Symposium Summary
Biology and Aquaculture

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We have heard some excellent presentations today. Groupers certainly deserve our attention. Because stocks of traditional species have diminished, fishermen are catching smaller species and going greater distances to catch groupers and their relatives, such as wreckfish. In some places, coneys and graysbys are the largest groupers available, and by default they have become major food fish.

Groupers are relatively easy to catch, especially with traps. They are territorial, bold, and curious, which makes them relatively easy targets for spearfishermen. Obviously, in areas with heavy fishing pressure, regulations are necessary for maintaining viable spawning stocks and optimal yields.

We know now that Nassau groupers do change sex. Examples of how groupers use color to communicate have been given. Much information has been presented on the unusual spawning migrations and behavior of groupers. Nassau and red groupers spawn in aggregations. Red hinds spawn in clusters within aggregations. Apparently, scamps spawn in aggregations or clusters. Jewfish and gags spawn in harems. Gags also go south for the winter (at least from North Carolina to Florida).

Nassau groupers and gags can be chemically induced to ovulate, and Nassau groupers can be reared from eggs. Young gags eat copepods, amphipods, crabs, shrimp, and fish—and they have the teeth to do the job. Groupers do not grow well at high temperatures such as those found in shallow Bahamian waters during the summer.

There is still much scope for research on the biology of Gulf and Caribbean groupers. Information is needed in many areas, including:

- Genetic differentiation of stocks (if possible)
- Details of spawning, distances traveled to spawning sites, fertility
- Early development to aid in systematic comparisons
- Identification of eggs and larvae necessary for ichthyoplankton surveys
- Dispersal and survival of eggs and larvae
- Recruitment of juveniles
- Environmental requirements of young and old fish
- Feeding habits of young and old fish
- Adult migration

- Pollution effects
- Fishing mortality and effects on size and sex composition of stocks
- Interaction with divers

A key area for research is early life history. Studies on the life history of western Atlantic groupers are being done by the Caribbean Marine Research Center and Florida State University (Colin, pers. comm.). Current efforts are directed toward documentation of natural spawning, growth, feeding, recruitment, and migration—particularly for gags, red groupers, and jewfish. A group from the Florida Institute of Technology has been working out of the CMRC laboratory at Lee Stocking Island (Exumas) to document early life history and recruitment of Nassau groupers in that area (Shenker, pers. comm.).

Information on development and identification of young western Atlantic groupers is scarce. Eggs, larvae, or early juveniles of at least 18 Caribbean serranids have been partially described (Manday and Fernandez, 1966; Moe, 1969; Presley, 1970; Hardy, 1978; Kendall, 1979; Kendall and Fahay, 1979; Roberts and Schlieder, 1983; Johnson and Keener, 1984; review of Leis, 1987; Powell and Tucker, in press). However, only three studies were based on larvae hatched in captivity (Manday and Fernandez, 1966; Roberts and Schlieder, 1983; Powell and Tucker, in press), and only one was based on a complete series from egg to juvenile (Powell and Tucker, in press). During spring 1991, red groupers were spawned and reared at Florida State University for description of development (Colin, pers. comm.). Better identification of young groupers will help to answer recruitment questions.

Culture of serranids (Table 1) can aid in the study of early life histories and also has the potential to reduce fishing pressure on natural populations through farming or stock enhancement. In the Far East and Mid East, groupers have been farmed in cages and ponds for more than ten years (Tookinwas, 1990). Several species (mainly *Epinephelus akaara*, *E. malabaricus*, *E. suillus*, and *E. tauvina*) are raised from wild juveniles, usually on a trash fish diet.

Some Gulf and Caribbean groupers are among those that have potential for farming (Tucker and Jory, 1991). In Florida, 1989 dockside prices for whole groupers were in the range US$1.20-2.00 per pound (McKenna, pers. comm.). In Florida and Texas, the 1991 retail price of grouper fillets was more than US$11.00 a pound. In Grand Cayman, skinned, gutted Nassau groupers sold for US$4.38 per pound. Nassau groupers and probably others can be reared to a market size of two pounds within 18 months. Commercial feasibility is still at least several years away and will ultimately depend on reliable, low-cost, large-scale production of juveniles.

In the western Atlantic, only experimental culture of serranids has been done. An HBOI project in the Cayman Islands and Florida developed Nassau grouper spawning and rearing techniques, which probably can be applied in the culture of other groupers. Tucker and coworkers first induced ovulation in

Table 1. Some serranid species in aquaculture research.

Black sea bass	*Centropristis striata*	SE U.S.
Highfinned rockcod*	*Cromileptes altivelis*	SE Asia
Sand perch	*Diplectrum formosum*	Venezuela
Redspotted grouper	*Epinephelus akaara*	SE Asia
		Japan
Blackspotted grouper	*Epinephelus amblycephalus*	Taiwan
Bluespotted grouper	*Epinephelus fario*	Taiwan
Blackspotted rockcod	*Epinephelus fasciatus*	Japan
Flowery cod	*Epinephelus fuscoguttatus*	Indonesia
		Micronesia
		Phillipines
Garoupa-verdadeira*	*Epinephelus guaza*	Brazil
Jewfish*	*Epinephelus itajara*	Venezuela
Red grouper	*Epinephelus malabaricus*	Japan
		SE Asia
Kelp grouper	*Epinephelus moara*	Japan
Red grouper*	*Epinephelus morio*	SE U.S.
Camouflage rockcod	*Epinephelus polyphekadion*	Micronesia
		Japan
		Tahiti
Nassau grouper	*Epinephelus striatus*	Caribbean
	Epinephelus suillus	Malaysia
Estuary grouper	*Epinephelus tauvina*	Kuwait
		SE Asia
		Taiwan
Hamlets	*Hypoplectrus* spp.	Florida
Black grouper*	*Mycteroperca bonaci*	Venezuela
Gag	*Mycteroperca microlepis*	Florida
Kelp bass	*Paralabrax clathratus*	California
Squaretail coral trout	*Plectropomus areolatus*	Micronesia
Coral trout	*Plectropomus leopardus*	Japan

*All but these have spawned in captivity.

Nassau groupers at Grand Cayman during the 1987 spawning season (Tucker *et al.*, in press) and reared them through the larval stage (Tucker and Woodward, 1994). Gags have been spawned in Florida, but the larvae were not raised (Roberts and Schlieder, 1983).

Nassau groupers once spawned voluntarily in the Havana Aquarium (Manday and Fernandez, 1966), and so have black sea bass (Hoff, 1970). Some eastern hemisphere groupers also have spawned voluntarily (Tookinwas, 1990).

Wild juvenile jewfish have been raised experimentally on a fresh fish diet in floating cages by the Center for Scientific Research, University of the Oriente, Margarita Island, Venezuela (Cervigon, 1983). Similar studies have been done with black groupers (Alfonso *et al.* ,1983). Jewfish are being investigated by the Florida Department of Natural Resources (Roberts, pers. comm.). The Rosenstiel School of Marine and Atmospheric Science (University of Miami) is doing preliminary research on the graysby, coney, red hind, and red grouper—primarily to answer questions about development, ecology, and recruitment (Clark, pers. comm.). Mote Marine Laboratory in Florida is beginning aquaculture research on the red grouper.

Sand perch were induced to ovulate with HCG at the FUNDACIENCIA Research Station, Mochima, Venezuela (Manrique, 1987b), and larval development was described (Manrique, 1987a). The black sea bass has been spawned and raised experimentally (Roberts *et al.*, 1976; Tucker, 1984), but it does not grow very fast. At RSMAS, hamlets have been spawned and reared (Domeier, pers. comm.).

Three main areas need to be refined in order for grouper aquaculture to be possible: Spawning methods—to reliably produce large numbers of eggs when needed. Larval nutrition (particularly inclusion of essential fatty acids in the diet through choice and enrichment of live foods)—to maximize survival and growth to the juvenile stage. Development of practical compound feeds—to ensure good survival and growth to market or stocking size at an acceptable cost

This symposium has provided a timely forum on current studies of these fish. We hope that it also stimulates further needed research.

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