabasco, México**.
13:10-13:50	David A. Blewett, Philip W. Stevens, Ronald G. Taylor, Thomas R. Champeau, and Brent L. Winner.	**Use of rivers and an open estuary by common snook, *Centropomus undecimalis*, and comments on factors influencing cyclical seasonal movements.**
13:50-14:30	Ronald G. Taylor, David A. Blewett, Alexis A. Trotter, Phillip W. Stevens, and Robert Muller.	**Aperiodic, novel migrations and use of riverine habitats by common snook: evidence for skip spawning**.
14:30-17:00	**LUNCH**	
17:00-17:40	Martha A. Perera-García, Manuel Mendoza-Carranza,	**Reproductive biology and status of populations of the common snook**

	Wilfrido Contreras-Sánchez, Eunice Pérez-Sánchez, Maricela Huerta-Ortiz, and Salomón Páramo-Delgadillo	**(*Centropomus undecimalis*), in Tabasco, México**.
17:40-18:20	Rosa María Lorán-Núñez, Fco. Rolando Martínez-Isunza and Manuel Garduño-Dionate	**Total mortality of the Mexican snook (*Centropomus poeyi)* in Laguna de Alvarado, Veracruz, México (2005)**.
18:20-19:00	Richard J. Kline and G. Joan Holt	**The difficulties with defining the spawning season for snook in Texas**.

19:00-19:40	Manuel Mendoza-Carranza, Martha A. Perera-Garcia, Salomon Paramo-Delgadillo and Eunice Perez-Sanchez	**Variations in Common snook (*Centropomus undecimalis*) catch per unit effort and climatic variation in southeastern Mexico coasts.**
Reception		

CONFERENCES
July 14

Biology and Ecology

Time	Authors	Title
9:00-9:40	Ma. Guadalupe Gómez Ortiz, Rodolfo Arteaga Peña, Juan Balderas Télles, Guillermo Acosta Barbosa, and Ariel López Salazar	**Reproduction of the common snook (*Centropomus undecimalis*) in the Panuco River, Veracruz.**
9:40-10:20	Rosa María Lorán-Núñez, Fco. Rolando Martínez-Isunza, Manuel Garduño-Dionate and Víctor Martín Zarate-Noble	**Reproduction of the mexican snook (*Centropomus poeyi*) and common snook (*C. undecimalis*) in Laguna de Alvarado, Veracruz (2005-2008)**.
10:20-11:00	Manuel Garduño Dionate, Rosa María Lorán Nuñez, Francisco Rolando Martínez Isunza and Erik Márquez García.	**Fecundity of the common snook (*Centropomus undecimalis*), in the coast of Ciudad del Carmen, Campeche**.
11:00-11:30	**BREAK**	
11:30-12:10	Vequi Caballero Chávez	**Size for fish maturation and capture**

		composition of common snook in Southern Campeche.
12:10-12:50	Francisco Rolando Martinez-Isunza, Rosa María Lorán-Nuñez, Manuel Garduño-Dionate, Vequi Caballero-Chavez, María Guadalupe Gómez-Ortiz, Victor M. Zarate-Noble, Martha Alicia Perera-García, Salomón Paramo-Delgadillo y Carlos Alfonso Alvarez-González	**Proposal for the regulation of snook capture in the Gulf of Mexico**.
Captive breeding		
12:50-13:30	Adolfo Sanchez Zamora	**Status of the Common Snook reproduction in captivity at UMDI, UNAM, Sisal.**
13:30-14:10	Matthew Resley, Kevan Main, and John Stubblefield	**An overview of Common Snook broodstock maturation and spawning research**.
14:10-14:50	María de Jesús Contreras-García, Wilfrido M. Contreras-Sánchez, Ulises Hernández-Vidal, Alejandro Mcdonal-Vera	**Induction of reproduction of Fat Snook in captivity using LHRHa implants and injections**.
14:50-17:00	**LUNCH**	
Culture		
17:00-17:40	Ulises Hernández-Vidal, Wilfrido M. Contreras-Sánchez, Reynaldo Patiño, Juan M. Vidal-López, Ana Y. Torres-Marín, Carlos A. Alvarez-González y Arlette A. Hernández-Franyutti	**Maintenance in captivity of the Common Snook (*Centropomus undecimalis*), Fat Snook (*Centropomus parallellus*) and Mexican Snook (*Centropomus poeyi*)**.
17:40-18:20	Sergio Escárcega-Rodríguez	**Fist evidence of aclimation to captivity for Pacific black snook (*Centropomus nigrescens*)**
18:20-19:00	G. Joan Holt and Rick Kline	**Culturing Texas Snook - What have we learned so far**.

CONFERENCES
July 15

Time	Authors	Title
9:00-9:40	Leonardo Ibarra-Castro	**Culture of the Asian Snook (Lates calcalifer) in Australia**.
9:40-10:20	Eduardo A. Zarza-Meza	**Grow-out of *Centropomus undecimalis* (Bloch, 1792) and *Centropomus parallelus* (Poey, 1860) in fresh water in Veracruz, Mexico.**
10:20-11:00	Vinicius Ronzani-Cerqueira	**Spawning and larviculture of the fat snook (*Centropomus parallelus*) in Brazil**.
11:00-11:30	**BREAK**	
11:30-12:10	Kevan Main, Carlos Yanes-Roca, and Nicole Rhody	**Status and challenges in larval rearing and fingerling aquaculture of Common Snook in Florida**.
12:10-12:50	Juan Manuel Vidal-López, Wilfrido M. Contreras-Sánchez, Carlos A. Álvarez-González, Arlette Hernando-Franyutti, Ulises Hernández-Vidal	**Feminization of Common snook (*Centropomus undecimalis*) juveniles using Estradiol in the diet.**
12:50-13:30	Carlos A. Alvarez-González*, Natalia Perales-García, Bartolo Concha-Frías, Adolofo Sanchez-Zamora, Gabriela Gaxiola, Luis D. Jiménez-Martínez, Leticia Arena-Ortiz, Talhia Martínez-Bruguete, Arlette A. Hernández-Franyutti, Juan M. Vidal-López, Lenin Arias-Rodriguez, Gabriel Marquez-Couturier, Dariel Tovar-Ramírez, Enric Gisbert, Francisco J. Moyano, Francisco J. Alarcón, Pedro H. Toledo-Agüero, Alfonso E. Silva-Arancibia	**Status of digestive biology studies of the common snook (*Centropomus undecimalis*) in Tabasco, Mexico**.
13:30-14:10	**CLOSING REMARKS**	

APPENDIX 2

HABITAT ECOLOGY OF YOUNG OF THE YEAR COMMON SNOOK (*Centropomus undecimalis*) IN TWO GULF OF MEXICO ESTUARIES, FLORIDA, USA

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Characterization and protection of nursery habitats of juvenile common snook is an important issue for proper management of the species. We conducted three different studies to examine habitat use and ecology of juvenile snook in two different regions of Florida. In each of the studies we used small haul seines to collect snook from permanently subtidal and shallow intertidal areas. We recorded water quality and habitat characteristics at each site to allow inferences about snook nursery areas. The first study was a 3-yr survey of habitat associations and density estimates of young of the year (YOY) common snook in four types of mangrove-lined, estuarine water bodies in Tampa Bay. Four hundred and thirteen snook were collected from 833 samples during this project. YOY snook were most abundant from August through January at salinities of 5-15 psu. Average densities were highest in natural tidal creeks followed closely by well-flushed, man-made, mosquito-control ditches. YOY were also relatively abundant in estuarine ponds that were well-connected to adjacent tidal channels. Man-made stormwater-control ditches consistently had only low densities of these fish, and apparently provided poor habitat for YOY snook. Such ditches are often scoured with high-velocity flows following heavy rain events. A second more-focused study specifically investigated small-scale habitat associations of YOY snook within a single tidal-creek drainage (Frog Creek in lower Tampa Bay), during the 2006 fall recruitment. Here Adam Brame collected YOY snook along the shorelines of a creek and four connected ponds, with the intent of better defining optimal nursery habitat. He collected 436 YOY snook from 144 samples and followed the growth of the cohort from a modal size class of 20 mm SL in September through 60 mm SL in February when sampling was terminated. Densities peaked in November and again in February indicating a prolonged recruitment. YOY snook were captured most frequently at 5-10 psu. Fish in ponds were slightly smaller than snook in adjacent tidal creeks. On average, the quiescent waters of the two upstream ponds contained four times as many YOY as any of the other three microhabitat types (downstream ponds, downstream creek, upstream creek). We hypothesize that YOY snook entering Frog Creek recruit preferentially to (or else exhibit higher survival in) low-salinity ponds in the upstream-most portion of the tidal section of Frog Creek. While working on a separate project in southwest Florida, we serendipitously discovered a previously unknown snook nursery area in Tarpon Bay, a large (48 km shoreline) upstream embayment along Shark River, the primary drainage for the Greater Everglades Ecosystem. Although there has long been a thriving recreational fishery for adult snook in the remote rivers and bays of SW Florida and in Florida Bay at the southern tip of the state, the nursery areas supporting this adult population were unknown. Our discovery paved the way for the third study whose objectives were to describe both the demographics and habitat use of juvenile snook in Tarpon Bay. We

collected 66 YOY and year-1 snook along shorelines in the NE-E part of Tarpon Bay between January 2006 and April 2007, most at salinities of 1-5 psu. However, subsequent directed random sampling from February 2008 through April 2009 (89 hauls over 6 dates) yielded no juvenile snook. Electrofishing in the uppermost low-salinity portion of the bay in November 2008 yielded 1 YOY and 6 year-1 fish. Why common snook demonstrated such wide recruitment variability in three consecutive years in this newly-identified, apparently suitable habitat is presently unclear. In summary, we found that YOY snook are predictably associated with shallow shorelines, underwater structure (prop roots, snags), relatively quiescent waters of low velocity, and low to moderate salinity. In west-central and SW Florida, such habitats are usually up-river away from the mouth of the estuary or tidal creek. Unless modified, these shorelines are generally mangrove-lined although in the lowest salinity habitats, there may be a mixture of mangroves with sawgrass (*Cladium jamaicense*) or cattails (*Typha* spp.). Some altered waterways (well-flushed mosquito-control ditches) may offer adequate nursery habitat whereas others (residential stormwater-control ditches) do not.

A CONCEPTUAL MODEL OF JUVENILE COMMON SNOOK *CENTROPOMUS UNDECIMALIS* HABITAT USE AND APPLICATION TO A VARIETY OF ESTUARINE SYSTEMS

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Habitats used by juvenile fishes can dramatically differ among estuaries. Thus, it is important to apply life-history models in a variety of estuarine settings to fully define a species' suite of juvenile habitats. To determine the locations of juvenile common snook *Centropomus undecimalis* habitat and to describe changing habitat affinities through ontogeny, datasets collected by the Florida Fish and Wildlife Conservation Commission, Fisheries-Independent Monitoring program were analyzed for Tampa Bay, Charlotte Harbor, the Caloosahatchee River estuary, Estero Bay, and the Indian River Lagoon.

Suitable habitat near larval sources (i.e., ocean passes) had higher juvenile densities than similar habitat farther into the estuary. In estuaries where rivers occurred in close proximity to passes, densities of small juveniles (15-150 mm SL) in riverine habitats were high, particularily in backwater wetland habitat. In the Calooshatchee River estuary, juvenile snook densities were 7 times greater in backwater embayments, tributaries, and oxbows than along the river's main stem. Not surprisingly, species known to be important prey for juvenile snook (e.g., mosquitofish *Gambusia holbrooki*, sailfin molly *Poecilia latipinna*, rainwater killifish *Lucania parva*) were an order of magnitude more abundant in the riverine backwaters.

In Charlotte Harbor, juvenile snook appear to make less use of riverine habitats and more exclusive use of coastal wetlands. The long distance of rivers from ocean passes (>30 km) may be unfavorable for dispersal of juvenile snook into upper Charlotte Harbor; less than 3% of small juvenile common snook captured during stratified-random sampling were found within riverine habitats compared to 67% in the Indian River Lagoon, and 97% in Tampa Bay. Moreover, the primary juvenile snook habitats in Charlotte Harbor appear to be located in coastal wetland ponds, creeks, and island networks, which are more widely available as potential habitat than in the other estuaries sampled in Florida, where wetlands have been impounded or have been lost to development.

As juvenile snook reach 100–150 mm SL, marked changes in their tolerance to high temperature and low dissolved oxygen occur, and juvenile snook are no longer abundant at the initial nurseries described above. Larger juveniles (151–350 mm SL) were found downstream or bayward of the initial nurseries. These data suggest that small juveniles occupy coastal-wetland ponds, creek networks, and riverine backwaters and subsequently inhabit the entrances to these areas as large juveniles before dispersing more broadly throughout the estuary. The general pattern of snook movement toward open water with size could be complicated at the most remote and isolated locations, which are highly dependent on water level in establishing connectivity to adjacent habitats. Anthropogenic changes in freshwater and tidal delivery to these wetland systems could effectively disconnect juvenile

snook habitat from the estuary. Continuing to refine life-history models to reflect habitat use in individual estuaries will aid in resource management at a local level, enabling managers to target specific areas for protection, land acquisition, and restoration.

HABITAT PREFERENCES OF JUVENILE COMMON SNOOK IN THE LOWER RIO GRANDE/BRAVO DEL NORTE

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The common snook, *Centropomus undecimalis*, is a euryhaline species that can tolerate a wide range of salinities. This species also displays protandric hermaphroditism, in which all individuals first develop as males and then change sex to females as they reach a certain size range. Common snook were once abundant off the Texas coast and supported commercial and recreational fisheries. However, its populations are now characterized by low abundance and erratic recruitment that may be caused by habitat degradation and historical overfishing. Although the lower stretch of the Rio Grande is believed to provide nursery habitat for common snook in Texas, little is known about the specific biology and habitat needs of juvenile snook along the Texas coastline. Knowledge of the general biology of common snook is a prerequisite for the development of management strategies designed to increase the numbers of wild snook. The primary objective of this study was to describe the habitat preferences of juvenile common snook in the lower portion of the Rio Grande, Texas. Fish were collected during January-March 2006 from the lower 51.5 km of the river using multiple gears; a trawl net was used to sample the river channel, and a castnet and boat electrofishing were used to sample the river bank. Measurements of water quality (temperature, dissolved oxygen, conductivity, etc.) and other habitat traits (bank slope, presence of vegetation or woody debris, flow, etc.) were recorded at each sampling site.

A total of 211 common snook were captured. Fish size-frequency distribution and otolith analyses revealed that most common snook collected were age-1 or age-2 fish of up to 303 mm SL. Histological analysis of the gonads indicated that these fish were juvenile males (a single fish of 360 mm SL was caught that appeared to be of a larger size class). A single, incidental electroshock of the river channel indicated that adult male and female common snook (up to 595 mm SL) are also present in the river. All common snook were captured in freshwater habitat (above river kilometer 12.9.) Because juvenile (age 1 and 2) common snook are able to withstand saline waters, their absence in the estuarine portion of the river suggests that they are choosing riverine habitat based on traits other than water salinity. Multivariate analyses revealed that the distribution of juvenile common snook within the freshwater portion of the river was not random but weakly associated with turbidity, temperature, conductivity, pH, and perhaps substrate type. This observation suggested that habitat preferences of juvenile common snook in the freshwater portion of Rio Grande are dictated by a complex interaction of

multiple environmental variables or by factors not measured and not included in the present analysis such as available forage or predation pressure. It is concluded that nursery habitat for common snook is available only in the freshwater portion of the Rio Grande.

COMPARACIÓN DE EDAD Y CRECIMIENTO DEL ROBALO BLANCO (*Centropomus undecimalis*), EN DOS DIFERENTES SISTEMAS TROPICALES, TABASCO, MEXICO

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El robalo blanco, *Centropomus undecimalis,* constituye una de las principales actividades económicas de las comunidades que se encuentran a lo largo del litoral y aguas interiores del Golfo de México. La captura de robalo, es considerada una pesquería artesanal y se ha estudiado de manera aislada; existen trabajos del área de la biología, pero son escasos aquellos que dimensionan la dinámica poblacional. El objetivo de este estudio fue comparar la estructura de edad y crecimiento del robalo blanco *C. undecimalis* de la zona costera y zona ribereña.

Mensualmente, desde julio de 2006 a marzo de 2008, se obtuvieron organismos de la zona costera (Barra el Bosque, Barra San Pedro) y de la zona ribereña (Tres Brazos, San Pedro, Balancán). De cada ejemplar, se tomó la longitud furcal (cm), peso eviscerado (g), se determinó el sexo y se extrajeron los otolitos *sagitta.* Los otolitos fueron seccionados (0.5 mm) con una cortadora Buehler Isomet, los cortes fueron montados con resina sintética, se contaron las bandas de crecimiento con un microscopio. Se realizó el análisis de incremento marginal para validar la formación de bandas de crecimiento. Se estimo la relación longitud-peso, y la relación longitud-radio del otolito. Los parámetros de la ecuación de Von Bertalanffy en longitud fueron estimados por métodos lineales y el método no lineal de Levenberg-Marquardt's.

Se analizó 557 otolitos seccionados. Las edades estimadas fueron de 2 a 17 años. La relación longitud-peso por sexos fue significativa (R^2=0.9). No se encontró diferencias significativas (X^2, P>0.05), en la formación de incremento marginal entre las áreas geográficas. Existe relación significativa entre la longitud furcal (LF) y radio del otolito (RO) de la zona costera y zona ribereña (P<0.01).

Los parámetros de la ecuación de von Bertalanffy en longitud fueron para la zona costera: Barra Bosque $Lf=109.21(1-e^{-0.21(t+0.57)})$, Barra San Pedro $Lf=94.56(1-e^{-0.27(t+0.48)})$, y para la zona ribereña: San Pedro, Balancán $Lf=97.15(1-e^{-0.17(t+1.32)})$ y Tres Brazos $Lf=83.77(1-e^{-0.26(t+0.49)})$, es importante mencionar que los resultados para Tres Brazos no se deben considerar sólidos debido a que la muestra total no fue significativa durante el periodo de estudio.

La prueba T^2 Hotelling mostró diferencias significativas entre los parámetros de crecimiento de machos y hembras (P<0.01). El análisis de la suma de cuadros residuales (RSS) indicaron que las curvas de crecimiento entre las poblaciones fueron estadísticamente diferentes (F=74.08, P=0.05). En general los valores obtenidos son característicos de un crecimiento relativamente lento, especies longevas, lo que hace la necesidad de estudiar y proteger esta especie de la sobreexplotación pesquera.

USE OF RIVERS AND AN OPEN ESTUARY BY COMMON SNOOK *Centropomus undecimalis* AND COMMENTS ON FACTORS INFLUENCING CYCLICAL SEASONAL MOVEMENTS

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Common snook were collected monthly in the Charlotte Harbor estuary from 1997 to 2007 using a 183-m haul seine (2,244 stratified-random samples) to determine their distribution, abundance, size, habitat use, and diet. Common snook were abundant in the estuary (~3.5 fish/100 m shoreline) and ranged in size from 100 to 1,140 mm TL. They were found in a variety of habitats; however, their abundance was significantly greater at sites with mangrove shoreline vegetation, seagrass bottom vegetation, and a high overall abundance of potential prey. Most large catches of common snook (>20) were made during summer in higher saline waters within the sounds and along the barrier islands. They fed on a wide variety of prey within the estuary; at least 37 different prey taxa were identified, including 19 taxa that had not been previously reported. Fishes made up 71% of the prey by number and three prey taxa made up almost 50% of the diet numerically – *Lagodon rhomboides*, *Anchoa* spp., and *Farfantepenaeus duorarum*. An ontogenetic shift in the prey preference of common snook was identified at around 550 mm SL. A significant, positive relationship between predator size and prey size was observed, and the size selection of their prey contributed to some seasonal differences in their consumption of *L. rhomboides*. Seasonal electrofishing surveys targeting common snook were conducted from 2004 to 2006 in the three major rivers leading to the Charlotte Harbor estuary. Common snook collected in the rivers ranged in size from 100 to 1,085 mm TL. They were abundant (~2.8 fish/100 m shoreline) and widespread in all three rivers, with catch rates even greater than those of a dominant freshwater predator, the largemouth bass. Common snook fed on a wide variety of prey in the rivers; at least 30 different prey taxa were recorded. The most numerous and frequently collected taxa were *Gambusia holbrooki*, *Hoplosternum littorale*, and *Procambarus* spp.

Sampling the rivers of southwest Florida provided an opportunity to examine a long held but untested theory – that common snook move from open estuarine and coastal marine habitats into rivers during colder months to find warmer or more stable water temperatures (the overwintering paradigm). Seasonal abundance of common snook in the tidal freshwater portions of the rivers was high in spring and summer, doubled in fall, and then decreased slightly in winter. In the open estuary, their abundance was significantly lower in winter compared to spring, summer, and fall. No specific size group alone appeared to be involved in these seasonal changes, as length frequencies did not differ between seasons. Although these results provide evidence that a portion of the population moves between the rivers and the open estuary, the reasons for these movements require further study. The strong presence of common snook in the rivers during summer and their peak abundance in fall as opposed to winter were unexpected and suggests that their

use of freshwater and marine environments is more complex than previously considered. Our current research is exploring the effects of river flow in relationship to the abundance of common snook, which may prove to be an important factor regarding their seasonal movements to rivers.

APERIODIC, NOVEL MIGRATIONS AND USE OF RIVERINE HABITATS BY COMMON SNOOK: EVIDENCE FOR SKIP SPAWNING

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Common snook support a valuable recreational fishery that contributes significantly to Florida's economy and have been the subject of numerous diverse studies that defined population level aspects of their life history, reproductive biology, and fishery dynamics. High levels of exploitation have resulted in numerous stock assessments with allied regulations; however the stocks remain in inexplicable over-fished conditions. Current assessment models contain assumptions based on historical reproductive schedules measured at the population level during the early 90's while integration of newly discovered variation of spawning dynamics may reveal that the stocks are more or less robust than predicted and that the current level of regulation is not appropriate. We conducted an acoustical telemetry study of the movements and migrations of individual common snook in the tidal reaches of the Caloosahatchee River, a major tributary of Charlotte Harbor, the largest estuary of southwest Florida. We implanted acoustic transmitters into adult common snook and monitored their movements along a 50 km stretch of the Caloosahatchee River. Locations and movements of individual snook were detected and recorded with an array of permanently deployed acoustic receivers along the lower 50-tidal km of the river. We determined that 40% (6/15), 44% (4/9), and 20 % (1/5) of the tagged snook remained inside the monitored portion of the river during 2005, 2006, and 2007, respectively. Overall, 65% of the tagged snook completed annual migrations outside our study area during the three year investigation, presumably to spawn. The mean total length (TL) of the 'residents' was significantly smaller than the mean TL of the 'migrants'. The onset, duration, and destination into the high salinity locations of the estuary of these annual migrations range within the findings of previous reproductive studies, however individual dynamics vary. The mean date of departure from and return to the array for the migrants was mid-June and early September, respectively. The mean number of days the migrants was absent from the array was 73 d (range 40 – 106 d). Fishery dynamics for the study group were calculated for year 1 (2005-2006) as follows: migrants = 9 (60%), residents = 6 (40%), exploitation (μ) = 20 or 27%, annual survival (S) = 9/15 or 60%, total instantaneous mortality (Z) = 0.51, total instantaneous fishing mortality = 0.25 or 0.34, and non-reporting = ~ 25%. For year 2 (2006- 2007) the parameters were: migrants 5 (56%), residents 4 (44%), μ = 11 or 33%, S = 5/9 or 56%, Z = 0.58, F = 0.15 or 0.43, and non-reporting = 66%. This high resolution information on the behavior and fate of individual snook should be incorporated into future stock assessments because this detailed data indicates differential individual contribution to total stock biomass which may affect the predicted condition of stocks.

BIOLOGIA REPRODUCTIVA Y POBLACIONAL DEL ROBALO BLANCO, *C. undecimalis*, EN DOS AMBIENTES TROPICALES, TABASCO, MÉXICO

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En Tabasco, la abundancia de *C. undecimalis* es escasa durante cierta época del año debido a los efectos de la sobreexplotación, principalmente cuando esta especie realiza migraciones durante el periodo reproductivo hacia las desembocaduras de los ríos, lo cual representa un peligro para las poblaciones. El objetivo de este estudio fue estudiar la biología reproductiva y poblacional de *C. undecimalis* capturados en la zona costera y ribereña de Tabasco.

Mensualmente, desde julio de 2006 a marzo de 2008, se obtuvieron organismos de la zona costera (Barra el Bosque, Barra San Pedro) y de la zona ribereña (Tres Brazos, San Pedro, Balancán). De cada ejemplar, se tomó la longitud furcal (cm), peso eviscerado (g), se determinó el sexo y el grado de madurez gonádica macroscópicamente. Se extrajeron los otolitos *sagitta,* los otolitos fueron seccionados (0.5 mm), los cortes fueron montados con resina sintética, se contaron las bandas de crecimiento. Se estableció la estructura poblacional, la relación longitud-peso, proporción sexual, el índice gonadosomático (IGS) y la talla y edad promedio de madurez sexual.

Se analizaron 790 organismos, el intervalo de la longitud furcal se muestra en la Figura 1. Se detectó diferencias significativas entre las longitudes medias de machos y hembras en ambas zonas (K.W., $p<0.05$). La proporción total de sexos, difirieron significativamente (X^2; $p<0.05$). La relación longitud-peso en la zona costera para ambos sexos fue $Pev=0.0059(LF)^{3.07}$ y para zona ribereña de $Pev=0.0086(LF)^{2.98}$, no se detectó diferencias significativas en la relación talla-peso para machos y hembras (Ancova, $P>0.5$). En la zona costera, el promedio mensual del IGS de machos mostró una tendencia similar al de las hembras, el periodo máximo de reproducción fue de abril a septiembre, se observó una relación con la época de lluvias y la temperatura. La L_{50} fue a los 64cm en los machos y de 80cm en las hembras. En relación a la edad de primera madurez sexual, los resultados fueron para los machos=5.8 años y hembras=8 años. El entendimiento de la biología reproductiva del robalo blanco, en tiempo como geográficamente, es fundamental para su manejo y determinar como la presión de pesca afecta la proporción de sexos a largo plazo.

Figura 2. Frecuencia relativa por tallas para machos y hembras de *C. undecimalis*, en (a) zona costera y (b) zona ribereña, Tabasco, México.

MORTALIDAD TOTAL DE ROBALO PRIETO (*Centropomus poeyi*) EN LA LAGUNA DE ALVARADO, VER., MÉXICO (2005-2008)

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Los robalos son especies que tienen importancia comercial tanto en la Laguna de Alvarado como en otros estados de la república Mexicana, y Veracruz se caracterizaba por tener la mayor captura dentro en el Golfo de México, pero a partir del año 2000 disminuyeron sus capturas, en cambio en Tabasco y Campeche aumentaron. Esto despertó la inquietud de las autoridades y pescadores para llevar a cabo estudios que se encaminaran a la regulación de la pesca, considerando uno de los lugares con capturas importantes de estas especies, inicialmente el objetivo principal de estimar la Captura por Unidad de Esfuerzo (CPUE) como un índice de abundancia de robalo prieto (*Centropomus poeyi*), pero posteriormente se cambio al estudio biológico pesquero y se incluyó el robalo blanco (*C. undecimalis*), y entre los objetivos se contempló la estimación de la mortalidad.

El estudio se inició en el año de 2005. Las zonas de muestreo fueron principalmente en la boca-barra de la Laguna de Alvarado, y de las capturas provenientes de los diferentes ríos que confluyen en dicha laguna y de lagunas cercanas que conforman el sistema lagunar de Alvarado. Se tomaron datos de tallas, pesos, sexo y madurez sexual de cada ejemplar, además se registró información relacionada con el esfuerzo pesquero, y se continuaron registrando los mismos datos para las dos especies hasta el 2008.
Para estimar la mortalidad total se requieren los parámetros de crecimiento, y para ello se procedió a estimar primeramente los grupos de edad por el método de Cassie (1954). A partir de los grupos de edad, se obtuvieron los parámetros de crecimiento: L_∞ se calculó con el método de Ford-Walford (1946), el valor de K se determinó con el valor de *b* resultante de la regresión de las tallas promedio de los grupos de edad (L_t y L_{t+1}) con la fórmula k = -1*lnb, y t_o con el gráfico de von Bertalanffy. Una vez obtenidos estos parámetros, se estimó la mortalidad total (Z) con la ecuación de Beverton y Holt (1956), $Z = k*((L_\infty - x)/(x-L'))$.

Obteniendo como resultados cinco grupos de edad, L_∞ igual a 116.9 cm, para *k* 0.342 y para t_o de 0.8955. Las estimaciones de mortalidad total (Z) para el año 2005 fue de 0.99, en el 2006 de 1.11, en el 2007 de 1.18 y en el año 2008 1.64.

Los valores de mortalidad total, indican que en el año 2005 este recurso estaba siendo explotado medianamente, pero en los años siguientes ha estado sometido a una explotación intensiva.

Palabras clave: Parámetros de crecimiento. Mortalidad. Explotación.

THE DIFFICULTIES WITH DEFINING THE SPAWNING SEASON FOR SNOOK IN TEXAS

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Prior to 1940, Common Snook, *Centropomus undecimalis*, were relatively abundant on the Texas coast and were commercially fished. In recent times, the Texas snook population has been small and highly variable. This depletion in snook can be attributed to various factors, namely over-fishing, reduced freshwater inflow and periodic freezes. More information regarding spawning season and size of the spawning population is needed to adequately manage this species along the Texas coast and to condition captive broodstock with appropriate photoperiod temperature regimes. Currently the snook population appears to be increasing in south Texas and juveniles are commonly captured in brackish canals and the Rio Grande. However, to date only one female has been captured in late stage maturation out of 100 adult snook sampled in the spring summer and fall. Thus the spawning season for common snook in south Texas is uncertain. In the bays and inlets sampled, the sex ratio for Texas snook appears skewed towards males, even at larger sizes. The size at female sex is similar to that reported for the East coast of Florida ranging from 650 to 900 mm TL. An analysis of trends in gonadal development seen in two years of sampling will be discussed as well as ongoing research to locate snook spawning aggregations in south Texas.

VARIATIONS IN COMMON SNOOK (*Centropomus undecimalis*) CPUE AND CLIMATIC VARIATION IN SOUTHEASTERN MEXICO COASTS.

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In this research are presented evidences of the relationship among common snook (*Centropomus undecimalis*) CPUE variations and environmental conditions (sea surface temperature and pluvial precipitation) in the coastal zone of Tabasco, Mexico from September 1999 to December 2007. Pluvial precipitation data were obtained from the Comisión Nacional del Agua and SST data from satellite images provided by The International Research Institute for Climate and Society. Monthly average data were standardized (Std. Score = (raw score -mean)/Std. deviation) and smoothed with moving average, multiple and simple correlation were tested. Results show that in the first quart of the analyzed period (May 2000 to December 2007) the peaks of Effort and CPUE precede the highest values of PP and SST (June to August each year). While in 2002 the highest values of effort (fishermen behavior) were observed from October to December (152 vessels/month), this is probably related to a change in annual climatic conditions. Along 2002 were registered anomalous peaks of PP during June (250mm), September (425mm), and November (300mm).

This change in rain pattern is coincident with 2002 El Niño event. After it the effort and CPUE repeated the behavior previously described, although CPUE was low (average 13.7 kg/vessel). We concluded that effort (fishermen behavior) is influenced principally the previous experiences about prevailing climatic conditions based principally on pluvial precipitation (Fig 1). Nevertheless, CPUE reflects success of the recruitment process of common snook into fishing area in response to the change in climatic conditions.

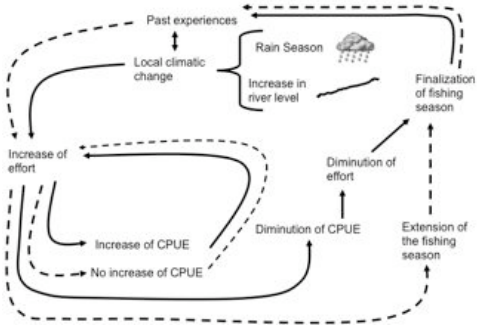

Fig. 1. Fishermen behavior in two climatic conditions.

ASPECTOS REPRODUCTIVOS DE ROBALO BLANCO (*Centropomus undecimalis*) EN EL RÍO PANUCO, VERACRUZ

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En la población del robalo existe en la actualidad una fuerte presión pesquera y un decremento tanto en su captura como en el hábitat disponible para su desarrollo, debido a que es una especie que sostiene dos pesquerías importantes, la que se desarrolla en las lagunas y ríos y la que se desarrolla en la costa y altamar. A pesar de que existe la veda de reproducción, en esta zona se considera desfasada la fecha propuestas en esa normatividad, incrementándose la captura en fechas cuando la especie se encuentra más vulnerable al agruparse en cardúmenes con fines reproductivos. Aunado a ello es un recurso que alcanza su madurez sexual en tallas mayores de los 50cm y la captura se realiza con artes de pesca poco selectivos además de un sistema de pesca inadecuado y el incremento de pescadores libres.

Se realizaron muestreos mensuales de junio a septiembre de 2008, con robalos capturados en el Río Pánuco, con red de arrastre y red trasmallo de luz de malla 6 pulgadas, registrando los datos morfométricos, sexo y madurez sexual. Se midieron un total de 332 robalos blancos, los cuales se distribuyeron entre las tallas 520 y 1,350mm de longitud total, con peso total variable de 2,650 a 12,750grs; la talla promedio en las hembras fue de 849mm y en machos de 798mm. La proporción hembra-macho fue de 1:1; el periodo reproductivo se observó desde junio, apareciendo la fase 5 de desove con el 21%, el 53% en julio, y para agosto y septiembre se presenta el máximo valor promedio del 68% (fig.1). La hembra sexualmente madura mas pequeña fue de 710mm de longitud total y la talla de madurez al 50% (Lc50) en hembras maduras fue de 870mm, mientras que el macho sexualmente maduro mas pequeño fue de 690mm, y el Lc50 fue de 800mm. De acuerdo a la curva de selectividad la L50% obtenida con redes de luz de malla de 6 pulgadas utilizada para la captura fue de 790mm en el total de la muestra.

Con los resultados obtenidos se puede observar que los machos son ligeramente mas pequeños que las hembras y que su madurez sexual la alcanzan a tallas menores. Se considera como fecha tentativa de veda adecuada para esta zona entre agosto y septiembre y una luz de malla en las redes optima para su captura de 6 pulgadas.

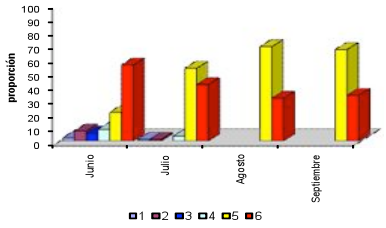

Figura 1. Proporción de las fases de madurez gonádica de robalo blanco *Centropomus undecimalis*, en el Río Panuco, Veracruz. 2008.

REPRODUCCIÓN DE ROBALO PRIETO (*Centropomus poeyi*) Y ROBALO BLANCO (*C. undecimalis*) EN LA LAGUNA DE ALVARADO VER., (PERIODO 2005- 2008)

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Debido a la importancia comercial de estas especies en la Laguna de Alvarado, a la disminución de la captura y la solicitud de los pescadores para cambiar el periodo de veda establecido oficialmente (del primero de julio al quince de agosto) se planteo este estudio cuyo propósito fue conocer la época de reproducción, con el fin de ratificar o rectificar dicho periodo.

Para ello se hicieron muestreos biológicos de cuatro a diez días por mes, en los años 2005, 2006, 2007 y 2008 en la boca-barra de la Laguna de Alvarado, y en las capturas provenientes de los diferentes ríos que confluyen en la Laguna y de lagunas cercanas que conforman el sistema lagunar de Alvarado, los datos registrados de cada ejemplar, incluyeron longitud total, sexo, madurez sexual, y peso, también se colectó información acerca de las características ambientales. La información obtenida se proceso mes por mes, se obtuvo el periodo de reproducción, la talla L_{C50} de madurez sexual, el crecimiento en relación a su peso, crecimiento individual entre otros.

En el año 2005 se midieron 223 robalos prieto y 163 robalos blancos; en el año 2006 fueron 210 robalos prietos y 885 robalos blancos y en el año 2007, fueron 1261 robalos blancos y 493 robalos prietos; y en el año 2008 se muestrearon 199 robalos prietos y 715 robalos blancos.
La reproducción para robalo prieto en el año 2005 se desarrollo en los meses de junio, julio y agosto siendo en julio en pico máximo, y se observó que durante estos meses se intensificó la época de lluvias; en el 2006 el periodo de reproducción fue de julio a septiembre, con un pico máximo en julio, también durante estos meses se intensifica las lluvias; en el año 2007 el periodo de reproducción fue de agosto a septiembre con pico en agosto (en este año las lluvias iniciaron a finales de julio), y en el año de 2008 la reproducción fue de junio a septiembre con un pico máximo en julio.
Con respecto al robalo blanco: El periodo de reproducción en el año 2005, fue de junio a agosto con un pico máximo en julio; en el 2006 fue de julio a septiembre con pico máximo en julio; en el año 2007 fue de junio a septiembre con un máximo en julio; en el año 2008 fue de junio a agosto con un máximo en agosto.

Se concluyó que las dos especies tienen un comportamiento reproductivo similar y que aparentemente las lluvias influyen en la reproducción.

Palabras clave: *Centropomus poeyi*. *C. undecimalis*. Veda. Características ambientales

FECUNDIDAD DE ROBALO BLANCO, *Centropomus undecimalis* EN LA COSTA DE CIUDAD DEL CARMEN, CAMPECHE

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Resumen
La población de robalo blanco *Centropomus undecimalis*, constituye una de las pesquerías ribereñas de mayor tradición e importancia económica en los estados de Campeche, Tabasco, Veracruz y Tamaulipas. Los estudios de fecundidad de los recurso pesqueros de escama son básicos dentro de las investigaciones biológico-pesqueras, que integrados a los estimados de la dinámica de las poblaciones, permiten las evaluaciones del tamaño de la población, caracterización de unidades de población, estimación del potencial reproductivo, entre otros. Se realizaron muestreos mensuales de la captura comercial ribereña de robalo blanco, en la localidad pesquera de Ciudad del Carmen, Campeche. Durante el período de reproducción de la especie de mayo a julio de 1987, se colectaron 33 gónadas maduras, estadio IV (Nikolsky, 1963) así como los datos de longitud total y peso total de las hembras. El sistema de captura utilizado fue la red de enmalle de 500 m de largo, 50 mallas de caída y tamaño de luz de malla de 6 pulgadas. La estimación de la fecundidad, se realizo a través del método propuesto por Vasconcelos-Pérez *et al.* (1976). La fecundidad promedio de robalo blanco se estimó en 3,260850 huevos, considerada alta entre las especies de escama. Asimismo se estableció las relaciones de fecundidad-longitud y fecundidad-peso de acuerdo a Bagenal *et al*. (1978a) con los siguientes resultados, respectivamente.

$F = 0.0109\ L^{4.2693}$

$F = -\ 1{,}917585.78 + 841.289\ P$

El análisis estadístico, de ANOVA indicó que existen diferencias significativas ($p < 0.05$) entre las fecundidades por talla y peso, calculadas.

TALLA DE PRIMERA MADUREZ Y COMPOSICIÓN DE LAS CAPTURAS DEL ROBALO BLANCO EN SUR DE CAMPECHE

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El robalo blanco (*Centropomus undecimalis*) es una de las especies de mayor importancia comercial en la región suroeste de Campeche. Se captura con redes de enmalle y soporta dos pesquerías. La que se realiza en lagunas y ríos y la de la franja costera. Las capturas más abundantes son durante la época de reproducción y cuando se inicia el reclutamiento de juveniles a las zonas de pesca, que es cuando más se capturan organismos que no han llegado a su primera reproducción. Para contribuir con información a la elaboración de los planes de manejo y la NOM (Norma Oficial Mexicana), el presente trabajo tuvo como objetivo ampliar el conocimiento sobre la relación que existe entre la talla de primera madurez y la composición de la captura comercial de la especie en el sur de Campeche.

Se analizó la composición de la longitud furcal (LF) de las capturas, la talla de primera madurez y la del 50% de organismos maduros, de robalo blanco de los años 1997, 2002, 2003, 2007 y 2009. Se hizo la comparación de la información por mes y por año, tanto entre la composición de las capturas como con las tallas de madurez y el 50% de madurez sexual. Por otra parte se hizo un análisis la relación que existe entre la composición de las capturas con la talla de primera madurez. Se tomó como talla de primera madurez cuando en la información que se obtuvo se encontró al menos una hembra o macho totalmente maduro. El 50% de organismos se obtuvo haciendo la frecuencia de LF acumulada por intervalos de clase, tanto de machos como de hembras.

Del análisis se obtuvo que la composición de la captura es muy similar en todos los años, sin embargo la talla de primera madurez y el 50 % de organismos maduros, ha disminuido de 86 cm. LF en 1997 a 76-78 cm. LF en 2007.
Aún y cuando se han encontrado organismos maduros entre 53 y 60 cm. de LF, si es importante mencionar que no se han encontrado tallas inferiores a los 50 cm. ovados.

En la figura1 se observa la estimación de $L_{m50\%}$ de robalo en 2007.

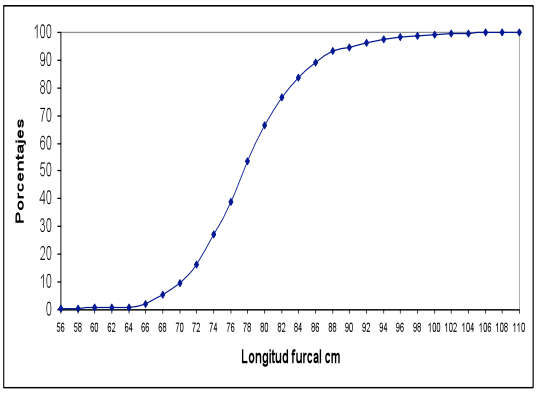

Fig. 1 Talla $L_{M50\%}$ de robalo blanco para sur de Campeche 2007.

PROPUESTA PARA LA REGULACIÓN DE LA CAPTURA DE ROBALO EN EL GOLFO DE MEXICO

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De acuerdo con las estadísticas oficiales (Anuarios Estadísticos de Pesca), en el Golfo de México, el recurso pesquero de robalo históricamente ha tenido importancia comercial, en Campeche, Tabasco y Veracruz. En los dos primeros estados la producción ha aumentado en 2001 y 2002, en cambio en Veracruz ha disminuido a partir del año 2000. No existen medidas de regulación pesquera generales aplicables al Golfo de México. A pesar de que existe una veda diferencial en tiempo en Veracruz y Tamaulipas, además, de manera local en Campeche se manejan, avisos de veda temporal implementadas por la Subdelegación Federal de Pesca (durante cinco días antes y cinco después de luna llena en los meses de junio a agosto). Por ello se consideró importante, elaborar un anteproyecto de Norma pesquera para regular la captura de los robalos en los Estados del Golfo de México.

Se revisaron todos los trabajos realizados en los diferentes estados y la normatividad aplicable y compatible, por lo que se hizo un documento base entre los investigadores de la Dirección General de Investigación Pesquera en el Atlántico, que se sometió a discusión en cuatro reuniones, con los investigadores de diferentes instituciones que han trabajado con la pesquería del robalo blanco (*Centropomus undecimalis*) y robalo prieto (*C. poeyi*). Este documento fue analizado y discutido en especial las recomendaciones técnicas, se incorporaron nuevas y se afinaron las que ya estaban, para quedar consensuadas en un documento final el cual quedo sustentado con la bibliografía correspondiente.

Las recomendaciones resultantes fueron encaminadas básicamente a las tallas mínimas de captura y a establecer un período de veda para las capturas de ambas especies. Del robalo blanco, se estimó una talla mínima de captura para las hembras de 85 cm de longitud total y en los machos de 80 cm; respecto del robalo prieto, se estimó una talla mínima de captura para las hembras de 82 cm de longitud total y en los machos de 78.

El periodo de veda propuesto fue, del 1 de julio al 15 de agosto de cada año, para proteger a los organismos durante el pico reproductivo. Se plantea una talla mínima de captura la de 85 cm con el fin de proteger a ambas especies y a los dos sexos en estado maduro. Con mismo enfoque se plantearon, las especificaciones de los artes de pesca, que serian redes de enmalle o agalleras, con luz de malla mínima de 152 mm (6 pulgadas) o mayores.

SITUACIÓN ACTUAL DE LA REPRODUCCIÓN DEL ROBALO BLANCO EN CAUTIVERIO, EN LA UMDI, SISAL, YUCATAN

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A la fecha, Una las especies de peces trabajadas en la UMDI sobre aspectos reproductivos es: el robalo blanco, *Centropomus undecimalis*; con esta especie se inicio el Programa; Cultivo de Peces Marinos; y se mantiene el objetivo original, de adecuar y/o desarrollar la tecnología existente para su cultivo con énfasis en la reproducción controlada.

La UMDI, es de reciente creación en Yucatán pero el Proyecto; Cultivo del robalo blanco, tuvo su origen años atrás en Cd del Carmen Campeche, donde se hicieron los primero ensayos sobre reproducción y se inició el banco de reproductores. Ahí fue donde se obtuvieron los primeros resultados positivos en maduración, desove en cautiverio y cría de larvas; de igual manera surgieron muchas interrogantes que consideramos como problemas prioritarios; por ejemplo, que factores determinan la maduración del robalo blanco en cautiverio?; cual es el mejor esquema para el cultivo larvario?. Las hembras de robalo blanco muy rara vez alcanzan la maduración final espontáneamente en cautiverio, pero a partir de cierto grado de maduración, se puede inducir con hormonas sintéticas; así, al hablar de maduración, nos referimos a, cuando los ovocitos alcanzan como mínimo 350 µ de diámetro.

Respecto al primer problema, surgieron algunas hipótesis respecto a los factores principales que inician la maduración, algunas de las cuales hemos intentado probar: el fotoperíodo fue uno de las variables a considerar, pero no hubo éxito; También, se utilizo la testosterona como agente promotor de la espermiación y el éxito fue parcial; la calidad de la dieta y la salinidad han sido otras variable incluidas; en cuanto a las larvas; únicamente se han ensayado los protocolos sugeridos por algunos investigadores, para la cría larvaria y la sobrevivencia ha sido baja; además se han hecho algunos ensayos sobre su fisiología.

En el 2008 se hizo un ensayo donde se aplicaron shocks de baja salinidad a 4 lotes de reproductores durante un mes; además se incluyo una dieta semihumeda, con pescado, calamar y Breed-M de INVE. Encontramos que, en agosto, el lote donde se aplico el cambio de salinidad en abril, maduraron 4 de 7 hembras y los dos machos, y en el control (alta salinidad constante) maduraron 2 de 7 hembras y los dos machos; en el resto de los tratamientos, no se encontraron hembras maduras y el 70% de los machos eran espermiantes, aunque con poco esperma. Actualmente se corre un experimento con el mejor tratamiento anterior, con el fin de conocer la repetibilidad de los resultados anteriores, esperando un número importante de hembras maduras y machos espermiantes. Es notorio el hecho que las hembras solamente han madurado de julio a septiembre.

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AN OVERVIEW OF COMMON SNOOK (*Centropomus undecimalis*) BROODSTOCK MATURATION AND SPAWNING RESEARCH IN FLORIDA

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Common snook (*Centropomus undecimalis*) are a very popular and important sportfish along the coast of Florida. Population declines in Florida, Texas and Mexico have generated interest in developing reliable aquaculture techniques to produce snook for stock enhancement and commercial production. Early attempts to spawn common snook in captivity were unsuccessful and efforts shifted to obtaining larvae from strip spawned wild fish or to capturing and inducing spawning in mature fish with hormones following capture. These approaches were not effective for large-scale production due to variability in catch of mature female snook and environmental influences on spawning success (e.g., presence of red tide). To more effectively obtain fry for stock enhancement, research at Mote Aquaculture Research Park shifted in 2005 to maturation and spawning of captive snook. Maturation methods include photo-thermal manipulation and hormone induced final maturation. Broodstock populations consist of wild caught fish, with an average of 14 fish per tank (7♂and 7♀). The broodstock systems (45,000 L volume) are 6.1 m diameter by 1.83 m deep tanks including biofilter, solids filter, UV sterilizers and heater-chiller unit. Snook were fed a regime consisting of a fresh frozen diet (50% shrimp, 25% squid, and 25% herring). After observing a possible nutrition problem, we tried many different feeding approaches in 2007 to increase and insure adequate levels of vitamins and later arachidonic acid (ARA). We determined that the best approach to delivering vitamins and ARA was a protein capsule containing the vitamin premix, which was placed in the fish or squid. In 2005, our captive snook populations where shifted into a shortened winter cycle, which included a 2 month winter (24°C; 12 hr light), one month spring (26°C; 13 hr light), followed by a prolonged summer (30°C; 14-15 hr light). Both photoperiod and lunar cycles are believed to be important in snook maturation. Solar 1000 lighting units allow us to control both daylight and lunar cycling. Previous research indicated that snook do not reach final maturation under photo-thermal control; although, maturation to a vitellogenic/post-vitellogenic stage was possible, which was observed in our fish. Using a dose of 50 µg/kg of gonadotropin releasing hormone analog (GnRHa) for mature females, we achieved the first captive spawns with common snook in May 2006. Fish were implanted three additional times in 2006, each roughly a month apart with varying spawning and larval success. In 2007, we successfully spawned snook out of season, nearly 2 months before the natural spawning timeframe. We had four successful spawning events and fish were then cycled back to winter in September. Besides spawning out of phase, the other major differences in 2007 were modifications in diet, allowing at least 6 weeks between sampling and hormone implantation, allowing fish to recover from sampling stress and implanting immature females and all males at 25 µg/kg GnRHa. In 2008, we added protein pellet enrichments to the feed and had 4-5 successful spawning events in our 3 tanks. Also in 2008 and in 2009, the feeding regimes were set up to look at ARA diet enrichments and determining the importance of ARA for egg quality and early larval survival. At this point in our study, there is a positive

correlation with the level of ARA in the eggs and the fish being fed the ARA supplement. More data is needed to determine egg/larval success based on ARA enrichment.

INDUCCIÓN DE LA REPRODUCCIÓN EN *Centropomus parallelus* BAJO CONDICIONES DE CAUTIVERIO EMPLEANDO INYECCIONES E IMPLANTES DE GnRH-a

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El robalo blanco (*Centropomus undecimalis*) y el chucumite (*Centropomus parallelus*), son especies de peces ampliamente distribuidas en la costa Atlántica de América, desde el sur de Estados Unidos hasta el sur de Brasil. En México son comunes en los Estados costeros del Golfo, particularmente en Tamaulipas, Veracruz y Tabasco en los cuales poseen un alto valor comercial. En el presente estudio se realizaron dos experimentos para la inducción de la reproducción *Centropomus parallelus* empleando inyecciones e implantes de GnRH-a para evaluar la efectividad de la hormona y determinar la calidad de huevos y larvas obtenidos a partir de esta hormona. En el primer experimento se utilizó la técnica de inyección (probando dosis de 75 y 150 µg/kg de pez), en el cual solo se evaluó la efectividad de la hormona y el diámetro de los huevos antes y después de la inyección puesto que no hubo desoves. De este modo se determinó que la dosis de 150 µg/kg fue la mejor al presentar el mayor diámetro de huevos antes y después de la inducción (Fig. 1). En el segundo experimento se empleó la técnica de implantes hormonales, determinándose la efectividad de la hormona, así como la calidad de huevos y larvas puesto que en las dosis probadas (100 y 200 µg/pez) se presentaron desoves; ambas dosis fueron mejores con respecto al control para el diámetro inicial de los huevos y huevos desovados (Fig. 2). Sin embargo, con la dosis más alta se obtuvo mejores resultados con huevos de hembras canuladas días después del desove. Se obtuvo un porcentaje de fertilización de 100 % con dosis de 100 y 200 µg. Para el caso de las larvas ambas dosis fueron similares en la talla inicial.

Esta investigación fue financiada por The F&A Collaborative Research Support Program a través del proyecto: Development of snook (*Centropomus spp*) seed production technology for application in aquaculture and restocking of over-fished populations.

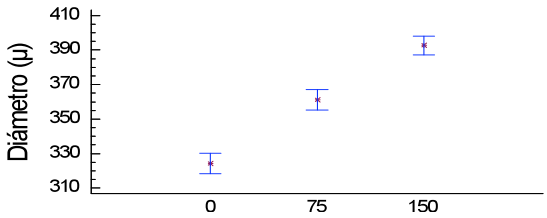

Fig. 1. Experimento 1. Diámetro final de huevos de *C. parallelus.*

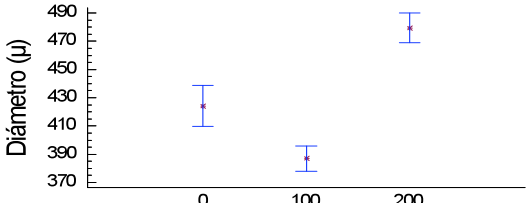

Fig. 2. Experimento 2. Diámetro final de huevos de *C. parallelus.*

PRIMERAS EVIDENCIAS EN LA ACLIMATACIÓN AL CAUTIVERIO DEL ROBALO PRIETO DEL PACÍFICO ORIENTAL, *Centropomus nigrescens* (GÜNTHER, 1864), EN LA COSTA DE MICHOACÁN

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Palabras Clave: Cautiverio, robalo prieto, estanques, costa de Michoacán.

El objetivo del trabajo fue documentar las primeras evidencias en México sobre la aclimatación al cautiverio del robalo prieto, *Centropomus nigrescens*, como una aportación tendente a generar las bases para su cultivo y como una fase inicial de un proyecto de reproducción y crianza de la especie en mesocosmos. El diseño consistió en la integración de un primer lote de juveniles de la especie a partir de la recolecta de crías en el delta del río Balsas, en la zona limítrofe de los estados de Michoacán y Guerrero, México, así como de dos fases de crecimiento. Una primera en agua dulce y una fase final en agua salobre a 22 $^{o}/_{oo}$, obteniendo la información de respaldo sobre la ubicación de los sitios de recolecta, calidad del agua, condiciones en el transporte, confinamiento en estanquería rústica, uso de anestésicos para la identificación de la especie, alimentación, crecimiento y sobrevivencia. A partir de la recolecta de 198 crías de 5-7 cm de L.T. en el brazo izquierdo del río Balsas y de las fases señaladas, en un período comprendido de noviembre de 2004 a junio de 2008 (43 meses), se integró un lote de 29 juveniles en una fase de final de confinamiento en estanquería rustica en Boca de Apiza, Mich. Los resultados alcanzados muestran a *C. nigrescens* como una especie con atributos para su cultivo, entre los que se destacan: facilidad para la recolecta de crías en el río Balsas, a 11 Km de la desembocadura, adaptabilidad para su manejo y crecimiento en estanques de agua dulce a valores de: 27.5° C, 5.38 mg/litro de oxígeno disuelto, 0.2 $^{o}/_{oo}$ de salinidad, pH de 8.0, 95 mg/litro de alcalinidad total, 153 mg/litro de dureza total y 0.051 mg/litro de amonio no ionizado; factibilidad en el uso de benzocaína a 60 mg/litro para la sedación total y el manejo de los organismos, adaptabilidad y resistencia al manejo con redes, factibilidad para la captura y aclimatación de ejemplares adultos en la zona de la desembocadura del río, rápida adaptación a cambios de salinidad (de 26 a 0.2 y de 0.2 a 22 $^{o}/_{oo}$ en dos horas), resistencia al manejo, y factibilidad para su transportación a tasas de 15 kg de biomasa/m^3 por espacio de 5 horas a una temperatura de 26° C. Será recomendable continuar con el proceso de maduración en agua salobre, valorar las condiciones de su protandrismo y maduración e integrar un lote de reproductores que permita avanzar a la fase de reproducción y crianza.

CULTURING TEXAS SNOOK - WHAT WE HAVE LEARNED SO FAR

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Research at the Fisheries and Mariculture Lab of the University of Texas Marine Science institute is based on spawning large marine fishes in captivity in recirculating tank systems using photoperiod and temperature conditioning to simulate natural seasonal changes (Fig. 1) that will induce natural spawning. Long term goals are to develop and publish reliable production technologies to farm new species of marine fish in recirculating systems. We have spawned red drum *Sciaenops ocellatus* for many years and cobia *Ranchycentron canadum* since 2001. We have carried out numerous studies to determine optimum conditions for larvae and juveniles. Recently we have applied the same techniques to the rearing of southern flounder *Paralichthys lethostigma* and hope they will be successfully applied to common snook *Centropomus undecimalis*. During the summer and fall of 2007 and 2008, more than 50 common snook (38-93 cm) were caught in the Laguna Madre and transported to Port Aransas. Snook were put into a 45,000 L recirculating seawater raceway (2.4m w x 13.7m L x 1m d) with a heat pump for temperature control and a cover with internal lights for photoperiod control. The temperature and photoperiod was cycled from 28^0 C and 14 hr light for summer to 21^0 C and 10 hr light for winter. A lunar cycle was also programmed to mimic natural moon phases. The goal was to induce natural spawns in the summer of 2008. No viable eggs were collected; a small number of unfertilized eggs were released on the full moon in August and again four days later. In early October the largest snook were checked for gonadal condition. Surprisingly, the majority of the large fish (80–94 cm) were males including the largest. Out of 10 fish checked, only 2 were identified as females (both 83.8 cm). Small, early stage eggs (200 um) were collected from one of the females and milt was collected from the males which could be activated and observed under a microscope. We had expected at least 50 % of these large snook would be males. Very little is known about the common snook in Texas including where and when they spawn and the sex ratio of large fish. New large snook were collected from the Brownsville Ship Channel in late October 2008 and transported back to Port Aransas and started on another seasonal photo-thermal cycle to induce spawning in the summer of 2009. Spawning by August is anticipated and if not the fish will be checked and eggs measured; if the size is $\geq$ 300 um they will be implanted with GnRHa pellets to try to induce spawning. We have raised larvae from eggs obtained from Kevan Main and are confident of production once good quality eggs have been produced.

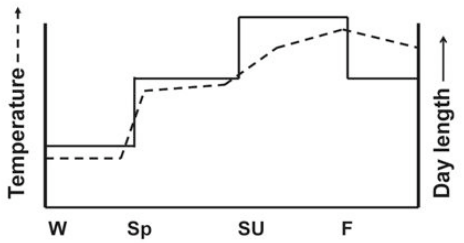

Figure 1. Photothermal cycle used at UTMSI to condition marine fish to spawn in the l

CULTURE OF THE ASIAN SNOOK (*Lates calcarifer,* Bloch) IN AUSTRALIA

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Asian snook (*Lates calcarifer* Bloch), also known as barramundi, is cultured in the Asian Pacific region, mainly in Thailand, Taiwan, Malaysia, Indonesia, as well as Australia. It belongs to the new family Latidae, which is closely related to "robalos" of the family Centropomidae in America. Barramundi is an important species for aquaculture in Southeast Asia and Australia were is one of the most suitable finfish for brackish water farming in earthen ponds and in floating net cages.

At Darwin Aquaculture Centre, Northern Territory, Australia, the breeders were maintained in two 20-m^3 fibreglass tank with recirculation system, at 28-32 ppt and 28-30^oC, with control of temperature and photoperiod. They were fed to satiation, three times a week with 60% of mullet, 34% squid and 6% of pellet INVE Breed-M 25mm, added with pre-mixture of vitamins. Two females and two males were induced to spawn with injections of LHRHa, 50 mg kg^{-1} to females and 25 mg kg^{-1} to males. The eggs were collected between 9-10 hr after the spawn and this were treated with ozone to a concentration between 0.4 to 0.5 mg L^{-1} during 2 minutes and incubated at 2000 eggs L^{-1} in 1-m^3 cylindroconical tanks with open flow until the larvae were transferred to culture larval tank on their second day after hatching (dah). The larval culture was carried out over 28 days in two 6-m^3 fibreglass tanks, with a recirculation system. Larvae were stocked at densities of 86.3 and 88.7 larvae L^{-1} in green water (*Nannochloropsis oculata* and *Isochrysis sp* (T-ISO)).

Recently fertilized egg diameter was 0.807 ± 0.17 mm and the oil droplet diameter 0.250 ± 0.06 mm, with 90 % of fecundity. A total of 3.5 x10^6 eggs obtained. The hatching period started 13 hr after the spawn. Hatching was 90 %, and between 23 to 25 hr later they were transferred to the larval rearing tanks. The average total length during the larval rearing is represented in Fig 1.

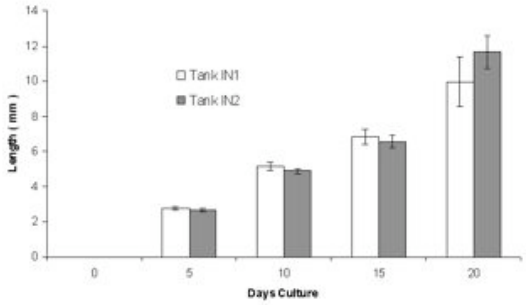

Fig. 1 Growth in total length of barramundi larvae ± standard deviations in two 6,000-L larval tanks in one rearing trial at Darwin Aquaculture Centre.

In the present work larval survival at day 25 was 60.8% for tank IN1 and 51.8% for tank IN2, and at the end of the larval rearing period (28th dah), total average survival was 69.5%. After 53 days of nursery a total of 497,866 juveniles survived (51.7%), with an average weight of 20 g, and a food conversion factor of 0.656. Usually the juvenile are grown to marketable size in ponds between 0.8 and 1.3 ha, and 2 m deep. After 14 months of pond culture fish are harvested with yields between 30 and 39 t ha^{-1} and average

individual weights from 2.5 to 3.0 kg, with a market value of 8 AUS dollar per kg of whole product.

ENGORDA DE ROBALO *Centropomus undecimalis* (Bloch, 1792) Y DEL CHUCUMITE *Centropomus parallelus* (Poey, 1860) EN AGUA DULCE EN EL ESTADO DE VERACRUZ, MEXICO.

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El robalo (*Centropomus undecimalis* Bloch, 1792) y el Chucumite (*Centropomus parallelus* Poey, 1860), son dos especies de importancia económica en el Golfo de México y dada esta importancia se llevaron a cabo 2 estudios para evaluar el crecimiento de estas 2 especies en estanques rústicos y de concreto. En los estanques rústicos se sembraron juveniles en diferentes proporciones: 1:1, 4:1 y 3:2. Previamente se sembraron reproductores de Tilapia, *O. niloticus,* en una proporción de 2 hembras por cada macho, para la producción de alimento. Se utilizaron 1,500 crías para los estanques rústicos (500 en cada uno) y 200 en el de concreto. Mensualmente durante 14 meses se pesaron y midieron. En ambos experimentos se estimo la curva de crecimiento para peso y longitud a partir de un modelo logarítmico $y = aL^b$, los resultados mostraron un crecimiento isométrico para ambas especies, en los estanques rústicos fue de 3.01 para el robalo y de 2.96 para el chucumite y en el de concreto 3.02 y 3.13 respectivamente. La tasa absoluta de crecimiento para longitud en robalo y chucumite en los estanques rústicos fue de 26.43 ± 0.135 cm y 12.0 ± 0.105 cm mientras que la tasa absoluta en peso fue de 265.3 ± 0.623 g y de 55.1 ± 0.191 g respectivamente, con crecimiento diario de 0.062 cm para el robalo y de 0.028 cm para el chucumite. En el estanque de concreto el crecimiento fue de 17.3 ± 0.74 cm y 14.9 ± 2.6 cm, respectivamente, con un crecimiento diario de 0.047 y 0.041 cm, mientras que la tasa absoluta en peso fue de 183.6 ± 2.02 g y 118.1 ± 1.38 g, con ganancia diaria de 0.50 y 0.32 g para el robalo y el chucumite respectivamente.

La velocidad de crecimiento en los estanques rústicos en talla fue semejante en estas especies 0.133 y 0.091 e igualmente en peso 0.347 y 0.279 para el robalo y el chucumite respectivamente, con una alimentación a base de especies forrajeras. En el estanque de concreto fue similar el crecimiento en longitud 0.063 y 0.085, sin embargo el crecimiento en peso en el chucumite mostro una mayor velocidad en relación a su especie con respecto el robalo 0.273 y 0.180, bajo un sistema de alimentación *ad libitum.*

Los datos obtenidos demuestran la factibilidad de que ambas especies puedan desarrollarse en cautiverio en estanques rústicos y con agua dulce de forma conjunta con la tilapia como alimento.

SPAWNING AND LARVICULTURE OF THE FAT SNOOK (*CENTROPOMUS PARALLELUS*) AND THE COMMON SNOOK (*C. UNDECIMALIS*) IN BRAZIL

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The fat snook, *Centropomus parallelus* Poey, 1860 and the common snook, *C. undecimalis* (Bloch, 1792) are distributed along the coast of Brazil, from Amapá to Rio Grande do Sul State, but they are more commonly found on the northern coast in tropical waters.

Presently the dominant coastal aquaculture activity in Brazil is shrimp culture. However, renewed interest in snooks is been stimulated largely by a need for the existing marine shrimp farming to diversify. Despite the studies carried out in the recent years, there is still no commercial production of these valuable fish.

In this work we describe the present status of snook reproduction and larviculture in Brazil, focusing on the results obtained at the experimental fish hatchery of the Universidade Federal de Santa Catarina.

Induced spawning of wild fat snook were first obtained in 1991 with a single injection of hCG. However, when broodstock were conditioned in maturation rooms and induced to spawn, there was a substantial increase in eggs quality. Although cultured females have ovaries containing oocytes at the tertiary yolk stage during the spawning season, they do not ovulate and spawn naturally. Different dosages of LHRH-a with saline injection and cholesterol implant were also tested to induce final maturation. As the fat snook exhibits group-synchronous oocyte development, females could be induced to spawn once a month resulting in up to four consecutive spawnings.

Experimental production of fingerlings has been successfully conducted from eggs. Results of larval culture have been highly variable at the

beginning, survival rates were frequently around 1% until the juvenile stage. With the improvement of the spawning induction technique and better larviculture practices, survival rates increased to 10-20%, using 5,000-L tanks, with initial stocking densities of approximately 40 eggs/L. Using tanks up to 15.000 L capacity, batches of 50.000 juveniles have been produced. Several experiments have been conducted to evaluate the effect of some factors on larval growth and survival: prey quality, photoperiod, light intensity, dietary fatty acids, prey density, weaning age, stocking density, etc.

Spawnings of the common snook were recently obtained by means of hormonal induction with LHRHa of wild fish captured during the natural reproduction season. First common snook juveniles were obtained with the same larviculture techniques employed with the fat snook. Adult females maintained in laboratory were not able to develop ovaries to attain vitelogenesis. Research is been conducted

in order to improve sexual maturation in captivity.

The fat snook proved relatively ease to rear through the larval stages. The common snook is a more promising species, due to a higher growth rate. However, to develop its maturation and routine spawning in laboratory to produce large amount of healthy eggs and larvae is still a challenge.

STATUS AND CHALLENGES IN LARVAL REARING AND FINGERLING AQUACULTURE OF COMMON SNOOK (*Centropomus undecimalis*) IN FLORIDA

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For more than twenty years, researchers have been investigating methods to produce common snook (*Centropomus undecimalis)* for stock enhancement by capturing mature fish and inducing spawning in tanks within a few days following collection, by strip spawning wild fish in the field, and more recently by maturing and spawning snook broodstock in captivity. Early research revealed that newly collected mature snook could be induced to spawn using hormone induction during the normal reproductive season, but this technique often resulted in small numbers of poor quality eggs and the broodstock often died following induced spawning. Another approach has been to strip spawn snook collected from natural spawning aggregations, which allowed us to obtain large numbers of fertilized eggs and to track the egg quality progression over the spawning season. Variability in field spawning success led us to develop maturation and spawning systems at Mote Aquaculture Research Park (MAP) and from 2006 through 2009 we matured and spawned snook in the photo-thermal controlled, recirculating systems at MAP. Common snook spawning primarily occurs in southwest Florida from May through September, but egg quality varies greatly within this time frame. A review of larval rearing data from several years revealed the highest survival rates from spawns collected just past the new and full moon cycle. We strip spawned wild snook from April through September 2003. Egg samples were collected 1 day before and up to 5 days after new and full moons. The highest quality eggs were obtained 2 to 3 days after new and full moon cycles. These results were used to predict maturation and schedule induced spawning trials with captive broodstock. Wild snook egg samples were collected over a 4-year period and analyzed for fatty acid (FA) composition. ARA concentrations in wild eggs were higher than those seen in other marine species, which may be related to parental diet or environmental conditions. The PUFA profile changed over the spawning season and egg quality was best in May, June and July. High DHA levels were significantly correlated with higher fertilization and hatch rates, and with larval survival. FA were analyzed for cultured larvae ranging from 1 to 80 days-post-hatch (DPH). A significant decrease in DHA occurred in the first 6 DPH. Additionally, large numbers of larvae failed to initiate feeding and mortality appeared to be due to starvation. Histology revealed that 2 DPH snook larvae develop their digestive and eye system sufficiently to locate, capture and digest prey. Differences in the initial design of the feeding apparatus are thought to have direct consequences for first feeding and mortality. Studies to identify morphological constraints to feeding demonstrated that 3 DPH snook larvae have a poorly developed feeding apparatus, which limits their ability to consume certain prey (i.e., rotifers) at first feeding. First feeding larvae primarily consumed ciliates, tintinnids, dinoflagellates and small copepod nauplii. Additional studies examined the influence of salinity (15, 25 and 35 ppt) on larval survival and growth. Growth and survival to 14 DPH was highest in salinities at or near full-strength seawater (35 ppt). Research is underway to determine a safe concentration and exposure time (no negative effects on survival and hatch rate) of hydrogen peroxide (H_2O_2) for surface disinfection of snook eggs. Following metamorphosis snook fingerling culture issues that must be resolved include high incidence of lordosis and cannibalism. The effect of diet and water current on both of these variables needs to be determined.

FEMINIZACIÓN DE JUVENILES DE ROBALO BLANCO (*Centropomus undecimalis*) EMPLEANDO 17- β ESTRADIOL EN LA DIETA.

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El robalo blanco *Centropomus undecimalis* en un pez protándrico hermafrodita con un alto potencial de cultivo en México. Diversos estudios indican que las hembras son más grandes y aparentemente su tasa de crecimiento es mayor que en machos. El objetivo del presente estudio consistió en evaluar el efecto del esteroide 17-β estradiol (E2) en la proporción de sexos de esta especie. En este estudio se evaluaron seis periodos de exposición con E2 (7, 14, 21, 28, 35 y 42 días) usando alimento biencapsulado e impregnado con 50 mg de E2. Después del periodo de exposición, los peces fueron cultivados con dieta sin E2 por 198 días adicionales, determinándose la proporción de sexos, crecimiento y supervivencia. Los peces alimentados con dieta enriquecida con E2 por 21 y 42 días muestran mayor proporción de hembras (93 %, Fig. 1 y 2a), mientras que el grupo control presentó 100 % de machos (Fig. 2b). El mayor crecimiento en longitud y peso se obtuvo en los peces expuestos por 21 días a la administración de E2 (193.11 ± 1.83 mm y 28.56 ±0.63 g) comparado con el resto de los tratamientos. La supervivencia varió entre 92 y 98 % en todos los tratamientos.

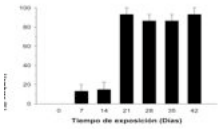

Figura 1. Promedio del porcentaje hembras de juveniles de *C. undecimalis* (± EE) por tratamiento del Experimento II. Letras iguales indican tratamientos que no fueron estadísticamente diferentes entre sí (X^2 P > 0.05). El Numero () indica el tamaño de muestra por tratamiento.

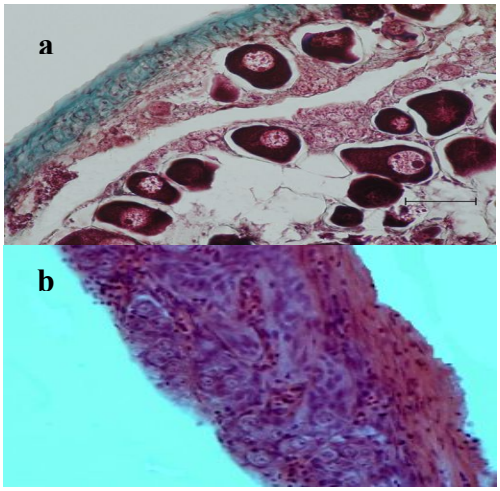

Fig. 2. Gónadas de juveniles de *C. undecimalis*. a) Ovario, b) Testículo

Esta investigación fue financiada por la Universidad Juárez Autónoma de Tabasco y por The Collaborative Research Program Support (CRSP) en colaboración con la Texas Tech University.

ADVANCES ON DIGESTIVE PHYSIOLOGY OF COMMON SNOOK (*Centropomus undecimalis*) IN TABASCO, MEXICO

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Common snook *Centropomus undecimalis* is one of the most important commercial native marine species in Southeast region of Mexico. However, this species has been highly over-exploited, for this reason the research that allows to implement its culture has become a priority. In this sense, is necessary to study the digestive physiology that allows developing its biotechnology. The objective of this project is to evaluate the digestive capacity using biochemical, histological and molecular tools during larval and juvenile stages.

Several samples of larvae and juveniles of *C. undecimalis* were sacrificed to study the digestive enzymatic ontogeny using colorimetric biochemical reactions and SDS-PAGE (for alkaline proteases) and PAGE (for acid proteases) zymograms. Also, samples of stomach and intestine were use for two purposes 1) the characterization of digestive proteases using pH and temperature as factors and the use of specific inhibitors, and 2) the in vitro degree of hydrolysis determination of several protein ingredients using pH-STAT system. Additionally, samples of the digestive system of juveniles were used for traditional H-E technique to describe the anatomical characteristics. Finally, some wild juveniles were sacrificed and stomach, intestine and pancreas were freeze in RNA later buffer for the study of the expression of trypsin and lipase digestive enzymes.

Our results showed that during the ontogeny trypsin, chymotrypsin, L-aminopeptidase, carboxypeptidase A, lipase, amylase, and phosphatase were detected from yolk absorption (2 days post-fertilization, dph) onwards, increasing their activities between 12 and 25 dph. Pepsin was detected from 34 dph onwards.

The alkaline protease zymogram showed two bands, the first (26.1 kDa) at 25 dph, and the second (51.6 kDa) at 36 dph. The acid protease zymogram showed two bands (0.32 and 0.51 rf´s) at 34 dph. On the other hand, acid protease activity in the stomach was optimum at pH 2.0 and a temperature of 75 ºC; it was inhibited in 86% with Pepstatin A. The stability for pH and temperature for acid proteases showed a wide range (2-8 pH and 25-55ºC). Alkaline proteases showed two peaks of pH maximum activity at 7 and 11, and the optimum temperature was obtained at 65ºC. The stability to different pH and temperature for alkaline proteases showed a wide range of values (4-10 pH and 35-65ºC). These proteases were inhibited with PMSF (60%), ovoalbumin (59%), SBTI (41%), TLCK (68%), and TPCK (17%), that indicate the presence of serine proteases (trypsin and chymotrypsin), between these two, trypsin had the highest activity. With EDTA metal proteases were inhibited 40% and 85% using 1-10 phenantrolin. Degree of hydrolysis for protein ingredients showed that blue crab meal, sardine meal, pork meal and beef blood meal had the higher values, additionally the maximum total

amino acid release was obtained for sardine meal in the acid stage, while, for the alkaline stage the maximum amino acid release was detected for the fish hydrolyze. The digestive tract in the common snook is formed, as in many species of Gnathostomata, by the, esophagus, stomach, intestine and accessory glands, liver and exocrine pancreas, and four intestine caecae. The digestive organs show the tissular layers; mucosa, submucosa, and smooth muscle. Finally, we amplified the gen of trypsin and lipase in pancreas of juveniles, these genes showed a similarity with other trypsin and lipase genes higher than 85% detected for other fishes.

APPENDIX
3

PARTICIPANTS IN TRAINING ACTIVITIES

Symposium. Snook biology and culture. Villahermosa, Tabasco, México, Julyl 10-15, 2009. Extension agents, students and small farmers. UJAT-TTU. This workshop took place at facilities of División Académica de Ciencias Biológicas (DACBiol-UJAT).

Name	Institution	Gender	Nationality
Manuel Mendoza Carranza	Researcher, ECOSUR	Masculino	Mexican
Richard Kline	Universidad de Texas	Masculino	North American
María Guadalupe Gómez Ortíz	INAPESCA-SAGARPA	Female	Mexican
Leonardo Ibarra	Researcher, CIAD	Male	Mexican
Carole McIvor	Researcher, U. S. Geological Survey	Female	North American
Adolfo Sánchez Zamora	Researcher, UNAM-UNDI Sisal, Yucatán	Male	Mexican
Vinicius Ronzani Cerqueira	Researcher, Universidad de Santa Catlina	Male	Brsilian
Salomón Páramo Delgadillo	Researcher, DACBiol-UJAT	Male	Mexican
María de Jesús Contreras García	Student, DACBiol-UJAT	Female	Mexican
Alejandro Mcdonal Vera	Researcher, DACBiol-UJAT	Male	Mexican
Ulises Hernández Vidal	Researcher, DACBiol-UJAT	Male	Mexican
Wilfrido Miguel Contreras Sánchez	Researcher, DACBiol-UJAT	Male	Mexican
Carlos Alfonso Álvarez González	Researcher, DACBiol-UJAT	Male	Mexican
Gabriel Márquez Couturier	Researcher, DACBiol-UJAT	Male	Mexican
Arlette A. Hernández Franyutti	Researcher, DACBiol-UJAT	Male	Mexican
Lenin Arias Rodríguez	Researcher, DACBiol-UJAT	Male	Mexican
Juan Manuel Vidal López	Researcher, DACBiol-UJAT	Male	Mexican
Manuel Garduño Dionate	Instituto Nacional de Pesca	Male	Mexican
Francisco Rolando Martínez Isunza	Instituto Nacional de Pesca	Male	Mexican
Rosa María Lorán Núñez	Instituto Nacional de Pesca	Female	Mexican
Martha Alicia Perera	Researcher, Ext. Ríos-UJAT	Female	Mexican

García			
David Blewett	F. L. Fish and Wildlife Conservation	Male	North American
Eduardo A. Zarza Meza	Asoc. Nal. de Profesionales del Mar, A. C.	Male	Mexican
Ron Taylor	FWRT-Florida	Male	Mexican
Kevan Main	Mote Marine Laboratory	Female	North American
Gloria Joan Holt	Texas University	Female	North American
Philip Stevens	F. L. Fish and Wildlife	Male	North American
Matthew Resley	Mote Marine Laboratoty	Male	North American
Kyle Vanderhugt	University of Arizona	Male	North American
Thomas Kaigler	University of Arizona	Male	North American
Rocio Guerrero Zárate	Student, CINVESTAV	Female	Mexican
Ronald Jesús Contreras	Student, DACBiol-UJAT	Male	Mexican
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Isidro López Ramos	SEDAFOP	Male	Mexican
Reynaldo Patiño	Texas Tech University	Male	North American
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Mario Fernández Pérez	Researcher, DACA-UJAT	Male	Cuban
Jeane Rimber Indy	Researcher, DACBiol-UJAT	Female	Indonesian
Anna Fiastro	University of Arizona	Female	North American
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Alejandra Paola Ramos Parada	Instituto Tecnológico Superior de Coatzacoalcos	Female	Mexican
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Irma Gallegos Morales	Researcher, DACA-UJAT	Female	Mexican
Patricia Arceo	Universidad Veracruzana	Female	Mexican
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Rosa Aurora Pérez Pérez	Student, DACBiol-UJAT	Female	Mexican
Natalia Perales García	Student, DACBiol-UJAT	Female	Mexican
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Carlos Alfonso Frias Quintana	Student, DACBiol-UJAT	Male	Mexican
Kenia Laparra Torres	Student, DACBiol-UJAT	Female	Mexican
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